Economic Analyses of Childhood and Workplace Injuries

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Centre for Health Economics

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Abstract

Although injury prevention and safety promotion policies have made tremendous progress over the last half century, injury remains a major public health problem in the developed world. Due to the substantive costs on individuals and families, an extensive multi-discipline literature has examined the economic determinants and consequences of injuries. There is, however, a significant lack of longitudinal studies on this topic. Longitudinal analysis may complement injury research, since it is able to carry out robust analysis by employing rigorous econometric methods. A better understanding of injury from panel-data research will help to form and target public prevention programs, which in turn helps mitigate injury's short- and long-term negative impacts.

This thesis conducts a thorough empirical investigation into injuries from an economic perspective. Using three detailed nationally-representative longitudinal datasets (Longitudinal Study of Australian Children, U.S. National Longitudinal Study of Youth-Child Supplement, and Household, Income, Labour Dynamics in Australia) and rigorous econometric techniques, I assess two particular types of injuries. The first is childhood injury, which is one of the major early-life physical health problems in the developed world. A number of questions in relation to childhood injury are researched in this thesis, including its parental socioeconomic determinants, future cognitive outcomes, and medical and pharmaceutical utilisations. The second type is work-related injury, which is a continuing concern in global industrial relations. In spite of the high prevalence of work-related injuries in the Australian labour force and the complexity of workers' compensation programs across states and territories, limited empirical work has focused on Australian injured workers' recovery and return-to-work outcomes. I fill in this research gap, and estimate the impacts of a severe work-related injury on future labour force participation, performance, and satisfaction in Australia.

I have three key empirical findings on the causes and consequences of childhood injuries. First, an occurrence of child injury is not strongly associated with parental socioeconomic background in Australia. Second, an injured child who stayed at hospital overnight, on average, has more absent school days, more doctors' visits, and consumes more health care services than other children in Australia. Third, I find no strong effect of injury on children's cognitive outcomes in Australia (this finding is further replicated by using a U.S. longitudinal dataset).

In regard to adult injury, this thesis finds that a compensated work-related injury has weak negative impacts on current weekly hours and wages, and substantially reduces a worker's self-reported job satisfaction in Australia. Although the compensation schemes have clearly helped Australian injured workers better recover from the accident, more efforts should be made towards return-to-work plans in the future.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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Chapter 1

Introduction

"Every six seconds someone in the world dies as a result of injuries."

World Health Organization, Injuries and violence: The facts 2014, 2014 p.2

1.1 Background and Motivation

1.1.1 Injury: A Major Global Health Issue

Injuries, or so-called 'accidents', account for 9% of the world's fatalities every year, which is almost double the number of deaths caused by HIV/AIDS, tuberculosis, and malaria combined (WHO, 2014). Although the majority of injury-related deaths take place in low- and middle-income countries, injury remains a serious public health and economic problem in the developed world. For example, every day in the U.S., approximately 20 children die as a result of preventable injury, which is more than deaths from all other main childhood killers combined (Borse & Sleet, 2009). The devastating loss of these lives that their families suffer, and the irrevocable damage to communities and societies, are immeasurable. Death, however, only represents a small tip of the 'injury pyramid'. Non-fatal injuries lead to hospitalisation, visits to emergency departments or general practitioners, or treatment involving informal medical care, which consume a considerable proportion of global health expenditure and cause a huge amount of economic loss. In Australia during 2011 and 2012, injury resulted in approximately 60,000 hospital separations for children and adolescents (AIHW, 2014).

Although all age groups suffer from injuries, children and adolescents are particularly affected for a number of reasons (WHO, 2008). First, young people have higher risks of sustaining an injury, due to their limited knowledge of safe behaviours and lack of self-control. Second, an early-life injury may have severe short- and long-run impacts on a child's future wellbeing. For instance, a severe brain injury may significantly reduce an individual's physical and cognitive development (NPHP, 2004). In the short term, injured children may be less able to participate in school activities than healthy children, and thus have worse academic performance and schooling outcomes. In the long run, they may achieve lower educational attainment and socioeconomic status (SES) (Case & Paxson, 2006). The third troubling reason is that the burden of childhood injury falls most heavily on families in poorer countries, and on disadvantaged families in all societies. Globally, 95% of total early-life injury deaths occur in low- and middle-income countries (WHO, 2008). Even amongst high-income countries, a strong socioeconomic gradient in injury risks has been reported. For example, a child from the lowest social class in the U.K. is 16 times more likely to be involved in a house fire than one from the highest class (Roberts et al., 1998). Importantly, the combination of low family SES and poor health caused by injuries during childhood may thus transform into a 'double disadvantage' that will greatly jeopardise an individual's wellbeing during adulthood (Case & Paxson, 2006).

Apart from children and adolescents, another group of people who are particularly vulnerable to injuries is workers. Of all injury deaths, more than 40% occur at the workplace (WHO, 2014). Long hours working, irregular shifts and schedules, short-term tenure, contract-based employment, and unskilled occupations are all strongly associated with higher risks of work-related accidents (Galizzi, 2013). After an accident, severely injured workers may suffer from a direct loss in health condition and labour force participation during recovery. If an injured worker does not fully recover or fails to return to his or her time-of-accident job, then such work injury may have long-term negative impacts, such as lost productivity or income, lower on-the-job satisfaction, and even lower quality of life (Leigh, 2011). Work injury prevention, workers' compensation, recovery, and return-to-work plans have been acknowledged as the main challenges in global industrial relations (Takala et al., 2014).

Over the last half century, many high-income countries have adopted a series of injury prevention strategies: rigorous scientific analysis of the problem, research on its causes and consequences, implementation of prevention programs for at-risk populations, and evaluations of effectiveness. Taken together, these strategies seem to have been effective in reducing injury rates. For example, among all countries of the Organisation for Economic Co-operation and Development (OECD), the injury-related deaths of children under the age of 15 years more than halved over the period between 1970 and 1995 (WHO, 2008). For adult injuries occurring in the workplace, the number of serious claims for workers' compensation in Australia has significantly decreased by 20% after the millennium, from 133,225 claims in 2001 to 106,565 in 2014 (SafeWorkAustralia, 2014). Because of the socioeconomic inequalities of injury, and its frequent long-lasting negative impacts and increased health expenditure, there is still a long way to go in formulating injury prevention programs. A better understanding of research in injury will help to mitigate the immeasurable cost of injuries on individuals, families, and societies.

1.1.2 Research Gaps on Economics of Injuries

Given young people and workers are particularly vulnerable to injuries, there is an extensive body of empirical research into childhood and workplace injuries. These studies from multiple disciplines have thoroughly examined the determinants and consequences of these two types of injuries. For example, a list of family socioeconomic factors are found to be strongly associated with child injury risks, including household income (Engstrom, Diderichsen, & Laflamme, 2002; Fang et al., 2014; Laursen & Nielsen, 2008; Leininger, Ryan, & Kalil, 2009), parental occupational status and educational attainment (Basu & Stephenson, 2005; Hong et al., 2010; Ma et al., 2010), and maternal labour supply (Glied, 2001; Morrill, 2011). In regard to work injuries, injured workers' documented economic costs include short-term earning loss (Galizzi & Zagorsky, 2009; Woock, 2009), long-term reductions in wealth and consumption (Galizzi & Zagorsky, 2009), and even failure to return to the labour market (Henderson, Glozier, & Elliot, 2005). Overall, the existing literature on childhood and work-related injuries has provided in-depth insights for health professionals, and has assisted policy-makers to develop more effective policies for injury prevention and safety promotion. There are, however, three identified research gaps in the existing literature that need to be addressed.

First, despite a large body of literature looking at the causes and costs of injuries, few researchers have utilised longitudinal data. Table 1.1 summarises a few notable longitudinal studies on youth injuries (empirical analyses in this thesis are relevant to these selected research, because of similar study design and empirical method). The main advantage of longitudinal data is that it is possible to control for unmeasured time-invariant confounders, which have the potential to bias estimates. For example, a mother's difficult-to-measure personality and supervision skills may determine both her child's injury risk and cognitive test scores. A worker's unobserved ability and self-discipline may confound both his or her likelihood of having an on-the-job injury and work-related outcomes. Due to the presence of such confounding factors, it is difficult to draw causal links and impacts of a severe injury from the many cross-sectional studies. Exploring the longitudinal properties of the panel data, within-individual fixed-effects models can address this source of bias. Another reason for using a fixed-effects approach is the strong time-variant nature of injury. In contrast to long-term chronic health conditions (e.g., obesity or mental illness), most accidents represent a one-off physical health shock. By comparing longitudinal patterns of four different child health problems (major injury, asthma, ADHD, and conduct problems), Currie et al. (2010) find that childhood injury is more random and unpredictable than other health conditions. At each observed period, some children who were injured previously recover and other children without initial injuries may suffer an injury. This finding further supports the idea that the individual fixed-effects method could be well employed to estimate the economic impacts (or determinants) of injury, given its identification requires sufficient cross-time variation.

Second, there is a lack of research that thoroughly compares the causes and consequences of different types of injuries. For instance, though overall there is a strong family SES gradient in child injuries, the directions of the gradient depend heavily on how the injury occurred. Roadside injuries are negatively associated with parental socioeconomic position, meaning that disadvantaged children are more likely to sustain traffic injuries (Laflamme & Diderichsen, 2000; Hasselberg, Laflamme, & Weitoft, 2001; Engstorm et al., 2002). Conversely, high-SES children participate more often in risky recreational activities, thus experiencing more sports-related injuries (Langley, Silva, & Williams, 1983; Lam, 2005; Simpson et al., 2005). Similar unresolved issues also exist in the literature on work-related injuries. Previous studies have found that irregular shift and schedule (Cottini, Kato, & Westergaard-Nielsen, 2011; Dembe et al., 2007), contract-based employment (Guadalupe, 2003; Hernanz & Toharia, 2006), and unskilled occupation and industry (Dembe et al., 2008; Galizzi, 2013) are all associated with a higher probability of all work injuries combined. However, it remains unclear how job- and individual-related determinants vary by different injury mechanisms in the workplace. For example, workers who have fractures and workers with mental stress may be from different occupations and industries, and thus may seek out different workers' compensation schemes and recovery plans.

Table 1.1 Selected Longitudinal Studies on Childhood Injuries

Authors	Journal	Data and Years	Empirical Method	Main Findings
Category 1: Parental Socioeconomic Determinants				
Currie & Hotz (2004)	*Journal of Health Economics*	NLSY Child Mother file and Vital Statistics Detailed Mortality data (1987-1998)	Child fixed-effects	Requiring day care centre directors to have more education reduces the incidence of unintentional injuries. This result is stronger among white children, and children with high-educated working mothers.
Gordon, Kaestner & Korenman (2007)	*Demography*	National Institute of Child Health and Human Development Study of Early Child Care	Child-mother fixed-effects	Maternal employment itself has no statistically significant adverse effects on the incidence of infectious disease and injury. Greater time spent by children in centre-based care is associated with increased rates of respiratory problems and ear infections (not injury).
Category 2: Short- and Long-term Consequences				
Currie et al. (2010)	*Journal of Human Resources*	Public Health Insurance Records for Canadian children born between 1979 and 1987 in Manitoba	Sibling fixed-effects	Early physical health problems (e.g., injury) are linked to young adult outcomes primarily because they predict later health. Early mental health problems have additional predictive power even conditional on future health and health at birth.
Category 3: Impacts of Prevention Regulations				
Carpenter & Stehr (2011)	*Journal of Law & Economics*	Fatality Analysis Reporting System (1991 -2005); Prevention's Behavioral Risk Factor Surveillance System (1995-2000)	Two-way fixed-effects models; D-in-D-in-D models	Mandatory laws increase youth helmet use and reduce fatalities, however a significant reduction in youth bicycle riding is also of great concern.
Markowitz & Chatterji (2015)	*Health Economics*	Patient-level data from National Electronic Injury Surveillance System from 1991 to 2008	D-in-D-in-D (age, year, and hospital fixed-effects)	Bicycle helmet laws are associated with reductions in bicycle-caused head injuries among children. This observed reduction, however, may be due to the reductions in the number of cyclists induced by the laws.

The third gap is that little evidence has been documented using Australia data. In line with other high-income countries, Australia has made enormous efforts towards child health and development over the past 50 years. This research on childhood injury may therefore provide insights into how current Australia's child safety programs prevent early-life injuries. In terms of workplace injuries, 4.3% of Australian workers suffered at least one work-related injury during the 2013-14 financial year, which consumed 4.1% of GDP for the same period (SafeWorkAustralia, 2014a). However, little is known about Australian injured workers' recovery and return-to-work outcomes. It is interesting to investigate if a severe injury reduces a worker's hours, wage, and on-the-job satisfaction. Research findings may potentially help improve current workers' compensation schemes in Australia.

1.2 Objectives

To fill in all three research gaps discussed above, this thesis conducts a thorough empirical investigation into injuries from an economic perspective. The analyses build on theoretical frameworks on the allocation of parental time, child quality (health) production, human capital development, and the individual utility-maximising function for work satisfaction (detailed discussions are provided in each of the following empirical chapters). Given children and workers are particularly vulnerable to injuries, this thesis focuses at:

1) **Childhood injury** – a major early-life physical health problem in the developed world; and

2) **Work-related injury** – a continuing concern in global industrial relations.

1.2.1 Childhood Injury

Over the last decade, many economists have researched different childhood health dimensions, including asthma (Currie et al., 2010; Fletcher et al., 2010), ADHD (Currie & Stabile, 2006; Fletcher & Wolfe, 2008; Currie et al., 2010), chronic conditions (Case et al., 2005), conduct disorder (Webbink et al., 2012), depression (Fletcher, 2010), general health (Smith, 2009), and mental conditions (Salm & Schunk, 2012). Currie et al. (2010) is a rare example that examines the young adult outcomes of a major injury suffered in childhood. A comprehensive exploration of injury effects on schooling and other long-term outcomes is therefore needed. The primary objectives of this thesis are as follows:

1. To examine the family SES gradient in childhood injury in Australia.

2. To investigate the impacts of a severe injury on several child outcomes in Australia, including school attendance, pharmaceutical and medical utilisation, and cognitive achievement.

3. To re-examine the cognitive effects of sustaining a hospitalised injury in the U.S., and to test if Australian results hold in the U.S. context. Given that the U.S. has different public health and education systems compared to Australia, the robustness test on this matter is especially important.

1.2.2 Work-Related Injury

Despite the high prevalence of work-related injuries in the Australian labour force and the complexity of workers' compensation programs across states and territories, little is known about Australian injured workers' recovery and return-to-work outcomes. Another important empirical task of this thesis is:

1. To estimate the impacts of a compensated work-related injury (most likely a physical injury) on future labour participation, performance, and satisfaction in Australia.

1.3 Outline of the Thesis

The thesis is structured as follows. Chapter 2 presents the first of three empirical studies in relation to childhood injuries. This chapter investigates the SES gradients in childhood injury using a nationally representative survey dataset—around 5,000 children observed from four waves of the Longitudinal Study of Australian Children (LSAC). Based on different measures of injury type, severity, and place, this chapter estimates a number of fixed-effects panel-data regression models, and includes a comprehensive set of socio-demographic controls; this empirical strategy allows for controlling for unmeasured child and family characteristics. Results overall indicate that SES does not strongly determine childhood injury rates in Australia, although there can be observed some unanticipated positive income effects. A child raised in a high-income family is estimated to have higher odds of suffering an injury than a child raised in a low-income family. Findings in this chapter are inconsistent with many previous international studies, which may be explained by differences in the empirical methods employed and the study context.

Chapter 3 extends the Australian analysis in Chapter 2 by examining the impacts of having a severe injury on later schooling outcomes. An injury occurrence occurred in the last 12 months is estimated to have weak contemporary effects on a range of different children's cognitive measurements. These measurements include national standard test scores and teachers' reported academic progress. Severely injured children, however, are instantly reported to have more missing school days, worse parent-assessed health status, and higher utilisation of medical and pharmaceutical services.

Chapter 4 re-examines the cognitive impacts of a severe injury requiring hospital admissions, using almost 10,000 U.S. children observed across 13 study rounds of the National Longitudinal Study of Youth-Child Supplement (NLSY-Child) from 1988 to 2012. Cognitive abilities of children are measured by several scores from the Peabody Individual Achievement Test (PIAT) and the Peabody Picture Vocabulary Test (PPVT). Exploiting the richness of a detailed longitudinal dataset and the time-variant nature of childhood accidental injury as a physical health shock, this chapter estimates both sibling and individual fixed-effects models. All fixed-effects estimates combined suggest that having a hospital-treated accidental injury does not strongly predict later cognitive development. This primary finding is insensitive to different injury mechanisms—causes of accidents, types of injuries, or time spans of an injury occurrence. The subgroup estimates using individual fixed-effects, however, show some significant associations among girls, children whose mothers are less educated, or children whose mothers are working full time. Overall, findings of no strong cognitive impacts of injuries in Chapter 3 are replicated in the U.S. context. Taking the results from Chapter 3 and Chapter 4 together, child injury, as a major source of early-life physical health problems, has weak effects on future cognitive development.

Chapter 5 turns to adult injuries occurring in a workplace. This chapter investigates the impacts of a compensated work-related injury on future labour force participation, performance, and satisfaction in Australia. The empirical strategy includes two main steps. First, using the Australian Bureau of Statistics-Work-Related Injury Survey (ABS-WRI) 2009-10 cross-sectional data, a link between a workplace injury and a workers' compensation claim is carefully studied. Injury severity (measured by the number of absent days) is found to be the most significant predictor of making a serious claim or receiving compensation. Second, exploring the time-variant nature of a compensated work injury and the longitudinal richness of the Household, Income, Labour Dynamics in Australia (HILDA) data from 2005 to 2014, the individual fixed-effects results overall suggest that having a compensated injury during the last year has moderate influences on current weekly working hours and wages, and it reduces a worker's future labour force participation (after two years). Further, individuals who sustain a compensated injury report considerably lower job satisfaction than others, especially on job security, work itself, stress, and difficulty. The reductions in job satisfaction are particularly large in the subgroups of female, younger, unmarried, low-skilled, and low-educated workers.

Finally, in Chapter 6, the main findings of this thesis are summarised and policy implications are discussed. The chapter concludes with some potential emphasis for future research.

Chapter 2

Socioeconomic Determinants of Childhood Injuries in Australia

2.1 Introduction

Every year around the world, approximately 830,000 children and adolescents die as a result of unintentional or accidental injury (Pedan et al., 2008). As a proportion of all early deaths worldwide, injury is responsible for over 25% of deaths among children aged five to 14 (WHO, 2006). Roadside traffic accidents, drowning, cutting or piercing, fire-related burns, falls, and poisoning are the most common fatal injuries, representing 60% of all child injury deaths (ACHC, 2007; Dowswell & Towner, 2002; Pedan et al., 2008). Although 95% of these fatal injuries take place in low- and middle-income countries, childhood injury remains a major public health concern in high-income countries (Pedan et al., 2008). For example, in Australia in 2003, accidental injuries accounted for nearly 40% of fatalities among children aged under 14 years (AIHW, 2008). Besides the deaths, severe injuries can also cause morbidity and disability, and therefore consume a considerable proportion of public health care resources (Dowswell & Towner, 2002). In Australia, injury is the second leading cause of hospitalisation for young people after respiratory illness (Richards & Leeds, 2012). During 2011 and 2012, injury resulted in approximately 60,000 admissions to hospital for young Australians, and in total led to 100,000 patient days in that period (AIHW, 2014).

The increased demand for medical services from injured children impacts heavily on public health care costs. In Australia, total health care expenditure caused by child injury is approximately 1.5 billion AUD per year (Richards & Leeds, 2012); most of these injuries are preventable. In addition, early childhood injury may significantly reduce an individual's physical and cognitive development (NPHP, 2004). A major internal or head injury may lead to permanent disability, for example through acquired brain or spinal cord injury. In the short term, children with severe health issues may be less able to attend and learn at schools. This could be evident in the form of more school days missed, worse academic performance, and lower educational achievement (Case & Paxson, 2006). More importantly, early injury can have long-term negative effects on a child's future health and adult SES (NPHP, 2004).

Another troubling fact is that childhood injury and the consequential disutility are concentrated among children growing up in low SES families; childhood injury may therefore widen socioeconomic inequalities (Case, Lubotsky, & Paxson, 2002; Currie & Stabile, 2003; Newacheck, 1994). Childhood injury is potentially correlated with parental SES due to the important role of supervising and educating children, the characteristics of the school and the neighbourhood in which the child lives, leisure time provided, and parental practices for injury prevention (Hong, Lee, Ha, & Park, 2010). For example, in China, the odds of being injured in the poorest wealth quintile are between 1.3 and 3.5 times greater than the odds found in the richest wealth quintile for permanent disabilities and fatal injuries, respectively (Fang et al., 2014). Furthermore, the combination of low childhood SES and poor health caused by injuries may thus transform into a 'double disadvantage' that will greatly and negatively affect an individual's wellbeing during adulthood (Case & Paxson, 2006).

A better understanding of the causes of childhood injury will help to formulate and target public prevention programs, which in turn will help mitigate the public health care costs, and the short- and long-term individual-level consequences of childhood injury. The focus in this chapter is on the SES determinants of injuries, a topic that has received considerable research attention. Higher levels of household income[1] (Engstrom, Diderichsen, & Laflamme, 2002; Fang et al., 2014; Laursen & Nielsen, 2008; Leininger, Ryan, & Kalil, 2009), parental occupational status, and educational attainment (Basu & Stephenson, 2005; Hong et al., 2010; Ma, Nie, Xu, Xu, & Zhang, 2010) have been shown to be associated with a lower probability of childhood injury (a negative SES gradient), while maternal labour market participation (S. Glied, 2001; Morrill, 2011) appears to be associated with a higher likelihood of injury (a positive SES gradient). Two recent studies suggest that the impact of maternal employment on child injury might be mediated through child care regulations (Currie & Hotz, 2004; Gordon, Kaestner, & Korenman, 2007). Their findings show that formal and centre-based child care centres, with more highly-educated staff, more stringent regulations, and more frequent facility safety inspections, have fewer occurrences of injuries than those without these characteristics. Other notable factors that may influence the relationship between family SES and child injury include family structure (Bzostek & Beck, 2011), neighbourhood

1 Though not necessarily related to child injury, a substantial literature consistently shows that household income positively determines children's general health status in the U.K. (Currie, Shields, & Price, 2007; Kruk, 2013; Propper, Rigg, & Burgess, 2007), Canada (Currie & Stabile, 2003), Germany (Reinhold & Jurges, 2012), the U.S. (Case et al., 2002; Condliffe & Link, 2008; Dowd, 2007; Murasko, 2008), and Australia (Khanam, Nghiem, & Connelly, 2009).

circumstances (Haynes, Reading, & Gale, 2003; Kendrick, Mulvaney, Burton, & Watson, 2005; Reading, Langford, Haynes, & Lovett, 1999), and parental psychosocial conditions (Phelan, Khoury, Atherton, & Kahn, 2007; Schwebel & Brezausek, 2008). The overall pattern indicates that injuries are more likely to occur among children who are supervised by a single parent, who are supervised by a parent who has a mental health condition, or who are members of families living in socio-economically disadvantaged neighbourhoods. In summary, the previous studies collectively suggest that there is a negative socioeconomic gradient in childhood injury (i.e., low SES children are more likely to experience injuries). The magnitude and direction of the gradient may, however, differ by country and study sample, and the main mechanisms linking family SES and child injury are still subject to debate.

Although there is a large body of literature in this field, few researchers have utilised longitudinal data. The main advantage of longitudinal data is that it is possible to control for more unmeasured child- and family-specific confounders, which have the potential to bias estimates. For example, a mother's personality and cognitive ability may determine both her employment status and child supervision skills. Due to the presence of such confounders, it is difficult to draw causal inferences between family SES and child injury from the many cross-sectional studies.

This chapter aims to advance the existing literature in several ways. First, using a rich longitudinal dataset, it carefully examines the family SES gradient in childhood injury. The within-child fixed-effects panel data models allow for accounting for all time-invariant confounders, which previous studies using cross-sectional data have been unable to do. In addition, it includes a comprehensive set of control variables that represent child, family, and neighbourhood characteristics that vary over time. This empirical strategy provides relatively robust estimates of the SES gradient in childhood injury.

The second contribution is to examine parental SES effects on multiple types of injury measures. The relevant literature suggests that family socioeconomic influences may vary substantially with different injury measures, such as severity levels (Fang et al., 2014) and mechanisms (Hong et al., 2010; Laursen & Nielsen, 2008). Notably, this chapter models dependent variables representing injury occurrence, total number of injuries, injury severity, location in which the injury occurred, and type of injury; some of these outcomes have not been widely used previously. In addition, since several studies indicate that gender differentials are strongly evident in childhood injury occurrence (Hong et al., 2010; Laursen & Nielsen, 2008), the estimation is conducted separately by gender.

Finally, this is the first Australian study examining socioeconomic determinants of childhood injury with panel data. Like most other high-income countries, Australia has adopted a number of child injury prevention regulations over the past 50 years. For example, in Australia, bicycle helmets, child restraints in vehicles, pool fencing, smoke alarms, and traffic speed limits are all mandatory (AIHW, 2008).[2] Notably, Australia was the very first country in the world to enforce laws for child safety seats and safe tap water temperatures (AIHW, 2008). These prevention regulations appear to have reduced child injury rates significantly in Australia. For instance, the injury-related deaths of children under the age of 14 years halved over a period of two decades, from 553 deaths in 1983 to 231 in 2003 (AIWH & ABS, 2006).

The within-child fixed-effects results overall suggest that there is no strong family SES gradient in child injury rates in Australia. There are, however, some unexpected positive income effects on the likelihood of injury, particularly for two specific types (i.e., fractures or dislocations, sprains or strains). For example, boys from high-income families have 0.11 more injuries and girls from very high-income families have 0.13 more injuries, relative to children from very low-income households. The findings contradict most earlier international studies, which might be due to the differences in empirical econometric methods employed and study context.

2.2 Conceptual Framework and Empirical Literature

A useful theoretical guide to the empirical analysis in this chapter is a model of child health production, or more generally, child quality production (Becker, 1976; Becker & Lewis, 1973; Grossman, 1972, 2000; Jacobson, 2000). Briefly, this approach proposes a family health production function which is mainly used to model a household member's accumulation and depreciation of health capital. Parents produce child health as part of a family utility-maximising process, and they are assumed to gain more utility from better

[2] However, the effects of these injury prevention regulations are complicated. For instance, Markowitz and Chatterji (2013) employ hospital-level panel data and triple difference models to investigate the impacts of bicycle helmet laws on children's injuries in the U.S. Their findings reveal that helmet laws are associated with a lower probability of bicycle-related head injuries among children. Laws are, however, also associated with a reduction in non-head cycling injuries, as well as significant increases in head injuries from other wheeled sports (i.e., substitutes for bicycle riding). Therefore, the observed decreases in cycling head injuries may be caused by reductions in bicycle riding induced by the laws.

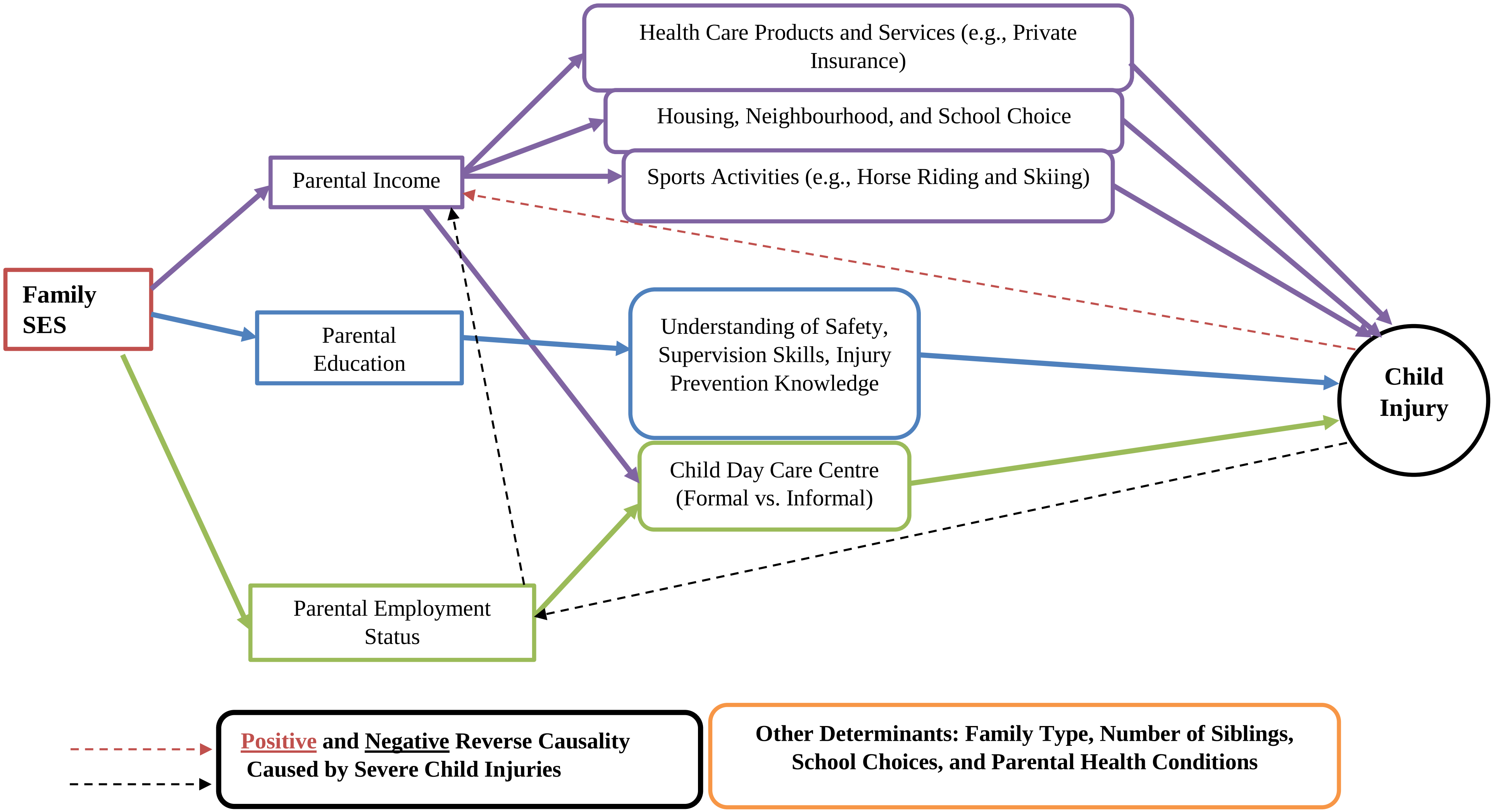
health of their children. Other factors affecting parents' utility include the consumption of market goods and services, as well as leisure time. In this child quality model, a dependent child's health capital is mostly an outcome of the child's parents' or caregivers' decisions and behaviours. Children are born with an initial health stock that depreciates over time. Rapid depreciations in the stock of health take place when children experience health shocks in the form of infectious disease, chronic conditions, or accidental injuries. Investment in child health by parents can occur through medical care, nutrition, healthy diet, time, and other market or non-market inputs that avoid or minimise the reductions from the health stock. In this conceptual framework, the risk of negative health shocks and the magnitude of positive health investments from parents both significantly influence a child's health status (Grossman, 1972, 2000; Jacobson, 2000).

Given that the level of parental investment in child health is dependent on parental resources (such as income, education, and health knowledge), it is likely that SES plays an important role in determining child health. Wealthy households are generally more able to provide better medical care (e.g., private insurance), more nutritious food, and even higher-quality leisure time spent with children. Regarding negative health shocks, high-income families are more likely to live in a newly renovated house with sufficient safety equipment and to settle in a prosperous neighbourhood. A large literature show that children growing up in advantaged families are overall less likely to suffer from severe health shocks, such as major accidental injuries, compared to those with low-income parents (Engstrom et al., 2002; Fang et al., 2014; Laursen & Nielsen, 2008; Leininger et al., 2009). However, higher incomes may increase opportunities for children to engage in risky sports activities, such as riding clubs and soccer classes, and thus increase the incidence of accidental injuries (Lyons et al., 2000). Therefore, the direction of parental income effects on children's injury rates and the underlying mechanisms are unclear.

Parental education is also likely to play an important role in child health investments (Jacobson, 2000). Parents with different educational backgrounds are expected to have different understandings of safety and injury prevention and this may affect their child supervision skills (Morrongiello, 2005). For example, studies from the Republic of Korea and China find that fewer years of parental education lead to higher injury rates for children (Hong et al., 2010; Ma et al., 2010). In contrast, O'Connor and his colleagues (2000) report a positive gradient between maternal education level and risk of child injury. The authors explain that this unanticipated finding may be due to differential recalls and reflect more accurate reporting of accidents in households with higher educational qualifications (O'Connor, Davies, Dunn, Golding, & Team, 2000).

Parental employment status and job characteristics are also believed to affect the risk of child injury. The direction of these effects, however, is ambiguous. Maternal labour participation may increase child injury risk if it reduces the amount of time, or lowers the quality, of child care. A U.S. state-level panel data study indicates that states with more working mothers tend to have greater rates of all causes of child mortality than those in which fewer mothers work (Giled, 2001). On the other hand, maternal working hours may positively influence child care if mothers gain self-esteem or reduced psychological distress from employment (Ali & Avison, 1997). In addition to direct effects, a growing literature suggests that parental employment status may have indirect impacts on child injury risk through child care arrangements (Kotch et al., 1997; Roberts & Pless, 1995). The child health production model indicates that time trade-offs between work, leisure, child care, and other activities are unavoidable (Becker, 1976; Becker & Lewis, 1973; Grossman, 1972, 2000; Jacobson, 2000). Therefore, families may have to purchase substitutes (such as formal child care) for maternal time in producing child health. Recent empirical studies indicate that formal and centre-based child care centres with more highly-educated staff have lower chances of injuries than those without these characteristics (Currie & Hotz, 2004; Kotch et al., 1997; Pearce et al., 2010; Roberts & Pless, 1995). Conversely, informal child care settings (e.g., grandparents and older siblings) tend to lead to higher chances of injuries. A series of studies conducted by Morrongiello and her colleagues focus on the effects of older sibling supervisions on child safety (Morrongiello, MacIsaac, & Klemencic, 2007; Morrongiello, Schell, & Keleher, 2013; Morrongiello, Schmidt, & Schell, 2010), using Canadian samples. They consistently conclude that supervisees (younger siblings) are allowed to engage in more risky behaviours when supervised by older siblings than by mothers or other formal caregivers.

Figure 2.1 Conceptual Framework Developed from Literature: The Relationship between Family SES and Child Injury



Apart from child care arrangements, a number of other significant confounding factors that are potentially correlated with both parental SES and the child injury rate include family structure (Bijur, Golding, & Kurzon, 1988; Bzostek & Beck, 2011; O'Connor et al., 2000; Wadsworth, Burnell, Taylor, & Butler, 1983), neighbourhood circumstances (Haynes et al., 2003; Kendrick et al., 2005; Reading et al., 1999) and parental psychosocial conditions (Phelan et al., 2007; Schwebel & Brezausek, 2008). Figure 2.1 presents a conceptual framework that describes how family SES directly and indirectly (through pathways) influences child injury rates. In addition, this framework also shows the potential reverse effects from a severe injury on parental SES. On one side, a severely injured child may require time-intensive care and thus reduce parental labour supply. In contrast, a major injury may place a financial burden on the family, and therefore increase the working hours of parents. Understanding inter-relationships behind this conceptual framework is important, since it provides the guidance to my empirical strategy (full discussion in section 2.4 below).

2.3 Data, Definitions, and Descriptive Statistics

2.3.1 Longitudinal Study of Australian Children (LSAC)

Data are from waves 2 to 5 of the nationally representative LSAC, a biennial survey designed to measure and trace child wellbeing, health, and development. The first wave in 2004 consisted of approximately 5,000 study children born between March 1999 and February 2000 (mean age of four years and nine months). In this chapter, only waves 2 to 5 are used because wave 1 contained a different set of injury questions (wave 1 does not ask about the severity of injury or the place where the most serious accident occurs), and because this ensures all children are of school age (median ages in waves 2 to 5 equal six, eight, 10, and 12, respectively). The LSAC response rates (of the original sample in wave 1) for these waves are 89.6%, 86.9%, 83.7%, and 79.4%. After omitting observations with missing information on key variables, the estimation sample sizes for waves 2 to 5 are 4,351, 4,209, 4,020, and 3,703, respectively. The overall number of observations (children across waves) equals 16,283.

The LSAC uses a variety of survey instruments, including face-to-face interviews, self-complete questionnaire forms, and direct assessments. Information is obtained from the primary caregiver who is "most knowledgeable" about the study child, which is the child's biological mother in 98% of cases in the estimation sample. The main survey questions covered in the LSAC include the study child's demographic information, health status, education, time use, and general development. This rich data set also records parents' socioeconomic details, such as educational attainment, net weekly income, employment, and neighbourhood SES.

2.3.2. Measures of Childhood Injury

Injuries are assessed by answers to a series of consecutive questions. The initial question is: "During the last 12 months, how many times was your child hurt, injured or had an accident and needed medical attention from a doctor or hospital?" Two dependent variables are derived from this question: (1) a binary variable indicating whether a study child experienced an injury; and (2) number of injuries. The survey then asks whether or not the injured child needed to stay at hospital overnight. Based on this information the third outcome variable is created: (3) an ordered categorical variable measuring injury severity (no injury; injury without hospital stay; injury with hospital stay). The survey also asks about the location where the most serious injury occurred. Answers to this question are used to derive binary variables indicating: (4) most serious injury at home; (5) most serious injury at school; and (6) most serious injury at other location. Finally, a set of (non-mutually-exclusive) binary outcome variables are created indicating whether the child has had: (7) an internal or head injury; (8) a fracture or dislocation; (9) a sprain or strain; (10) a cut or scrape; or (11) other injury (includes dental, burn, poisoning).

Table 2.1 presents sample means for each injury outcome variable, separately for each wave and for the pooled sample. Overall, a child has an almost 20% likelihood of experiencing an injury in the past 12 months that required medical attention. This likelihood is strongly influenced by age, with the sample mean increasing from 0.155 in wave 2 to 0.224 in wave 5. This age gradient is largely driven by non-hospital injuries, injuries that occur out of the home, and by fractures, dislocations, sprains, and strains. Additional analysis (not shown) demonstrates that boys are significantly more likely to be injured than girls. This difference is evident in non-hospital injuries (19.3% versus 15.3%), injuries that require hospitalisation (1.9% versus 0.8%), and the total number of injuries (0.290 versus 0.217).

2.3.3. Measures of Family SES

The LSAC includes detailed information on household income, educational achievement, and employment status. Household income from all sources is measured each wave by six categories: very low (<10^{th} percentile), low (10^{th} to 25^{th}), middle-low (25^{th} to 50^{th}), middle-high (50^{th} to 75^{th}), high (75^{th} to 90^{th}) and very high (>90^{th}).[3] This approach allows for non-linear effects. Parents' employment status is measured by: not in labour force (mostly home-makers), unemployed (but looking for and wanting a job), part-time employed (< 35 hours per week); and full-time employed (≥ 35 hours per week).

In addition to family SES, neighbourhood and school SES indicators are included. Neighbourhood SES is measured with the main Socioeconomic Indexes for Areas (SEIFA) score developed by the Australian Bureau of Statistics that ranks small areas in Australia according to relative socioeconomic advantage and disadvantage using Census data. This score has a mean and standard deviation equal to 10.113 and 0.748, respectively (for the convenience of interpretation, raw SEIFA scores are divided by 100). School SES is broadly measured with dummy variables reflecting whether the school is public (government run) or private. The latter category is split between the Catholic and independent sectors, with independent schools in Australia typically having the greatest resources. Sample means for each of the SES variables are presented in the bottom panel of Table 2.1.

Importantly, the highest sample correlation between two non-mutually-exclusive SES variables is 0.25 (highest income group and SEIFA score), implying that the joint inclusion of employment, income, school, and neighbourhood SES variables in the regression models (described below) does not create a multicollinearity problem.

[3] In the pooled sample, approximately 30% of families are missing information on income (either or both parents do not report income). To maintain the estimation sample size, I create another group of income-missing families.

Table 2.1 Sample Means and Cross-Wave Stabilities of Injury and SES Variables

	Wave 2	Wave 3	Wave 4	Wave 5	Pooled Sample	Cross-Wave Stability (%)
Child Injury Outcome Variables						
Occurrence	.155	.172	.193	.224	.184	68.1
Number	.181	.172	.270	.354	.240	65.9
Severity						
Non-Hospital	.142	.158	.179	.210	.171	69.6
Hospital	.013	.014	.013	.014	.014	95.4
Location						
Home	.065	.065	.051	.041	.056	85.1
School	.039	.054	.058	.070	.054	85.5
Other	.052	.054	.084	.113	.074	81.6
Type						
Head or Internal	.011	.014	.010	.018	.013	95.6
Fractures or Dislocations	.038	.048	.058	.073	.053	85.8
Sprain or Strain	.020	.040	.061	.089	.051	86.7
Cut or Scrape	.063	.060	.036	.031	.048	86.8
Other Injury	.037	.030	.059	.067	.048	86.8
SES Explanatory Variables						
Mother – Not in Labour Force	.356	.281	.277	.250	.293	70.0
Mother – Unemployed	.046	.036	.030	.031	.036	91.0
Mother – Part-Time Employed	.421	.460	.451	.430	.440	66.4
Mother – Full-Time Employed	.178	.223	.243	.290	.231	77.2
Father – Not in Labour Force	.082	.078	.098	.101	.089	84.7
Father – Unemployed	.020	.012	.017	.016	.017	96.2
Father – Part-Time Employed	.056	.047	.058	.062	.056	90.7
Father – Full-Time Employed	.841	.862	.826	.821	.838	75.9
Father – Not in Household	.148	.161	.175	.208	.172	86.7
Very-Low Income (<10th)	.100	.100	.105	.100	.101	86.3
Low Income (10th-25th)	.150	.148	.146	.141	.146	80.5
Middle-Low Income (25th-50th)	.250	.249	.251	.260	.252	73.0
Middle-High Income (50th-75th)	.244	.253	.249	.244	.248	73.8
High Income (75th-90th)	.156	.150	.154	.154	.153	81.9
Very High Income (>90th)	.099	.100	.096	.102	.099	90.2
Public School	.671	.659	.636	.521	.625	81.1
Independent School	.110	.123	.141	.231	.149	86.1
Catholic School	.219	.218	.223	.248	.226	86.6
Neighbourhood SEIFA Score	10.09	10.11	10.12	10.13	10.11	40.5
Sample Size	4,351	4,209	4,020	3,703	16,283	

Notes: Figures in columns 1-5 are sample means. Figures in column 6 are cross-wave stability, which equals the percentage of observations with the same value in every wave. Other location refers to roadside, friend's, or relative's home, outside in a public place (sports ground), inside in a public place (shopping centre), and all other places. Other injury includes dental, burn or scald, poisoning, dog bite, bee sting, and any other types of injury. Sample means for father's employment status are calculated for the subsample of households with non-missing fathers.

2.4 Empirical Methodology

Estimating the effects of family SES on childhood injury is difficult due to the existence of unmeasured confounding factors (e.g., maternal personality and cognitive ability). Utilising the longitudinal nature of LSAC, the main approach of this study is to control for confounders by applying within-child fixed-effects models. In particular, it uses a logit regression for the likelihood of experiencing at least one injury, linear regression for the total number of injuries, ordered logit regression for the severity of injury, and further logit regressions for the place of most serious injury and injury types. For the logit regression, the estimated odds ratios with 95% confidence intervals are reported, while for linear and ordered logit regressions, the estimated coefficients along with standard errors are presented.

2.4.1. Fixed-Effects Logistic Regression for Likelihood of Injury

Following Chamberlain (1980), I use a logistic regression to model the binary outcome variable that indicates the reporting of an injury by child i in period t (inj_{it}):

$$inj_{it} = \Lambda(Z_i\delta_1 + X_{it}\gamma_1 + SES_{it}\beta_1 + \alpha_{1i}) + \varepsilon_{1it} \,, \tag{2.1}$$

where Λ denotes the logistic cumulative distribution function, Z_i is a vector of observable time-invariant factors (e.g., child's gender, number of older siblings), X_{it} is a vector of measurable time-varying control variables (e.g., age in months, father not in household), SES_{it} is a vector of observable time-varying socioeconomic factors (e.g., family income, maternal employment status, school choices), α_{1i} represents all unobservable time-invariant child and family characteristics (e.g., maternal cognitive ability), and ε_{it} is a random error term representing unobservable time-varying factors. The coefficient vector β_1 is of my primary interest in this empirical framework, and represents the effects of time-varying family SES on child injury likelihood (this is why I do not estimate effects of parental education, as it varies little over time).

Note that the fixed-effects (or conditional) logit regression models are estimated by conditioning on the sample of individuals who have at least one change in the dependent variable across waves. When estimating a fixed-effects logit model of injury occurrence, all children who were never injured (52.2%) and all children who were injured in each wave (0.4%) are omitted. This leads to a smaller sample size (47.4% of all children). Given sample means of family SES between two groups (used by fixed-effects logit regressions vs. not used by fixed-effects logit regressions) are statistically insignificant, this analysis is not concerned with external validity issue.

2.4.2. *Fixed-Effects Linear Regression for Number of Injuries*

The number of injuries during the past 12 months prior to the survey ($ninj_{it}$) is modelled using the linear regression:

$$ninj_{it} = Z_i\delta_2 + X_{it}\gamma_2 + SES_{it}\beta_2 + \alpha_{2i} + \varepsilon_{2it} \ , \qquad (2.2)$$

where the parameters and variables are defined as above in equation (2.1). Given $ninj_{it}$ is a continuous outcome variable, Equation (2.2) is estimated using the within-group transformation to difference out the individual fixed effect (ε_{2it}):

$$ninj_{it} - \overline{ninj}_i = \left(SES_{it} - \overline{SES}_i\right)\beta + \left(X_{it} - \overline{X}_i\right)\gamma + \varepsilon_{it} \ , \qquad (2.3)$$

where $\overline{ninj}_i$ is the mean number of injuries experienced by child i across all four waves. Equation (2.3) makes clear that my main coefficients of interest (represented by β) are identified by the association between changes in family SES and changes in injury occurrence across time.

2.4.3. *Fixed-Effects Ordered Logistic Regression for Severity of Injury*

A representation of the ordered logit within-child fixed-effects regression is given by:

$$sinj^*_{it} = Z_i\delta_3 + X_{it}\gamma_3 + SES_{it}\beta_3 + \alpha_{3i} + \varepsilon_{3it}, \qquad (2.4)$$

$$sinj_{it} = k \ \leftrightarrow \ sinj^*_{it} \in [\tau_k, \tau_{k+1}] \ , \qquad (2.5)$$

where $sinj^*_{it}$ denotes an underlying latent variable for severity of injury, $sinj_{it}$ represents the initial measure of the severity ($sinj_{it}$ = 0 for no injury; =1 for injury without hospital stay; =2 for injury with a hospital stay), $\tau_k$are thresholds increasing in k, and ε_{3it} is a time-variant error term that follows a logistic distribution. Ferrer-i-Carbonell and Frijters (2004) develop this estimation method, which uses an individual-specific threshold to transfer the ordinal dependent variable, $sinj_{it}$, into a binary variable. Therefore, the original fixed-effects ordered logit model in turn degrades to a fixed-effect logit model, and a conditional approach proposed by Chamberlain (1980) can be applied for estimation. In this chapter, I use a widely used approximation to this method that utilises the within-group mean values of $sinj_{it}$ as the individual-specific threshold (Jones & Schurer, 2011).

3.4.4. Fixed-Effects Logistic Regressions for Locations and Types of Injury

The choices of the place where the most serious injury occurs (i.e., $pinjh$ =1 for home, $pinjs$ =1 for school, $pinjo$ =1 for other place) are modelled by a group of uncorrelated fixed-effects logistic regressions:

$$pinjh_{it} = \Lambda(Z_i\delta_4 + X_{it}\gamma_4 + SES_{it}\beta_4 + \alpha_{4i}) + \varepsilon_{4it} \quad (2.6)$$

$$pinjs_{it} = \Lambda(Z_i\delta_5 + X_{it}\gamma_5 + SES_{it}\beta_5 + \alpha_{5i}) + \varepsilon_{5it} \quad (2.7)$$

$$pinjo_{it} = \Lambda(Z_i\delta_6 + X_{it}\gamma_6 + SES_{it}\beta_6 + \alpha_{6i}) + \varepsilon_{6it} \quad (2.8)$$

Further, this chapter uses the same method to regress another set of binary indicators representing five non-mutually-exclusive types of injuries experienced by child i in period t ($tinjh_{it}$=1 for head or severe internal injury; $tinjf_{it}$=1 for fracture or dislocation; $tinjs_{it}$=1 for sprain or strain; $tinjc_{it}$=1 for cut or scrape; $tinjo_{it}$=1 for other type of injury):

$$tinjh_{it} = \Lambda(Z_i\delta_7 + X_{it}\gamma_7 + SES_{it}\beta_7 + \alpha_{7i}) + \varepsilon_{7it} \quad (2.9)$$

$$tinjf_{it} = \Lambda(Z_i\delta_8 + X_{it}\gamma_8 + SES_{it}\beta_8 + \alpha_{8i}) + \varepsilon_{8it} \quad (2.10)$$

$$tinjs_{it} = \Lambda(Z_i\delta_9 + X_{it}\gamma_9 + SES_{it}\beta_9 + \alpha_{9i}) + \varepsilon_{9it} \quad (2.11)$$

$$tinjc_{it} = \Lambda(Z_i\delta_{10} + X_{it}\gamma_{10} + SES_{it}\beta_{10} + \alpha_{10i}) + \varepsilon_{10it} \quad (2.12)$$

$$tinjo_{it} = \Lambda(Z_i\delta_{11} + X_{it}\gamma_{11} + SES_{it}\beta_{11} + \alpha_{11i}) + \varepsilon_{11it} \quad (2.13)$$

Definitions of parameters and variables from (2.6) to (2.13) are described in equation (2.1). Note that each of the equations from (2.6) to (2.13) is estimated separately, not simultaneously.

2.4.5 Cross-Wave Variations and Potential Bias

As discussed above in Section 2.4.1, the non-linear fixed-effects models (logit and ordered logit) are unable to remove the ‘fixed-effect’ by a simple within-child transformation, as is possible for a linear regression. The non-linear approach is only identified using observations with across-time variation in the binary dependent variable. Therefore, the appropriateness of these models depends partly upon the cross-wave variations of the dependent variables.

The last column in Table 2.1 reports the cross-wave stability for all variables of interest in this chapter. The lower the overall stability, the higher is the cross-wave variation. With regard to injury occurrence (inj_{it}), 68% of children have either '0' or '1' in all four waves; therefore, the fixed-effects logit estimator only models the variation among the remaining 32%. For the three mutually exclusive locations where the most serious injury occurs, the cross-wave variation ranges from 15% to 18%. There is only 4% of children in which different responses are provided to the question about head or severe internal injury across waves (due to the rare occurrence of this injury type), while the variation rate for other injury types is around 15%. In terms of family SES indicators, the variability of parental employment and household income are observed to be between 10% and 34%, which implies that there is sufficient variation in family SES with which to identify the model coefficients.

A key strength of my empirical methodology is that it allows me to control for all time-invariant characteristics of the child and parents (e.g., personality and IQ) that may confound the relationship between family SES and child injury. However, this methodology is limited in its ability to estimate causal effects due to the potential for unmeasured time-varying confounders or reverse causality. The latter may be particularly important in this context. For instance, the occurrence of a major injury by a child, which needs time-intensive care, may significantly reduce parental work hours, and in turn affect family income.[4] Conversely, if a serious injury causes a strong financial burden on the family, it may have a positive effect on the mother's labour supply (Gould, 2004). Australia's universal health system may, however, limit the size of such biases. A growing literature provides some empirical evidence on this two-way causation and contributes several ideas to overcome this methodological issue (Baker, Gruber, & Milligan, 2008; Frijters, Johnston, Shah, & Shields, 2009; Morrill, 2011; Xu, 2013). If such bias exists, the previous literature utilising instrumental variables methods suggests that the estimates of impacts of family SES on child health outcomes are likely to be upward biased or, in other words, lead us to conclude that SES gradients exist, wrongfully (Baker et al., 2008; Frijters et al., 2009; Morrill, 2011; Xu, 2013). Given the main results

[4] These potential negative causal effects, however, may not necessarily be concerned with my study. In contrast with most previous child injury literature, particularly that using developing countries' data (see Fang et al., 2014, for example), this Australian analysis does not include extremely severe injuries (i.e., those that lead to death or permanent disability). In the LSAC survey, the most serious consequence of an injury or accident is "hospital stay."

(discussed in Section 2.4) show that there is no strong SES impact, this analysis has little concern on this possible bias.

Another source of potential bias in the opposite direction arises from the possibility that seeking medical attention following a childhood injury is itself socially graded. As discussed in Section 2.2.2, the child injury measures are based on an initial question regarding the occurrence of an injury that “needed medical attention from a doctor or hospital.” A large literature demonstrates socioeconomic gradients in health care utilisation and waiting times (see Ellis et al. (2013) and Johar et al. (2013) for two recent Australian examples).[5] Therefore, children from low SES households may have fewer injuries that “needed medical attention,” but not necessarily fewer injuries or fewer severe injuries. This bias would lead us to wrongly conclude that SES gradients do not exist. I would, however, expect that this bias is small with regards to hospitalisations requiring overnight stays (severe injuries recorded by the LSAC survey), given such injuries could simply not be treated at home or ignored by doctors.

2.4 Main Results

Table 2.2 presents estimated odds ratios of SES on the likelihood of an injury requiring medical attention in the past 12 months (top panel). Also shown are joint tests for the statistical significance of each set of SES coefficients from fixed-effects models (middle panel), and for comparative purposes, joint test results from random-effects models (bottom panel). Overall, the fixed-effects logit estimates show that family SES is a weak predictor of childhood injury occurrence. Two of the 28 estimated coefficients are statistically significant at the 5% level—for example, a girl with a part-time employed mother is estimated to have 27% higher odds of suffering an injury than a girl whose mother is not working—but they should be interpreted with caution given they may be only significant by chance (type 1 error). The joint test results support this conservative view, with the sets of maternal and paternal employment coefficients not being statistically significant (p-values equal 0.269, 0.761, 0.110, and 0.114). However, the set of family income coefficients are jointly significant at the 10% level for girls. Although none of the coefficients are individually significant, the estimates suggest that high-income girls are more likely to experience an injury. In terms of the control variables (not shown), only age in months is observed to have a

5 Using an Australian study sample, their results show that the most socioeconomically advantaged patients are prioritised at all quantiles of the waiting time distribution, while in terms of variation in supply endowments, these patients also benefit more than those from a disadvantaged social class.

significant impact on child injury risk. On average, if a study child's age increases by one month, his or her odds of experiencing an injury will increase by 1%.

Table 2.2 Estimated Odds Ratios from Fixed-Effects Logistic Regressions of Injury Occurrence

	Boys		Girls	
	OR	95% C.I.	OR	95% C.I.
SES Odds Ratio Estimates				
Mother – Unemployed	1.33	[0.91,1.96]	0.83	[0.52,1.33]
Mother – Part-Time Employed	1.19	[0.98,1.44]	**1.27****	[1.01,1.59]
Mother – Full-Time Employed	1.15	[0.89,1.49]	1.22	[0.91,1.64]
Father – Unemployed	1.30	[0.64,2.62]	1.27	[0.55,2.92]
Father – Part-Time Employed	1.10	[0.70,1.73]	0.86	[0.52,1.42]
Father – Full-Time Employed	0.95	[0.71,1.28]	**0.72****	[0.52,0.99]
Low Income (10^{th}-25^{th})	1.07	[0.74,1.56]	1.24	[0.82,1.86]
Middle-Low Income (25^{th}-50^{th})	1.15	[0.79,1.67]	1.48	[0.99,2.23]
Middle-High Income (50^{th}-75^{th})	1.34	[0.91,1.99]	1.10	[0.70,1.72]
High Income (75^{th}-90^{th})	1.53	[0.98,2.37]	1.20	[0.73,1.97]
Very High Income (>90^{th})	1.11	[0.67,1.84]	1.76	[0.98,3.14]
Independent School	0.98	[0.72,1.34]	0.82	[0.58,1.15]
Catholic School	0.86	[0.63,1.16]	0.88	[0.61,1.25]
Neighbourhood SEIFA Score	0.92	[0.73,1.15]	0.93	[0.73,1.18]
FE Joint Tests (*p*-value)				
Maternal Employment	.269		.110	
Paternal Employment	.761		.114	
Family Income	.259		.081	
School and Neighbourhood	.647		.513	
All SES Variables	.450		.087	
RE Joint Tests (*p*-value)				
Maternal Education	.989		.190	
Paternal Education	.103		.196	
Maternal Employment	**.048**		.182	
Paternal Employment	.636		.154	
Family Income	.325		.097	
School and Neighbourhood	.158		.901	
All SES variables	.198		.138	
Sample Size	4,407		3,447	

Notes: Robust 95% confidence intervals are presented in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. A constant term, age in months, school grade, number of younger siblings, father missing, and missing income information variables are included in regressions but are not shown. Omitted categories are: mother not in labour market, father not in labour market, family with very low income (10^{th} percentile), and public school. FE denotes fixed-effects logit regression and RE denotes random-effects logit regression.

Notably, parental education indicators, as well as other time-invariant explanatory variables (e.g., parental ethnicity), are necessarily omitted from the fixed-effects logit model (only the effects of time-varying variables can be identified). Previous injury studies, however, often use these variables, particularly parental education, to measure how family SES affects child injury (Basu & Stephenson, 2005; Hong et al., 2010; Ma et al., 2010). In this analysis, I also include all time-invariant factors in a random-effects logistic regression to determine whether the generally weak SES results from fixed-effects models are replicated in random-effects models. Importantly, the random-effects logistic estimates (presented in Appendix Table 2A) also show that, even when exploiting the cross-sectional variation, SES is not a strong predictor of childhood injury occurrence (see the joint test results in the bottom panel of Table 2.2).

Table 2.3 Estimated Coefficients from Fixed-Effects Linear Regressions of Number of Injuries

	Boys		Girls	
	Coef.	Std Error	Coef.	Std Error
SES Coefficient Estimates				
Mother – Unemployed	0.05	(0.05)	-0.07	(0.05)
Mother – Part-Time Employed	0.00	(0.02)	0.02	(0.02)
Mother – Full-Time Employed	0.00	(0.03)	0.01	(0.03)
Father – Unemployed	0.00	(0.08)	0.05	(0.08)
Father – Part-Time Employed	-0.00	(0.05)	-0.03	(0.05)
Father – Full-Time Employed	-0.05	(0.04)	-0.06*	(0.03)
Low Income (10^{th}-25^{th})	0.05	(0.04)	0.05	(0.04)
Middle-Low Income (25^{th}-50^{th})	0.06	(0.04)	0.07*	(0.04)
Middle-High Income (50^{th}-75^{th})	0.09*	(0.04)	0.02	(0.04)
High Income (75^{th}-90^{th})	**0.11****	(0.05)	0.06	(0.05)
Very High Income (>90^{th})	-0.01	(0.06)	**0.13****	(0.06)
Independent School	0.02	(0.04)	-0.02	(0.04)
Catholic School	**-0.06****	(0.04)	-0.03	(0.04)
Neighbourhood SEIFA Score	-0.04	(0.03)	-0.02	(0.03)
FE Joint Tests (*p*-value)				
Maternal Employment	.735		.321	
Paternal Employment	.364		.226	
Family Income	.059		.085	
School and Neighbourhood	.085		.750	
All SES Variables	.099		.234	
RE Joint Tests (*p*-value)				
Maternal Education	.864		.976	
Paternal Education	.317		.386	
Maternal Employment	.118		.418	
Paternal Employment	.425		.085	
Family Income	.451		.509	
School and Neighbourhood	.051		.722	
All SES Variables	.267		.642	
Sample Size	8,299		7,984	

Notes: Robust standard errors are presented in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. A constant term, age in months, school grade, number of younger siblings, father missing, and missing income information variables are included in regressions but are not shown. Omitted categories are: mother not in labour market, father not in labour market, family with very low income (10^{th} percentile), and public school.

Table 2.4 Estimated Coefficients from Fixed-Effects Ordered Logistic Regressions of Injury Severity

	Boys		Girls	
	Coef.	Std Error	Coef.	Std Error
SES Coefficient Estimates				
Mother – Unemployed	0.31	(0.19)	-0.17	(0.24)
Mother – Part-Time Employed	0.15	(0.10)	0.24**	(0.12)
Mother – Full-Time Employed	0.11	(0.13)	0.17	(0.15)
Father – Unemployed	0.28	(0.35)	0.24	(0.43)
Father – Part-Time Employed	0.09	(0.23)	-0.16	(0.26)
Father – Full-Time Employed	-0.03	(0.15)	**-0.35****	(0.17)
Low Income (10^{th}-25^{th})	0.06	(0.19)	0.20	(0.21)
Middle-Low Income (25^{th}-50^{th})	0.15	(0.19)	**0.38****	(0.21)
Middle-High Income (50^{th}-75^{th})	0.30	(0.20)	0.07	(0.23)
High Income (75^{th}-90^{th})	**0.45****	(0.22)	0.14	(0.25)
Very High Income (>90^{th})	0.16	(0.26)	**0.58****	(0.29)
Independent School	-0.00	(0.16)	-0.24	(0.17)
Catholic School	-0.17	(0.16)	-0.12	(0.18)
Neighbourhood SEIFA Score	-0.08	(0.11)	-0.09	(0.12)
FE Joint Tests (*p*-value)				
Maternal Employment	.287		.112	
Paternal Employment	.764		.115	
Family Income	.255		.063	
School and Neighbourhood	.611		.489	
All SES Variables	.500		.073	
RE Joint Tests (*p*-value)				
Maternal Education	.997		.100	
Paternal Education	.085		.113	
Maternal Employment	.072		.324	
Paternal Employment	.549		.164	
Family Income	.308		.096	
School and Neighbourhood	.121		.702	
All SES Variables	.186		.103	
Sample Size	4,421		3,454	

Notes: Robust standard errors are presented in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. A constant term, age in months, school grade, number of younger siblings, father missing, and missing income information variables are included in regressions but are not shown. Omitted categories are: mother not in labour market, father not in labour market, family with very low income (10^{th} percentile), and public school. FE denotes fixed-effects ordered logistic regression and RE denotes random-effects ordered logistic regression.

With an identical format to Table 2.2, Table 2.3 reports results from linear fixed-effects regression models of the number of injuries in the past 12 months. Again, the coefficient estimates and joint test results suggest that SES is not a strong predictor of childhood injury; results from random-effects models also support this conclusion. Nevertheless, the estimates do reinforce the weak finding from Table 2.2 that children from high-income families may experience a greater number of reported injuries than children from low-income families. It is estimated that boys from high-income families have 0.11 more injuries and that girls from very high-income families have 0.13 more injuries, relative to children from very low-income households (though again, weakly significant coefficients should be interpreted with caution). These income effects are jointly significant at the 10% level for boys (p-value equals 0.059) and for girls (p-value equals 0.085). If a log income variable is used instead of the income categorical variables, the estimated coefficients equal 0.03 and 0.01 for boys and girls, respectively.

The same general pattern is found when I model injury severity using an ordered logit specification. Table 2.4 shows that SES is a weak determinant of injury severity, but children from high-income families are more likely to experience injuries requiring hospitalisation—the income coefficients are jointly significant for girls. As per Table 2.4, maternal part-time employment and paternal full-time employment are estimated to significantly increase and decrease injury severity, respectively, but the sets of employment coefficients are not jointly significant.

Notably, the general statistical insignificance of SES in Tables 2.2-2.4 is not due to the joint inclusion of variables representing correlated measures of SES. If I re-estimate the injury occurrence, number, and severity regressions including each SES group (maternal employment, paternal employment, family income, school sector, and neighbourhood) separately, I also find that no set of SES variables is jointly significant at the 5% level in any model. Moreover, only the family income variables are marginally significant at the 10% level among girls (see Appendix Table 2C).

Table 2.5 Joint Significance Tests from Fixed-Effects Logistic Regressions of Injury Location and Type

	Maternal Employment		Paternal Employment		Family Income		Schools & Neighbours		All SES	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Location										
Home	.320	.116	.204	.372	.858	.309	.577	.222	.668	.221
School	.325	.507	.953	.899	.420	.470	.556	.751	.689	.871
Other	.475	.269	.731	.212	.556	.383	.583	.999	.794	.562
Type										
Head or Internal	**.039**	.173	.720	.999	.874	.321	.493	.355	.487	.601
Fractures	.600	.345	.528	.890	**.023**	.431	.779	.946	.221	.797
Sprain or Strain	.355	.129	.405	.066	.613	.345	.264	.981	.575	.258
Cut or Scrape	.299	.432	**.023**	.064	.727	.629	.247	.841	.112	.443
Other Injury	.425	.570	.138	.510	.838	.618	.841	.387	.753	.764

Notes: Figures are p-values from joint significance tests from fixed-effects logistic regressions. Each row denotes a separate regression model. All regressions have the same set of controls as those in Table 2.2. Bold font denotes statistical significance at the 5% level.

The final set of results investigates whether SES affects the likelihood of injury in certain locations or affects the likelihood of certain injury types. Before discussing the specific findings it is important to note that Table 2.5 contains results from 80 hypothesis tests and so the probability of type I errors (false positives) is substantially higher than 5% (i.e., there is a multiple comparisons problem). A popular approach for overcoming this problem is the Bonferroni correction method. This conservative approach involves adjudicating statistical significance using a comparison *p*-value rate that is substantially smaller than the typical 5% level. In terms of Table 3.5, the application of the Bonferroni method would require *p*-values to be smaller than .05/80 = 0.0006 to declare statistical significance. The results in Table 2.5 show that I can reject only three of the 80 joint hypothesis tests with a 5% comparison rate. In each instance the *p*-value is greater than .01, and so my conclusion is that the results support my overall finding that SES is a weak predictor of childhood injury in Australia. Nevertheless, in light of the joint significance tests of family income in Tables 2.2, 2.3, and 2.4, it is worth detailing the income effect for fractures or dislocations. The estimated odds ratios suggest that the odds of being fractured for a boy in the high-income group are about 1.47 times greater than the odds for a boy in the very-low-income group.

2.6 Discussions and Concluding Remarks

This chapter contributes to the existing literature in three ways. First, using a rich longitudinal dataset, I carefully investigate the family SES gradient in childhood injury. The fixed-effects panel data models allow me to account for unmeasured confounders, which previous cross-sectional studies have been unable to do. Second, I examine multiple types of injury measures, including occurrence, total number, severity, location, and type, and estimate the effects of several measures of SES, including employment, income, and neighbourhood and school type. Third, this is the first statistically rigorous study examining the socioeconomic determinants of childhood injury in the Australian context.

This chapter concludes that there is no strong SES gradient in childhood injury in Australia. This main finding is inconsistent with most of the earlier international literature, which finds the existence of considerable socioeconomic inequalities in child injuries (Currie & Hotz, 2004; Engstrom et al., 2002; Fang et al., 2014; Gordon et al., 2007; Hong et al., 2010; Laursen & Nielsen, 2008; Leininger et al., 2009; Ma et al., 2010; Morrill, 2011). This significant difference in results might be explained by both methodological and contextual factors. On the methodological side, my study firstly applies a fixed-effects panel-data method to control for unmeasured confounders, which may play a key role in variations in child injuries, although my main findings are supported by models that exploit cross-sectional variation. On the contextual side, Australia has developed a world-leading child safety system (AIHW, 2008). These prevention regulations have reduced child injury rates significantly over the last half century, which may explain the absence of family socioeconomic differentials in child injury risk propensities in Australia (AIHW, 2008). As discussed above, several recent Australian studies on this field (Lam, 2005; Poulos et al., 2007; Turner et al., 2006), coupled with this chapter, combined find no high child injury risk propensities among socially disadvantaged families. This empirical evidence may further suggest that Australia has already developed a world-leading child safety system.

Another interesting finding from this chapter are some weak to mild associations between social advantage and higher injury risks (particularly injuries causing sprain or strain, or those occurring at a place other than school or home). This unexpected result may be due to the greater opportunity that wealthier Australian children have to participate in more adventurous sporting or recreational activities such as horse riding and skiing, as participation in such activities is likely to be associated with an increased risk of physical injuries (Spinks & McClure, 2007).[6] Two prior Australian studies in paediatric and child health investigate the socioeconomic determinants of sports injuries (Jolly et al., 1993; Turner et al., 2006). Both studies find that the family SES shows weakly positive effects on sports-related injuries, which is not evident in any other injury mechanisms (see more findings of Australian studies in *Table 2D* in *Appendices*). Jolly et al. (1993) explain that such difference may be owing to the limited access to sports activities of low-income Australian children. Further, a Canadian study asserts that higher parental SES is associated with increased risks for sport and recreational injuries (Simpson et al., 2005).

My empirical methodology is not without limitations. The within-child fixed-effects models control for all time-invariant characteristics of the child and parents, which are likely to be crucial determinants of child injury rates. However, these models are not robust to reverse causality or to systematic differences in the likelihood of reporting injuries (measurement error). The latter concern may be more important in my study, since my results overall find

[6] In the LSAC, the occurrence of these particular injuries, as well as family income, appears to be positively associated with the frequency of sports-related activities and entertainment events that children participate in. This fact may support my suspicion that weak positive income effects on child injuries are mediated through participation in sport activities.

no strong SES gradient. As discussed in Section 2.4.5, previous literature suggests that reporting bias caused by socioeconomic differentials would lead us to wrongly conclude that SES gradients do not exist. There is little empirical evidence on the pervasiveness of these issues, and so it is difficult to judge if and to what extent they may be influencing my results. Understanding these potential issues is an important area of future research.

2.7 Appendices

Table 2A Estimated Odds Ratios from Random-Effects Logistic Regressions of Injury Occurrence

	Boys		Girls	
	Coef.	Std Error	Coef.	Std Error
SES Coefficient Estimates				
Mother – Completed Year 12	0.97	[0.75,1.25]	0.91	[0.68,1.21]
Mother – Diploma	1.00	[0.82,1.22]	0.96	[0.77,1.21]
Mother – Degree	0.99	[0.79,1.23]	1.16	[0.90,1.50]
Father – Completed Year 12	1.04	[0.76,1.44]	0.92	[0.64,1.34]
Father – Diploma	1.20	[0.95,1.51]	0.93	[0.71,1.20]
Father – Degree	0.98	[0.75,1.27]	0.75	[0.56,1.02]
Mother – Unemployed	1.41**	[1.03,1.93]	0.87	[0.59,1.30]
Mother – Part-Time Employed	1.16**	[1.00,1.35]	1.16	[0.97,1.38]
Mother – Full-Time Employed	1.03	[0.86,1.23]	1.19	[0.97,1.47]
Father – Unemployed	1.27	[0.74,2.21]	0.87	[0.44,1.72]
Father – Part-Time Employed	1.17	[0.81,1.69]	0.88	[0.60,1.30]
Father – Full-Time Employed	1.01	[0.79,1.28]	0.75**	[0.58,0.97]
Low Income (10^{th}-25^{th})	0.97	[0.72,1.32]	1.06	[0.75,1.50]
Middle-Low Income (25^{th}-50^{th})	1.03	[0.78,1.37]	1.41**	[1.02,1.94]
Middle-High Income (50^{th}-75^{th})	1.11	[0.83,1.48]	1.14	[0.82,1.59]
High Income (75^{th}-90^{th})	1.27	[0.93,1.75]	1.22	[0.85,1.76]
Very High Income (>90^{th})	1.27	[0.90,1.81]	1.47	[0.97,2.21]
Independent School	1.22**	[1.02,1.46]	0.99	[0.80,1.21]
Catholic School	0.99	[0.85,1.16]	0.99	[0.83,1.18]
Neighbourhood SEIFA Score	0.99	[0.90,1.09]	0.96	[0.86,1.07]
Sample Size	8,222		7,909	

Notes: Robust standard errors are presented in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. A constant term, gender, age in months, school grade, number of younger siblings, father missing, missing income information variables, aboriginal, parent born in overseas English-speaking country, parent born in overseas non-English-speaking country, number of older siblings, maternal age at birth, breastfeeding more than six months, low birth weight, and whether smoked during pregnancy are included in regressions but are not shown. Omitted categories are: mother has not completed Year 12, father has not completed Year 12, mother not in labour market, father not in labour market, family with very low income (10^{th} percentile), and public school.

Table 2B Joint Significance Tests from Fixed-Effects Logistic Regressions by Individual Inclusion of SES

	Maternal Employment		Paternal Employment		Family Income		Schools & Neighbourhood	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Measure of Injury								
Occurrence	.227	.187	.824	.318	.248	.122	.632	.497
Number	.759	.400	.446	.383	.074	.114	.081	.760
Severity	.244	.193	.824	.316	.255	.097	.594	.479

Notes: Figures are *p*-values from joint significance tests from fixed-effects logistic regressions. Each cell denotes a separate regression model. All regression models have the same set of controls as those in Table 2.2.

Table 2C Estimated Odds Ratios from Fixed-Effects Logistic Regressions of Injury Occurrence (Limited to Fracture, Dislocation, Sprain, or Strain)

	Boys		Girls	
	OR	95% C.I.	OR	95% C.I.
SES Odds Ratio Estimates				
Mother – Unemployed	1.23	[0.73,2.06]	0.95	[0.54,1.68]
Mother – Part-Time Employed	1.14	[0.87,1.49]	1.32	[0.97,1.78]
Mother – Full-Time Employed	0.94	[0.65,1.34]	1.17	[0.81,1.69]
Father – Unemployed	1.26	[0.47,3.39]	0.93	[0.30,2.89]
Father – Part-Time Employed	0.90	[0.47,1.72]	0.66	[0.34,1.27]
Father – Full-Time Employed	0.89	[0.59,1.34]	0.70	[0.46,1.07]
Low Income (10^{th}-25^{th})	1.32	[0.79,2.23]	1.64	[0.93,2.88]
Middle-Low Income (25^{th}-50^{th})	1.34	[0.79,2.26]	1.85**	[1.06,3.23]
Middle-High Income (50^{th}-75^{th})	1.80**	[1.03,3.12]	1.40	[0.76,2.57]
High Income (75^{th}-90^{th})	1.82	[0.99,3.33]	1.97**	[1.00,3.88]
Very High Income (>90^{th})	1.18	[0.59,2.38]	2.61**	[1.22,5.61]
Independent School	0.84	[0.56,1.27]	0.89	[0.57,1.37]
Catholic School	1.00	[0.66,1.52]	0.84	[0.53,1.34]
Neighbourhood SEIFA Score	0.84	[0.62,1.12]	0.92	[0.67,1.25]
FE Joint Tests (*p*-value)				
Maternal Employment	.500		.298	
Paternal Employment	.859		.376	
Family Income	.176		.074	
School and Neighbourhood	.560		.814	
All SES Variables	.552		.282	
RE Joint Tests (*p*-value)				
Maternal Education	. 062		.134	
Paternal Education	**. 010**		.101	
Maternal Employment	**. 004**		.326	
Paternal Employment	. 930		.334	
Family Income	. 521		.079	
School and Neighbourhood	. 135		.893	
All SES Variables	. 063		.235	
Sample Size	2,549		2,240	

Notes: Robust 95% confidence intervals are presented in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. A constant term, age in months, school grade, number of younger siblings, father missing, and missing income information variables are included in regressions but are not shown. Omitted categories are: mother not in labour market, father not in labour market, family with very low income (10^{th} percentile), and public school. FE denotes fixed-effects logit regression and RE denotes random-effects logit regression.

Table 2D Australian Literature in Socioeconomic Determinants of Child Injury Risks

Study	Data and SES Measures	Findings
Jolly et al. (1993)	National Injury Surveillance Data unit collected from selective hospitals in Brisbane and Melbourne; ABS Socioeconomic Index	A consistent pattern of moderately strong statistically significant associations found between disadvantage and injury rate at postcode level of aggregation
Lam (2005)	3,164 children and adolescents admitted to hospitals due to sports-related injuries in New South Wales; ABS Socioeconomic Index	No association between family SES and child hospitalisation with sports-related injury
Turner et al. (2006)	A random household sample survey of primary school children from 32 schools in Brisbane; Household Income, Employment/Occupation Status and Educational Attainment	Higher SES children are associated with playground/outside injuries, whilst lower SES children are more likely to be exposed to home injuries
Poulos et al. (2007)	110,549 unintentional injury-related hospital separations for New South Wales children aged 0-14 years; ABS Socioeconomic Index	No clear relationship between family SES and child injury when all injury mechanisms were combined; relative socioeconomic disadvantage is associated with transport-related injuries, fires and burns, and poisoning
Osborne et al. (2016)	556 children (aged 2-4 years) whose mothers enrolled in the Environments for Healthy Living (EFHL), Brisbane; Quartile Indicators for Total Home Risk Score	Children in socioeconomically deprived families have higher rates of injury, even though their home environment contains substantially fewer injury risks
My Study	4,351 children aged 6-13 years observed across five waves from a nationally-representative **longitudinal** dataset (LSAC); Quartile Indicators for Household Income	No strong association between family SES and child injury when all injury mechanisms were combined; boys in the most advantaged families have more sprains/strains and those injuries happened outside school and home

Chapter 3

Impacts of Childhood Injuries in Australia

3.1 Introduction

Over the last two decades, a sizeable economic literature has shown that early early-life health (health status during childhood and adolescence) is a crucial predictor of adult socioeconomic outcomes, particularly an individual's educational attainment and schooling years (Case, Fertig, & Paxson, 2005; Case & Paxson, 2006, 2010; Currie & Hyson, 1999; Currie & Stabile, 2003; Ding, Lehrer, Rosenquist, & Audrain-McGovern, 2009; Haas, 2007; Jackson, 2009). These studies overall have established a strong adverse relationship between early-life health problems and schooling attainments in the developed world. For example, low birth weight (Black, Devereux, & Salvanes, 2007; Case et al., 2005; Currie & Hyson, 1999), ADHD (Currie & Stabile, 2006; Currie et al, 2010; Ding et al., 2009; Fletcher, 2014), conduct disorder (Currie, et al., 2010; Webbink, et al., 2012), overweight or obesity (Cawley & Spiess, 2008; Ding et al., 2009; Kristjansson, Sigfusdottir, & Allegrante, 2010), depression (Ding et al., 2009; Fletcher, 2008, 2010), asthma (Currie et al., 2010; Fletcher, Green, & Neidell, 2010) and poor general health status (Auld & Sidhu, 2005; Case et al., 2005; Contoyannis & Li, 2011; Currie, 2009; Currie et al., 2010; Jackson, 2009; Le, Roux, & Morgenstern, 2013; Smith, 2009) all appear to be negatively associated with childhood cognitive achievement and educational attainment.

The economic literature has also hypothesised and tested several channels through which early-life health conditions may play a significant role in children's education production. First, health problems can lead to school absence because of medical appointments and hospital episodes. Earlier studies have suggested that excessive missing school days predicts future educational failure (Barnes et al., 2001; Klerman, 1988). Second, unhealthy children may be less physically and psychologically able to focus on lessons and complete homework, which in turn impedes their educational progress. Even worse, a severe health problem may reduce a child's cognitive functions permanently, for example, an early-life traumatic brain injury (Janusz, et al., 2002). Third, children in poor health may have more difficulties in communicating with teachers and peers, and participating in school activities. This may shape the learning environment among ill children, and cause more non-cognitive and behavioural problems (e.g., peer problems), which could further lower their academic performance (Ding et al., 2009; Le et al., 2013). Fourth, a major unrecoverable health problem may reduce educational expectations and investments from parents, teachers, and children themselves. Recently, a number of studies have found differentials in intra-family investments from parents, with respect to different siblings' health conditions and cognitive abilities (Datar, Kilburn, & Loughran, 2010; Frijters et al., 2013; Rosales-Rueda, 2014). The first two pathways directly affect school outcomes by own poor health inputs, while the latter two channels indirectly influence educational production through other inputs from peers, teachers, and parents. In summary, an early-life health problem may decrease a child's early human capital accumulation and educational achievement, in the forms of lower cognitive ability, poorer academic performance, and fewer schooling years. Further, these negative educational consequences will in turn reduce adult SES and wellbeing.

Though a substantial body of empirical economic literature has investigated the relationship between early-health problems and educational outcomes, much less has been documented on the cognitive and developmental consequences of childhood injuries. Currie et al. (2010), as an exception, shows that an experience of major injury during late childhood (aged nine to 13), or adolescence (aged 14 to 18), is a significant predictor of young adult outcomes. This is mainly because a major injury condition suffered between nine and 18 leads to poorer young adult health status. Currie et al. (2010) do not, however, find significant impacts of having an injury during early childhood (aged 0 to eight) on future wellbeing. In contrast with early mental health problems (ADHD or conduct disorder), major injuries and asthma have smaller negative impacts on future educational attainment or reliance on social assistance after they control for future health conditions. Further to Currie et al. (2010), another economic study finds significant adult earnings penalty of poor health status at age 18 (mental problems are also more harmful than injuries) (Lundborg, Nilsson, & Dan-Olofrooth, 2014). [7]

The magnitudes and pathways on how injuries affect child development depend mainly on the injury mechanisms and severities. Using a detailed four-wave Australian panel data set, this chapter aims to progress the small health economic literature on the effects of injuries in

[7] Over the last three decades, a considerable body of literature in public health and paediatric medicine has found the long-term negative effects of various head injuries on cognitive abilities and schooling attainments, particularly for concussion (Browne & Lam, 2006; Duff & Stuck, 2015), and traumatic brain injury (Janusz et al., 2002; Koskiniemi et al., 1995; Mahoney et al., 1983; Taylor et al., 2002).

several ways. First, it is the first study using a statistically rigorous method to investigate the cognitive influences of childhood injury. Despite the high prevalence of this physical health shock in the developed world, little has been studied about the short-term educational consequences of injury.[8] My main outcome variables include school teachers' Academic Rating Scores (ARS) and parents' evaluation of cognitive progress. Second, this chapter examines the potential impacts of child injuries on a number of intermediate channels, such as school absence and child general health status. In addition to parent-reported health status, this analysis also examines the injury effects on child's utilisation of medical and pharmaceutical services (a proxy for child health condition). Previous studies suggest that these intermediate outcomes are the main pathways through which early-life health problems affect cognitive development and educational achievement. *Figure 3A* in *Appendices* presents a conceptual framework for how different injury mechanisms directly and indirectly (through intermediate pathways) influence child development. Third, I test the hypothesis that the educational effects of childhood injuries do not vary across different socioeconomic and demographic groups. For the econometric methods, I first provide evidence showing that childhood injury is not selected on observable characteristics, and then estimate its potential causal effects on several scholastic outcomes using individual-level fixed-effect models (Contoyannis & Li, 2011; Palermo & Dowd, 2012; Zavodny, 2013). This empirical strategy controls for unobserved time-invariant confounders that may determine both injury risk and cognitive development, such as the child's self-discipline and the mother's cognitive ability.

3.2 Economic literature on Early Health Problems and Child Development

Despite some occasional anomalies, previous economics studies on early-life health problems and child outcomes show two general patterns. First, the most prominent finding is that childhood psychological health problems are more harmful than physical health conditions. Depression, ADHD, and other types of diagnosed mental health conditions appear negatively associated with cognitive ability and educational attainment, and these negative impacts seem to last throughout childhood (Currie & Stabile, 2006; Currie et al., 2010; Ding et al., 2009; Fletcher, 2008, 2010, 2014; Salm & Schunk, 2012). For example, Currie and Stabile (2006) use a large study sample of children from the U.S. and Canada diagnosed with the symptoms of ADHD. They found large negative effects on future test scores and schooling attainments,

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8 Currie et al. (2010) only explores "major injury" as one early-life health condition, and estimates its long-term effects (not contemporary effects) on future health, schooling attainment, and reliance on social assistance.

and concluded that childhood mental health conditions are strongly predictive of future outcomes. On the contrary, most early-life physical health problems have generally smaller impacts on cognitive development and educational attainment (Currie et al., 2010; Kaestner & Grossman, 2009; Palermo & Dowd, 2012). An exception is Fletcher et al (2010) who found that childhood asthma had long lasting effects on adolescence schooling outcomes. Currie et al. (2010) compared the educational effects of both mental and physical health conditions. Their key finding was that early physical health problems (major injury or asthma) are related to future outcomes only because they determine future health, while childhood psychological health problems (ADHD or conduct disorder) have additional predictive power even conditional on future health. Salm and Schunk (2012) is another notable economic study that compares the impacts of childhood physical and mental health problems. Using administrative German data and the sibling fixed-effects method, their results show that most physical health conditions (for example overweight and eye problems) have small or insignificant effects on child development. However, mental health conditions (particularly hyperactivity) account for 14% to 36% of the gap in cognitive ability.

The second pattern from the existing literature is the rapid growth in analyses using longitudinal data. Over the last decade, a number of world-renowned longitudinal datasets in child health and development have been employed in this literature, including the National Longitudinal Survey of Youth (NLSY) (Case & Paxson, 2010; Currie & Stabile, 2006; Jackson, 2009; Kaestner & Grossman, 2009), the Canadian National Longitudinal Survey of Children and Youth (NLSCY) (Contoyannis & Li, 2011; Currie & Stabile, 2006), the Panel Survey of Income Dynamics (PSID) (Palermo & Dowd, 2012; Smith, 2009), the Early Childhood Longitudinal Study-Kindergarten (ECLS-K) (Zavodny, 2013), the National Child Development Study (NCDS) (Case et al., 2005; Case & Paxson, 2008; Currie & Hyson, 1999), the Add Health study (Fletcher, 2008, 2010, 2014), and the Child Development Supplement (CDS) (Le et al., 2013; Palermo & Dowd, 2012). Importantly, unobserved individual heterogeneity plays a key role in early health conditions and their consequential developments. For example, children's natural self-discipline or genetic factors may determine both own health status and academic performance. The omission of these unobservable confounders may lead to serious estimation biases under an ordinary least squares approach. For example, Currie et al. (2007) estimate that almost 60% of the explained variations in child health are due to unobserved family effects, using a sample of English siblings surveyed from 1997 to 2002. Utilising within-group panel data methods permits the potential bias that is caused by time-invariant child-specific characteristics to be addressed. This is something that cannot be done with cross-sectional data.

Another notable trend in the longitudinal literature on this topic is the increasing use of models that account for sibling- or family-level fixed-effects (Case & Paxson, 2008, 2010; Currie & Stabile, 2006; Currie et al., 2010; Fletcher, 2010, 2014; Fletcher et al., 2010; Jackson, 2009; Le et al., 2013; Salm & Schunk, 2012; Smith, 2009). For instance using both NLSY and NLSCY data and controlling for sibling fixed-effects, Currie and Stabile (2006) show that a hyperactivity score at the 90th percentile of the distribution based on ADHD symptoms increases the probability of grade repetition by 6% in Canada, and by 7% in the U.S. Case and Paxson (2006) use height as a marker to examine the long-term effects of child health on adult outcomes. Their findings argue that taller siblings obtain better scores in cognitive tests and progress more quickly in school, even among children with the same mother. They further explain that a large proportion of differences between siblings is due to differences in their birth weights caused by maternal prenatal behaviours. Employing data from three waves in ECLS-K and the individual fixed-effects method, Zavodny (2013) examines whether children’s weight is related to their test scores and teacher assessments from kindergarten through to the eighth grade. Her results indicate that weight is not significantly related to standardised test scores in reading, mathematics, and science. However, an adverse correlation between weight and teacher’s assessment of child performance is found, particularly in reading and mathematics (it remains unclear if such correlation is caused by pure discrimination based on weight or it points to a true effect).

In addition to family and individual fixed-effects, another common econometric strategy dealing with endogeneity of child health is instrumental variables (IV) (Ding et al., 2009; Kaestner & Grossman, 2009). A valid instrument must be both strongly correlated with child health problems, and not directly affect school outcomes other than through the influences on child health. Compared to the fixed-effects method, an obvious advantage of IV is to control for endogeneity bias caused by unobserved time-varying factors and reverse causality. Only very few studies in the existing literature employ an IV approach, because it is empirically difficult to identify an instrument that is uncorrelated with the error term in the school outcome or cognitive ability equations. Genetic markers, however, are an important exception. Ding et al. (2009) exploit natural variation within a set of genetic markers across individuals, and argue that specific genetic markers are proper instrument to isolate the exogenous sources of child health problems. Their IV results indicate that depression and obesity both cause almost a one standard deviation reduction in academic performance (0.45-point decrease in GPA) among study adolescents. Without a valid instrument to measure the impact of child injury on cognitive development, and given the empirical data used only surveys of one child from each unique family, this chapter will conduct empirical analysis using child-specific individual fixed-effects models.

3.3 Data, Definitions, and Descriptive Statistics

This chapter employs data from the LSAC waves 2 to 5, which have been used in Chapter 2 above. In addition to the main LSAC survey, I also utilise the information from the teachers' survey forms. This separate form records the corresponding teacher's evaluation on the study child's performance at school, such as attendance, attention in class, cognitive development (e.g., progress in reading and mathematics), and non-cognitive development (e.g., interaction with teachers and peers). There is a descent response rate from teachers, as around 30% of the surveys sent to schools were returned. Importantly, these responses are broadly random on the observables.

3.3.1 Intermediate Outcomes Linking Injury and Cognitive Development

As discussed in Section 3.2, the combined economic literature proposes several linking mechanisms between early-life health problems and educational achievement. This chapter investigates the effects of injury experience on a number of intermediate outcomes. The most straight-forward outcome is absenteeism. A list of empirical studies in paediatrics and epidemiology has reported long-term educational effects of unnecessary school absence, since children obtain most of their social and academic skills at school (Barnes et al., 2001; Klerman, 1988). For example, Klerman (1988) shows that excessive absence from high school is significantly associated with failure in education, particularly for children who miss more than 11% of school days. My study utilises the answers to two surveyed questions, including: 1) parents' record of the number of missing school days in the last four weeks, and 2) school teachers' report of frequent absence during the last year.

The second possible linking mechanism is the child's general health condition, since a growing body of economic literature has found negative educational influences of poor childhood health (Case et al., 2005; Contoyannis & Li, 2011; Currie et al., 2010; Jackson, 2009; Le et al., 2013; Smith, 2009). The LSAC collects every study child's general health status using a 5-point scale of excellent, very good, good, fair, and poor, from the first parent. Since children included in my study sample are mainly of primary school age, I define: 3) very good condition as my binary dependent variable in child health status if the first parent answers this question by either "excellent" or "very good" (87% of observations).

The third category of intermediate outcomes between child injury and later outcomes is the utilisation of medical care and pharmaceutical services (a proxy to child health status). In the LSAC, the child injury measures are based on an initial question regarding the occurrence of an injury that "needed medical attention from a doctor or hospital" (more details will be discussed in Section 3.3.3 below). The key reason to examine health care utilisation is to confirm if injuries are indeed serious health shocks that do require medical attention and resources and can therefore have a significant effect on the child's outcomes. A useful feature of LSAC is that it is linked to the Medicare Benefits Schedule (MBS) and the Pharmaceutical Benefits Scheme (PBS), which include a child's Medicare records and pharmaceutical usage subsidised by the Australian Government.[9] More specifically, the MBS mainly records different types of non-hospital medical care services, for example, consultation provided by a general practitioner (GP) or a standard blood test; while the PBS includes all subsidised pharmaceutical consumption, such as the eligible prescribed medications.[10] By exploiting the rich information from the MBS, I derive two outcome variables: 4) number of GP visits, and 5) number of medical tests or examinations. I then use all pharmaceutical records included in the PBS and construct the last outcome variable: 6) number of pharmaceutical scripts. In order to estimate the contemporary effects of injuries, all three outcome variables derived from the MBS or the PBS only include those medical or pharmaceutical services performed within six months before the LSAC interviews. The selection of this relatively shorter time window is due to the nature of child injury as a health shock. In contrast with chronic health problems (for example asthma and ADHD), an injury is more likely to consume temporary health care usages. For example, a fracture or dislocation may only cause a handful of visits to local GP and pathology.

9 A total of 4,983 children participated in the first LSAC survey; approximately 94% of them are linked to the MBS and the PBS. Consequently, only these children who are linked to the MBS or the PBS are available for inclusion in this chapter.

10 Public hospital costs that are funded by Commonwealth (and state) governments are not included in this linked MBS dataset, while medical services performed in private hospitals are included (though a very small proportion, less than 3%). To avoid selection bias, this chapter limits estimation to non-hospital medical items.

3.3.2 *Cognitive Achievement*

Following the existing literature on the correlations between child health problems and educational outcomes (Glewwe, Jacoby, & King, 2001; Zavodny, 2013), I utilise the school teachers' assessments to derive my main dependent variables. In the separate form for teachers, there is a list of questions regarding the study child's development in language and literacy: for example, if a child reads age-appropriate books fluently, if a child conveys ideas clearly when speaking, and if a child makes editorial or mechanical corrections when reviewing a written draft. Teachers answer each question by giving one of five ordinal answers (1 to 5 represent "not yet," "beginning," "in progress," "intermediate," and "proficient," respectively). The LSAC calculates the average score of teachers' answers to all relevant questions, and is used as my first cognitive outcome variable: 1) an Academic Rating Score (ARS) in literacy and language ('ARS Literacy'). Similarly, in the teachers' survey, there is a series of questions investigating the child's development in mathematical understanding: for example, if a child uses measuring tools accurately (e.g., a ruler), if a child makes reasonable estimates of quantities and checks answers, and if a child demonstrates algebra thinking. In light of teachers' answers to all these mathematics-related questions, I can develop the second outcome variable in cognitive ability: 2) an ARS in mathematical ability ('ARS Mathematics'). Although the mathematical understanding is not surveyed in wave 5,[11] ARS scores cover more aspects of a child's cognitive development and are expected to be more objective compared to those obtained from parents.

In addition to teachers' evaluations, the LSAC also collects parents' answers to a child's study progress in reading and mathematics compared to other students at the same age. Based on answers from the first parent (1 to 5 represent five ordinal answers: "much worse," "a little worse," "about the same," "a little better," and "much better"), I further derive two outcome variables: 3) parent's evaluation of the child's reading progress; and 4) mathematics progress. Higher scores indicate better cognitive progress. The main advantage of parents' measurements is that they are surveyed in all study periods with no substantial sample loss, which provide rich longitudinal properties to panel-data methods (i.e., child-specific individual fixed-effects estimator). However due to the nature of subjective measures reported by parents, they may be biased by parent-specific heterogeneity. For the

[11] I regress the variation in "whether teacher returns the form" by a number of family- and child-specific characteristics, using panel-data linear and logistic models. The results show that it is exogenously selected in both within- and between-individual estimators.

convenience of comparison and interpretation, all cognitive scores reported by teachers and parents are standardised with a mean of zero and a standard deviation of one at each study round (see sample statistics in Table 3.1).

Table 3.1 Descriptive Statistics of Main Variables in Pooled Sample (Waves 2 to 5, Maximum Estimation n=15,858)

	Obs.	Mean	S.D.	Min.	Max.	Variation
Child Development Outcomes						
i. Cognitive Measures						
ARS Literacy	13,064	.000	1.000	-3.46	1.377	67.1
ARS Mathematics	10,023	.000	1.000	-2.74	1.471	57.3
Progress in Reading	15,033	.000	1.000	-2.77	1.367	72.1
Progress in Mathematics	15,033	.000	1.000	-3.01	1.347	72.8
ii. Absenteeism						
No. of Absent Days	15,682	1.215	2.144	0	20	55.1
Frequent Absence	13,675	.058	.234	0	1	11.1
iii. Child Health						
Very Good Health Condition	15,858	.870	.336	0	1	20.4
iv. Medical/Pharmaceutical Usage						
No. of GP Visits	14,272	1.294	1.799	0	42	65.3
No. of Other Medical	14,272	1.642	2.857	0	58	59.9
No. of Pharmaceutical Scripts	14,381	.495	2.044	0	33	48.1
Childhood Injury Indicators						
i. Severity						
Non-Hospital	15,858	.172	.377	0	1	29.8
Hospital	15,858	.014	.117	0	1	44
ii. Types						
Head or Internal	15,858	.014	.116	0	1	4.3
Fractures or Dislocations	15,858	.054	.225	0	1	15.0
Sprain or Strain	15,858	.052	.221	0	1	13.1
Cut or Scrape	15,858	.049	.215	0	1	13.0
Other	15,858	.048	.214	0	1	12.9

Notes: All cognitive scores are standardised. All summary statistics of injury measures have been limited to the maximum estimation sample (n=15,858).

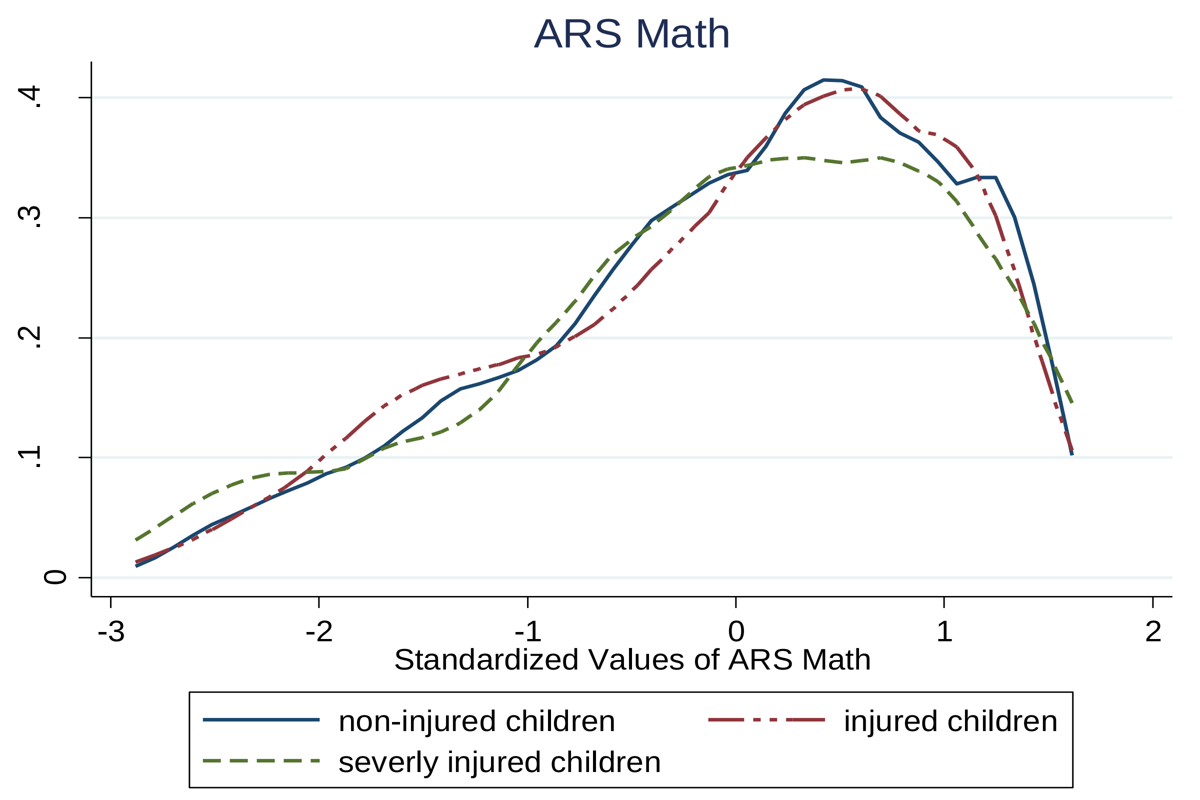
Previous international studies investigating educational effects of early-life health issues prefer to use nationally-representative test scores to avoid reporting bias (Ampaabeng & Tan, 2013; Case & Paxson, 2010; Currie & Stabile, 2006; Kaestner & Grossman, 2009; Venkataramani, 2012; Zavodny, 2013). However, teachers and parents may assess children on more aspects of academic ability than do standardised tests, and all these aspects are related to children's health status to a certain extent. For example, teachers' evaluations may also reflect children's motivation, effort, and engagement

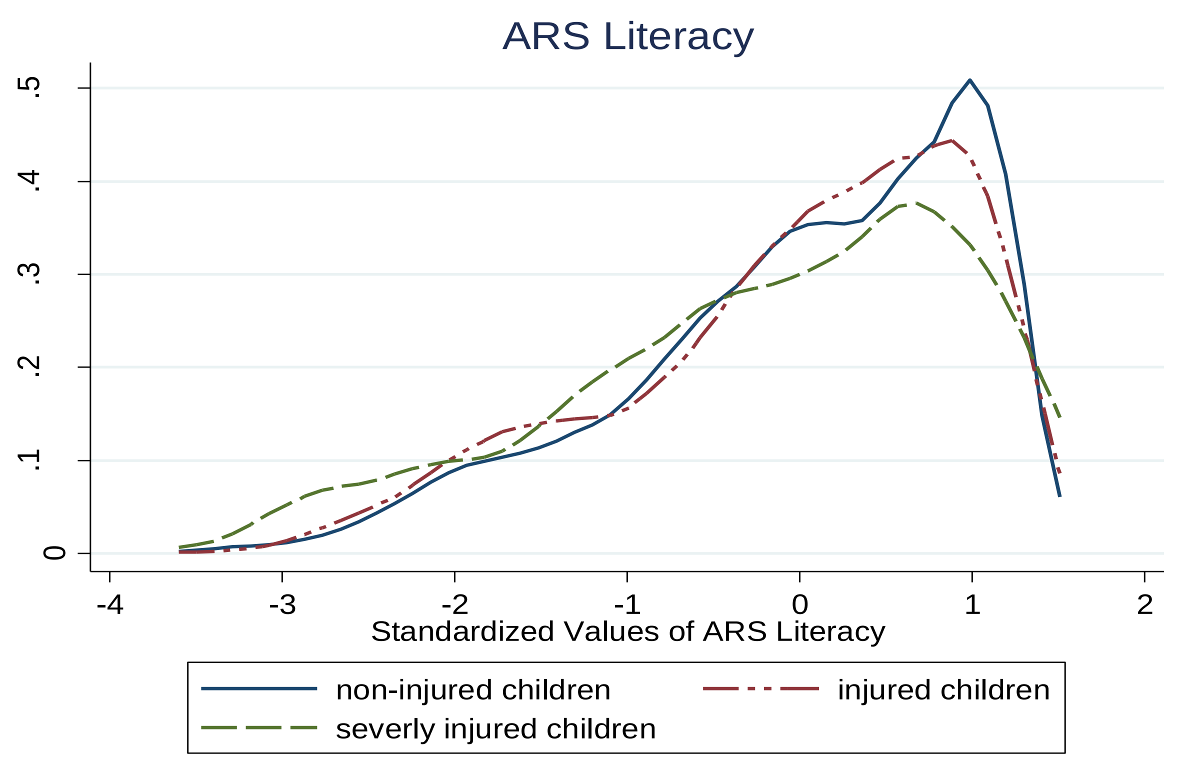
3.3.3 *Measures of Child Injury*

In the LSAC, injuries are assessed by the first parent's answers to a series of consecutive questions. The initial question is: "During the last 12 months, how many times was your child hurt, injured or had an accident and needed medical attention from a doctor or hospital?" The survey then asks whether or not the injured child needed to stay at hospital overnight. Based on this information, combined with the first question, I derive my main measure of child injuries: (1) a group of three mutually-exclusive variables measuring injury severity (no injury; injury without hospital stay; injury with hospital stay). This specification aims to identify the variations in cognitive development among uninjured, injured, and severely injured children. The LSAC also investigates the exact type of injury that a child experienced during the last 12 months, from a list of 10 options. I then create: (2) a set of (non-mutually-exclusive) binary variables indicating whether the child has had an internal or head injury; fracture or dislocation; sprain or strain; cut or scrape; or other injury (includes dental, burn, poisoning).

There are three reasons to group injury severity according to this taxonomy. First, due to the nature of injuries, I believe that different injuries cause different problems in child development. For example, previous literature in paediatrics has found serious long-term negative effects of head-related injuries and internal non-head injuries, for example, traumatic brain injury, concussion, and internal bleeding (Browne & Lam, 2006; Duff & Stuck, 2015; Janusz et al., 2002; Koskiniemi et al., 1995; Mahoney et al., 1983; McCarthy et al., 2006). On the contrary, external non-head injuries are more likely to influence children's cognitive and non-cognitive developments through intermediate pathways such as school absence. Second, the factor analysis, along with sample correlations, indicates that some specific types of injuries show very similar patterns and variation. For instance, "fractured bones" and "dislocations" always seem to happen simultaneously, which may be due to the fact that those two types of injuries are always caused by one single accident. Third, in the LSAC, I observe that several common injuries have much higher sample proportions than others, such as "sprain or strain" and "cut or scrape." To better model and identify the unique variations in these two main injuries, I treat each of them as a single group (see summary statistics in Table 3.1). In contrast, I group all the other minor types of injuries together as one category, including "burn or scald," "dental," "poisoning," and "other injuries."

Figure 3.1 Kernel Density Estimates of ARS Mathematics and Literacy Scores by Injury Status





Sample means of each injury measure observed at different age intervals are reported in Table 2.1 in Chapter 3. Figure 3.1 presents the distribution of two main cognitive scores, ARS Mathematics and Literacy, among uninjured, injured, and severely injured children. The estimated kernel densities show that both scores have left-skewed distributions, which implies that most children score higher than the average. Injury severity seems to have weak to mild impacts on cognitive skills. The proportion of severely injured children scoring highly (right tail) is smaller than the proportions of uninjured and injured children, particularly for ARS Literacy scores. However, this difference is marginal, and all three groups have similar shapes of distributions.

3.3.4 Key Controls

My key covariates include the at-birth information (e.g., breastfed for six months and low birth weight), the determinants of parental inputs (e.g., family income and maternal labour participation), and some other observed family and child characteristics (e.g., child's school grade and number of younger siblings). Importantly, LSAC has rich details about parents' SES, such as disposable weekly income, educational attainment, and employment status. I include these family SES factors in my estimation, because previous studies suggest that they may influence the child's academic performance (Todd & Wolpin, 2003; Todd & Wolpin, 2007), or confound the relationship between the child's injury risks (Basu & Stephenson, 2005; Currie & Hotz, 2004; Fang et al., 2014; Hong et al., 2010; Laursen & Nielsen, 2008; Leininger et al., 2009; Morrill, 2011). All time-invariant covariates (e.g., low birth weight and number of older siblings) are omitted in the child-specific fixed-effects model, which is my main empirical method in this chapter, but I include them in the alternative random-effects model. Sample statistics of all covariates are presented in *Table 3A* in *Appendices*.

In addition, non-cognitive abilities may also confound early-life injuries and cognitive development (Borra, Iacovou, & Sevilla, 2012; Palermo & Dowd, 2012). Essentially, children with conduct problems or hyperactivity disorder experience more injuries than others, which may in turn negatively affect their learning environment and study skills (the second hypothesised channel discussed in section 3.1 above). The LSAC measures non-cognitive development using the 25-question Strengths and Difficulties Questionnaire (SDQ).[12] In the main estimation, I omit SDA scores as covariates to avoid the potential biases

[12] The SDQ contains 25 items comprising five scales (five items for each scale), including the Prosocial

caused by over controlling. Nevertheless, a further inclusion of SDQ scores on the right side of equation does not change the main results.

A number of studies on the determinants of cognitive outcomes control for parental inputs (Black, Johnston, & Peeters, 2015; Nghiem, Nguyen, Khanam, & Connelly, 2015), such as the number of books at home, the weekly hours spent watching television, and whether parents undertake daily activities with children. This chapter excludes these parental covariates in the estimation of injury effects on cognitive outcomes, since the quality and quantity of these parental inputs may be affected by a major injury. For example, if a severely injured child requires a long recovery period away from school, parents are likely to spend extra time with him or her and purchase extra books to read. I do, however, control for a number of lifestyle factors to identify if an injury experience is exogenously selected, including weekly usage of television and e-games, and participation in sporting activities.

3.4 Empirical Econometric Framework

The existing economic literature suggests that unobserved child- or family-specific characteristics play a key role in early-life health problems and their negative educational consequences (Case & Paxson, 2008; Currie et al., 2010; Fletcher, 2014; Fletcher et al., 2010; Jackson, 2009; Zavodny, 2013). For example, unmeasured time-invariant factors, such as child's self-discipline or mother's cognitive ability, could confound the relationship between injury risks and cognitive achievement. In order to estimate the potential causal effects of childhood injuries on scholastic outcomes, my empirical econometric strategy is to: 1) use fixed-effects panel-data models to show that injury severity or occurrence is exogenously selected within-child across time in Australia (main finding from Chapter 2 above); and 2) treat injury as an exogenous health shock, and apply random-effects and fixed-effects estimators, respectively, to model the between- and within-child variation in children's cognitive development.

Childhood injury may have direct and indirect effects on cognitive development. In this section, I investigate the direct impacts of injury occurrence during the last 12 months on four

Scale, the Hyperactivity Scale, the Emotional Symptoms Scale, the Peer Problems Scale, and the Conduct Problem Scale. The child's parent answers each specific item by giving one of the three responses: "Not True," "Somewhat True," or "Certainly True." The SDQ then records each response by 0, 1, and 2, respectively. The final score for each scale is equal to the summation of scores from all five related items, which has a range from 0 to 10. Except for the prosocial score, higher scores in SDQ indicate a higher concern of behavioural problems.

cognitive assessments. I also estimate the association between child injury and a number of intermediate pathways. As a starting point, a linear equation is given:

$$CD_{it} = INJ_{it}'\beta_1 + X_{it}'\gamma_1 + Z_i'\delta_1 + \alpha_{1i} + \varepsilon_{1it} \ , \qquad (3.1)$$

where CD denotes a development outcome for child *i* at time *t* (e.g., ARS Literacy or Mathematics scores reported by teachers, number of missing school days during the last four weeks, medical or pharmaceutical usage), Z_i is a vector of observable time-invariant factors (e.g., child's gender, number of older siblings), X_{it} is a vector of observable time-varying control variables (e.g., age in months, father not in household), INJ_{it} represents either injury severity status (non-hospital injury and hospital injury) or an occurrence of a specific type of injury (head or internal, fracture or dislocation, sprain or strain, cut or scrape, and other injuries). α_{1i} represents all unobservable time-invariant characteristics (e.g., child self-discipline and mother's IQ), and ε_{1it} is a random error term representing unobservable time-varying factors. As fully explained in Section 3.2, my preferred empirical methodology is a within-child fixed-effects method. Due to the nature of linear regressions in (1), I difference out the individual fixed effect (α_i) by within-group transformation. The resulting econometric equations of my second approach are as follows:

$$CD_{it} - \overline{CD}_i = \left(INJ_{it} - \overline{INJ}_i\right)\beta_2 + \left(X_{it} - \overline{X}_i\right)\gamma + (\varepsilon_{2it} - \bar{\varepsilon}_{2it}) \ , \qquad (3.2)$$

where $\overline{CD}_i$, $\overline{INJ}_i$,and $\overline{X}_i$ represent the within-group means of child development, injury severities, and time-variant controls for child i across all waves, respectively. Intuitively, by time-demeaning the data, this fixed-effects method removes all initial time-invariant components included in the random-effects estimator, particularly the unobserved error term, α_i . This empirical method relaxes the assumption of unobserved time-invariant heterogeneity,α_i, and theoretically produces consistent estimates. However, in equation (3.2), β_2 is driven by changes in child development for individuals who have experienced changes in injury conditions, and therefore depends partly upon the cross-wave variations in the main variables. The last column in Table 3.1 reports the cross-wave variations for all variables of interest in this chapter. For the four main cognitive skills, the cross-wave variations range from 57% to 73%; with regards to injury severity, there appears to be 30% of children in which different responses are provided to the question about the experience of an injury without hospitalisation. In terms of injury types, the variability is observed to be around 14%, except for head or internal injuries. All these rates combined suggest that there is sufficient variation to identify the model coefficients under fixed-effects specification.

3.5 Main Results

3.5.1 Is Childhood Injury Exogenously Selected?

As fully discussed in Chapter 2, there is no strong family SES gradient in childhood injuries in Australia. To sum up and recall the main findings from Chapter 2, in Table 3.2, I report all estimated determinants of an injury experience (not only family SES) in the last 12 months across four waves within children. If family SES or other covariates have significant impacts on child injury risks, then estimated effects of injury on child cognitive ability, as my main interest in this chapter, may be biased. For example, if severe injuries are more likely to happen among children from low-SES families, the variation in children's cognitive skills caused by injuries may be caused by parental socioeconomic differentials. Therefore, it will be difficult to estimate the true causal effects of an injury on later child development.

The estimated results in Table 3.2 overall suggest that, after controlling for unobserved time-invariant characteristics such as mother's IQ and personality, an occurrence of injury does not appear to be determined by parental socioeconomic background, lifestyle, child's non-cognitive ability, or other important covariates. This important finding allows me to treat injury as an exogenous health shock in the model of cognitive outcomes. Any potential within-child across-time variations in cognitive or developmental outcomes among uninjured, injured, and severely injured children are likely to be caused by injuries themselves.

Table 3.3 explores the longitudinal pattern of injury experience across four waves (from age 6 to 13), using a balanced panel (n=3,682). For example, a child is recorded as "1000" if he or she only had one injury at the second wave of the LSAC survey (aged six to seven) and no injury in later waves. The percentages of children that ever had an injury, hospital injury, head or internal injury, fracture or dislocation, sprain or strain, and cut or scrape are 51.87%, 4.97%, 4.97%, 17.65%, 16.33%, and 16.35%, respectively. Only small numbers of children have a reported injury in every age group. This longitudinal pattern of injury occurrence suggests that at each observed period, some children who were injured previously recover and other children without initial injuries may suffer them. The within-child over-time variation supports my view from Table 3.2, injury is a random health shock in Australia.

Table 3.2 Determinants of Childhood Injuries from Fixed-Effects Ordered-Logit/Logit Models in LSAC

	Injury Severity (1)		*Head or Internal* (2)		*Fracture or Dislocation* (3)		*Sprain or Strain* (4)		*Cut or Scrape* (5)	
SES Covariates										
Mother – Employed	0.204*	(0.105)	0.049	(0.376)	0.351*	(0.181)	0.357	(0.212)	0.017	(0.185)
Father – Employed	0.179	(0.184)	-0.631	(0.659)	-0.097	(0.308)	-0.304	(0.375)	0.504	(0.325)
Mother – Working Hours	-0.002	(0.003)	**0.025****	**(0.012)**	-0.005	(0.005)	-0.009	(0.006)	0.006	(0.006)
Father – Working Hours	**-0.007****	**(0.003)**	0.020	(0.012)	-0.002	(0.006)	0.000	(0.007)	**-0.017*****	**(0.006)**
Log Weekly Income	0.036	(0.065)	**-0.279****	**(0.120)**	0.015	(0.139)	0.218	(0.155)	0.237	(0.144)
Independent School	-0.082	(0.123)	-0.378	(0.430)	-0.048	(0.205)	-0.083	(0.228)	0.355	(0.239)
Catholic School	-0.103	(0.123)	-0.623	(0.447)	-0.099	(0.212)	0.208	(0.243)	-0.017	(0.238)
SEIFA	-0.060	(0.089)	-0.506	(0.325)	-0.079	(0.149)	-0.207	(0.161)	-0.014	(0.176)
Lifestyle Covariates										
Team Sport	0.095	(0.094)	0.361	(0.313)	-0.174	(0.160)	0.244	(0.161)	0.225	(0.184)
Individual Sport	-0.021	(0.134)	-0.460	(0.459)	-0.029	(0.232)	0.102	(0.225)	0.096	(0.252)
No. of V/F	-0.022	(0.021)	-0.093	(0.071)	0.017	(0.037)	-0.032	(0.040)	-0.007	(0.038)
Weekday Television	-0.075*	(0.044)	-0.163	(0.154)	0.012	(0.075)	-0.122	(0.081)	-0.118	(0.082)
Weekend Television	-0.035	(0.037)	-0.173	(0.138)	-0.107	(0.063)	-0.016	(0.070)	-0.032	(0.068)
Weekday E-Game	0.001	(0.041)	-0.078	(0.147)	0.036	(0.071)	-0.081	(0.076)	-0.022	(0.076)
Weekday E-Game	-0.012	(0.033)	0.054	(0.119)	-0.012	(0.056)	-0.018	(0.062)	-0.016	(0.060)
SDQ Covariates										
Pro-Social Score	0.016	(0.024)	**0.210****	**(0.086)**	0.014	(0.041)	0.017	(0.046)	-0.028	(0.041)
Emotional Problem	0.037	(0.025)	-0.124	(0.089)	0.046	(0.043)	**0.099****	**(0.046)**	0.020	(0.046)
Peer Problem	0.003	(0.022)	0.106	(0.075)	-0.004	(0.038)	0.026	(0.040)	-0.014	(0.040)
Hyperactivity Score	0.020	(0.021)	**0.175****	**(0.076)**	-0.019	(0.037)	-0.021	(0.039)	0.049	(0.036)
Conduct Problem Score	0.004	(0.030)	**0.252****	**(0.112)**	-0.080*	(0.054)	0.023	(0.054)	0.015	(0.054)
Other Covariates										
Age in Months	0.010	(0.011)	0.058	(0.039)	-0.013	(0.020)	0.023	(0.021)	**-0.042****	**(0.021)**
School Grade	-0.038	(0.138)	-0.648	(0.477)	0.271	(0.240)	0.011	(0.259)	0.357	(0.252)
No. of Younger Siblings	-0.028	(0.130)	-0.069	(0.414)	0.091	(0.230)	-0.303	(0.260)	-0.012	(0.229)
Maternal Mental	0.407	(0.274)	0.091	(0.798)	0.994*	(0.548)	0.730	(0.465)	-0.603	(0.655)
Father Missing	-0.000	(0.188)	0.959	(0.743)	-0.226	(0.335)	-0.377	(0.363)	0.063	(0.348)
F-test *p*-value – SES	.151		**.012**		.730		.407		.634	
F-test *p*-value – Lifestyle	.426		.400		.694		.359		.675	
F-test *p*-value – SDQ	.538		**.008**		.490		.266		.619	
F-test *p*-value – All	**.000**		**.023**		**.001**		**.000**		**.000**	
Sample Size	7,136		697		2,615		2,425		2,291	

Notes: Figures are estimated coefficients. Standard errors clustered at the child IDs are presented in parentheses. The dependent variable is an experience of injury in the last 12 months. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The omitted categories include public school, and parents not in the labour market. Though not shown, each model also has controls for missing observations on household income, father missing, and usage of television/e-games.

Table 3.3 Patterns of Injury Experiences Across Age Groups for Balanced Panel Dataset

Age Pattern	Injury	Hospital Injury	Head or Internal	Fracture or Dislocation	Sprain or Strain	Cut or Scrape
0000	48.13	95.03	95.03	82.35	83.67	83.65
0001	10.92	1.30	1.68	5.22	6.05	2.36
0010	8.45	1.20	0.87	3.95	3.83	2.74
0100	7.12	1.14	1.22	3.11	2.40	4.56
1000	6.98	1.09	0.90	2.77	1.34	4.62
0011	3.59	0.03	0.05	0.46	1.05	0.16
0101	2.93	0.03	0.05	0.48	0.35	0.22
0110	2.17	0.00	0.05	0.59	0.44	0.38
1001	2.17	0.05	0.03	0.21	0.02	0.27
1100	1.74	0.03	0.05	0.27	0.20	0.57
0111	1.55	0.00	0.00	0.12	0.33	0.03
1010	1.41	0.08	0.05	0.33	0.11	0.27
1011	1.14	0.00	0.00	0.05	0.02	0.05
1101	0.62	0.00	0.00	0.05	0.14	0.03
1110	0.54	0.03	0.00	0.02	0.00	0.03
1111	0.54	0.00	0.00	0.02	0.05	0.05
Balanced Panel Sample Size, n=3,682						

Notes: Reported numbers are percentages of children with a reported injury in the last 12 months. Patterns reflect whether the child had a diagnostic code for a particular condition in each of the age categories 6-7, 8-9, 10-11, and 12-13. For example, "0000" denotes having no injury for any of the four age categories, while "0001" denotes having a reported injury in ages 12-13 only, and "1111" denotes having a reported injury at all age groups. Injury reported in the first column includes both non-hospital and hospital injuries. All patterns have been ranked by the percentages presented under the column "Injury," from the highest to the lowest.

Table 3.4 Estimated Relationship between Injury and Intermediate Outcomes by Fixed-Effects Linear Regressions

	No. of Absent Days (1)		Frequent Absence (2)		Very Good Health (3)		No. of GP Visits (4)		No. of Other Medical Services (5)		No. of Pharmaceutical Scripts (6)	
Severity												
No Hospital Stay	0.037	(0.052)	0.001	(0.006)	0.003	(0.007)	**0.412*****	**(0.047)**	**0.626*****	**(0.073)**	-0.049	(0.051)
Hospital Stay	**0.651*****	**(0.182)**	**0.057****	**(0.029)**	**-0.060****	**(0.027)**	**0.653*****	**(0.176)**	**0.678*****	**(0.252)**	**0.373****	**(0.173)**
Types												
Head or Internal	0.321*	(0.185)	0.017	(0.025)	0.001	(0.038)	0.250	(0.140)	0.201	(0.329)	0.107	(0.192)
Fracture or Dislocation	0.151*	(0.085)	0.003	(0.010)	-0.033*	(0.020)	**0.480*****	**(0.077)**	**0.888*****	**(0.179)**	-0.008	(0.078)
Sprain or Strain	0.052	(0.090)	0.016	(0.012)	-0.035*	(0.021)	**0.352*****	**(0.082)**	**0.694*****	**(0.187)**	0.013	(0.099)
Cut or Scrape	0.031	(0.100)	-0.006	(0.012)	0.001	(0.020)	**0.253*****	**(0.081)**	**0.298****	**(0.151)**	-0.114	(0.092)
Other Injuries	0.154	(0.100)	-0.001	(0.012)	-0.022	(0.021)	**0.315*****	**(0.087)**	0.388	(0.224)	0.112	(0.093)
Sample Size	15,862		12,981		15,858		14,273		14,029		14,383	

Notes: Standard errors are clustered by children's ID and presented in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. "No injury in the last 12 months" is the reference category when the effects of injury severities are estimated. "Number of absent days" records the missing school days in the last four weeks. Other injuries include non-head internal, dental, dog bites, bee sting, accidental poisoning, scald, burn, and other injuries. "Frequent Absence" and "Very Good Health" are binary dependent variables, which have been modelled by panel-data linear probability models rather than logit models. The fixed-effects model only includes time-variant controls listed in *Table 3A* in *Appendices*.

3.5.2 *Impacts of Injuries on Intermediate Outcomes*

Table 3.4 reports the estimated associations between childhood injury and three potential mediating mechanisms using fixed-effects estimators. Two measures of absenteeism show that higher values indicate more missing school days or more frequently absent. For example, according to within-child fixed-effects estimates in columns (1) and (2) in Table 3.4, an injured child who stayed in hospital overnight has 0.7 more absent school days than an uninjured child in the last four weeks. Further, this severely injured child has a 6% higher probability of being reported as "frequently absent" by the teacher. Further, injury severity seems to have strong predictive power on general health status and usage of medical and pharmaceutical care. In columns (3) to (6) in Table 3.4, a severe injury reduces the probability of having "very good health" by approximately 6%, and causes an extra 0.7 GP visits, 0.7 other medical services, and 0.4 pharmaceutical scripts in the last six months. [13]

There appears to be no clear effect of any specific type of injuries on frequent absence, general health status, or pharmaceutical services. However, the number of GP visits and use of other medical services are still associated with all later four categories of injuries to varying extents. Having a head or internal injury has no effect on the consumption of both medical services. This may be explained by the fact that a head or internal injury most likely results in a hospital episode, which is not covered in the MBS dataset linked to the LSAC.

Results in Table 3.4 overall suggest that a severe injury has significant impacts on school absence, parent-reported health status, GP visits, and utilisation of other medical and pharmaceutical services. These results suggest possible pathways through which severe injuries may affect cognitive development.

3.5.3 *Impacts of Injuries on Cognitive Development*

Table 3.5 presents estimated coefficients of injuries on cognitive abilities. Overall, the estimates show that the injury severity is a very weak predictor of cognitive

[13] I also estimate the effects of injury severity on attention span in schools. Fixed-effects results stress that having an injury without hospital stay significantly reduces the probability of "Paying Attention Well" and "Having a Good Attention Span," though in very small magnitudes (2.6% and 3%, respectively).

development (top panel). None of the eight estimated coefficients is statistically significant. The joint test results support this view, with all sets of injury severity coefficients being statistically insignificant. Turning to the effects of each specific type of injury (bottom panel), children who suffered a sprain or strain in the last 12 months are estimated to have a 0.069 standard deviation lower ARS Literacy score than uninjured children; while having a head or internal injury is estimated to increase the ARS Literacy score by 0.117 standard deviations. The latter estimated coefficient is unexpected, which may be due to the fact that children with head or brain injuries turn more attention towards literacy learning (e.g., read more books) during their longer period of recovery. Neither the individual coefficient nor the joint test show any considerable correlation between ARS Mathematics scores and injury.

Table 3.5 Estimated Relationship between Injury and Cognitive Achievement

	Teacher's ARS Literacy (1)	Teacher's ARS Mathematics (2)	Parent's Progress in Reading (3)	Parent's Progress in Mathematics (4)
Severity				
Ever Injured (No Hospital)	-0.030	-0.019	0.025	0.026
	(0.019)	(0.026)	(0.019)	(0.019)
Ever Injured (Hospital)	0.030	0.059	0.045	0.019
	(0.059)	(0.077)	(0.056)	(0.060)
Joint Test (p-value)	.243	.520	.328	.399
Types				
Head or Internal	**0.117****	0.098	0.034	-0.008
	(0.057)	(0.084)	(0.060)	(0.058)
Fracture or Dislocations	-0.021	-0.070	-0.006	-0.021
	(0.032)	(0.045)	(0.030)	(0.031)
Sprain or Strain	**-0.069****	-0.018	0.013	0.021
	(0.032)	(0.047)	(0.032)	(0.032)
Cut or Scrape	-0.014	0.023	**0.075****	0.064*
	(0.034)	(0.043)	**(0.033)**	(0.035)
Other Injuries	-0.053*	-0.038	-0.009	0.005
	(0.033)	(0.043)	(0.034)	(0.035)
Joint Test (p-value)	**.025**	.436	.332	.515
Maximum Sample Size	12,591	9,581	15,033	15,062

Notes: Standard errors are clustered by children's ID. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. "No injury in the last 12 months" is the reference category when the effects of injury severities are estimated. Other injuries include non-head internal, dental, dog bites, bee sting, accidental poisoning, scald, burn, and other injuries. All cognitive scores are standardised.

A similar pattern is found when I model the two cognitive outcomes reported by parents, progress in reading and mathematics (Table 3.5, columns (3) and (4)). Overall, I do not find strong impacts of childhood injuries on these two outcomes. Given by fixed-effects results, somewhat surprisingly, having a cut or scrape in the last 12 months is estimated to cause a 0.075 standard deviation lower reading score (no effect on mathematics score). It is uncertain that a minor and short-term injury (cut or scrape) would be able to have such a significant positive impact. Again, injuries in general could steer children towards more academic activities while they recover, and these potential positive effects may counteract any negative effects of injuries on academic performance. This may explain why I observe an insignificant association between cognitive abilities and injury status.

3.6 Sensitivity Analysis

3.6.1 Are Results Robust to the Persisting Effects of Childhood Injuries?

In each of the above reported models, it is assumed that an injury experience has no persistent impacts on child development (more than 12 months). This assumption is based on the fact that the LSAC does not survey extremely severe injuries that cause mortality or long-term morbidity. Alternatively, another strategy is to define an "injured child" as someone who had an injury or accident requiring medical service that occurred in any previous wave (including wave 1). Essentially, a major health shock that initially happened in early childhood may have persistent and lasting effects on a child's later outcomes throughout the entire lifetime. In fact, a growing empirical literature in paediatrics and preventive medicine has reported strong long-term effects of severe concussions on educational attainment (Browne & Lam, 2006; Duff & Stuck, 2015). This alternative approach assumes that a child may not recover quickly from a previous injury condition, and his or her scholastic outcomes may be still affected after 12 months. Using this assumption, I further derive one group of three mutually exclusive variables recording an injury (no injury ever; ever had an injury without hospital stay; ever had an injury that led to hospital stay) that happened in any previous wave. The fixed-effects models are given by:

$$CD_{it} = INJEVER_{it}'\beta_3 + X_{it}'\gamma_3 + Z_i'\delta_3 + \alpha_{3i} + \varepsilon_{3it} \,, \qquad (3.3), \quad \text{and}$$

$$CD_{it} - \overline{CD}_i = \left(INJEVER_{it} - \overline{INJEVER}_i\right)\beta_4 + \left(X_{it} - \overline{X}_i\right)\gamma + (\varepsilon_{4it} - \bar{\varepsilon}_{4it}) \,, \qquad (3.4)$$

where $INJEVER_{it}$ is the new dummy group for injury severities and $\overline{INJEVER}_i$ represents the within-group mean of child injury severities for child *i* across all four waves, respectively. All the other parameters and variables are defined as above in equations (3.1) and (3.2).

Another similar strategy is to include a lagged term representing the injury condition in the previous wave, $_{t-1}$. Compared to the models in equations (3.3) and (3.4), this approach simply intends to capture the persistent effects of an injury condition that happened in the last study round but not earlier. There is, however, a potential concern for these two alternative specifications. The LSAC is a biennial follow-up study, so I only have the information of child injury in every second year when the survey was conducted. Hence, these two alternative injury constructions may suffer from missing information in the gap years, and may not persistently record the complete injury history of childhood. Based on this significant disadvantage, this chapter only discusses the estimated results under these two constructions for sensitivity analysis.

Table 3B in *Appendices* re-estimates the effects of injuries on all four cognitive outcomes, using the alternative two specifications as discussed above. Overall, the previous estimated impacts of "injured during the last twelve months" on cognitive scores are replicated by using "ever injured in any previous wave." A fixed-effects model using lagged terms (bottom pane) estimates that ARS Literacy scores of children who had a severe injury in the previous survey are 0.159 standard deviations lower than those who had no injury in that period. Further, a student who experienced an injury without a hospital stay in the last period is expected to have a 0.065 standard deviation lower score in mathematical thinking. Though not shown in the results, I also find that a concussion or internal injury has more persistent effects on child outcomes than all the other types of injuries, which corresponds to the conclusions from the literature in paediatrics and public health.

3.6.2 Are Results Robust to Objective Cognitive Test Scores?

In addition to cognitive scores reported from teachers and parents, I employ test scores from the National Assessments Program-Literacy and Numeracy (NAPLAN) tests. The NAPLAN tests are a nationally mandatory assessment for all Australian students in Years 3, 5, 7, and 9, which has been carried out on the same days each year since 2008. The main advantage of the NAPLAN test scores is that they are standardised and externally marked, therefore minimising assessment bias caused by individual heterogeneity. However, there are potential timing issues between the NAPLAN tests and my main survey data, the LSAC. First, the NAPLAN tests are administered in May each year, and approximately 75% of parents in my pooled sample completed the LSAC surveys after May and it is therefore it's possible that the injury occurred after the NAPLAN tests. Second, LSAC children are enrolled in different school grades in the same calendar year. For example, in wave 5, about 5%, 71%, and 23% of participants are respectively enrolled in Years 6, 7, and 8, meaning that students completed the NAPLAN tests in a different year than when the LSAC survey was conducted. On average, a student participated in the NAPLAN tests almost 16 months, after his or her parents completed the LSAC surveys. Therefore, it is empirically difficult to estimate the timely effects of an injury on NAPLAN test scores.

Nevertheless, for sensitivity analysis, I use the following approach:

$$NAPLAN_{it} = TINJ_{it}'\beta_5 + X_{it}'\gamma_5 + Z_i'\delta_5 + \alpha_{5i} + \varepsilon_{5it} \ , \qquad (4.5),$$

where $NAPLAN_{it}$ represents two cognitive scores: literacy and mathematics.[14] $TINJ_{it}$ is group of dummy variables that record an injury experience at different points of time (between 0 and 12 months; between 13 and 24 months; more than 25 months) before the NAPLAN tests. This approach helps distinguish between contemporary effects and persistent effects. Alternatively, I may simply include an interaction term:

$$NAPLAN_{it} = INJ_{it}\beta_6 + (INJ_{it} * DIST_{it})\varphi_6 + X_{it}'\gamma_6 + Z_i'\delta_6 + \alpha_{6i} + \varepsilon_{6it} \ , \qquad (4.6),$$

where $DIST_{it}$ represents the timing gap (months) between the LSAC interviews and the NAPLAN tests.

Table 3C in *Appendices* shows the estimated effects of injuries on NAPLAN scores. Despite one significant coefficient (a student who sustained a hospital injury, happened between 13 and 24 months before the test, has a 0.388 standard deviation higher score in mathematics than another student who did not have any injury at all), the overall finding of weak academic impacts of having an injury are robust.

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[14] The literacy score is calculated by the average of four separate NAPLAN test results, including reading, writing, spelling, and grammar (following Black et al., 2015).

3.6.3 Do Results Differ by Family Socioeconomic Groups or School Types?

As discussed in Chapter 2 above, seeking medical attention following a childhood injury might be itself socially graded. To examine whether the influences of injuries on child development differ by parental SES, I re-estimate fixed-effects models with respect to different SES subgroups separately. SES subgroups are created by household income quartiles, whether a parent has a degree or is currently employed, whether a child goes to government-run public school, and whether the child is living in a neighbourhood above the average SEIFA scores. As presented in *Table 3D* in *Appendices*, the weak associations between injury severity and ARS scores do not vary by family or school SES indicators.

3.7 Discussions and Concluding Remarks

Injury is one of the major childhood health problems in the developed world. However, to date, the potential impacts of injuries in child health and development have not been clearly researched by earlier economic literature. Currie et al. (2010), as a notable exception, examines the association between young adult outcomes and major injury condition suffered at four periods of time (0-3, 4-8, 9-13, and 14-18), respectively. Their results show that major injuries in childhood do not have lingering effects on future outcomes, though major injuries occurring during adolescence have significant impacts on academic performance in college and receipt of social assistance. Currie et al. (2010) further concludes that childhood mental health conditions, for example ADHD or conduct disorder, are more harmful than childhood injuries or asthma. Children who sustain early-life physical health problems and recover shortly afterwards are observed to have no lasting effects on future educational performance and reliance on social welfare.

My study is not a simple parallel to Currie et al. (2010). I firstly investigate the short-term effects of injuries on cognitive outcomes during childhood, using a detailed longitudinal dataset in Australia. In light of my individual-level fixed-effects results, I do not find strong short-term impacts of injuries on cognitive abilities. This primary finding corresponds to the general conclusion from the existing economic literature that early-life physical health problems do not strongly predict later outcomes (Currie et al., 2010; Kaestner & Grossman, 2009; Palermo & Dowd, 2012). It is primarily because an injury only reduces physical health and an injured child will most likely be cured in the short term, in contrast with mental health conditions. This chapter, however, may still progress the literature on early-life health problems and child outcomes in several ways. First, I demonstrate that childhood injury is an exogenous health shock within-child across time in Australia. Apart from age, gender, and school grade, I do not find any strong and consistent predictor to the injury severity or occurrence. The exogeneity of injury allows me to estimate its potential causal effects on child development. Second, in contrast to earlier international studies, my main scholastic outcomes are measured by school teachers rather than objective tests. Essentially, teacher assessments may capture a broader concept of academic performance than objective tests do. In addition to analytical abilities in problem-solving, teachers may also evaluate children on self-motivation, daily effort, and engagement, in the form of class participation and homework completion (Zavodny, 2013). Third, I find considerable effects of injuries on a number of intermediate outcomes. School absence and child health status (as well as its proxy, usage of medical care services), as the main pathways that mediate child health and cognitive development, both seem to be significantly affected by injuries. For example, an injured child who required a hospital stay has 0.7 more absent school days in the last four weeks than an uninjured child. Further, such severe injury consumes an extra 0.7 GP visits, 0.7 other medical services, and 0.4 pharmaceutical scripts, respectively. Given the heavy financial burden that childhood injuries place on the Australian public health system, this result is potentially of great concern.

The major finding of no clear cognitive impact of childhood injuries in Australia may be interpreted in two ways. First, the most serious consequence of injury from my sample is hospital admission. Due to a lack of linked hospital-level data, it is difficult to judge how severe an injury is among the LSAC children (e.g., if such injury causes long-term morbidity). Pursuing this further, a substantial account of literature in paediatrics and public health has documented long-term negative outcomes of head injuries, particularly for traumatic brain injury (Janusz et al., 2002; Koskiniemi et al., 1995; Mahoney et al., 1983; Taylor et al., 2002). The head injury investigated in this chapter, however, is mainly concussion, which may cause fewer negative effects on child development than traumatic brain injury. Second, the strong and robust association between injury experience and medical care utilisation indicates that injured children receive required treatment and recover in a timely manner, which may further explain the absence of contemporary or persistent cognitive effect of injuries in Australia. However, with a lack of details on the treatment an Australian child received after a serious injury, this explanation needs to be supported with more empirical evidence.

This chapter is not without limitations. In my main empirical method, the individual fixed-effects model, the key parameter (academic impacts of having an injury) is only identified if the removed unobserved heterogeneity is fixed over time. This approach does not address any time-varying unobserved characteristics that determine the within-individual variation in injury risks and cognitive skills, for example, parental relationship history or child's peer pressure at school. It also assumes that there is no reverse causality (i.e., that cognitive scores influence the occurrence of injury). Both an unobserved time-varying confounder and reverse causality would bias the results. Furthermore, results in this analysis may be challenged by measurement errors, as children's cognitive skills are reported by school teachers and information regarding injury experiences is given by parents. Potential bias caused these problems are discussed in previous chapter (Sections 2.3 and 2.6).

3.8 Appendices

Figure 3A Conceptual Framework Developed from Literature: Childhood Injuries and Later Outcomes

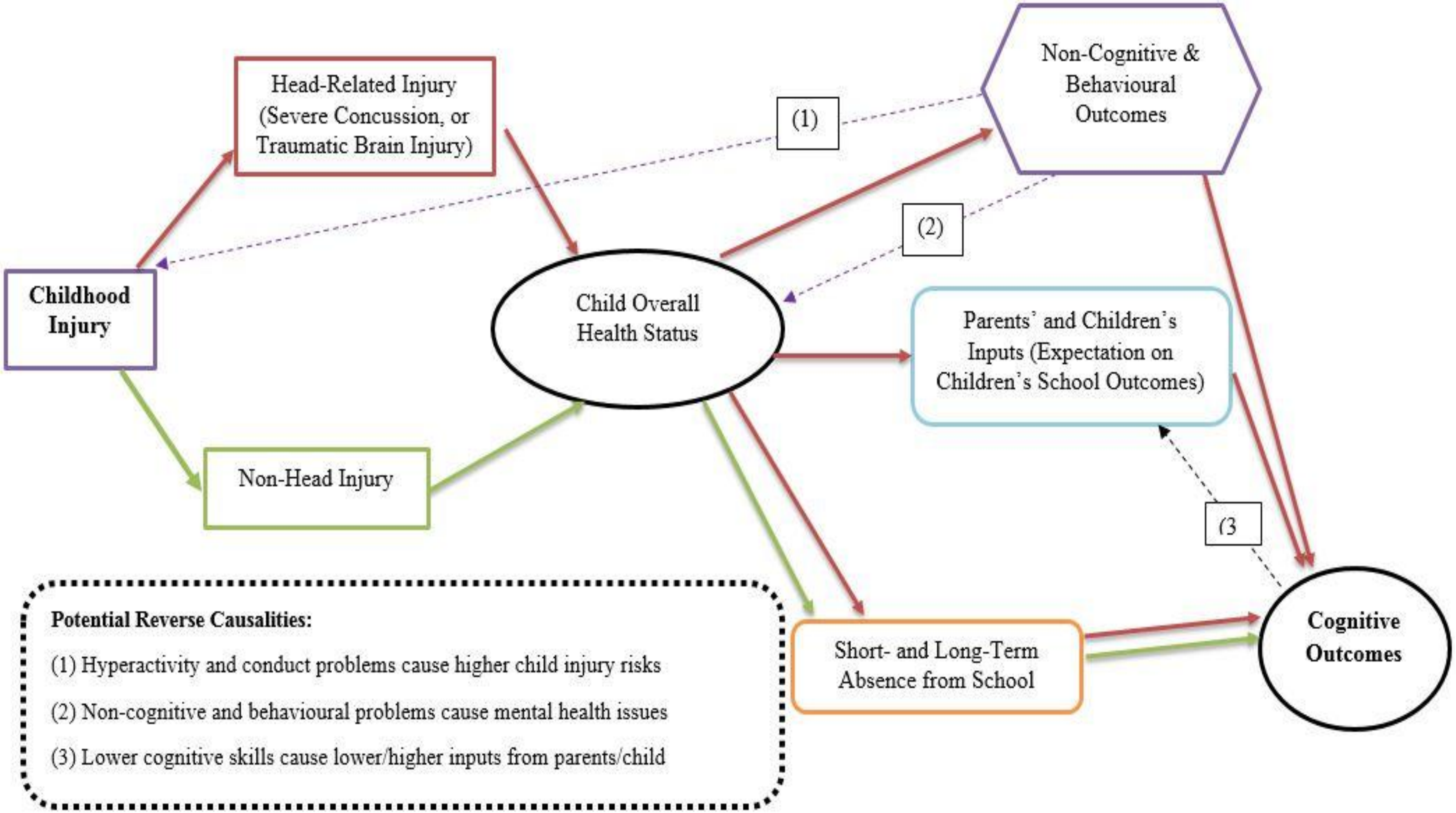


Table 3A Descriptive Statistics of Covariates in Pooled Sample (Waves 2 to 5, n=16,920)

Covariates	Obs.	Mean	S.D.	Min.	Max.	Variation
i. Parental Socioeconomic Status						
Mother – Degree*	16,903	.316	.465	0	1	3.5
Father – Degree*	16,836	.260	.439	0	1	3.6
Mother – Employed	16,882	.654	.476	0	1	30.5
Father – Employed	16,853	.740	.439	0	1	22.3
Mother – Working Hours	16,544	18.590	17.285	0	120	61.5
Father – Working Hours	16,857	34.685	23.358	0	168	59.3
Income – Not Reported	16,920	.243	.429	0	1	25.0
Log Family Income	16,920	5.664	3.263	0	10.0	68.5
ii. School and Neighbourhood						
Public School	16,813	.629	.483	0	1	81.1
Private School	16,813	.147	.355	0	1	86.1
Catholic School	16,813	.223	.416	0	1	86.6
SEIFA Advantage Scores	16,914	10.101	.764	5.8	12.1	40.5
iii. Child Characteristics						
Girls*	16,920	.489	.500	0	1	0
Age in Months	16,920	116.919	27.401	75	166	62.5
School Grade	16,761	4.089	2.277	0	9	62.3
Aboriginal*	16,920	.030	.171	0	1	0
Prosociality – Parent 1	16,112	8.307	1.725	0	10	56.5
Hyperactivity – Parent 1	16,109	3.151	2.334	0	10	59.5
Peer Problems – Parent 1	16,112	1.754	1.846	0	10	55.0
Emotional Symptoms – Parent 1	16,111	1.489	1.646	0	10	57.2
Conduct Problems – Parent 1	16,112	1.301	1.468	0	10	52.2
iii. Child Characteristics						
Individual Sport	16,737	.143	.350	0	1	23.12
Team Sport	16,737	.056	.231	0	1	11.4
No. of V/F	16,728	3.105	1.494	0	6	38.4
Weekday TV	16,854	2.930	.781	1	5	45.1
Weekend TV	16,858	3.437	.887	1	5	51.0
Weekday E-Game	16,711	1.618	.831	1	5	48.6
Weekday E-Game	16,728	2.236	1.085	1	5	44.8
v. Family Socio-Demographic						
Parents Overseas (English)*	16,920	.151	.358	0	1	0
Parents Overseas (Non-English)*	16,920	.156	.363	0	1	0
No. of Younger Siblings	16,910	.771	.878	0	6	12.5
No. of Older Siblings*	16,910	.812	.909	0	8	0
Father Missing in Household	16,835	.172	.378	0	1	10.6
Maternal Mental Health	16,674	.010	.100	0	1	2.7
vi. At-Birth Information						
Maternal Age at Birth*	16,699	30.676	5.072	15	48	0
Smoked During Pregnancy*	16,920	.145	.352	0	1	0
Breastfed > Six Months*	16,845	.590	.4925	0	1	0
Low Birth Weight *	16,920	.063	.243	0	1	0
"Who Am I" Test Scores*	16,671	64.259	8.026	29.941	96.882	0

*time-invariant covariates will be omitted in fixed-effects methods.

Table 3B Estimated Persistent Effects of Injury Severities on Cognitive Scores (Fixed-Effects)

	ARS Literacy	ARS Mathematics	Progress in Reading	Progress in Mathematics
	(1)	(2)	(3)	(4)
Severity				
Ever Injured (No Hospital)	-0.042	-0.065*	0.010	0.002
	(0.028)	(0.037)	(0.028)	(0.028)
Ever Injured (Hospital)	-0.135*	-0.078	0.038	-0.030
	(0.078)	(0.113)	(0.070)	(0.075)
Joint Test (*p*-value)	.111	.207	.831	.913
Types				
No Hospital Stay	-0.031	-0.038	0.030	0.029
	(0.020)	(0.027)	(0.019)	(0.020)
Hospital Stay	-0.007	0.012	0.059	0.001
	(0.060)	(0.083)	(0.060)	(0.064)
No Hospital Stay (t-1)	-0.015	**-0.065****	0.030	0.008
	(0.019)	**(0.026)**	(0.020)	(0.021)
Hospital Stay (t-1)	**-0.159****	-0.136	0.056	-0.079
	(0.066)	(0.087)	(0.064)	(0.069)
Joint Test (*p*-value)	.066	.052	.330	.450
Maximum Sample Size	12,591	9,581	15,033	15,062

Notes: Standard errors are clustered by children's ID. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively "No injury ever" is the reference category when the effects of injury severities are estimated. All ARS scores have been standardised. The fixed-effects model only includes time-variant controls.

Table 3C Estimated Persistent Effects of Injury Severities on NAPLAN (Fixed-Effects)

	NAPLAN Literacy	NAPLAN Mathematics
	(1)	(2)
Injuries at Different Points of Time		
No Hospital Stay (0-12 Months)	0.015	0.031
	(0.048)	(0.047)
No Hospital Stay (13-24 Months)	-0.058	-0.008
	(0.045)	(0.038)
No Hospital Stay (> 24 Months)	0.001	-0.035
	(0.024)	(0.026)
Hospital Stay (0-12 Months)	-0.121	-0.113
	(0.123)	(0.126)
Hospital Stay (13-24 Months)	0.111	**0.388*****
	(0.088)	**(0.144)**
Hospital Stay (> 24 Months)	-0.067	-0.028
	(0.094)	(0.078)
Joint Test (*p*-value)	0.419	0.081
Maximum Sample Size	9,109	9,036
*Injury*Time Distance*		
Injury	0.005	-0.022
	(0.028)	(0.029)
Injury*Distance (Months)	-0.004	0.001
	(0.004)	(0.004)
Joint Test (*p*-value)	0.551	0.693
Sample Size	9,105	9,032

Notes: Standard errors are clustered by children's ID. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. "No injury at all" is the reference category when the effects of injury severities are estimated. All NAPLAN scores have been standardised. The fixed-effects model only includes time-variant controls. Distance measures the number of months between LSAC interviews and NAPLAN tests. On average, students participated in NAPLAN tests approximately 15.5 months after their parents completed the last LSAC interviews.

Table 3D Fixed-Effects Estimated Associations between Injury Severities and Cognitive Scores w.r.t Different SES Groups

	ARS Literacy				ARS Mathematics			
Family Income	1st Income Quartile	2nd Income Quartile	3rd Income Quartile	4th Income Quartile	1st Income Quartile	2nd Income Quartile	3rd Income Quartile	4th Income Quartile
No Hospital Stay	-0.025	-0.067	-0.023	-0.060	0.014	-0.068	0.101	-0.050
	(0.063)	(0.051)	(0.055)	(0.044)	(0.083)	(0.071)	(0.073)	(0.061)
Hospital Stay	-0.079	0.209	0.043	-0.059	0.252	0.172	-0.150	0.265
	(0.178)	(0.233)	(0.189)	(0.140)	(0.249)	(0.328)	(0.272)	(0.172)
Joint Test (*p*-value)	.848	.280	.884	.367	.599	.551	.308	.192
Sample Size	2,295	2,583	2,494	2,652	1,783	1,975	1,919	2,021
Parental Employment	Mother Employed	Mother Unemployed	Father Employed	Father Unemployed	Mother Employed	Mother Unemployed	Father Employed	Father Unemployed
No Hospital Stay	-0.016	-0.012	**-0.051******	0.049	-0.013	0.042	-0.037	0.041
	(0.023)	(0.044)	**(0.022)**	(0.050)	(0.033)	(0.058)	(0.029)	(0.070)
Hospital Stay	0.063	-0.065	0.078	-0.137	0.044	0.152	0.093	-0.043
	(0.074)	(0.140)	(0.068)	(0.149)	(0.101)	(0.176)	(0.090)	(0.207)
Joint Test (*p*-value)	.527	.873	**.026**	.377	.828	.539	.233	.815
Sample Size	8,747	4,132	9,723	3,156	6,488	3,320	7,512	2,296
Parental Education	Mother with Degree	Mother w/o Degree	Father with Degree	Father w/o Degree	Mother with Degree	Mother w/o Degree	Father with Degree	Father w/o Degree
No Hospital Stay	**-0.077*******	-0.014	-0.034	-0.032	-0.065	-0.014	-0.019	-0.023
	(0.030)	(0.024)	(0.035)	(0.022)	(0.042)	(0.032)	(0.048)	(0.029)
Hospital Stay	-0.050	0.065	0.076	0.017	-0.100	0.133	0.146	0.039
	(0.097)	(0.075)	(0.108)	(0.071)	(0.128)	(0.101)	(0.136)	(0.097)
Joint Test (*p*-value)	**.031**	.560	.466	.331	.238	.358	.498	.656
Sample Size	4,273	8,601	3,467	9,373	3,176	6,627	2,613	7,156
School and Neighbourhood	Public School	Non-Public School	SEIFA Below Average	SEIFA Above Average	Public School	Non-Public School	SEIFA Below Average	SEIFA Above Average
No Hospital Stay	-0.021	-0.041	-0.019	**-0.055******	0.004	-0.053	0.010	-0.065*
	(0.026)	(0.030)	(0.028)	**(0.027)**	(0.032)	(0.042)	(0.036)	(0.037)
Hospital Stay	0.012	-0.043	0.026	0.040	0.033	0.024	-0.066	0.213*
	(0.076)	(0.105)	(0.088)	(0.092)	(0.098)	(0.144)	(0.113)	(0.124)
Joint Test (*p*-value)	.690	.363	.746	.109	.941	.441	.802	**.035**
Sample Size	7,965	4,914	6,270	6,609	6,397	3,411	4,917	4,891

Notes: Standard errors are clustered by children's ID. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. "No injury ever" is the reference category when the effects of injury severities are estimated. All ARS scores have been standardised. The fixed-effects model only includes time-variant controls. "Mother/father employed" means the parent of the child is either part-time or full-time working. "Non-public" school means the child goes to two types of private schools (independent and Catholic). The average score for SEIFA is 1010.

Chapter 4

Childhood Injuries and Cognitive Achievement in the U.S.: A 25-Year Longitudinal Study

4.1 Introduction

Although the last three decades have witnessed a tremendous decline in childhood accident rates around the developed world, accidental and unintentional injury remains the leading cause of early-life mortality and morbidity in the U.S. (Borse & Sleet, 2009; Glied, 2001; Peden et al., 2008; Wallis, Cody, & Mickalide, 2003). For instance, a national public health report estimates that about 20 American children die every day from a preventable injury—more than deaths from other main causes combined, including infectious diseases and congenital problems (Borse & Sleet, 2009). In addition to fatal injuries, the non-fatal injuries cause approximately 12 million physician visits and nine million emergency room visits every year (Borse & Sleet, 2009; Wallis et al., 2003). These accidents overall affect more than 20 million American children and families, and place an annual financial burden of 17 billion USD on the national public health system (Borse & Sleet, 2009).

Given the substantial socioeconomic cost incurred by childhood accidental injuries in the U.S., previous American studies mainly focused on the determinants of an accident's occurrence (Currie & Hotz, 2001; Gordon et al., 2007; Leininger et al., 2009; Morrill, 2011). There is, however, a significant lack of research on the impact of childhood accidents on an individual's cognitive and educational outcomes. Using population data collected from the public health insurance system in Manitoba (a province in Canada), Currie et al. (2010) compares the short- and long-run educational effects of accidental injuries suffered at different periods of childhood and adolescence (0-4, 5-9, 10-13, and 14-18). Their research shows that a major injury (suffered between ages 10 and 18) has negative effects on test scores at grade 12 and college. Chapter 3 in this thesis explores a detailed longitudinal study sample of 5,000 Australian children and concludes that having an injury within the last 12 months does not affect short-term cognitive abilities measured by both national standard test scores and teacher-reported academic progress. A severe injury, however, significantly increases school absence, worsens overall child health status, and causes higher utilisation of medical and pharmaceutical services. It is not known whether these findings of weak associations between an early-life injury and later development in Australia also hold in the U.S. context (i.e., the U.S. has different public health and education systems compared to Canada and Australia). For example, if an injured U.S. child from a disadvantaged family has no access to quality health services, he or she may fail to receive timely treatment. If this child does not recover well from a severe injury, he or she may suffer from long-term negative influences. Therefore, it is interesting to examine if previous results are replicated by using American children and families.

As discussed in Section 3.1, a severe childhood injury may adversely affect a wide array of future outcomes. Of all, one important consequence is that an injury may greatly reduce an individual's human capital development and accumulation, in the forms of lower cognitive ability, poorer academic performance, and fewer schooling years. In addition to education, a childhood injury may further harm other adult socioeconomic outcomes and wellbeing, such as earning potential, labour force participation, and adult health status.

This chapter aims to make several contributions to the existing economic literature in child health and development. First, using a very detailed longitudinal dataset and rigorous econometrics framework, I carefully estimate the impacts of having a severe childhood accident on short- and long-term cognitive abilities in the U.S. Severe injuries refer to those causing hospital admissions, while cognitive development is given by four different objective test scores that measure a child's age-appropriate analytical-thinking and problem-solving skills in mathematics and language. The purpose of selecting these outcome variables is to examine if previous results from Australia (Chapter 3 in this thesis) and Canada (Currie et al., 2010) are replicated in the U.S. context, a country that has a larger population and higher inequality in health and education.

The second question this chapter addresses is whether the cognitive and educational cost of childhood accidental injuries vary by different socioeconomic and demographic groups. Previous U.S. empirical studies and public health reports investigating the causes of childhood injuries have overall suggested several high-risk factors, including low income (Leininger et al., 2009), high maternal labour supply (Glied, 2001; Morrill, 2011), single- or step-parenthood (Dawson, 1991), disadvantaged neighbourhood (Durkin, Davidson, Kuhn, O'Connor, & Barlow, 1994), and non-white ethnicity (Wallis et al., 2003). If the estimated educational effects of injuries are themselves socially graded (for example if cognitive skills of children from low-income families are more seriously affected by a hospital-treated accident), then injury prevention programs could more efficiently target particularly high-risk children and families.

Third, taking advantage of a rich U.S. longitudinal dataset, I use a combination of sibling- and individual-level fixed-effects estimators to control for unobserved confounding factors (main empirical issues in this chapter),. Both of these empirical strategies are adopted because the presence of unobserved confounding factors between child injury and later development may arise from different sources, such as neighbourhoods, schools, families, mothers, and children themselves (see detailed discussion in Section 4.3).

4.2 Data, Definitions, and Summary Statistics

4.2.1 NLSY-Child (1988 to 2012)

The National Longitudinal Study of Youth, 1979 cohort (NLSY79), began in 1979 with approximately 6,000 men and 6,000 women. This chapter utilises the data from the Child Supplement of NLSY79 (NLSY-Child), which is a biennial questionnaire that has followed the children born to and living with female respondents of NLSY79 since 1986. The Child Supplement is designed to record a child's wellbeing, health, and development throughout his or her entire childhood (from birth to 15 years). By 2012, 11,512 children born to 4,932 NLSY79 mothers had been studied. It is noteworthy that NLSY79 oversamples low-income whites, Hispanics, African Americans, and military personnel, which indicates that children surveyed by this dataset are more likely to represent the target population for public health policies. Children's cognitive test scores are directly assessed by professional interviewers, while health information and accident experience are provided by mothers. Given the longitudinal nature of study design, the rigorous method which biennial surveys have been conducted, and the richness of information spanning the entire childhood, the NLSY-Child has been widely accepted as one of the best datasets used by the literature exploring child health and development. In this chapter, I limit my attention to study rounds from 1988 to 2012, because the main variables of interest (child injury and cognitive abilities) are only available in these waves. The maximum estimation sample includes 36,303 child-year observations across 13 cross-sections and 9,447 unique children from 4,132 NLSY79 mothers. On average, one child participated in 4.54 study rounds and one family provided 12.73 child-year observations (children are aged 5 to 15 in NLSY).

Table 4.1 Summary Statistics of Main Variables

	Sample					
	Obs.	Mean	S.D.	Min.	Max.	Variation (%)
Cognitive Outcomes						
PIAT Mathematics	32,172	100.8	11.4	65	135	69.7
PIAT Recognition	32,048	104.1	12.1	65	135	69.3
PIAT Comprehension	27,617	100.9	11.0	65	135	66.5
PPVT	17,032	92.2	13.8	40	160	48.3
Average PIAT/PPVT	36,303	99.3	14.9	40	160	73.6
PIAT Index	27,436	.000	1	-3.0	2.6	74.5
Injury Indicators						
i. Severity						
Medical Attention	36,303	.101	.301	0	1	22.0
Hospital	36,303	.024	.154	0	1	7.3
Time Distance (Months)	645	17.4	11.2	0	36	8.9
ii. Consequential Injuries						
Fractures or Dislocation	36,265	.004	.064	0	1	1.5
Sprain or Bruise	36,265	.001	.032	0	1	0.4
Head or Concussion	36,265	.001	.030	0	1	0.3
Wound, Cut or Scrape	36,265	.001	.030	0	1	0.7
Other Injuries	36,265	.004	.063	0	1	0.5
iii. Causes of Accidents						
Roadside	36,303	.004	.121	0	1	4.8
Fall (Non-Sport)	36,303	.006	.187	0	1	10.6
Fall (Sport)	36,303	.004	.152	0	1	7.4
Other Known	36,303	.002	.151	0	1	7.1

Notes: PIAT stands for Peabody Individual Achievement Test, while PPVT stands for Peabody Picture Vocabulary Test. All cognitive scores have been standardised with a mean of 100 and a standard deviation of 10 at each study round. a) "Other Injuries" include cut or scrape, burn, poison, and other unknown types of injuries. b) "Other Known" includes the following causes: hot liquid, toy or item intended for child use; equipment or device not intended for a child; smashed body part; car/door/window; stepped on or cut by sharp object, etc. "Time Distance" here refers to the time window (measured by months) between an injury occurrence and survey date. Only 645 injured children report this information.

4.2.2. Cognitive Achievement

Following the existing literature on the correlations between child health problems and later life outcomes (Ampaabeng & Tan, 2013; Case & Paxson, 2010; Currie & Stabile, 2006; Kaestner & Grossman, 2009; Venkataramani, 2012; Zavodny, 2013), this chapter uses four cognitive test scores administered by NLSY-Child surveys, including: 1) the Peabody Individual Achievement Test (PIAT) of mathematics, which assesses the fundamental mathematic skills, such as recognising numerals; 2) the PIAT of reading recognition, which assesses basic linguistic skills such as matching letters and reading single words aloud; 3); the PIAT of reading comprehension, which assesses the child's ability to derive meaning from simple sentences that are read silently; and 4) the Peabody Picture Vocabulary Test (PPVT), which assesses receptive vocabulary for standard American English and provides a quick estimate of verbal ability and scholastic aptitude. To measure the overall performance, I further create 5) an average score of 1) to 4) (for those child-year observations with missing results in either PIAT or PPVT, the mean cognitive score is taken by averaging all non-missing scores); and 6) a PIAT index calculated by a principal component factor analysis that loads all three PIAT scores. These tests have been found to be strongly correlated to alternative aspects in relation to childhood cognitive development (e.g., information processing, conceptual resources, perceptual skill, language learning), and each has very high completion rates; see Baker et al. (1993) for a detailed discussion of each test. For the convenience of comparison and interpretation, all cognitive scores from 1) to 5) have been standardised with a mean of 100 and standard deviation of 10 among children at the same age at each survey wave (longitudinal sample statistics are reported in Table 4.1). [15]

4.2.3 Childhood Injuries

In the NLSY-Child, injuries are biennially assessed by the mother's answer to a series of consequential questions. The initial question asks: "Since the last survey, has the child ever had an accident requiring hospitalization?" Based on this question, I derive: (1) a binary indicator measuring whether a child had an injury requiring hospital admission. The NLSY-Child then asks about the specific type of injury that a child experienced. I construct: (2) a set of five non-mutually-exclusive binary variables representing the subsequent injuries after an accident, including broken bones or dislocation; sprain, bruise, and pulled muscle; head injury or concussion; cut or scrape; and other injuries. The survey also investigates the cause of the accident, from a list of more than 20 options. I create: (3) a set of five mutually-exclusive binary variables indicating the cause of the accident, including roadside, sports-related fall, non-sports-related fall, other known and other unknown (see sample statistics in Table 4.1). In this chapter, I use (1) and (2) as the main explanatory variables to estimate the

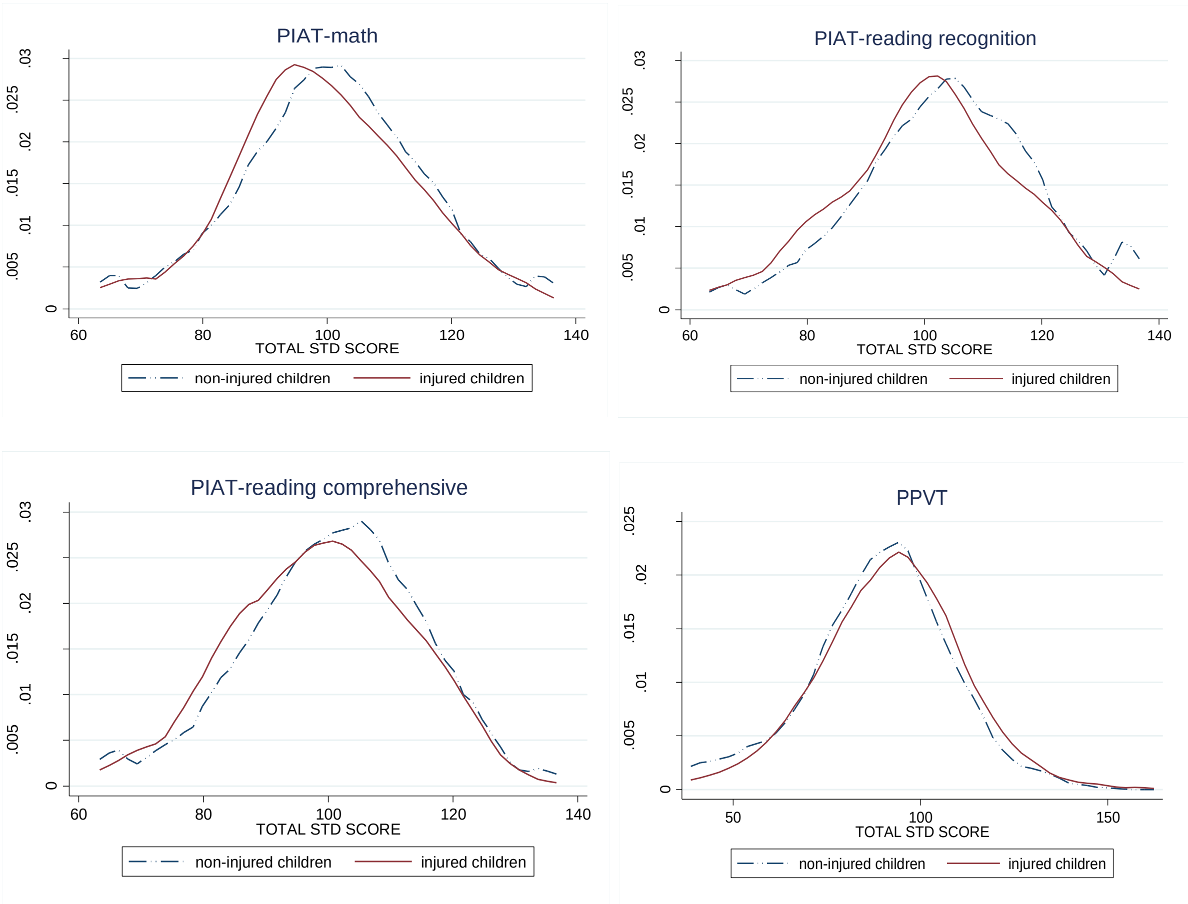
[15] PIAT scores are mainly collected from children aged five to 14, whilst PPVT tests are mainly conducted among children between three and 11. To increase the estimation sample size, I exclude the PPVT score when constructing this cognitive index. Otherwise, the sample will significantly drop to 11,155 if the principal component loads PPVT.

cognitive and educational impacts of injuries. Variables defined in (3) are used in sensitivity analyses.

4.2.4 Descriptive Association between Cognitive Test Scores and Injuries

Figure 4.1 presents the kernel density estimates for four cognitive test scores separated by whether or not the child had an accidental injury that required hospitalisation in the same study round. An injury experience, overall, shifts the distribution of all three PIAT cognitive scores to the left. This pattern given by the data indicates that an injury is associated with lower levels of cognitive skills in mathematics and reading. The two-group mean *t* tests show that injured children have significantly lower PIAT scores than those who are uninjured (at the 5% level). The main objective of this chapter is to determine whether these negative correlations are robust once I control for observed and unobserved characteristics that may confound both child injury risks and cognitive development.

Figure 4.1 Kernel Density Estimates of Cognitive Scores by Injury Status



Notes: Peabody Individual Achievement Test (PIAT) and Peabody Picture Vocabulary Test (PPVT).

Table 4.2 Determinants of Childhood Injuries from Individual Fixed-Effects – *Is an Injury Exogenously Selected Within-Child Across-Time?*

	Overall	Types of Accidental Injury				Causes of Accidental Injury		
	Hospital Injury	Fracture or Dislocation	Sprain or Bruise	Head or Concussion	Wound, Cut, or Scrape	Roadside	Fall (Non-Sport)	Fall (Sport)
Maternal Characteristics								
Log Weekly Income	-0.000	-0.000	0.000	-0.000	0.000	-0.001	0.000	-0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother's Weekly Working Hrs	0.000**	-0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Single Mother	-0.002	0.000	-0.000	-0.000	0.000	0.001	-0.001	0.000
	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Child Covariates								
Age in Months	-0.000***	0.000	0.000**	0.000	-0.000***	-0.000	-0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Behavior Problem Index (BPI)	0.000	-0.000	-0.000	0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Neighbourhood								
Very Safe Neighbourhood	-0.002	-0.002	-0.000	-0.000	-0.002*	-0.001	-0.001	-0.001
	(0.002)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Sample Size	35,562	35,781	35,815	35,822	35,771	35,795	35,791	35,806

Notes: ***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All family incomes have been inflated using 2012 prices. A mother's weekly working hours are the total hours from the last calendar year divided by 52. The Behavior Problem Index (BPI) is the average score of six dimensions that measure a child's psychological and behavioural problems, including antisocial, anxious/depressive, headstrong, hyperactive, dependent, and peer conflicts.

Table 4.3 Determinants of Childhood Injuries from Sibling Fixed-Effects – *Is an Injury Exogenously Selected Within-Family Between-Siblings?*

	Overall	Types of Accidental Injury				Causes of Accidental Injury		
	Hospital Injury	Fracture or Dislocation	Sprain or Bruise	Head or Concussion	Wound, Cut, or Scrape	Roadside	Fall (Non-Sport)	Fall (Sport)
Child Covariates								
Gender – Boy	0.003	0.001	0.000	0.001	0.001	0.001	0.001	0.001
	(0.002)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Age in Months	-0.000	-0.000	0.000	-0.000	-0.000	-0.000	-0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
BPI	-0.000	-0.000	-0.000	0.000	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Before and At-Birth								
Smoked in Pregnancy	0.001	-0.001	-0.000	-0.002	-0.004	0.001	-0.001	-0.001
	(0.005)	(0.002)	(0.001)	(0.001)	(0.003)	(0.002)	(0.002)	(0.001)
Drank in Pregnancy	0.004	0.001	-0.001	0.000	0.001	0.001	-0.001	0.001
	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
C-Section	0.005	0.000	-0.000	-0.000	0.001	-0.001	0.000	-0.003
	(0.006)	(0.004)	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)
Low Birth Weight	-0.020***	-0.001	0.002	0.001	-0.002	-0.001	-0.001	0.000
	(0.007)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)
Breastfed > 6 Months	0.003	-0.000	0.000	0.000	0.000	0.003	-0.000	0.001
	(0.006)	(0.003)	(0.001)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
Maternal Age at Birth	0.001	-0.000	0.000	0.000	0.001	0.000	-0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Sample Size	35,562	35,781	35,815	35,822	35,771	35,795	35,791	35,806

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All covariates are defined as above in Table 4.2.

4.3 Determinants of Childhood Accidental Injuries

Estimating the impacts of childhood injuries on later outcomes is difficult, because the occurrence of an injury (like other childhood health problems) does not necessarily occur at random. Rather, it may depend on a set of observed and unobserved individual or family characteristics. Over several decades, the causes of childhood injuries have been debated by health professionals and social science researchers. One considered view is that accidents just happen. For instance, an American Institute of Medicine report on injury prevention argues, "For centuries, human injuries have been regarded either as random and unavoidable occurrences ("acts of gods") or as untoward consequences of human malevolence or carelessness" (Bonnie, Fulco, & Liverman, 1999). This characterisation is controversial compared to another more commonly held view that child injury is the outcome of choices made by parents, caregivers, neighbourhood, community, and even the entire society, since children and young adolescents are particularly vulnerable and have little knowledge of safe behaviours. As discussed in Chapter 2, a large empirical literature has documented a strong association between child injury risks and parental socio-economic factors due to the crucial role of supervising and educating children, the characteristics of school and neighbourhood, as well as the parental practices for injury prevention. For example, parents decide whether to place their toddlers in booster seats and what sports events their children participate in. In addition to parental SES, other important determinants of childhood injuries include family structure (Bzostek & Beck, 2011), neighbourhood circumstances (Haynes et al., 2003; Kendrick et al., 2005), maternal psychological conditions (Phelan et al., 2007), childcare settings (Currie & Hotz, 2004; Gordon et al., 2007), and child behavioural problems (Lalloo, Sheiham, & Nazroo, 2003). Therefore, in order to identify the main empirical method in this chapter, it is important to examine what causes a childhood accidental injury in the U.S context (although two previous empirical analyses conclude with no strong cause of injury amongst Australian children). And, more importantly, whether the determinant is child-specific or family-specific, and whether it changes over time.

Table 4.2 reports the individual fixed-effects results on the potential risk factors of an accidental injury requiring hospitalisation in the next study round – approximately two years later. After I control for all time-constant child-specific characteristics, the estimates overall suggest that the occurrence of an accident, regardless of the different causes or consequences, is not strongly selected by any potential time-varying family- or mother-specific factor observed in the last study wave, such as income, labour market participation, or whether the mother had a partner living in the household. Although the estimated coefficient for the mother's weekly working hours is statistically significant at the 5% level, this result could be ignored for two reasons. First, the coefficient is extremely small in magnitude and economically insignificant; the likelihood of a child having an accident increases by 0.006% if his or her mother works one more hour per week. This estimate generally suggests that maternal labour supply has no impact on child injury risk. Second, the estimate is no longer statistically significant if I use an alternative specification of mother's employment status, for example, a group of four dummy variables including "not in labour force or unemployed," "part-time working," "full-time working," or "over-time working." The only significant risk factor as shown in Table 4.2 is age in months, and could be easily controlled as an exogenous covariate in the main estimation of cognitive effects of accidental injuries.

In Table 4.3, I further investigate the potential individual determinants of an accident by using a sibling fixed-effects method. After I control for all equally shared parental resources received by siblings within the same household, an accidental injury overall does not seem to be strongly predicted by any child-specific factor, such as gender, age, behavioural problems, or before- and at-birth conditions (except low birth weight). The estimated results presented in Tables 4.2 and 4.3 suggest that an accidental injury is an exogenous health shock within-child over-time and within-family across-sibling, respectively.[16] Its occurrence in the future is not strongly predicted by any classical risk factor in the NLSY-Child, once I control for individual- or family-level fixed-effects. This important finding is encouraging, and provides me with more confidence that the results can be interpreted causally.

4.4 Empirical Strategy

4.4.1 Empirical Challenges – Selection Bias and Unobserved Confounding Factors

The main empirical challenge in this chapter is the presence of observed and unobserved confounders that may determine both child injury risk and later outcomes. For example, as a significant determinant of childhood injury, parental SES is also a crucial predictor for children's cognitive development and future educational attainment (Bradley & Corwyn, 2002). This is primarily because family socioeconomic background directly determines the

[16] In Tables 4.2 and 4.3, I use fixed-effects linear probability models to regress the likelihood of suffering an accidental injury (overall or a particular type), which helps maintain the estimation sample size. Non-linear models, such as fixed-effects logit, estimate very similar results.

quantity and quality of family input into a child's education production and human capital development (Becker & Tomes, 1994; Cunha & Heckman, 2007). For instance, the choice of child care setting is strongly associated with household income, as well as the mother's labour supply. In addition to parental SES, other confounding factors include family structure, home environment, and a list of characteristics from school, neighbourhood, and children themselves. The classical selection bias problem takes place if the likelihood of suffering an injury is positively correlated with those confounders that reduce child cognitive test scores, for example poor parenting skills or living in a disadvantaged neighbourhood. Another example of unobserved characteristic is a child's risk preference: a risk-loving child may suffer more injuries and may also perform better academically. Consequently, unobserved heterogeneity is likely to bias the estimated comparisons of cognitive development between injured and uninjured children. Although there is a lack of empirical evidence on the educational cost of childhood injuries, the literature on child health and development overall suggests that ignoring those difficult-to-measure confounding factors may over-estimate the association between child health problems and subsequent wellbeing. In other words, results estimated by a traditional OLS model may be upward biased.

At first glance, the presence of an unobserved confounding characteristic and its consequential selection bias are major empirical challenges in this chapter. Essentially, the unobserved confounders between child injury and later educational development may arise from different aspects, depending on: 1) whether they are family- or child-specific; and 2) whether they vary over time. First, some difficult-to-measure characteristics may be family-specific and fixed over time, for example a parent's personality and responsibility for child care (a mother may be naturally more devoted and always taking better care of children than other mothers). Second, some parental characteristics may be equally shared by all siblings within a household but change over time, such as home environment and mother's transient supervision style. For example, living in a deprived neighbourhood or a disadvantaged home environment may simultaneously increase the probability of an accident and reduce the test scores. Further, if a mother has relatively more weekly working hours due to a short-term job commitment at a point of time, then this change in her supervisory style may temporarily affect both child health and cognitive development. Given almost 40% of child-year observations are solely supervised by single mothers, this difficult-to-measure factor may play a very important role in this chapter. Third, some unobserved family fixed effects may be time-specific but constant to children at the same age range, such as some specific household traditions or rules. For instance, a household may always send children to soccer classes or allow them to watch television regularly once they are seven years old, and such a firm rule fairly applies to all children in the household. Fourth, but probably the most important, some unobserved child-specific characteristics may drive both injury risks and cognitive skills. These individual-level unobservables could be either time-constant (natural self-discipline or genetic factors) or time-varying (whether a child gets along with other children and teachers at school). Table 4.4 summarises the important unobserved confounding factors that may bias the estimation in this chapter, and provides a potential empirical solution to each.

As opposed to unmeasured confounders, measurement errors and two-way causality may less likely bias the estimation in this analysis.[17] Although child accident experience is reported by mothers in NLSY-Child, I limit attention to the major injuries leading to hospital admission, and exclude the minor injuries causing medical attention (minor injuries are more likely to be ignored). Moreover, in the survey, if a mother answers "yes" to the question of whether a child ever had an injury requiring hospitalisation, then she is required to record when the most recent accident happens (specific to month and year). This information provides me with further confidence in a mother's memory and the precision of her reported child injury experiences. With regards to two-way causality, the overall findings in the literature suggest that cognitive test scores have very weak reverse impacts on childhood health status, particularly physical health problems (Chatterji, Kim, & Lahiri, 2014; Fletcher, 2008; Pieterse, 2015). More importantly, since an accident always occurred before cognitive tests in the NLSY-Child survey (on average 17 months prior), my estimated results are unlikely to be threatened by the reverse causality.

[17] Previous studies normally use questions with ordinal answers to measure the severity of a health condition, and thus they are more concerned with measurement errors. This is because respondents have too many options to tell the severity or frequency of a health problem, rather than simply ticking either "yes" or "no." Typical examples include global five-scale health status, symptoms of mental health disorders, severity of asthma, etc.

Table 4.4 A List of Potential Unobserved Confounders that may Determine both Injury Risks and Cognitive Development

Unobserved Confounders	Time-Invariant or Time-Varying?	Potential Empirical Solution
Family-level		
1. Maternal supervision style	Either or both	Sibling-year fixed-effects & individual fixed-effects (only for time-invariant fixed-effects)
2. Neighbourhood characteristics and home environment	Time-varying	Sibling-year fixed-effects
3. Family tradition / rule	Time-varying but age-constant	Sibling-age fixed-effects
Individual-level		
4. Personality / self-discipline / genetic factors / risk preference / propensity	Time-invariant	Individual fixed-effects
5. Whether a child gets along with other children and teachers at school	Time-variant	Valid instrument

Notes: This analysis may be concerned with the second type of unobserved confounding factors, since 52% of severe injuries happened at home in my study sample. In terms of neighbourhood quality, there is a question asking whether the family lives in a very safe neighbourhood. I include it in the estimation equation to reduce this type of confounding issue.

4.4.2 Empirical Framework—Three Different Within-Group Fixed-Effects Methods

This chapter uses sibling fixed-effects methods to overcome the selection bias and omitted variable problems arising from within the family (or specific to the mother), which is an empirical approach that has been widely used in the existing economic literature in child health and later development (Case & Paxson, 2010; Chatterji et al., 2014; Colen & Ramey, 2014; Currie & Stabile, 2006; Fletcher, 2014; Fletcher et al., 2010; Le et al., 2013; Rees & Sabia, 2014; Smith, 2009; Webbink, Vujic, Koning, & Martin, 2012). This approach controls for all shared time-constant family inputs that may contribute to the production of a child's health and education, and therefore better estimates the 'true' effects of childhood injuries on later cognitive and educational outcomes than OLS (Griliches, 1979; Moffitt, 2005).

I start with within-family comparisons by restricting the sample to NLSY children who have at least one injured sibling at one year and incorporating sibling-year fixed-effects:

$$CS_{ify} = INJ_{iy}'\beta_1 + X_{iy}'\gamma_1 + \alpha_{1fy} + \varepsilon_{1ify} \, , \qquad (4.1)$$

where CS_{ify} represents one of six cognitive test scores (PIAT-mathematics, PIAT-reading recognition, PIAT-reading comprehension, PPVT, average score, and PIAT index) for child *i* from family *f* observed at survey year *y*. X_{iy} refers to a vector of individual-level characteristics that vary between siblings, including gender, age, child behaviour problem index, and before- and at-birth information. α_{2fy} represents all unobservable family-level factors that are common to all siblings at year *y* (e.g., neighbourhood characteristics or maternal supervisory style) and removed by the sibling-year fixed-effects model, and ε_{2ify} is a random disturbance term that varies by child, family, and year. The coefficient vector β_1 is of my primary interest in this framework, and represents the estimated difference in cognitive test scores between an injured sibling and an uninjured sibling within the same family in one particular survey year. Note, sample means of cognitive skills (as well as covariates) between two types of families (at least one injured sibling vs. no injured sibling at all) are indifferent.

In addition to sibling-year fixed-effects as specified in equation (4.1), the family-specific difficult-to-measure confounders may alternatively arise between siblings at the same age (not the same time). For example, a family tradition (e.g., a child starts to help parents with housework from nine years old) may apply to all siblings once they grow up to a certain age level. I next attempt to estimate a sibling-age fixed-effects regression:

$$CS_{ifa} = INJ_{ia}'\beta_2 + X_{ia}'\gamma_2 + \alpha_{2fa} + \varepsilon_{2ifa} \text{ ,} \qquad (4.2)$$

where CS_{ifa} represents one cognitive test score for child *i* from family *f* observed at age *a*, X_{ia} is a vector of all observed individual- and family-level characteristics that vary between siblings across different ages, α_{2fa} represents all unobservable family-fixed characteristics that are equal to all siblings at the same age interval *a* (e.g., a family tradition) and swept out by the fixed-effects model, and ε_{2ifa} is a random error term that varies by child, family, and age. In contrast with equation (4.1), this approach performs within-sibling comparisons between one injured child and one uninjured child within the same age interval at different survey years, for example one older sibling may be seven years in 1994 and one younger sibling may turn seven in 1998. If the unobserved family-specific heterogeneity arises from either the sibling-year or the sibling-age aspect or both, I expect the bias to be positive, and the estimated results by sibling fixed-effects models to be smaller than those estimated by baseline OLS.

These two alternative within-family across-sibling approaches as proposed in equations (4.1) and (4.2), however, may still suffer omitted variable bias for two reasons. First, some unmeasured family-level characteristics may confound the injury risk and cognitive ability for one sibling but not another, or affect all siblings but with different magnitudes. For instance, an older child may be more affected by a parental job loss than a younger child. Second, both sibling fixed-effects method are unable to control for unobserved individual-level confounders (for example child self-discipline and risk propensity). In this chapter, I deal with the second potential bias by using the individual fixed-effects model. This approach estimates the cognitive or educational cost of an injury using only the associations between within-child changes in injury experience and within-child changes in cognitive test scores (Contoyannis & Li, 2011; Palermo & Dowd, 2012; Zavodny, 2013). In the final set of analysis, I further propose an individual fixed-effects model:

$$CS_{iy} = INJ_{iy}'\beta_3 + X_{iy}'\gamma_3 + \alpha_{3i} + \varepsilon_{3iy} \ , \qquad (4.3)$$

where CS_{iy} represents one cognitive test score for child i observed at year y, α_{3if} captures all difficult-to-measure confounders that do not vary within-individual across different survey years—for example child's self-discipline and IQ, X_{iy} is a vector of all observed time-varying characteristics, and $\beta_3$measures the impacts of having an injury on cognitive ability. This empirical method compares cognitive test scores within the same child observed at different study rounds. In other words, it estimates the difference between a score received after an accidental injury and another score received without any injury. The validity of this approach, however, may be challenged by the presence of any unobserved time-varying confounding factor. For example, whether a child gets along with others at school may determine both the likelihood of having injury and cognitive skills. To minimise this source of bias, equations (4.1) to (4.3) further control for the child Behavior Problem Index (BPI), given by the answers to a series of question about child psychological and behavioural problems.

To identify model coefficients under each fixed-effects specification, there must be sufficient variations at three levels: within-family across-sibling at the same year; within-family across-sibling at the same age interval; and within-child across-time. I create a dummy variable for each individual mother (family), and all siblings of this mother who were surveyed in the same round are considered as one group—sibling-year ID. I further construct another ID—sibling-age ID—this ID treats all siblings from the same mother who were surveyed in the same age interval but different years as one group. Child ID is given from the NLSY-Child dataset, and thus directly used in the individual fixed-effects model. In each of the three alternative fixed-effects approaches I use, the within-group comparisons always compare one cognitive test score received after an accident (treatment) and another score without any injury (control). Therefore, one fixed-effects model is better identified if its corresponding ID has richer longitudinal properties. After further exploring the data, I have found that 570 sibling-year IDs, 589 sibling-age IDs, and 741 child IDs include at least one mother-reported accident that leads to hospital admission, respectively. This provides sufficient within-group variations to identify all three proposed fixed-effects models using different types of IDs. Each fixed-effects method uses a different set of covariates as listed in Table 4.5 below.

Table 4.5 Covariates for Each Fixed-Effects Model

Sibling-Year Fixed-Effects (1)	Sibling-Age Fixed-Effects (2)	Individual Fixed-Effects (3)
Age in Months	-	Age in Months
School Grade	-	School Grade
Type of School or Child Care	Type of School or Child Care	Type of School or Child Care
Behaviour Problem Index	Behaviour Problem Index	Behaviour Problem Index
Before & At-Birth Condition	Before & At-Birth Condition	-
-	Maternal Weekly Hours	Maternal Weekly Hours
-	Log Weekly Household Income	Log Weekly Household Income
-	Father Present in Household	Father Present in Household
-	Number of Siblings	Number of Siblings
-	Urban/Rural Area	Urban/Rural Area
-	Neighbourhood Safety	Neighbourhood Safety

Notes: Sample statistics of all covariates are presented in *Table 4A* in *Appendices*.

With a lack of empirical guidance, it is unclear which aspect, either within-family across siblings or within-child across time, captures more variation in the relationship between child injury risk and cognitive development. The sibling fixed-effects approach is preferred if most unobserved confounders arise from the within-family across-sibling aspect, while the individual fixed-effects approach is preferred if most unobservable confounders arise from the within-child across-time aspect. Given fewer unobserved confounders arise from within-family between-siblings at the same age level (e.g., only some specific family rules that apply to children who turn a certain age), in this chapter, sibling-age fixed-effects results are only presented as a supplement in *Table 4C* in *Appendices*. In the main results, I use both sibling-year and individual fixed-effects identification approaches (spelt out in equation (4.1) and equation (4.3), respectively) with different underlying assumptions to examine whether there is a robust relationship between accidental injury and later cognitive skills.

4.5 Main Results

4.5.1 Do Accidental Injuries Affect Cognitive Test Scores?

My main results are presented in Tables 4.6 and 4.7 by using sibling-year and individual fixed-effects methods, respectively. The top panel in each table shows the estimated marginal effects of having an accidental injury requiring hospital admission on the five cognitive test scores and PIAT index, while the bottom panel reports the cognitive impacts with respect to each of the specific type of injuries.

Table 4.6 Estimated Impacts of Accidental Injuries on Cognitive Test Scores from Sibling-Year Fixed-Effects Models

	PIAT M (1)	PIAT RR (2)	PIAT RC (3)	PPVT (4)	AVG (5)	PIAT Index (6)
Overall						
Hospital – Accident	-0.014	-0.462	-0.733	-1.716	-0.738	-0.020
	(0.647)	(0.707)	(0.786)	(1.299)	(0.618)	(0.051)
Types of Injuries						
Fracture/Dislocation	0.205	0.677	1.674	-5.918**	-0.073	0.054
	(1.570)	(1.533)	(1.609)	(2.884)	(1.325)	(0.115)
Sprain or Bruise	1.770	3.123	1.215	8.732**	1.272	0.185
	(2.638)	(3.612)	(3.102)	(4.269)	(2.626)	(0.235)
Head or Concussion	-3.959	-0.462	-6.119	-8.367	-4.829	-0.428
	(3.873)	(3.621)	(3.917)	(6.924)	(3.421)	(0.264)
Cut or Scrape	2.427**	0.520	-0.232	-1.388	0.859	0.082
	(1.198)	(1.382)	(1.456)	(2.339)	(1.190)	(0.097)
Other Injuries	-2.871*	-3.566**	-2.333	-3.935	-3.378**	-0.232**
	(1.604)	(1.689)	(1.782)	(3.934)	(1.396)	(0.110)
Joint Test (*p*-value)	.069	.354	.440	**.043**	.111	.155
Est. Sample Size	32,100	31,976	27,556	17,289	36,219	27,368

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Num,bers in parentheses are standard errors. Cognitive outcomes in columns (1) to (5) are the Peabody Individual Achievement Test (PIAT) of mathematics, reading recognition, and reading comprehension, the Peabody Picture Vocabulary Test (PPVT), and an average of all PIAT and PPVT scores, respectively. Cognitive test scores from (1) to (5) are standardised with a mean of 100 and a standard deviation of 10, while PIAT Index (6) is standardised with a mean of 0 and a standard deviation of 1. This fixed-effects model includes a set of covariates as listed in column (1) in Table 4.5.

Table 4.7 Estimated Impacts of Accidental Injuries on Cognitive Test Scores from Individual Fixed-Effects Models

	PIAT M (1)	PIAT RR (2)	PIAT RC (3)	PPVT (4)	AVG (5)	PIAT Index (6)
Overall						
Hospital – Accident	0.482	-0.571	-0.479	0.356	-0.117	-0.015
	(0.420)	(0.396)	(0.480)	(0.902)	(0.400)	(0.026)
Types of Injuries						
Fracture/Dislocation	0.801	-1.408*	0.840	-4.006*	-1.067	0.015
	(0.912)	(0.736)	(0.920)	(2.103)	(0.733)	(0.049)
Sprain or Bruise	-1.259	0.985	-0.325	1.245	-0.865	-0.052
	(2.087)	(1.580)	(1.536)	(5.612)	(1.502)	(0.096)
Head or Concussion	-4.142	2.807	-8.155*	-0.823	-3.239	-0.251
	(2.585)	(1.855)	(4.790)	(3.235)	(2.102)	(0.165)
Cut or Scrape	0.775	0.024	0.050	1.984	1.279	0.055
	(0.862)	(0.876)	(0.960)	(1.521)	(0.832)	(0.055)
Joint Test (*p*-value)	.488	.202	.376	.450	.185	.348
Est. Sample Size	32,100	31,976	27,556	17,289	36,219	27,368

Notes: Cognitive test scores from (1) to (6) are defined the same as in Table 4.6 above. This fixed-effects model includes a set of covariates as listed in column (3) in Table 4.5.

Collectively, the main results give me two impressions. First, suffering a severe accident with hospital admission overall has no impact on any cognitive test score, according to the results presented on the top panel in Tables 4.6 and 4.7 and in *Table 4C* in *Appendices*. This finding is robust across all three alternative fixed-effects model specifications with different underlying assumptions. Though not presented in the main text, OLS results in *Table 4B* in *Appendices* show very strong associations between an injury occurrence and all six cognitive ability measures. Therefore, my main results support the initial hypothesis that unobserved characteristics play a significant role. The second impression is that most types of injuries have no effect on cognitive scores, as shown in the bottom panels in Tables 4.6 and 4.7. This pattern is evident in both individual coefficients and *p*-values for joint significance tests (a test for the joint significance of all five different types of injuries). Among the main estimates in the two tables, only one out of 12 *p*-values for joint tests and six out of 60 individual coefficients are statistically significant at 5% level. A notable exception is the significant negative effects of suffering a fracture or dislocation on PPVT scores. Sibling-year and individual fixed-effects estimates show that having an accident causing fractured bone or dislocation reduces PPVT scores by 5.918 and 4.006, respectively. In NLSY-Child, PIAT scores are mainly collected from children aged five to 14, whilst PPVT tests are mainly conducted among children between three and 11. Therefore, this exception may be due to the relatively younger estimation sample in PPVT scores. This means that a broken or fractured bone suffered in early childhood may require more hospital episodes, and thus lead to more negative short-term impacts on cognitive development.

Table 4.8 Estimated Impacts of An Accidental Injury on Cognitive Test Scores w.r.t Different Subgroups – Time-Invariant Factors

	PIAT-Mathematics (1)		PIAT-R Recognition (2)		PIAT-R Comprehension (3)		PPVT (4)		PIAT Index (5)	
	Sib-Y FE	Ind. FE	Sib-Y FE	Ind. FE	Sib-Y FE	Ind. FE	Sib-Y FE	Ind. FE	Sib-Y FE	Ind. FE
Gender										
All	-0.085	0.482	-0.304	-0.571	-0.623	-0.479	-1.726	0.356	-0.016	-0.015
	(0.645)	(0.420)	(0.707)	(0.396)	(0.786)	(0.480)	(1.299)	(0.902)	(0.051)	(0.026)
Boys	-0.639	0.615	0.526	-0.027	-0.146	0.387	-2.069	-0.152	-0.015	0.032
	(1.087)	(0.527)	(1.299)	(0.542)	(1.469)	(0.588)	(2.365)	(1.287)	(0.095)	(0.034)
Girls	-0.796	0.289	-1.308	-1.333**	-1.911	-1.676**	-1.030	1.279	-0.121	-0.082**
	(1.216)	(0.686)	(1.411)	(0.569)	(1.448)	(0.792)	(2.340)	(1.216)	(0.105)	(0.039)
Race										
Black	-0.339	0.568	-0.286	-0.540	0.680	0.499	-0.807	1.709	0.027	0.015
	(1.074)	(0.774)	(1.226)	(0.657)	(1.352)	(0.777)	(2.180)	(1.843)	(0.087)	(0.044)
Hispanic	1.676	0.775	-1.360	-0.816	-0.427	-0.523	-1.332	-1.374	0.030	0.007
	(1.502)	(0.935)	(1.571)	(0.840)	(1.806)	(0.905)	(2.869)	(1.726)	(0.123)	(0.053)
Others	-0.460	0.254	0.382	-0.547	-1.508	-1.051	-2.731	0.306	-0.054	-0.044
	(0.933)	(0.582)	(1.030)	(0.601)	(1.103)	(0.744)	(1.712)	(1.214)	(0.071)	(0.037)
Mother's Highest Education										
No High School	1.407	3.506***	0.622	0.831	0.631	1.432	-3.494	-1.346	0.070	0.148**
	(1.447)	(1.082)	(1.788)	(1.002)	(1.817)	(1.103)	(2.556)	(1.648)	(0.121)	(0.067)
High School	-0.885	-0.426	-1.139	-0.962*	-1.470	-0.613	-0.866	0.545	-0.057	-0.052
	(1.000)	(0.571)	(0.987)	(0.519)	(1.098)	(0.578)	(1.974)	(1.333)	(0.072)	(0.033)
Tertiary Degree	0.459	0.602	0.566	-0.766	1.040	-1.157	1.935	0.888	0.024	-0.038
	(1.109)	(0.735)	(1.305)	(0.768)	(1.479)	(1.057)	(2.282)	(1.732)	(0.096)	(0.050)
M's Age at 1st Birth										
Younger than 18	0.621	2.422***	0.071	-0.933	-2.502*	-0.073	-3.815	1.610	-0.033	0.040
	(1.239)	(0.924)	(1.385)	(0.841)	(1.429)	(1.015)	(2.493)	(1.666)	(0.095)	(0.056)
18-24	0.111	0.158	0.423	-0.499	0.551	-0.050	0.427	-0.517	0.033	-0.014
	(0.919)	(0.561)	(0.995)	(0.516)	(1.182)	(0.577)	(1.645)	(1.059)	(0.076)	(0.034)
Older than 24	-1.536	-0.562	-1.847	-0.443	0.037	-1.746	-5.418	1.044	-0.045	-0.061
	(1.377)	(0.925)	(1.561)	(0.986)	(1.485)	(1.482)	(3.367)	(3.250)	(0.098)	(0.062)

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Cognitive test scores from (1) to (6) are defined the same as in Table 4.6 above. Sibling-year fixed-effects and individual fixed-effects models include a set of covariates as listed in columns (1) and (3) in Table 4.5, respectively.

4.5.2 Do Results Vary by Different Socioeconomic and Demographic Subgroups?

Although an injury occurrence is not strongly selected by any specific child or family characteristic (Section 4.3), cognitive test scores are correlated with several socioeconomic and demographic factors, such as gender, race, and maternal SES. For example, African American children, on average, receive lower cognitive test scores than children from other ethnic groups (Todd & Wolpin, 2007). If the effects of injuries on cognitive achievement are particularly strong in one subgroup, for example disadvantaged children, then policy makers could target the high-risk population and better design policy interventions. Next, I re-estimate the cognitive effects of injuries using different subgroups. Table 4.8 reports the subgroup estimates with respect to four time-constant characteristics: gender, ethnicity, mother's highest educational achievement, and mother's age at first child's birth. Overall, accidental injuries don't appear to have large, robust, statistically significant effects for any subgroups. There are two interesting findings from the individual fixed-effects regression. First, an accidental injury reduces a girl's reading recognition and comprehension scores by 1.333 and 1.676, respectively. Further, an injured girl has a 0.082 standard deviation lower PIAT index score than one who did not suffer an injury. Second, there is a surprising positive association between the incidence of a hospital-treated accident and cognitive scores among children whose mothers do not complete high school. After I remove all individual time-constant fixed effects, an accidental injury increases the mathematics score by 3.506 in the subgroup of children with low-educated mothers. Given NLSY mothers who do not complete high school, on average, have one more child than those with higher educational attainment (2.977 vs. 1.812), this unexpected pattern may be due to the compensating behaviours of low-educated mothers. In the short-run, injured children may receive more attention from mothers and gain more family resources, and therefore have better cognitive scores (particularly in mathematics). I will further examine this speculation by estimating the potential impacts of injuries on within-household resource allocations in Section 4.6.4.

Additional estimates in *Table 4D* in *Appendices* presents the subgroup estimates in terms of four time-varying factors, including family income, whether the mother is full-time working, whether the mother raises children with a partner, and whether the family lives in a very safe neighbourhood. I need to interpret these results with caution, since these subgrouping factors are time-variant and endogenous. Nevertheless, individual coefficients, coupled with joint test results, collectively show very weak associations between cognitive scores and injury occurrences. Notably, two subgroups seem to be more negatively affected by an incidence of accidental injury, including children whose mothers are full-time working and those from two-parent families. Again, I will estimate the impacts of injuries on parental investments to these two specific subgroups in Section 4.6.4.

4.6 Sensitivity Analysis

4.6.1 Are Results Robust to the Length of Time Since the Accident?

In the first set of sensitivity analysis, I investigate if the potential effects of an injury on later cognitive abilities are robust to the length of time since the accident, in two alternative ways. First, I include an interaction term between an injury occurrence and the number of months measuring how long ago the accident took place (provided by NLSY mothers). This specification allows for testing if the negative impacts of injuries diminish over time. Second, I use a set of four exclusive dummy variables representing different time spans that an accident occurred before the survey: within six months; seven to 12 months; 13 to 18 months; and longer than 18 months.

Table 4E in *Appendices* compares the fixed-effects estimated results using two alternative specifications of injuries. In the top-half panel, all estimates for PIAT mathematics and reading recognition show expected signs, with negatives on the binary indicator for an injury occurrence and positives on the interaction term. Though most estimated coefficients are statistically insignificant, these expected signs indicate that the short-term negative effects diminish when the length of time increases. Turning to results using dummy variables for different time spans, the fixed-effects results further support my main finding that the occurrence of an injury has very weak influence on cognitive test scores, regardless of when the accident happens. Among all estimates in the bottom-half panel, none of 10 *p*-values for joint tests, and only two out of 40 individual coefficients, are statistically significant at the 5% level. In light of these results, it is difficult to identify a dominant pathway between school absenteeism and health problems.

4.6.2 Are Results Robust to the Addition or Removal of Certain Covariates?

Taking advantage of the detailed information from NLSY-Child, my fixed-effects models include a list of covariates capturing family demographics, maternal SES, child characteristics, and school and neighborhood quality (see Table 4.5 for the specific set of controls for each fixed-effect method). In this sub-section, I examine if my main results are robust to the addition or removal of certain covariates. In particular, given my main finding concludes with no strong impact of injuries on cognitive scores, I may over-control some observed confounders (such as child behaviour problems). Although not presented, almost all fixed-effects regressions show that child behavioural problems have considerable effects on cognitive scores (either strong or weak in magnitude, but mostly statistically significant). Due to the possible two-way causality, it is difficult to estimate the 'true' effects of accidental injuries on child behaviour problems. Therefore, I am unable to investigate how child behaviour development mediates the association between an incidence of injury and later cognitive outcomes. But it is interesting to conduct the sensitivity analysis by removing the measures of the child Behavior Problem Index (BPI) as covariates. The top-half panel in *Table 4F* in *Appendices* reports the re-estimated results without controlling for standard BPI scores, while the bottom-half panel shows the estimates by including a group of dummies for the causes of accidents. The main conclusion I draw in the main results is replicated by using these two alternative sets of covariates.

4.6.3 Do Results Differ by the Coverage of Private Health Insurance?

The initial survey question asking about the experience of a severe accidental injury is: "…since the last survey, has the child ever had an accident requiring hospitalization?" Given the U.S. has no universal health insurance, and the NLSY survey oversamples children and families from the disadvantaged class, my results may be biased if NLSY mothers under-report the number of serious accidental injuries. Children may have suffered a certain amount of unreported severe injuries but were not properly sent to the hospitals, since their families were unable to afford the medical cost. If this is true, I may under-estimate the cognitive and educational penalty of severe injuries. Because the coverage of private health insurance is expected to be a significant determinant of a child's medical utilisation in hospitals, I further re-estimate the results by using two subgroups: 1) children whose health is covered by the mother's employers or private insurance; and 2) children who are not covered. The estimates as compared in *Table 4G* in *Appendices* overall show no new finding. However, a hospital-treated accidental injury has weak but positive impacts on PIAT mathematics scores among children with no insurance cover. This estimate may be just significant by chance, or indicate that some compensating behaviours from low-income parents, just as what I suspect for children with less educated or full-time working mothers. This speculation will be tested by estimating the potential impacts of injuries on within-household resource allocation in Section 4.6.4.

4.6.4 Do Intra-Household Investments Mediate the Association between Injury Risk and Cognitive Development?

As discussed earlier, one potential linking mechanism between childhood injury and later scholastic outcomes is parental investment. Recently, several studies have found clear differentials of intra-family resource allocations with respect to different siblings' health conditions and cognitive abilities (Datar et al., 2010; Frijters et al., 2013; Rosales-Rueda, 2014). If parents make less investment in an ill child's education production, then such enforcing behaviour may exacerbate the negative effects of a childhood health problem. In contrast, sick or injured children may be more able to recover if parents pay more attention to them. For example, parents spend more quality time with children, or buy injured children more books during the period of recovery. If I can find the supporting evidence of the latter possibility, parental compensatory behaviour, then my main finding that there is no significant cognitive impact of injuries could be better explained. Table 4.9 reports the estimated influences of having an accidental injury with hospital admissions on three standardised scores measuring the within-family resources: Home Inventory, Cognitive Stimulation, and Emotional Support.[18] Overall, results show that an accidental injury has no strong impact on within-family resource allocation.

With regards to different injury mechanisms, children who suffered sprain, strain, or pulled muscle after an accident seem to receive less attention from parents in terms of home inventory and emotional support. Since the same type of injuries is not significantly associated with lower cognitive test scores (Tables 4.6 and 4.7), I am less concerned with this finding. Further, I limit my estimation to those subgroups that show stronger cognitive impacts of injuries, including girls, children whose mother never completed high school, children whose mothers are full-time working, and children who are raised by two parents at home. Although not presented, one notable finding among children with low-education mothers is that an accidental injury increases scores in Home Inventory and Emotional

[18] The NLSY-Child quantifies the children's home environment using the Home Observation Measurement of the Environment-Short Form ('HOME-SF') survey. The HOME-SF scale was constructed to assess the levels of cognitive stimulation and the levels of emotional support that children receive from their parents and their home environment.

Support by 0.108 and 0.103 standard deviations, respectively. This compensating behaviour corresponds to the main result shown in Table 4.8 (injured children in the same subgroup have 0.148 standard deviation higher PIAT index scores than uninjured children). Given children with low-educated mothers also have a greater chance of growing up with more siblings, this positive pattern may indicate that children in these socially disadvantaged families originally receive lower quality care than those from more advantaged families. An accidental injury actually helps them gain more resources and improve cognitive ability, though their siblings experience sacrifice by receiving fewer at-home resources.

Table 4.9 Impacts of Accidental Injuries on Parental Resource Allocation: Home Inventory, Cognitive Stimulation, and Emotional Support

	Home Inventory		Cognitive Stimulation		Emotional Support	
	Sib-Y FE (1)	Ind. FE (2)	Sib-Y FE (3)	Ind. FE (4)	Sib-Y FE (5)	Ind. FE (6)
Overall						
Hospital – Accident	-0.001	0.032	-0.003	0.023	-0.002	0.020
	(0.020)	(0.021)	(0.016)	(0.017)	(0.016)	(0.017)
Types of Injuries						
Fracture or Dislocation	-0.013	0.022	-0.058*	0.002	0.015	0.052
	(0.045)	(0.046)	(0.034)	(0.042)	(0.032)	(0.033)
Sprain or Bruise	-0.149*	-0.216**	0.005	-0.076	-0.080	-0.179**
	(0.083)	(0.091)	(0.065)	(0.069)	(0.063)	(0.075)
Head or Concuss	0.098	0.142	0.071	0.020	0.117	0.075
	(0.106)	(0.103)	(0.091)	(0.078)	(0.075)	(0.073)
Cut or Scrape	0.036	0.084*	0.043	0.040	-0.014	0.065**
	(0.039)	(0.044)	(0.034)	(0.033)	(0.032)	(0.033)
Other Injuries	0.046	0.028	0.002	0.020	-0.002	-0.039
	(0.052)	(0.053)	(0.042)	(0.041)	(0.035)	(0.043)
Joint Test (p-value)	.450	**.043**	.349	.746	.534	**.023**
Est. Sample Size	35,374	35,374	34,025	34,025	32,312	32,312

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All three measures of within-household resources are standardised with a mean of 0 and a standard deviation of 1. Sibling-year fixed-effects and individual fixed-effects models include a set of covariates as listed in columns (1) and (3) in Table 4.5, respectively.

4.7 Discussions and Concluding Remarks

Accidental injury is the leading cause of childhood mortality and morbidity in the U.S. However, to date, the potential impacts of injuries on later cognitive development have not been clearly researched by earlier economic literature. This chapter firstly investigates the short-run effects of injuries on cognitive test scores in the U.S., using a very detailed longitudinal dataset. Given the main empirical challenge, that unobserved confounders may arise from different aspects, I apply both sibling and individual fixed-effects to confront this main empirical challenge. The causal relationship between childhood injury and subsequent cognitive development could be identified if, and only if, having an injury is exogenous to later child outcomes after controlling for all unobserved heterogeneous characteristics (either family- or child-specific, either constant or variant over time). The sibling and individual fixed-effects results combined show no strong impact of injuries on cognitive abilities. This primary finding is consistent with the main results in Chapter 3, and results from one notable earlier economic study that also concludes with no significant effect of major childhood injuries on future outcomes (Currie et al., 2010). One plausible explanation for this finding is that an accidental injury only reduces short-run physical health and causes temporary school absences; injured children mostly receive proper medical attention (for example hospitalisation admissions) and recover in a short space of time. Therefore, there is overall no long-term harmful impact on cognitive or educational outcomes.[19]

In addition to the main finding, this chapter also progresses the existing health economic literature in several other ways. First, I have identified that childhood accidental injury is an exogenous health shock in the U.S. This result is robust within-family across siblings and within-child over time. The exogeneity of injury allows me to pursue its causal effects on child development. Second, although there is no strong association between childhood injury and cognitive abilities in the entire sample, individual fixed-effects models find some significant results in some particular subgroups. The negative associations are evident among girls, children whose mother is full-time working, and children from two-parent families, while the unexpected positive impacts of injuries are found if I limit estimation to children whose mother never completed high school. I have provided some explanations by estimating the effects of injuries on within-family parental investments, which is a potential intermediate pathway between accidental injuries and cognitive outcomes. Except for children with less-educated mothers, I have not found any considerate parental compensating or enforcing behaviours in these highlighted subgroups. Third, taking advantage of the rich longitudinal properties in my dataset, this chapter utilises both sibling and individual fixed-effects models with different underlying assumptions to perform empirical analysis. The sibling fixed-effects approach is preferred if most unobserved confounders arise from the within-family across-sibling aspect, while the individual fixed-effects approach is preferred if most unobservables

[19] Given there is no strong association between an injury experience and childhood cognitive ability, this chapter does not pursue the long-term impact on young adult educational outcomes, such as high school completion and college enrolment.

arise from the within-child across-time aspect. Overall, both approaches show similar estimated results and generate a robust pattern.

My empirical strategy in this chapter, however, is not without any limitations. First, the sibling fixed-effects model is unable to address the bias from within-family heterogeneity. For instance, if parents treat injured children differently in response to a similar accident, and such unobserved difference is correlated with future development and cannot be controlled for, then sibling fixed-effects results will be biased.[20] Second, neither the sibling nor the individual fixed-effects estimator is able to capture the spillover impacts from an injured child to other siblings. If the accidental injury is indeed a one-off health shock and places no long-term adverse influences on a family, then this caveat will not threaten the estimation. Otherwise, the estimated effects may be under-estimated.

[20] This chapter may have little concern on this potential issue. In my limited estimation sample, 725 out of 4,132 unique families (mothers) have reported accidental injuries causing hospital admission over the 13 study rounds. However, only 156 families (of 725) have suffered more than one accident (less than 4%).

4.8 Appendices

Table 4A Summary Statistics of Covariates in NLSY-Child (13 waves, n=36,303)

Covariates	Obs.	Mean	S.D.	Min.	Max.
i. Maternal Characteristics					
Tertiary Degree	35,522	.341	.474	0	1
Employed^+	35,824	.738	.440	0	1
No. of Weekly Hrs^+	26,445	31.578	15.406	1	168
Log Weekly HH Income^+	30,483	10.700	.993	1.950	14.170
Has A Partner in HH^+	36,257	.395	.489	0	1
Age of First Child Birth	36,303	22.456	5.112	11	45
ii. Child Characteristics					
Gender- Boys*^	36,303	.503	.500	0	1
Black	36,303	.306	.461	0	1
Hispanic	36,303	.206	.405	0	1
Non-Black or Non-Hispanic	36,303	.487	.500	0	1
Age in Months*+	36,257	110.555	38.447	25	180
No. of Siblings	36,303	1.961	1.418	0	10
iii. Child Behavior Problem Index (BPI)					
Standard BPI Score*^+	33,207	104.938	15.071	72	149
Antisocial Score	33,194	105.864	14.073	88	146
Anxious/Depressive Score	34,016	102.835	13.079	86	145
Headstrong Score	34,086	102.566	13.326	82	145
Hyperactive Score	34,067	103.761	14.069	85	145
Dependent Score	25,836	105.042	13.476	87	145
Peer Score	34,144	104.463	12.651	89	145
Bullies or Bullied at School*^+	34,372	.224	.417	0	1
Uses Drugs for Behaviour Problem	36,216	.027	.163	0	1
iv. School, Neighbourhood & Residence Status					
Northeast	36,040	.148	.355	0	1
North Central	36,040	.254	.436	0	1
South	36,040	.394	.489	0	1
West	36,040	.204	.403	0	1
Very Safe Neighbourhood^+	20,999	.323	.468	0	1
Public School^+	13,799	.822	.382	0	1
v. Before- & At-Birth Information					
Maternal Age at Birth*^	32,577	26.530	5.609	11	46
Smoked During Pregnancy*^	36,303	.209	.407	0	1
Drunk During Pregnancy*^	36,303	.249	.432	0	1
C-Section*^	29,550	.232	.422	0	1
Breastfed > Six Months*^	30,702	.497	.500	0	1
Low Birth Weight *^	24,980	.083	.276	0	1

Notes: *, ^ & + refer to covariates used in sibling-year, sibling-age, and individual fixed-effects specifications, respectively.

Table 4B Estimated Impacts of Accidental Injuries on Cognitive Test Scores from OLS

	PIAT M (1)	PIAT RR (2)	PIAT RC (3)	PPVT (4)	AVG (5)	PIAT Ind. (6)
Overall						
Hospital – Accident	-1.438***	-2.565***	-1.507***	-2.276**	-2.128***	-0.127***
	(0.494)	(0.541)	(0.551)	(0.935)	(0.486)	(0.038)
Types of Injuries						
Fracture/Dislocation	2.087*	-0.241	1.626	-0.137	0.900	0.095
	(1.187)	(1.181)	(1.181)	(2.392)	(1.092)	(0.086)
Sprain or Bruise	-0.324	0.367	-1.826	-2.463	-1.494	-0.060
	(2.390)	(2.353)	(2.058)	(4.383)	(2.020)	(0.163)
Head or Concussion	-1.315	1.886	-8.155	-4.202	-3.188	-0.254
	(3.374)	(3.308)	(5.133)	(5.583)	(3.135)	(0.268)
Cut or Scrape	-0.664	-2.556**	-1.378	-1.813	-1.341	-0.111
	(0.917)	(1.051)	(0.989)	(1.922)	(0.938)	(0.070)
Other Injuries	-0.724	-1.232	-0.792	1.848	-1.357	-0.033
	(1.254)	(1.417)	(1.284)	(2.609)	(1.298)	(0.089)
Joint Test (p-value)	.597	.208	.137	.684	.321	.399
Est. Sample Size	32,100	31,976	27,556	17,289	36,219	27,368

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Cognitive test scores from (1) to (6) are defined the same as in Table 4.6 above. All robust standard errors are clustered by child IDs. The results of individual t-tests seem robust if I use the alternative two IDs to cluster standard errors- sibling-year and sibling-age IDs. This baseline OLS model only controls for gender, age (months), ethnicity, and whether the mother has a partner living in the household.

Table 4C Estimated Impacts of Accidental Injuries on Cognitive Test Scores from Sibling-Age Fixed-Effects Models

	PIAT M (1)	PIAT RR (2)	PIAT RC (3)	PPVT (4)	AVG (5)	PIAT Ind. (6)
Overall						
Hospital – Accident	0.608	-0.344	1.053	-0.583	-0.011	0.059
	(0.596)	(0.639)	(0.689)	(1.329)	(0.551)	(0.046)
Types of Injuries						
Fracture /Dislocation	-0.332	-1.032	0.840	-8.145**	-1.068	-0.002
	(1.277)	(1.399)	(1.382)	(3.452)	(1.191)	(0.099)
Sprain or Bruise	-0.374	1.422	0.150	-0.325	0.117	0.031
	(2.821)	(2.972)	(2.525)	(5.077)	(2.222)	(0.209)
Head or Concussion	-0.379	0.575	0.531	-4.907	-1.638	0.002
	(3.308)	(3.309)	(5.609)	(5.703)	(2.816)	(0.281)
Cut or Scrape	1.856*	1.023	1.270	0.965	1.569	0.098
	(1.122)	(1.244)	(1.305)	(2.359)	(1.003)	(0.084)
Other Injuries	-0.685	-1.877	-1.137	3.058	-1.344	-0.050
	(1.328)	(1.447)	(1.308)	(2.972)	(1.343)	(0.092)
Joint Test (p-value)	.666	.653	.843	.187	.432	.873
Est. Sample Size	31,815	31,691	27,301	17,027	35,846	27,114

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Cognitive test scores from (1) to (6) are defined the same as in Table 4.6 above. This fixed-effects model includes a set of covariates as listed in column (2) in Table 4.5.

Table 4D Estimated Impacts of An Accidental Injury on Cognitive Test Scores w.r.t Different Subgroups – Time-Varying Factors

	PIAT-Mathematics		PIAT-R Recognition		PIAT-R Comprehension		PPVT		PIAT Index	
	Sib-Y FE	Ind. FE	Sib-Y FE	Indi FE	Sib-Y FE	Ind. FE	Sib-Y FE	Ind. FE	Sib-Y FE	Ind. FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Income										
1st Qtl (Low)	0.932	1.754*	-0.786	0.398	-0.418	0.807	-2.021	0.250	0.011	0.062
	(1.210)	(0.968)	(1.226)	(0.856)	(1.406)	(0.894)	(2.264)	(2.256)	(0.095)	(0.055)
2nd Qtl (Mid-Low)	-2.034	0.169	-0.584	-2.231**	-0.797	-1.396	2.812	-2.226	-0.086	-0.132**
	(1.299)	(0.976)	(1.670)	(0.969)	(1.716)	(1.136)	(3.167)	(3.594)	(0.108)	(0.058)
3rd Qtl (Mid)	0.090	0.386	0.811	0.523	-2.700	-0.174	1.351	5.087***	-0.129	0.017
	(1.590)	(1.214)	(1.712)	(1.043)	(1.829)	(1.021)	(2.791)	(1.958)	(0.120)	(0.068)
4th Qtl (High)	0.056	1.428	-0.303	-0.770	-0.957	-1.582	0.125	9.200*	-0.043	-0.009
	(1.690)	(1.104)	(1.683)	(1.196)	(1.795)	(1.593)	(3.122)	(4.824)	(0.115)	(0.073)
Mother-F/T work										
Yes	0.469	-0.841	1.245	-0.597	-0.334	-1.980**	0.904	1.167	0.012	-0.092**
	(1.059)	(0.763)	(1.290)	(0.725)	(1.402)	(0.835)	(2.145)	(1.946)	(0.087)	(0.043)
No	-0.306	0.795	-0.962	-0.718	-0.803	0.244	-3.026*	-0.198	-0.032	0.010
	(0.798)	(0.574)	(0.841)	(0.513)	(0.948)	(0.580)	(1.550)	(1.207)	(0.063)	(0.033)
Single Mother										
Yes	1.200	1.917***	0.544	-0.440	0.889	0.350	-0.718	2.416	0.097	0.044
	(0.983)	(0.616)	(1.059)	(0.578)	(1.149)	(0.649)	(1.901)	(1.487)	(0.074)	(0.037)
No	-1.221	-0.543	-1.327	-0.474	-2.193**	-1.537**	-2.998*	-0.545	-0.133*	-0.075**
	(0.883)	(0.596)	(0.985)	(0.606)	(1.081)	(0.726)	(1.783)	(1.332)	(0.072)	(0.038)
Very Safe Neighbourhood										
Yes	3.361*	-0.259	0.904	-0.474	2.336	0.367	0.294	2.110	0.205*	-0.017
	(1.992)	(1.181)	(2.067)	(0.942)	(1.902)	(1.105)	(4.274)	(3.404)	(0.124)	(0.048)
No	-0.115	0.593	-0.076	-0.545	-0.935	-0.898	-2.187	-0.484	-0.021	-0.019
	(0.726)	(0.469)	(0.841)	(0.465)	(0.967)	(0.596)	(1.571)	(0.989)	(0.062)	(0.031)

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Cognitive test scores from (1) to (6) are defined the same as in Table 4.6 above. The fixed-effects model includes covariates as listed in Table 4.5.

Table 4E Estimated Impacts of An Accidental Injury on Cognitive Test Scores w.r.t Different Subgroups – Alternative Specifications of Injuries

	PIAT-Math		PIAT-R Recognition		PIAT-R Comprehension		PPVT		PIAT Index	
	Sib-Y FE (1)	Indi FE (2)	Sib-Y FE (3)	Indi FE (4)	Sib-Y FE (5)	Indi FE (6)	Sib-Y FE (7)	Indi FE (8)	Sib-Y FE (9)	Indi FE (10)
Injury & Time Distance										
Hosp-Accident	-0.122	-0.450	-1.652	-0.722	0.002	-0.563	-0.781	0.086	-0.015	-0.047
	(0.909)	(0.574)	(1.020)	(0.528)	(1.055)	(0.706)	(1.882)	(1.273)	(0.072)	(0.035)
Acc*Month	0.010	0.085**	0.101*	0.014	-0.058	0.008	-0.084	0.026	-0.000	0.003
	(0.050)	(0.036)	(0.053)	(0.035)	(0.062)	(0.041)	(0.114)	(0.082)	(0.004)	(0.002)
Joint Test (p-value)	.978	**.031**	.156	.312	.439	.605	.282	.879	.909	.362
Different Time Spans										
0–6 Months	-0.998	-1.073	-2.058	-0.518	-1.963	-0.065	-4.904	2.904	-0.035	-0.025
	(1.922)	(1.164)	(1.940)	(0.838)	(2.007)	(1.006)	(3.743)	(1.921)	(0.143)	(0.063)
7– 2 Months	-0.906	0.524	-2.349	-1.527*	-2.994	-0.614	-0.060	0.987	-0.202*	-0.052
	(1.554)	(1.001)	(1.718)	(0.888)	(1.956)	(1.120)	(2.605)	(1.686)	(0.118)	(0.058)
13–18 Months	-0.832	0.485	-1.189	0.851	-2.950	-0.438	-2.569	1.523	-0.157	0.002
	(1.559)	(0.956)	(1.521)	(1.020)	(1.867)	(0.948)	(2.364)	(1.688)	(0.126)	(0.056)
>18 Months	0.801	2.356**	2.629**	-0.585	-0.871	-0.462	-3.711	-0.059	0.042	0.052
	(1.205)	(0.958)	(1.309)	(0.946)	(1.598)	(1.008)	(3.005)	(2.413)	(0.092)	(0.067)
Joint Test (*p*-value)	.858	.110	.105	.343	.216	.948	.351	.486	.331	.817

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Cognitive test scores from (1) to (6) are defined the same as in Table 4.6 above. The fixed-effects model includes covariates as listed in Table 4.5. "Distance" here refers to the length of time (months) between the interview date of NLSY-Child and the time when the most recent accidental injury took place. In the pooled sample, 881 child-year observations are observed to have suffered a hospital-treated injury. A total of 15% happened within six months prior to the survey, 14% happened between the 7th and 12th months, 19% happened between the 13th and 18th months, 24% happened longer than 18 months before the survey, and 28% did not report the date of accident. Alternatively, I can construct a group of injuries occurring in different time spans, e.g., 0-8 months, 9-16 months, 17-24 months, and >24 months, and the results show a very similar pattern.

Table 4F Estimated Associations between the Occurrence of an Accidental Injury and Cognitive Test Scores – With Different Sets of Covariates

	PIAT M (1)	PIAT RR (2)	PIAT RC (3)	PPVT (4)	AVG (5)	PIAT Ind. (6)
Without Behaviour Problem Index						
Sibling-Year FE	0.010	-0.219	-0.556	-1.724	-0.733	-0.009
	(0.651)	(0.714)	(0.798)	(1.298)	(0.620)	(0.052)
Sibling-Age FE	0.490	-0.457	1.019	-0.424	-0.094	0.057
	(0.598)	(0.641)	(0.692)	(1.328)	(0.552)	(0.046)
Individual FE	0.474	-0.581	-0.487	0.365	-0.125	-0.016
	(0.421)	(0.396)	(0.479)	(0.902)	(0.402)	(0.026)
With Causes of Accident						
Sibling-Year FE	-1.713	-5.217	-0.887	18.474***	2.022	-0.191
	(3.165)	(4.758)	(4.794)	(6.313)	(4.351)	(0.308)
Sibling-Age FE	3.616	-1.355	-2.700	8.715	-0.191	-0.052
	(2.629)	(5.664)	(3.829)	(10.335)	(3.644)	(0.294)
Individual FE	3.019	-0.029	0.237	1.038	0.018	-0.073
	(3.422)	(5.907)	(4.662)	(6.502)	(3.102)	(0.325)
Largest Est. Sample	32,100	31,976	27,556	17,289	36,219	27,368

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Cognitive test scores from (1) to (6) are defined the same as in Table 4.6 above. Each fixed-effects model includes a set of covariates as listed in Table 4.5.

Table 4G Estimated Associations between the Occurrence of an Accidental Injury and Cognitive Test Scores by the Coverage of Private Health Insurance (PHI)

	PIAT M (1)	PIAT RR (2)	PIAT RC (3)	PPVT (4)	AVG (5)	PIAT Ind. (6)
With PHI						
Sibling-Year FE	-1.152	-0.609	-1.232	-0.203	-1.025	-0.079
	(0.800)	(0.901)	(0.988)	(1.606)	(0.720)	(0.063)
Sibling-Age FE	0.099	-0.481	1.261	-1.042	0.152	0.070
	(0.767)	(0.818)	(0.937)	(1.811)	(0.678)	(0.059)
Individual FE	-0.296	-0.703	-0.983	0.642	-0.245	-0.049
	(0.524)	(0.525)	(0.626)	(1.206)	(0.462)	(0.033)
Largest Est. Sample	23,414	23,341	20,308	12,234	26,349	20,181
Without PHI						
Sibling-Year FE	1.873*	0.197	0.517	-1.856	-0.515	0.095
	(1.123)	(1.240)	(1.399)	(2.277)	(1.259)	(0.092)
Sibling-Age FE	1.027	-0.279	1.545	2.907	-0.278	0.081
	(1.242)	(1.320)	(1.291)	(2.705)	(1.232)	(0.092)
Individual FE	2.373***	-0.275	0.814	0.662	0.505	0.066
	(0.838)	(0.698)	(0.863)	(1.916)	(0.931)	(0.050)
Largest Est. Sample	8,686	8,635	7,248	5,055	9,870	7,187

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Cognitive test scores from (1) to (6) are defined the same as in Table 4.6 above. Each fixed-effects model includes a set of covariates as listed in Table 4.5.

Chapter 5

Work-Related Injuries, Workers' Compensation, and Labour Force Outcomes in Australia

5.1 Introduction

Every year around the world, there are approximately 2.3 million fatal work-related injuries and diseases occurring in labour force, which cost an estimated 28 trillion USD or 4% of annual global GDP (Takala et al., 2014). According to the recently released data by the ABS Work-related Injuries Survey (ABS-WRI), 4.3% of Australian workers suffered at least one work-related injury during the 2013-14 financial year (SafeWorkAustralia, 2014a). The total economic cost of those injuries and illness is estimated to be 61.8 billion AUD, representing 4.1% of GDP for the same period (SafeWorkAustralia, 2014a). Although recent years have witnessed a global decline of work-related accident rates, the consequence of injuries are still quite costly (Leigh, 2011). In addition to the direct loss in health and labour force participation during recovery, a serious work-related injury may also have indirect long-run costs on injured workers' return-to-work outcomes, such as lost productivity or income, modified job duties and roles, reduced job satisfaction, and even lower quality of life. For example, a study shows that only about 50% of injured workers with more than six months' absence return to their normal occupations and duties (Henderson, Glozier, & Elliott, 2005).

Due to the importance of occupational health and safety in the workplace, a considerable body of empirical literature in labour economics and industrial relations has examined the impacts of experiencing a work-related incident on subsequent labour force outcomes. Using U.S. National Longitudinal Study of Youth 1979 (NLSY79) data observed from 1988 to 2000,[21] Galizzi and Zagorsky (2009) estimate the economic cost of work injuries. Their individual fixed-effects results show that having a workplace injury not only affects short-term employers' costs and individuals' incomes, but also causes a long-term reduction in wealth and consumption. Another NLSY79 study examines the important role of receiving

[21] Beginning in 1988, a substantial series of survey questions was initiated on workplace injuries or illnesses in the NLSY79. The respondent has been asked particularly for the most recent and most severe work-related injury. The questions are designed to identify the nature and extent of the condition – e.g., whether the respondent applied for and received workers' compensation benefits, when the incident occurred and what body parts were affected, or whether there were lost wages or missed working days or the worker lost the job as a consequence of the injury or illness. About one-third of NLSY79 respondents, baby boomers, were ever hurt at work, but 38% of them did not file for workers' compensation.

workers' compensation on the earning loss of workplace injuries (Woock, 2009). It finds that workers who received compensation benefits actually lost more income than those who did not apply for benefits, because compensated workers sustained more serious injuries and had longer periods of absence. In addition, a number of studies in public health and industrial relations have also employed NLSY79 data and researched the consequences of suffering a work-related injury from different aspects, including income growth (Don et al., 2015a), long-term health cost (Dong et al., 2015b), union membership (Donado, 2015; Woock, 2009), worker's risk tolerance (Galizzi & Tempesti, 2015), changes in occupations and industries (Dembe, Delbos, & Erickson, 2008), effects on later work schedules and arrangements (Dembe, Delbos, Erickson, & Banks, 2007), application for workers' compensation, and reoccurrence of an additional injury (Galizzi, 2013).

Surprisingly, few studies have examined the impacts of experiencing a workplace injury using Australian data. Australia is an interesting context in which to examine the effects of workplace injuries, as during the last two decades there have been a number of significant changes in Australian labour markets and industrial relations policies. These important changes include industry shifts, fluctuations of business cycles, union membership decline, and perhaps most importantly, the development of workers' compensation programs. Each of these may have significant influences on injured workers' recovery and return-to-work outcomes (Galizzi, 2013). Workers' compensation is a legally enforced statutory form of insurance for all employers in Australia, and provides protection to their employees who sustain a work-related injury or disease (SafeWorkAustralia, 2014a). The fundamental principle behind workers' compensation is that employers should bear the full cost associated with work-related incidents. Depending on the nature and extent of the injury, an injured worker may be entitled to one or multiple types of compensation: income replacement during recovery; reimbursement of medical costs; return to work plans (e.g., modification of work duties); or a lump sum payment for permanent impairment or death benefits (SafeWorkAustralia, 2011). Among those Australian injured workers who suffered at least one work-related injury or illness during the 2013-14 financial year, 34.5% received workers' compensation benefits, while 4.2% of injured workers filed a claim but failed to be compensated (SafeWorkAustralia, 2014a).

Earlier studies, including those that do not use NLSY79 data, have mainly focused on how an occurrence of work-related injury reduces future labour force participation or performance (e.g., weekly earnings and hours). However, to date, there is no research looking at its potential influence on a worker's subjective wellbeing, such as self-reported job security and satisfaction.[22] Following the theoretical framework developed by Clark and Oswald (1996), job satisfaction could be defined as a utility production function of four inputs: income, hours, individual characteristics, and job-specific characteristics. Under this utility-maximising process, workers are assumed to gain more utility from higher income, more convenient hours, better individual- and work-related conditions (for example a joyful relationship with the top management). Importantly, a severe work injury may significantly reduce an individual's future job satisfaction through its negative impacts on these four inputs. First, an injury typically leads to absence at work, and thus a potential loss in wages. If an injured worker is not fully compensated by insurers with income replacement and reimbursement of medical costs during recovery, or if he or she never returns to the time-of-accident job (i.e., disability as a result of injury), then his or her work-related wellbeing will be lower. Second, even if the worker receives the full compensation benefits and keeps his or her job after recovery, duties or roles may be shifted due to extended period of absence. The retraining experiences for the alternative duties may increase the worker's stress and difficulty at work, and decrease freedom and flexibility. All these significant changes in job-related characteristics could in turn reduce an injured worker's subjective job-related wellbeing (Waddell, 2006).

The third hypothesised channel is a permanent depreciation on individual health status. A severe injury may cause long-term health reductions, for example chronic musculoskeletal pain and traumatic brain damage. This reduces one significant input in the production function for job satisfaction: the individual-specific factor. Further, the process of claiming compensation benefits may also have adverse impacts on injured workers' mental health conditions. Recently, two studies have shown that stressful interactions between injured workers and insurance companies may cause 'secondary victimisation' (Elbers, Akkermans, Lockwood, Craig, & Cameron, 2015; Kilgour, Kosny, McKenzie, & Collie, 2015). The mental health problem is mainly caused by delayed compensation payments, mountains of paperwork, discussions about liability, and lack of communication (Elbers et al., 2015). *Figure 5A* in *Appendices* presents a conceptual framework on how a severe injury affects later job satisfaction.

[22] Over the last two decades, a large body of literature in industrial relations and human resources has found many determinants of self-reported job satisfaction, such as gender (Clark, 1997), comparison income and education (Clark & Oswald, 1996), nature of work itself and relationship with management (Sousa-Poza & Sousa-Poza, 2000), work-related burden (Bovier & Perneger, 2003), and locus of control (Ng, Sorensen, & Eby, 2006).

Therefore, two important research gaps have emerged the review of previous studies. First, there is a significant lack of Australian evidence. The job-related determinants of a work-related injury, and its contemporary (potentially long-term) costs on later labour force outcomes, have not been researched in Australia. Second, the potential interactions between workplace injuries and future job satisfaction are still unknown. Theoretically, a severe work injury may significantly reduce inputs of an individual's utility production.

This chapter aims to fill in these research gaps, using two sets of empirical data from Australia: 1) work-related injuries (WRI) surveys, conducted by the Australian Bureau of Statistics (ABS) from July 2009 to June 2010; and 2) Household, Income and Labour Dynamics in Australia (HILDA). Given HILDA only has information on workers' compensation receipt but only limited detail on injuries, my empirical strategy includes two main steps. First, using ABS-WRI 2009-10 cross-sectional data, I carefully examine the associated factors (particularly job- and industry-related) that predict an individual's probability of having a workplace injury and the probability of receiving a workers' compensation benefit, respectively. The first-step results show that injury severity (measured by the number of absent days) is the single dominant predictor of making or receiving a serious claim. In the second step, exploring the time-varying nature of receiving a workers' compensation benefit (indicator for a severe injury as proved in first-step analysis) and the longitudinal richness of the HILDA panel, I estimate a range of individual fixed-effects models to quantify the injury effects on future labour force participation, performance, and satisfaction. This chapter has two major findings. First, individual fixed-effects results show that severe work-related injuries, even those that have been compensated, have weak negative impacts on weekly working hours and wages within one year, and mild effects on labour force participation after two years. This result corresponds to the primary findings in early studies using NLSY79 data. Second, workers who sustained an injury report considerably lower job satisfaction than others, particularly on job security, flexibility, and stress. Further, the reductions in subjective job-related wellbeing are stronger in the subgroups of female, younger, unmarried, non-office-based, and low-educated workers. For example, injured females report lower overall job satisfaction by 0.107 within-individual standard deviation (or 0.177 units on a 0 to 10 scale).

5.2 Workers' Compensation Schemes in Australia

As explained in Section 5.1 above, with a lack of information in the HILDA survey, this chapter is only able to examine the labour costs of those Australian work injuries resulting in compensation benefits. Therefore, this section will briefly define workers' compensation and introduce its development in different legislation in Australia. Further, this section will highlight some observed cross-state differences in the likelihood of successful compensation claims, which suggests that injured workers may be more likely to be compensated in some states or territories than others.

Workers' compensation is a mandatory statutory form of insurance for all employers in every state and territory in Australia, and serves as a financial protection for their employees who experience a work-related injury or disease (SafeWorkAustralia, 2014a). In principle, any private business or public sector organisation that employs workers with any type of employment (full-time, part-time, or casual basis; under an oral or written contract of service; or apprenticeship) must have workers' compensation insurance, although the schemes vary substantially by states and territories (SafeWorkAustralia, 2012). If workers sustain workplace injuries or sickness, the workers' compensation program should provide them with weekly income replacement or equivalent benefits, medical and hospital expenses, rehabilitation services, certain personal items, and a lump-sum payment for permanent impairment on a basis set out by the particular scheme. Along with public or private health insurance and all other forms of financial assistance, the compensation scheme helps injured workers recover during periods of time away from work, and seeks to promote effective rehabilitation and return-to-work outcomes.

The original legislation of the Australian workers' compensation scheme was introduced in late 19th century, in the form of the *Employment Liability Act 1880* (UK) (SafeWorkAustralia, 2012). The 'no-fault' principle in this act firstly spelt out that to be entitled to compensation benefits, workers only had to prove their injuries or illnesses were work-related and were no longer required to prove the negligence of the employer. With a rise of human rights and increasing industrialisation, coverage of compensation schemes was extended to most workers in the Australian labour market in the early 20th century (SafeWorkAustralia, 2012). Between the 1920s and the 1970s, eligibility for workers' compensation continued to widen to cover all injuries that arise out of or in the course of employment. From the 1990s, the focus of schemes has changed to emphasise the role of workplace health and safety, and the need for rehabilitation and return-to-work plans for severely injured workers (SafeWorkAustralia, 2012). To date, it has been broadly agreed that further change to compensation schemes should aim to achieve a reasonable balance between the interests of employers, workers, insurers, and society, while at the same time: 1) supporting early and effective return to work; 2) providing fair compensation for workplace injuries and illness; 3) reducing the overall social and economic costs to the community; and 4) ensuring that costs borne by employers are equitably distributed and contained within reasonable limits (SafeWorkAustralia, 2012, 2014b).

In Australia, each state or territory has its own compensation laws and arrangements. This diversity leads to some inconsistencies in the operation of workers' compensation (SafeWorkAustralia, 2012). The process of making a workers' compensation claim is largely similar between states and territories. Injured workers must provide their employer, and in some cases their insurer, with information about their injury. This information, recorded on a 'claim form', must be accompanied by a medical certificate from a general practitioner or any other qualified medical practitioner. The employer must then report this claim to the claims management organisation within a specific period of time, and the organisation must determine whether the claim is eligible or acceptable for workers' compensation benefits under the legislation within a specified period. However, the various schemes are administered in different ways and insurers may have different roles within the schemes. For example in Western Australia, Tasmania, the Northern Territory, and the Australian Capital Territory, insurers privately underwrite the scheme, while in New South Wales, Victoria, and South Australia, insurers operate as scheme agents on behalf of the government authority. In contrast to these two types of arrangements in which the commonality is that insurers play a key role, in Queensland, the scheme is operated entirely by the state without insurers (SafeWorkAustralia, 2012). Besides the roles of insurers, other important differences between states and territories include the proportion of the labour force covered, time period limits and caps on off-work income replacement and access to medical treatment, and post-injury rehabilitation (Collie et al., 2016). For example, Tables 5.1 and 5.2 below compare income replacements and medical reimbursements across different schemes, which are two major forms of compensation benefits (SafeWorkAustralia, 2012).

As businesses and workers become more mobile, the need to understand the various workers' compensation systems at the national level is becoming increasingly important. In addition, the differences in system design and access policy incentivises comparative research to identify the most effective policy setting that minimises the duration of time off work and maximises post-injury outcomes. Collie et al. (2016) conducted an analysis to compare the periods of injury recovery between different Australian states, using a population-based administrative dataset that includes 95,976 workers with accepted compensation claims at 2010. Compared to those from New South Wales, injured workers in Victoria and South Australia had significantly longer durations of time off work and higher chances of receiving income replacements at 104 weeks after the injury. On the contrary, workers in Tasmania and Queensland had shorter durations of time off work (Collie et al., 2016).

In contrast with state-level differences that are mainly caused by laws, there is no clear legislative distinction in workers' compensation systems between industries and occupations in Australia. Each industry or occupation does not regulate its own scheme. However, the incident rates of serious claims seem to vary significantly among different industries and occupations (SafeWorkAustralia, 2011, 2014a, 2014b, 2015).[23] For example in the 2012-13 financial year, the industry of "Health care & social assistance" had the highest total number of serious claims. "Agriculture, forestry and fishing" was the riskiest industry with the highest incidence rates of serious claims, while workers had much lower rates from "Professional, scientific & technical services," "Financial & insurance services," and "Information media & telecommunications" (SafeWorkAustralia, 2014a). With regards to occupational differences, "Managers," "Professionals," and "Clerical & administrative workers" seemed to have much lower probabilities of making a serious claim than others, whilst labourers and female "Machine operators & drivers" were more likely to make serious claims (SafeWorkAustralia, 2014a).

In summary, incidence rates of compensation claims vary across Australian states and territories due to legislative distinctions. They also seem to be different across industries and occupations. Therefore, in the section devoted to the main results, this chapter will perform sensitivity analysis to examine if labour market costs of having a compensated injury vary by different states, industries, and occupations.

[23] SafeWork Australia defines a serious compensation claim as being one for an incapacity that results in a total absence from work of one week or more. "Incident rate" equals the number of claims per 1,000 employees.

Table 5.1 Summary of Income Replacement by States and Territories (SafeWork Australia, 2012, p. 39)[24]

Parameter	New South Wales	Victoria	Queensland	Western Australia	South Australia	Tasmania	Northern Territory	Australian Capital Territory *	Commonwealth
100% Wage Replacement (No. of Weeks)	26	13 (95% replacement).	26	13	13	26	26	26	45
Final Step-Down (After Week . . .)	26	13	104	13	26	78	26	26	45
Minimum Amount	>26 weeks: the lesser of 90% average weekly earnings or $321.10.	80%	Greater of 75% worker's normal weekly earnings or 70% of Queensland full-time adult's ordinary time earnings.	85%	80%	80% (safety net – payments cannot fall below 70% of basic salary or 100% weekly payment, whichever is lower).	75% low income earners, where their entitlement can be up to 90% of their loss of earning capacity.	65% of pre-injury earnings or statutory floor ($543.78) whichever is greater.	Lesser of 75% or statutory amount of $402.06.
Variation	More for dependants, less capacity to earn.	Less current weekly earnings.	-	Subject to award rates.	Less capacity or deemed capacity to earn.	Less capacity to earn.	More for dependants, less capacity to earn.	More for dependants, less capacity to earn.	More for dependants, less capacity to earn.
Financial Limit	$1,716.40 per week.	$1,810 per week.	Until weekly compensation totals $265,485.	Limit on weekly payments of 2.0 x ABS average weekly earnings ($) Statutory maximum - $183. 394.	$2,381.60 per week.	-	-	-	150% of Average Weekly Ordinary Time Earnings of Full-time Adults (Cth) Comcare ($1,884.45).
Time Limit	-	130 weeks unless no current work capacity likely to continue.	Five years.	-	130 weeks unless no current and continuing work capacity.	Depends on the worker's degree of whole person impairment.	-	-	-

24 Income replacement payments are 'stepped down' by a percentage or to a set amount for workers who cannot earn an income because of a work-related injury. In almost all arrangements, detailed provisions are made to further reduce the amounts of income replacement based on an injured person's capacity to earn. Each scheme provides (within limits) for a period of near-full income replacement of pre-injury earnings for workers who cannot earn.

Table 5.2 Summary of Maximum Amounts for Medical Treatment by States and Territories (SafeWork Australia, 2012, p. 42)

Jurisdiction	$ limit	Other
New South Wales	No limit.	Medical expenditure above $50,000 requires regulator approval.
Victoria	No limit.	Ceases 52 weeks after weekly payment entitlement ceases, or after 52 weeks if compensation is payable only for medical and like services unless common law claim or ongoing need.
Queensland	No limit.	-
Western Australia	$55,018.	Additional $50,000 where the worker's social and financial circumstances justify it. An additional $250,000 beyond the $50,000 may be ordered by an arbitrator under certain circumstances.
South Australia	No limit.	-
Tasmania	No limit.	If the worker is entitled to weekly payments for incapacity in respect of the injury, entitlement to compensation for medical expenses ceases 52 weeks after the lawful termination of weekly payments. If the worker is not entitled to weekly payments for incapacity in respect of the injury, entitlement to compensation for medical expenses ceases 52 weeks after the date the claim was made.
Northern Territory	No limit.	-
Australian Capital Territory	No limit.	Total amount must not be more than the maximum amount agreed between employer and worker or $617.63 for each treatment.
Commonwealth Comcare	No limit.	-

5.3 Determinants of Work-Related Injuries and Workers' Compensation

5.3.1 Work-Related Injuries Survey by Australian Bureau of Statistics, 2009-10

The first empirical dataset used in this chapter is the 2009-10 Work-Related Injuries (WRI) survey published by Australian Bureau of Statistics (ABS) ('ABS-WRI').[25] The ABS-WRI collected information from 18,941 workers aged 15 years or above, and who were active in

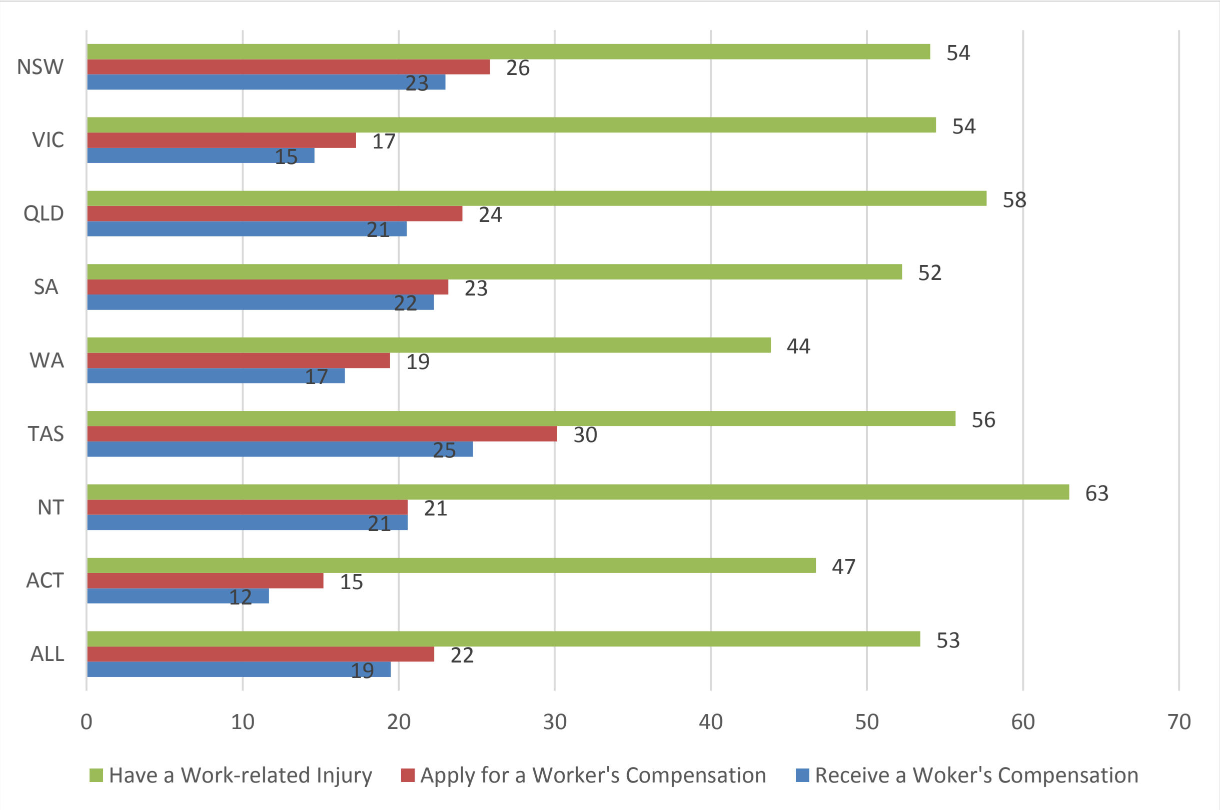
25 The WRI topic was initially included in the Multipurpose Household Survey, which was conducted throughout Australia from July 2009 to June 2010 as a supplement to the ABS monthly Labour Force Survey. The WRI survey has been collected three times: 2005-06, 2009-10, and 2013-14. Only ABS-WRI 2009-10 is used in this chapter, since it is the only cross-section released for private use by the ABS. In this analysis, "injury" refers to all work-related adverse health conditions including illness and disease.

the labour market between July 2009 and June 2010. The survey broadly defined work-related injuries as any injury or accident that occurred in the last 12 months, where a person suffered either physically or mentally from a condition that has arisen out of, or in the course of, employment. The ABS-WRI also asked for the following details about their most recent work-related injury: the type of injury they suffered from, how and where the injury occurred, the number of days or shifts absent from work due to the injury, whether they applied for and received workers' compensation, and the reason they did not apply for workers' compensation. In addition, this survey collected detailed labour force information, such as employment type, tenure, occupation, industry, weekly hours, and Occupational Health and Safety (OHS) training experience before the injury took place. Essentially, every job-related question was asked twice of those injured workers for both the time-of-accident job and the current main job. Further, socioeconomic and demographic information was also collected. This chapter utilises the ABS-WRI 2009-10 to perform a first-step empirical analysis, which estimates the associated factors (particularly job-related factors) that determine a worker's probability of suffering from a workplace injury and an injured worker's probability of receiving compensation benefits, respectively. The estimates will inform the second-step HILDA analysis. Given that HILDA provides information about an individual's receipt of workers' compensation but no detail about workplace injuries, ABS-WRI results help explain why the receipt of workers' compensation is a useful proxy for a severe work-related injury. Descriptive associations between job-related characteristics and injury occurrences are presented in *Table 5A* in *Appendices*.

Figure 5.1 compares incidence rates between eight Australian states and territories. Of the 18,941 workers surveyed by the ABS-WRI 2009-10, approximately 53 per 1000 people (1,012 workers in the ABS-WRI sample) suffered from a work-related injury or illness who had worked at some time in the last 12 months. The Northern Territory had the highest work-related injury rate (63 per 1,000 people or 52 out of 826 workers in the sample), closely followed by Queensland (59 per 1,000 people or 194 per 3,364 workers). Western Australia recorded the lowest rate (44 per 1,000 people or 106 per 2,418 workers). The jurisdiction with the highest rate of receiving, as well as applying for, a workers' compensation benefit was Tasmania (30 and 25 per 1,000 people, or 39 and 32 per 1,293 workers), while the jurisdiction with the lowest rate was the Australian Capital Territory (15 and 12 per 1,000 people, or 13 and 10 per 856 workers).

Figure 5.2 displays the incidence rates among 18 industries classified by ANZSIC 2006. “Accommodation & food services” and “Art & recreation services” had the highest work-related injury rates among all industries (83 and 82 per 1,000 people, respectively), while “Information media & telecommunications” had the lowest incidence rate (36 per 1, 000 people or 12 per 337 workers in the ABS-WRI sample). The industry group with the highest rate of having compensation benefits was “Transport, post and warehousing” (34 per 1,000 people or 20 per 885 workers), in contrast with “Professional, scientific & technical services” that reported only seven receipts per 1,000 people (10 out of 1,350 workers in the ABS-WRI sample). Note that the distribution of work-related injuries across the different industries will be influenced to some extent by the proportions of genders (as well as occupations) in those particular industries. And the incidence rates of being compensated may be associated with different union power in each industry. All these descriptive statistics, coupled with those shown in *Table 6B* in *Appendices*, seem to be consistent with WorkSafeAustralia (2014a).

Figure 5.1 Work-Related Injuries and Workers' Compensation: Incidence Rates by States and Territories, ABS WRI Data 2009-10



Notes: Incidence rate of work-related injury equals the number of injuries per 1,000 workers.

Figure 5.2 Work-Related Injuries and Workers' Compensation: Incidence Rates by Industries, ABS WRI Data 2009-10

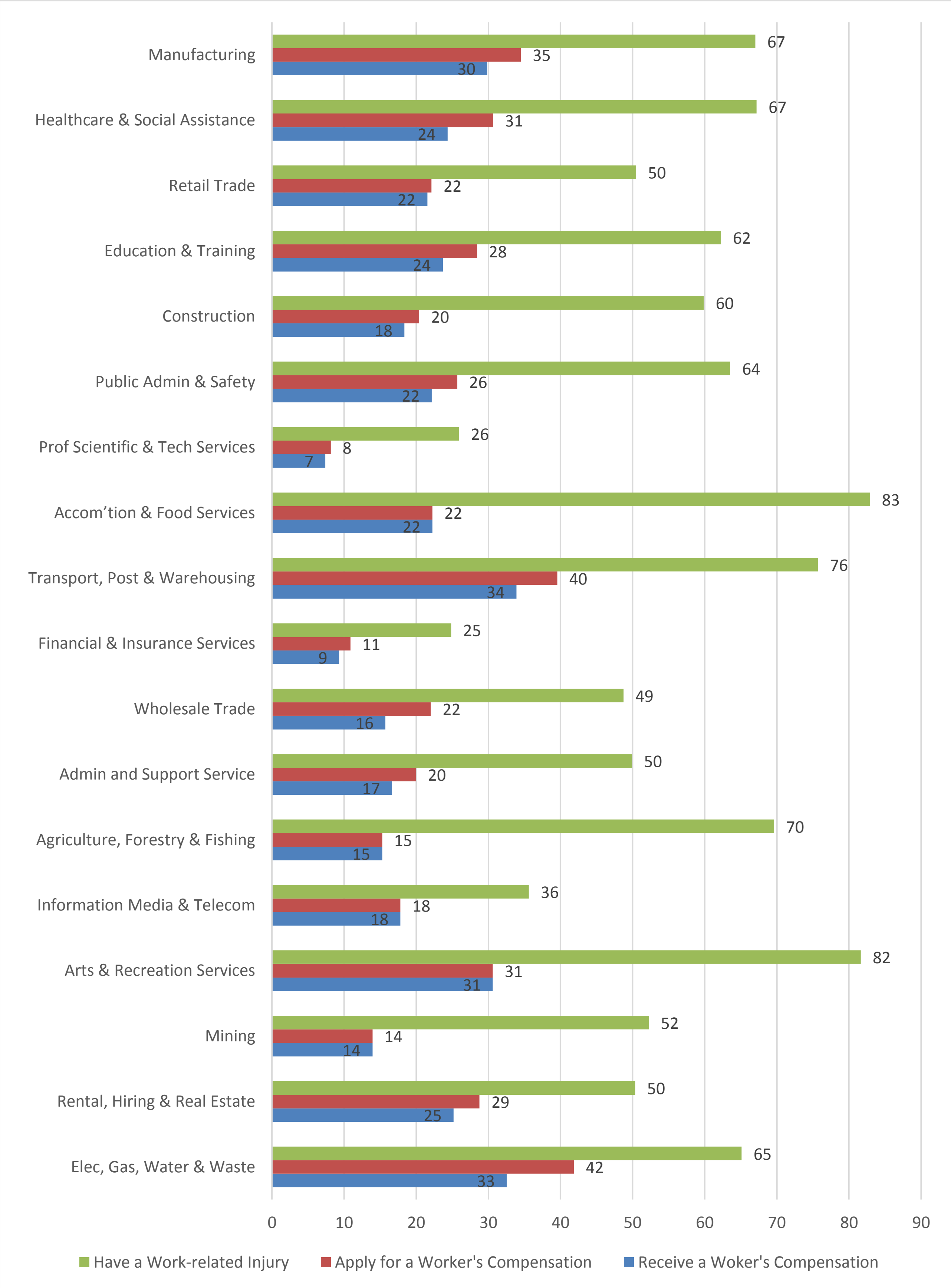


Table 5.3 Injury Types Associated with Having Work-Related Injury, Applying for and Receiving Workers' Compensation, ABS WRI Data 2009-10

	All Work-Related Injuries (WRI)				
		Apply for Workers' Compensation Benefit		Receive Workers' Compensation Benefit	
Injury Types	Total	N	Row %	N	Row %
Fractures [REF]	78	42	53.8	40	95.2
Chronic Joint/Muscle Condition	183	88	48.1	80	90.9
Sprain/Strain	303	136	44.9	119	87.5
Cut/Wound	152	58	38.2	54	93.1
Crush or Internal Organ Damage	72	28	38.9	20	71.4
Superficial Injury	33	10	30.3	8	80.0
Stress or Other Mental Health Problem	64	20	31.3	13	65.0
Burns	38	13	34.2	13	100.0
Others	89	27	30.3	22	81.5
All	1,012	422	41.7	369	87.4

Notes: Bold figures indicate that sample means are statistically different with having a fracture at the 5% level. Of those 590 injured workers who did not apply for workers' compensation, 269 (45.6%) reported the reason as "minor injury only or not considered necessary." Other main reasons include "not covered or not aware of workers' compensation," "did not think eligible," "negative impact on current or future employment," and "inconvenient or required too much effort or paperwork."

Turning attention to injured workers only, Table 5.3 compares the chances of making a claim between different injury types, and the chances of being compensated conditional on making claims. Fractures had the highest rate of applying for a workers' compensation benefit (53.8%), followed by chronic joint or muscle condition (48.1%) and sprain or strain (44.9%), while superficial injury had the lowest rate (30.3%) as expected. Apart from crush or internal organ damage (71.4%) and stress or other mental health problem (65.0%), workers with all other injuries had at least an 80% chance of being compensated if they make a claim. Notice that this diversity was mainly due to the different degrees of injury severity. In addition to injury mechanisms, earlier studies also suggest that the duration of time off work is a significant indicator of injury severity—a longer period of recovery before return to work means a workplace injury is more serious (Collie et al., 2016). Table 5.4 shows a strong gradient of injury severity (measured by the number of absent working days) in the likelihood of applying for, and receiving, a workers' compensation benefit. Of those injured workers who had more than 10 absent days, about 70% made claims and 88% of these claims were accepted.[26] Conversely, only 23% of injured workers applied for compensation if they missed any day or shift, and 79% of their claims were accepted. The first-step empirical analysis in the following sub-section will examine if all these descriptive associations are robust when using regression analysis.

Table 5.4 Days/Shifts Absent from Work after Work-Related Injury: Applying for and Receiving Workers' Compensation, ABS WRI Data 2009-10

	All Work-Related Injuries				
		Apply for Workers' Compensation Benefit		Receive Workers' Compensation Benefit	
Days/Shifts	Total	N	Row %	N	Row %
None [REF]	428	98	22.9	77	78.6
Part of a Day/Shift	78	28	35.8	23	82.1
One to 4 Days	222	108	48.6	104	96.3
Five to 10 Days	99	67	67.3	57	85.1
11 Days or More	154	107	69.5	94	87.9
Had Not Returned to Work	31	14	45.2	14	100.0
All	1,012	422	36.46	369	87.4

Notes: Bold figures indicate that sample means are statistically different with reference category- fractures at the 5% levels.

5.3.2 What Determines Work-Related Injuries and Workers' Compensation?

Estimating the impacts of workplace injuries on later labour force outcomes is difficult, because the occurrence of an injury or illness does not randomly occur among workers (i.e., it depends on a range of observed and unobserved heterogeneous characteristics). A widely acknowledged view is that work-related injury is partially dependent upon the choices made by workers, employers, and trade unions. Over the last three decades, a voluminous body of empirical literature has documented a strong association between occupational injuries and job-related characteristics. Long hours and overtime (Dembe et al., 2008; Dembe, Erickson, Delbos, & Banks, 2005), irregular shift and schedule (Cottini, Kato, & Westergaard-Nielsen, 2011; Dembe et al., 2007), shorter tenure (Galizzi, 2013), contract-based employment (Guadalupe, 2003; Hernanz & Toharia, 2006), union membership (Donado, 2015), unskilled occupation, and industry (Dembe et al., 2008; Galizzi, 2013) have been shown to be

[26] Of those injured workers who missed more than 10 days and did not make a compensation claim, most have received other forms of financial assistance, such as regular sick leave from employers, income security insurance, and payments from a social security agent (e.g., Centrelink).

associated with higher probability of on-the-job injuries, while workplace safety and OHS training experiences (Economou & Theodossiou, 2015) appear to be associated with lower likelihood of injury. More recently, many scholars have turned attention to compensation claims among injured workers. In addition to job-related characteristics (Bolduc, Fortin, Labrecque, & Lanoie, 2002; Du & Leigh, 2011; Galizzi, Miesmaa, Punnett, & Slatin, 2010), other important determinants of making claims or receiving workers' compensation benefits include injury severity (Shannon & Lowe, 2002), business cycle (Davies, Jones, & Nuñez, 2009), and local legislation (Ruser, Pergamit, & Krishnamurty, 2004). Guided by these empirical findings, my first-step analysis estimates what causes a work-related injury and a receipt of a workers' compensation benefit, respectively.

Table 5.5: Estimated Determinants of Work-Related Injury and Workers' Compensation Using OLS, ABS-WRI 2009-10

	Have a Work-Related Injury (1)	Receive a Workers' Compensation Benefit (2)	Receive a Workers' Compensation Benefit (3)
No. of Absent Days-Injury Severity			
None [Reference]	-	-	-
Part of a Day/Shift	-	-	**.113(.054)****
One to Four Days	-	-	**.266(.037)*****
Five to 10 Days	-	-	**.411(.049)*****
11 Days or More	-	-	**.445(.043)*****
Had Not Returned to Work	-	-	**.320(.084)*****
Injury Types			
Fracture [Reference]	-	-	-
Chronic Joint/Muscle	-	-.098(.063)	-.057(.058)
Sprain/Strain	-	**-.146(.059)****	-.056(.055)
Cut or Open Wound	-	**-.165(.066)****	-.012(.063)
Crushing or Internal Organ Damage	-	**-.252(.076)*****	-.120(.072)*
Superficial Injury	-	**-.348(.097)*****	-.178(.091)*
Stress or Other Mental Health	-	**-.309(.079)*****	-.359(.074)***
Burns	-	-.137(.096)	-.008(.090)
Job-Related Characteristics			
Employment Type			
Casual [Reference]	-	-	-
Fixed-Term Contract	-.007(.009)	-.010(.077)	-.026(.072)
Permanent	-.002(.005)	**.157(.046)*****	**.133(.043)*****
Self-Employed	**-.021(.007)*****	**-.196(.072)*****	**-.204(.067)*****
Occupation			
Managers [Reference]	-	-	-
Professionals	-.000(.006)	.080(.066)	.051(.061)
Technicians & Trades	**.043(.007)*****	**.181(.067)*****	.082(.063)
Community & Personal Service	**.028(.008)*****	**.192(.069)*****	.120(.065)*
Clerical & Admin	-.004(.007)	.033(072)	.005(.067)

Sales Workers	.005(.008)	.137(.083)*	.043(.078)
Machinery Operators & Drivers	**.051(.009)***	.188(.077)*	.071(.073)
Labourers	**.051(.008)***	**.205(.066)***	.093(.062)
Industry			
Manufacturing [Reference]	-	-	-
Healthcare & Social Assistance	.007(.008)	.100(.072)	.035(.068)
Retail Trade	-.000(.008)	.119(.071)*	.127(.066)*
Education & Training	**.019(.009)**	.149(.080)*	.082(.075)
Construction	-.009(.008)	-.044(.069)	-.057(.065)
Public Admin & Safety	.010(.009)	.047(.074)	.042(.069)
Prof Scientific & Tech Services	-.013(.008)	.101(.093)	.059(.087)
Accommodation & Food Services	.012(.010)	-.014(.075)	-.037(.070)
Transport, Post & Warehousing	.003(.010)	.057(.077)	.036(.072)
Financial & Insurance Services	-.017(.011)	.085(.130)	.057(.121)
Wholesale Trade	-.006(.011)	-.065(.095)	-.014(.089)
Admin and Support Service	-.010(.011)	.065(.098)	.074(.091)
Agriculture, Forestry & Fishing	**.025(.011)**	-.012(.092)	-.011(.086)
Information Media & Telecom	-.016(.014)	.200(.143)	.241(.133)*
Arts & Recreation Services	.026(.014)*	.035(.107)	.106(.100)
Mining	**-.033(.015)**	-.238(.133)*	-.211(.124)*
Rental, Hiring & Real Estate	.003(.015)	.156(.131)	.146(.122)
Electricity, Gas, Water & Waste	.001(.016)	.035(.131)	-.016(.123)
Other Job-Related			
Weekly Working Hours	**.001(.000)***	.002(.001)*	.002(.001)
Tenure	.001(.001)	.015(.013)	.015(.012)
Shift Work	**.032(.005)***	.013(.037)	.044(.034)
OHS Training	**.009(.004)**	.020(.038)	.018(.035)
State of Residence			
NSW [Reference]	-	-	-
VIC	.000 (.005)	-.154(.045)	-.135(.042)
QLD	.000(.005)	-.064(.046)	-.075(.043)
SA	.005(.006)	.030(.054)	.049(.050)
WA	**-.012(.006)**	-.030(.055)	-.001(.051)
TAS	-.003(.007)	.026(.063)	.015(.058)
NT	.002(.009)	-.090(.073)	-.101(.068)
ACT	-.003(.009)	-.158(.081)	-.153(.075)
Other			
Male	**-.014(.004)***	**.081(.037)**	**.084(.034)**
Age	-.000(.000)	.000(.001)	.002(.001)
High School	-.004(.005)	-.087(.049)*	-.066(.045)
Diploma/Certificate	.003(.005)	-.036(.039)	-.040(.037)
Degree	-.006(.005)	**-.114(.054)**	-.096(.051)*
Sample Size	18,941	1,012	1,012

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. A constant term, missing information indicators for occupation/industry, and injury type are also included in linear probability models but are not shown. An omitted reference category is “not completed high school” for education. Although not reported, OLS results on the probability of applying for workers’ compensation (without controlling for injury severity) are close to the results shown in model (2).

Table 5.5 reports the first-step results using three OLS models: 1) probability of having a work-related injury conditional on all workers; 2) probability of having a workers' compensation benefit conditional on all injured workers; and 3) further controls added to model (2) for injury severity, measured by the number of absent days. [27]Based on model (1) results, self-employed, male, and Western Australian workers in the mining industry had slightly lower chances of injuries than others. Relative to workers in higher occupations with regular schedules, technicians, machinery operators or drivers, or labourers who worked long hours and who had irregular shifts were more likely to suffer from work injuries. Moving on to model (2), of all 1,012 injured workers, injury types and occupations appeared to be the two major predictors of receiving a workers' compensation benefit. For instance, workers who suffered from mental health conditions, crushing or internal organ damage, or cut or open wound were less likely to be compensated than workers with fractures by 30.9%, 25.2%, and 16.5%, respectively. Technicians, community workers, and labourers were estimated to have higher probabilities of receiving compensation benefits compared to managers by 18.1%, 19.1%, and 20.5%, respectively.

Turning to model (3), there seems to a strong gradient of injury severity on the likelihood of receiving a workers' compensation benefit. More absent working days cause higher chances of being compensated.[28] Moreover, both injury types and occupations turn insignificant in this specification. This change indicates that injury mechanisms and occupations may indirectly affect compensation claims through their influences on the severity of a workplace health condition, which is measured by the period of time off work. *Figures 5B* and *5C* in *Appendices* further support this point of view, as highly compensated injury types and occupations were associated with more absent days. In addition to injury severity, only the coefficients of "stress or other mental health problem," "permanent," "self-employed," and "male" are significant in model (3). Regardless of the inclusion of injury severity, a mental health illness is consistently associated with lower probability of receiving a compensation benefit. Though not presented, workers with mental health conditions are 23.8% less likely to make a claim than those with fractures. I interpret this finding in a number of ways. First, stress or other mental health illnesses are more difficult than a physical health problem to be

[27] For the convenience of interpretation and comparison, OLS is used to estimate the determinants of having a worker's compensation in this analysis. Importantly, OLS results reported in Table 5.5 are mainly replicated by an alternative classic binary model (e.g., Logit).

[28] This estimate, however, must be interpreted with great caution, since injury severity may be itself endogenous. For example, a serious compensation claim may reversely affect the duration of time loss at work.

diagnosed by general practitioners. Therefore, workers without medical certificates are unable to make a claim. Second, since the barriers to workers' compensation are higher for mental health issues, affected workers may have to seek other financial assistance (Lane, Collie, & Hassani-Mahmooei, 2016; SafeWorkAustralia, 2014b). Last, it normally takes a longer time for compensation organisations to assess mental health claims than others (SafeWorkAustralia, 2014b). Therefore, some injured workers may have not received the outcomes of claims yet.

Overall, my first-step ABS-WRI results are consistent with primary findings in the existing literature, and provide guidance for the second-step empirical analysis using HILDA. Injury severity is the most powerful determinant of having a workers' compensation benefit, even after controlling for all job-related factors and injury mechanisms. Longer duration of time off work means an injury is more serious, which in turn means a higher chance of the worker being compensated. This finding helps me believe that receiving a workers' compensation benefit is a strong indicator for having a serious injury in the workplace, particularly a physical injury (e.g., fractures and chronic joint pain) rather than a mental illness.

5.4 Impacts on Labour Force Outcomes and Job Satisfaction

5.4.1 Household, Income and Labour Dynamics in Australia, 2005-14

The second empirical dataset employed in this chapter is the Household, Income, Labour Dynamics in Australia (HILDA), which is a continuing nationally representative longitudinal survey of the Australian population. It initially started in 2001 with the interview of 13,969 individuals from 7,682 households through a combination of face-to-face interviews and self-completion questionnaires of all household members aged 15 years old and over (Watson & Wooden, 2001). HILDA has a strong focus on respondents' labour force characteristics, each year collecting details on income, employment, and a range of other important job-related factors. In addition, HILDA includes rich information about a respondent's subjective wellbeing, including self-reported job satisfaction in terms of security, flexibility, payment, training opportunities, and workplace stress or difficulty. In this chapter I use the latest 10 waves of HILDA spanning 2005 to 2014, which asked questions in relation to workers' compensation, and I limit my attention to individual-year observations aged 20 to 64 years, given that respondents in this age range are more likely to be active in the labour market. Further, I omit respondents with missing information on labour force outcomes, workers' compensation experiences, or covariates, and those who only participated in one study wave (due to the exclusive use of individual fixed-effects methods). Therefore, the main estimation sample includes 107,082 observations on 19,030 unique individuals aged 21 to 64 observed from 2005 to 2014.

Table 5.6 Number of Individual-Year Observations Reported Workers' Compensation in HILDA, 2005 to 2014

E2: In last 12 months, how much time spent on workers' compensation?	F32: In last financial year,[29] how much workers' compensation received as a source of income?		
	Receive $0	Receive > $0	Total
Spend < One Working Day	104,186	**480**	104,666
Spend ⩾ One Working Day	**1,633**	**783**	2,416
Total	105,819	1,263	107,082

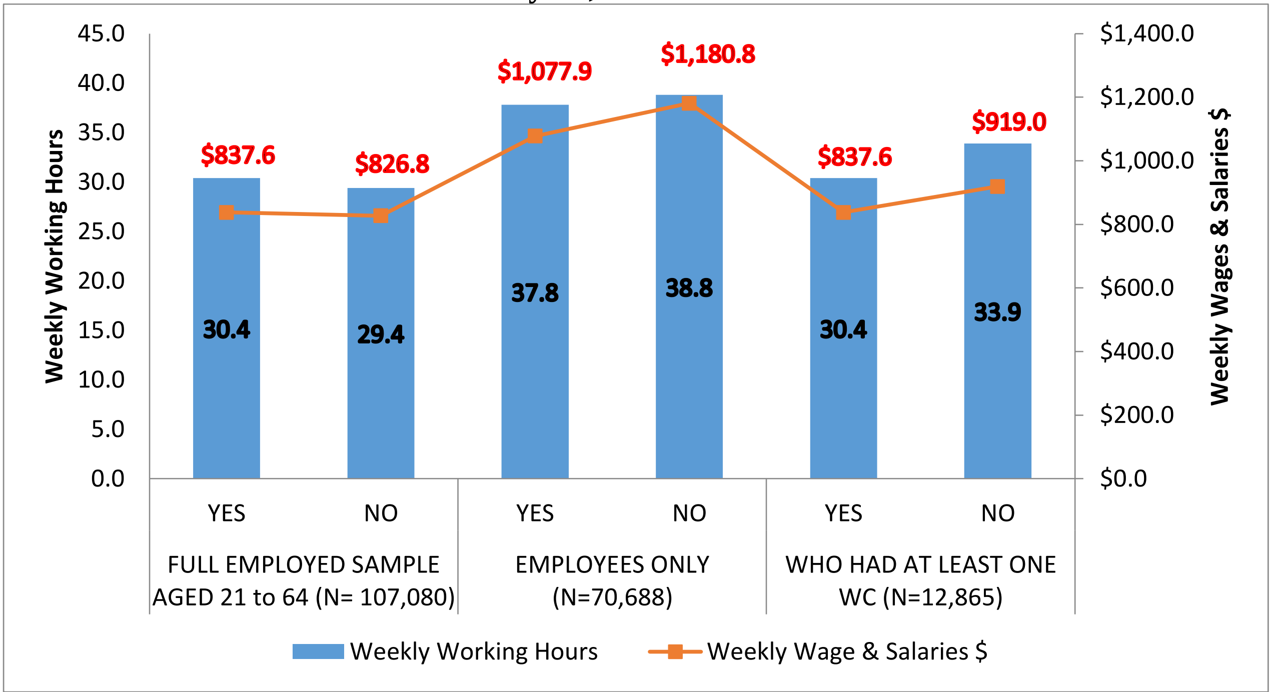
Since the 2005 survey, the HILDA Continuing Person Questionnaire (CPQ) has consistently asked two sets of questions about: 1) how much time a respondent spent on workers' compensation benefits during the last 12 months; and 2) how much workers' compensation a respondent received as source of income during the last financial year. Table 5.6 presents cross tabulations between answers to these two questions. This chapter defines an occurrence of a "workers' compensation" if a respondent either "had at least one day off," "received some income compensation," or both. In the pooled full sample including all respondents aged 21 to 64 (n=107,082), 2,896 individual-year observations (2.7%) reported an experience of workers' compensation using this definition during the year before the survey.

Following the literature on the economic consequences of workplace injuries and illness (Boden & Galizzi, 1999; Dong, Wang, Largay, & Sokas, 2016; Galizzi & Zagorsky, 2009), this analysis examines three major labour consequences: 1) employed with a paid job; 2) the number of hours usually worked in all jobs per week; and 3) the most recent weekly wage received. Figure 5.3 compares weekly hours and wages between compensated and other workers. In the fully employed sample (n=107,082), there appears no significant difference in

[29] Given most respondents completed questionnaires from August to October every year, the different terms used in E2 and F32, "last 12 months" and "last financial year," are likely to refer to the same time period.

both working hours and wages. After restriction to employees only (n=70,688), a receipt of workers' compensation benefit during the last year, on average, reduces the current weekly wage by over $100. If I further limit the sample to respondents who experienced at least one workers' compensation benefit (n=12,865), compensated workers have $80 less in wages and 3.5 fewer workings hours than others. Overall, current labour force outcomes are negatively associated with an occurrence of workers' compensation in the last year. However, this association is sensitive to sample selection.

Figure 5.3 Average Weekly Hours/Wages ($) by Whether Had Workers' Compensation in the last year, HILDA 2005-14



In the HILDA data, respondents' work-related wellbeing is annually assessed by self-reported questions. Respondents are asked to report current job satisfaction with respect to six different items: pay, job security, work itself (what you do), hours, flexibility to balance work and non-work commitments, and overall satisfaction. To answer each item, respondents choose a number ranging from 0 to 10, where "0" means completely dissatisfied and "10" means completely satisfied. Compensated workers report lower work satisfaction than others in all six items (sample statistics of all variables used from HILDA are presented in *Table 5B* in *Appendices*). The gaps are particularly large in work itself, flexibility, and overall job satisfaction. The main objective of this chapter is to determine whether the observed negative impacts of receiving a workers' compensation benefit are robust, once I use rigorous statistical methods.

5.4.2 *Empirical Methods*

There are two main empirical challenges in the second-step analysis: measurement error and unobserved confounding factors. Measurement error is a general problem for survey data analysis, especially in studies using self-reported health measures (Bound, Brown, & Mathiowetz, 2001; Butler et al., 1987). The occurrence of a compensated work-related injury is likely to be reported with error in the HILDA data, because injured workers may not receive a benefit for different reasons. For instance, workers with mental health illness may seek other financial assistance, due to longer processing time and higher barriers to workers' compensation for mental health issues (Lane et al., 2016). Omission of these uncompensated injured workers will under-estimate the cost of a severe work-related injury. Without a valid instrumental variable, I am unable to correct the estimation bias caused by measurement errors completely. However, two reasons make me believe that a receipt of a compensation benefit is a strong indicator for having a serious injury. First as shown in Section 5.3.2 above, injury severity (measured by the number of absent days) is the most dominant predictor of receiving a workers' compensation benefit in the ABS-WRI 2009-10, even after controlling for job-related factors and injury mechanisms. Longer periods of time lost at work means the injury is more serious, which thus leads to higher chances of receiving a benefit. Second, workers' compensation is also strongly associated with an incidence of serious personal injury or illness (not necessarily work related).[30] Table 5.7 reports individual fixed-effects results. To capture the potential persistent effects, a serious personal injury is observed at three different periods: within the last 12 months, between 12 and 24 months, more than 24 months. Regardless of selection of estimation sample or whether there is further inclusion of an indicator for a serious injury that took place more than 24 months ago, there seem to be strong positive associations between two types of health shocks occurring in the last year. The positive associations, however, were substantially weakened after 12 months, and turned negative after 24 months. This finding further proves that receiving a compensation benefit is a valid proxy for severe work-related injuries.

30 In HILDA Self-Completed Questionnaires, every year collects the information on whether a respondent experienced an important life event, such as job loss, divorce, or a serious personal injury or illness, etc. Notice that injury or illness surveyed in this question may also include those that occur outside the workplace.

Table 5.7 Estimated Association between Workers' Compensation and Serious Personal Injury Using Individual Fixed-Effects

	Received a Worker's Compensation in Last Year			
	Full Sample (1)	Ever Received a Workers' Compensation (2)	Full Sample (3)	Ever Had a Workers' Compensation (4)
Injury (≤12 Months)	0.068***	0.293***	0.062***	0.262***
	(0.004)	(0.016)	(0.004)	(0.017)
Injury (12 to 24 Months)	0.027***	0.109***	0.019***	0.067***
	(0.004)	(0.015)	(0.004)	(0.015)
Injury (> 24 Months)	-	-	-0.263***	-0.334***
			(0.012)	(0.016)
Sample Size	85,427	10,322	77,007	9,240

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. A constant term, age in years, age squared, married, number of dependents, state, and wave dummies are also included in individual fixed-effects models, but are not shown.

Another major empirical difficulty is the presence of observed and unobserved confounding factors that may affect both serious injury risk and later labour force outcomes. For example, as a significant determinant of having a work-related injury, occupation is also a crucial predictor for job participation, performance, and satisfaction. Compared to low-skilled labourers, a manager or professional has a lower chance of injuries and earns higher wages. The classical selection bias problem takes place if the likelihood of suffering an injury or illness is positively correlated with those confounders that reduce a worker's wages, working hours, and job satisfaction. The observed confounders could be mostly addressed by including a wide range of covariates in the estimation equation, while the unobserved characteristics are more difficult to deal with and thus place a higher risk when pursuing causal analysis. Ignoring difficult-to-measure confounding factors may over-estimate the association between an adverse on-the-job health condition and subsequent work-related wellbeing. Donado (2015) estimates that 40% of the gap in non-fatal occupational injury rates between unionised and non-unionised workers is reduced after controlling for time-invariant individual fixed-effects. Essentially, the majority of unobserved confounders between on-the-job injury risks and later labour outcomes are within-individual and time-invariant (Galizzi & Zagorsky, 2009). These important difficult-to-measure heterogeneous factors include IQ, cognitive ability, self-discipline, attitude towards work, and risk tolerance.

Table 5.8 compares the number-of-waves frequencies between severe work-related injury (indicated by having a workers' compensation benefit) and long-term health condition across 10 study rounds from 2005 to 2014 in HILDA. Of all workers in the fully employed sample, only 9% ever had a severe workplace injury, which is much less than the occurrence of a long-term health condition (41%). In addition, about 3.2% of individuals were injured in more than one wave over a 10-year panel, whilst 25.7% reported they suffered from a chronic health problem more than once. At each observed study round, some workers who were injured previously recover and other workers without initial injuries may suffer them. The sufficient within-individual cross-time variations shown in Table 5.8 suggest that workplace injury is more likely to be a one-off health shock rather than a long-term condition.

Table 5.8 Workers' Compensation vs. Long-Term Health Condition: Across-Time Variation, HILDA 2005-14

No. of	Full Sample Aged 21 to 64 (n=19,030 Unique Individuals)			
Waves	Had a Worker's Comp		Had a Long-Term Health Condition	
	Frequency	%	Frequency	%
0	17,333	91.08	11,149	58.59
1	1,080	5.68	2,990	15.71
2	357	1.88	1,444	7.59
3	129	.68	892	4.69
4	61	.32	708	3.72
5	24	.13	393	2.07
6	16	.08	321	1.69
7	8	.04	300	1.58
8	7	.04	252	1.32
9	7	.04	219	1.15
10	8	.04	362	1.90

Notes: In HILDA, common long-term health conditions include sight problem, speech problem, hearing problem, limited use of arms or fingers, chronic or recurring pain, nervous or emotional condition, and mental illness.

Following the existing literature in labour economics and industrial relations (Davies et al., 2009; Donado, 2015; Dong et al., 2016; Galizzi & Zagorsky, 2009), this chapter uses individual fixed-effects methods to overcome the potential selection bias and omitted variable problems arising from worker-specific heterogeneity.

$$LFO_{it} = WC_{it}'\beta_1 + X_{it}'\gamma_1 + STATE_{1i} + Year_{1t} + \alpha_{1i} + \varepsilon_{1it}, \qquad (5.1)$$

where LFO_{it} represents one labour force outcome (e.g., weekly wages, hours, or self-reported job satisfaction) for individual *i* observed at year *t*, X_{it} is a vector of all observed time-varying individual characteristics (e.g., age, marital status, number of dependents, etc.), α_{1i} captures all difficult-to-measure confounders that do not vary within-individual across time (e.g., self-discipline and IQ), and β_1 measures the impacts of having a severe injury (indicated by receiving a workers' compensation benefit, WC_{it}) on labour force outcome. Estimated β_1 is the main interest of this analysis. Further, equation (5.1) controls for state and year fixed-effects. State dummies may capture the different incidences of injuries across eight Australian states and territories, while year dummies are used to control for the impacts of variant business cycles (recessions vs. booms). Statistically, this empirical approach compares labour force outcomes within the same group (worker) observed at different study rounds. For example, weekly wages reported after a serious injury at one specific year is compared to wages without any injury observed at other years. The individual fixed-effects method removes all unobserved individual-specific confounding factors that do not change over time, and thus helps better estimate the 'true' effects of a workplace injury on job-related outcomes. *Table 5B* in *Appendices* reports summary statistics of all variables used in the HILDA analysis.

5.4.3 Main Results

Table 5.9 shows the estimated marginal effects of having a serious workplace injury on later employment outcomes using two extreme estimation samples: 1) full sample including all individuals aged 21 to 64; and 2) those who ever had a workers' compensation benefit. After controlling for all individual fixed-effects,[31] a work-related injury in the last year has no impact on the probability of having a current paid job. However, a compensated worker is estimated to lose 0.880 working hours (about 50 minutes), and earn $23.6 less wages (only significant at the 10% level), per week. Further, an injured worker's current hourly wage is not affected (not presented in Table 5.9). Table 5.10 presents the cost of compensated injuries on subjective job-related wellbeing. After removing all time-invariant unobserved characteristics, a workplace injury in the last year significantly reduces a worker's overall job satisfaction by 0.075 within-individual standard deviation. Further, an injured worker's self-reported satisfaction on payment, work itself (what he or she does), and flexibility to balance between work and non-work commitments have reduced by 0.122, 0.118, and 0.103 units, respectively. Note, a worker's self-perception on pay and hours are not significantly affected, which corresponds to the results shown in Table 5.9 (there seems to be only a weak impact of a workplace injury on weekly working hours and wages). Taking all results in Tables 5.9 and

[31] Pooled OLS results, reported in *Table 6C* in *Appendices*, show strong associations between an occurrence of workers' compensation last year and all four main current labour force outcomes (employed with a paid job, weekly hours, wages, and self-reported overall job satisfaction).

5.10 together, although a serious injury has no effect on current labour force participation (whether a worker is employed with a paid job), it causes a small but significant reduction in weekly hours and wages. More importantly, an injured worker's current self-reported satisfaction has decreased, especially with respect to job security, feelings towards work itself, and flexibility between work and leisure. These results correspond to my initial hypothesis: with compensation benefits, injured workers are not financially worse off than workers who did not sustain an injury, but their perceived job satisfaction may still be affected as a result of important changes at work after recovery (for example, a change in job duties and responsibilities). Further, since results using two extreme estimation samples show no significant difference, I limit my attention to the full sample (individuals aged 21 to 64) in the following sub-group analysis.

Table 5.9 Estimated Impacts of Having Worker's Compensation (WC) on Employment/Wages using Individual Fixed-Effects, HILDA 2005-14

	Full Sample (21 to 64), n=107,002			Ever Had a WC, n=12,854		
	Paid Job (1)	Hours (2)	Wage $ (3)	Paid Job (4)	Hours (5)	Wage $ (6)
WC	0.011	**-0.881****	**-23.415***	0.011	**-0.879****	**-23.793***
	(0.008)	**(0.349)**	**(12.834)**	(0.009)	**(0.351)**	**(12.861)**
Age in Years	0.037***	2.405***	108.947***	0.030***	1.967***	86.108***
	(0.003)	(0.103)	(4.315)	(0.007)	(0.300)	(10.212)
Age Squared	-0.000***	-0.031***	-1.196***	-0.000***	-0.028***	-0.987***
	(0.000)	(0.001)	(0.054)	(0.000)	(0.003)	(0.116)
Married	-0.036***	-1.201***	-5.475	-0.036**	0.653	2.892
	(0.007)	(0.277)	(11.774)	(0.017)	(0.797)	(28.994)
No. of Children	-0.045***	-2.588***	-67.712***	-0.023***	-2.200***	-52.450***
	(0.003)	(0.130)	(6.085)	(0.008)	(0.352)	(11.597)

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All reported weekly wages have been inflated to 2014 $AUD. A constant term, state, and wave dummies are also included in all individual fixed-effects models, but are not shown.

Table 5.10 Estimated Impacts of Having Worker's Compensation (WC) on Job Satisfaction Using Individual Fixed-Effects, HILDA 2005-14

Had a WC Last Year	Pay (1)	Job Security (2)	Work Itself (3)	Hours (4)	Flexibility (5)	Overall (6)
Full Sample (Max. n=82,369)	-0.040 (0.045)	-0.120** (0.049)	-0.116*** (0.041)	-0.038 (0.046)	-0.106** (0.049)	-0.123*** (0.040)
Ever Had a WC (Max. n=10,751)	-0.038 (0.045)	-0.124** (0.049)	-0.119*** (0.041)	-0.039 (0.046)	-0.100** (0.050)	-0.124*** (0.041)

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Each estimate represents one separate individual fixed-effects model. A constant term, age in years, aged in years squared, married, number of dependents, state, and wave dummies are also included in all individual fixed-effects models, but are not shown.

Table 5.11 Estimated Impacts of Having Worker's Compensation (WC) on Selected Outcomes in Subgroups Using Individual Fixed-Effects, HILDA 2005-14

Had a WC Last Year	Weekly Hours/Wages		Job Satisfaction			
	Hours (1)	Wages ($) (2)	Job Security (3)	Work Itself (4)	Flexibility (5)	Overall (6)
Male (Max. n=50,869)	-1.836***	-51.453**	-0.095	-0.093*	-0.075	-0.079
	(0.495)	(20.035)	(0.063)	(0.052)	(0.065)	(0.051)
Female (Max. n=56,133)	0.198	11.175	-0.155**	-0.144**	-0.142*	-0.177***
	(0.473)	(13.973)	(0.078)	(0.065)	(0.073)	(0.066)
Young, 21-40 (Max. n=50,821)	-0.525	-7.254	-0.069	-0.127*	-0.163**	-0.156**
	(0.522)	(19.231)	(0.076)	(0.067)	(0.077)	(0.067)
Old, 41-64 (Max. n=56,180)	-0.980**	-30.847*	-0.150**	-0.099*	-0.062	-0.088*
	(0.454)	(17.129)	(0.066)	(0.051)	(0.063)	(0.050)
Unmarried (Max. n=51,193)	-0.417	-6.450	-0.123*	-0.175***	-0.187***	-0.181***
	(0.503)	(18.484)	(0.071)	(0.059)	(0.072)	(0.060)
Married (Max. n=55,809)	-1.488***	-39.825**	-0.114	-0.049	-0.015	-0.066
	(0.493)	(18.468)	(0.070)	(0.060)	(0.071)	(0.058)
No Children (Max. n=55,930)	-1.028**	-18.355	-0.081	-0.126**	-0.111	-0.093
	(0.462)	(17.368)	(0.067)	(0.059)	(0.068)	(0.057)
Have Children (Max. n=51,072)	-0.933*	-28.837	-0.154**	-0.093	-0.052	-0.128**
	(0.508)	(18.736)	(0.077)	(0.059)	(0.077)	(0.059)
Office[32] (Max. n=45,543)	-0.983**	-39.869*	-0.014	-0.101	-0.072	-0.062
	(0.394)	(20.425)	(0.082)	(0.070)	(0.082)	(0.068)
Non-Office (Max. n=36,792)	-0.461	-31.284**	-0.148**	-0.102**	-0.032	-0.132***
	(0.310)	(14.781)	(0.061)	(0.050)	(0.061)	(0.051)
Degree (Max. n=29,536)	-1.218	-62.911*	0.035	-0.053	0.027	-0.063
	(0.753)	(34.521)	(0.107)	(0.093)	(0.111)	(0.095)
No Degree (Max. n=77,423)	-0.748*	-15.917	-0.146***	-0.133***	-0.126**	-0.137***
	(0.389)	(13.771)	(0.055)	(0.046)	(0.055)	(0.045)

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All estimated results are generated using full sample of workers. All reported weekly wages have been inflated to 2014 $AUD. Each estimate represents one separate individual fixed-effects model. A constant term, age in years, age in years squared, married, number of dependents, state, and wave dummies are also included in all individual fixed-effects models, but are not shown. Regardless of selection of subgroups, a work injury has no estimated impact on other labour force outcomes (i.e., probability of having paid job, hourly wage, self-reported job satisfaction on pay and hours).

In addition to job-related factors, earlier studies on this field have argued that a work-related injury is also strongly selected by a range of socioeconomic and demographic characteristics

32 Based on occupations classified by ANZSCO 2006, this chapter has grouped "Managers," "Professionals," and "Clerical & Administrative" as office workers, while others (including "Technicians & Trades," "Community & Personal Service," "Sales Workers," "Machinery Operators & Drivers," and "Labourers") have been grouped as non-office workers.

(e.g., gender, marital status, educational attainment, etc.). Next, I re-estimate the future job-related effects of injuries using different subgroups. Table 5.11 reports the subgroup results with respect to six different factors: 1) two exogenous factors, gender and age; and 2) four endogenous factors: marital status, number of children, office-based occupation (managers, professionals, and admin workers), and university degree. The estimates, overall, draw my attention in two ways. First, the return-to-work outcomes after a serious injury vary substantially between subgroups. Males, older individuals (aged 41 to 64), those who are married, and office workers all suffer from a significant loss in weekly working hours and wages by different magnitudes. For example, a serious injury decreases current weekly payment for males and married workers by $50 and $40, respectively. In contrast, females, younger individuals (aged 21 to 40), the unmarried, non-office workers, and those without a university degree report a considerable reduction in subjective job-related wellbeing by varying extents. Females and the unmarried report a lower overall job satisfaction by 0.177 and 0.181 units, respectively.

The second important pattern shown in these subgroup results is that workers with unaffected hours or wages suffer from a lower subjective job satisfaction, whilst those who lose weekly hours and payment (although not in hourly wage) report no significant change in self-reported wellbeing. Looking at the former type of workers who are mostly female, young, unmarried, non-office-based, and less educated, they have greater chances to participate in low-skilled, blue-collar (except females), and casual or contract-based jobs. Additionally, these types of workers are more likely to be placed in lower occupations with irregular shifts or schedules. All these occupational characteristics strongly predict serious workplace injuries as documented in the existing literature (Cottini et al., 2011; Dembe et al., 2008; Dembe et al., 2007; Donado, 2015; Galizzi, 2013; Guadalupe, 2003). Further, although these injured workers' current labour participation and payment are not affected after recovery, it is highly likely that their on-the-job duties, roles, and responsibilities will have to change over time. These important changes to their role may in turn reduce an injured worker's perceived job satisfaction, which is evident in the forms of lower security, flexibility, and feelings about work itself. Conversely, high-skilled professional workers may be less likely to experience these occupational changes after they recover and return. Therefore, their self-reported job satisfaction is not affected. This chapter will further test this speculation using alternative outcome variables in Section 5.5.2.

5.5 Sensitivity Analysis

5.5.1 Are Results Robust to the Persisting Effects of a Workplace Injury?

In the main analysis, I treat a work-related injury (indicated by receipt of workers' compensation benefit) as a one-off health shock. In other words, it has been strongly assumed that an injury only has a contemporary impact on return-to-work outcomes within 12 months. However, an extremely severe injury (e.g., causes a loss of body parts or eyesight) may have persistent effects on a worker's future labour force participation and performance. Given HILDA does not provide information about the severity of workplace injury, I cannot completely rule out this possibility. In an alternative model, I assume an injured worker does not fully recover within 12 months after an incident happens. Using this assumption, I further include two indicators representing work-related injuries that occurred more than 12 months before. The alternative individual fixed-effects model is given:

$$LFO_{it} = WC_{it}'\beta_2 + WC_{i,t-1}'\theta_2 + WC_{i,t-2}'\delta_2 + X_{it}'\gamma_2 + STATE_{2i} + Year_{2t} + \alpha_{2i} + \varepsilon_{2it}, \quad (5.2)$$

where $WC_{i,t-1}$ and $WC_{i,t-2}$ refer to an occupational injury that took place: 1) between 12 and 24 months; and 2) more than 24 months prior to the HILDA survey, respectively. Other parameters and variables are defined above in equation (5.1). Since I find strong gender differentials in the main results, I perform all sensitivity analysis using subgroups of males and females.

Table 5.12 Estimated Persistent Impacts of Having Workers' Compensation on Selected Labour Force Outcomes Using Individual Fixed-Effects by Gender, HILDA 2005-14

	Paid Job		Weekly Hours		Wages/Salaries $		Job Satisfaction	
Workers' Comp	Male (1)	Female (2)	Male (3)	Female (4)	Male (5)	Female (6)	Male (7)	Female (8)
⩽ 12 Mths	-.024*	.006	**-2.002*** **	-0.376	**-68.995*** **	3.620	-.058	**-.163** **
	(.013)	(.015)	**(0.617)**	(0.621)	**(25.576)**	(19.114)	(.056)	**(.079)**
12-24 Mths	-.023*	-.028*	-1.033*	-2.247***	-41.971*	-25.172	.017	-.071
	(.014)	(.016)	(0.616)	(0.642)	(25.498)	(19.428)	(.061)	(.076)
>24 Mths	**-.051*** **	**-.117*** **	**-1.798** **	-2.968***	-44.871	**-65.163** **	.004	-.062
	(.018)	**(.021)**	**(0.842)**	(0.857)	(31.529)	**(27.024)**	(.076)	(.090)
Sample	42012	46294	42012	46294	42011	46294	35396	32540

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All reported weekly wages have been inflated to 2014 $AUD. Each column represents one separate individual fixed-effects model. A constant term, age in years, age in years squared, married, number of dependents, indicators for missing information on workplace injury in previous years, state, and wave dummies are also included in all individual fixed-effects models, but are not shown. Although not presented, a workplace injury, regardless of when it occurred, has no estimated impact on hourly wage.

Using the new approach specified in equation (5.2), Table 5.12 estimates short- and long-term injury impacts on return-to-work outcomes. For both subgroups, the contemporary labour effects of having a workplace injury estimated by equation (5.1) are replicated in this alternative specification. Within 12 months after an injury occurred, males lose two hours and $70 in wages, while injured females' overall job satisfaction has reduced by 0.163 units. The estimated persistent impacts show three interesting findings. First, work-related injury that happened more than two years ago has significant negative effects on a worker's current labour force participation and performance. For example, it reduces a female's probability of employment by 12%, weekly working hours by three hours, and wages by $65. Second, injured males overall seem to suffer less than injured females in work-related outcomes after two years. Their current wages are not affected, and the negative impacts on the chances of being employed in a paid job are much less than those on females (5% vs. 12%). The third notable finding is that an injury does not predict job satisfaction in the long term at all.

5.5.2 Are Results Robust to Alternative Measures of Labour Force Outcomes?

In this sub-section, I continue my sensitivity analysis using a range of questions from the HILDA Self-Completion Questionnaire (SCQ). In every study round, SCQ asked if a respondent had a major life event over the last 12 months. These major life events include significant job-related changes, such as "fired or made redundant by employer," "changed jobs," and "promoted at work." *Table 5D* in *Appendices* estimates short- and long-term impacts of serious occupational injuries on the probability of having a major change at work over the last 12 months. Compared to those without any serious compensation claim, an injured female worker is estimated to have a 2% higher chance of losing her job in the future, and a 3% lower probability of being promoted in the next 12 months. Additionally, injured male workers are associated with a higher chance of being fired or made redundant in 12 months (2%). These findings correspond to the results in Section 5.5.1. Pursuing this further, I find no injury effects on the likelihood of retirement, change in job, or occupation for both males and females.

Every year, HILDA SCQ also asks a series of 21 questions in relation to respondents' feelings and perception at work. Using self-reported answers and the factor analysis method, I have generated five additional outcome variables that measure different aspects of job satisfaction: 1) freedom and flexibility; 2) skills learning and training opportunities; 3) stress and difficulty; 4) workload pressure; and 5) pay and job security. Individual fixed-effects results in *Table 5E* in *Appendices* show that on-the-job feelings of males are not strongly affected by a compensated workplace injury, despite a 0.075 standard deviation lower score in freedom and flexibility. On the contrary, injured females report lower job satisfaction than uninjured females, in the form of less skills training opportunities, more stress or difficulties, or lower freedom or flexibility and security at work. Note that I omit the single question about "pay," and create another factor which is only loaded by questions in relation to "job security." An injured female worker is estimated to have a 0.034 standard deviation lower level of satisfaction in future job security. These strong gender differences in job satisfaction extend my earlier conclusion drawn from Table 4.11: in terms of loss in psychological work outcomes, females suffer much more from a serious work-related injury than males.

Table 5.13 Estimated Impacts of Having Worker's Compensation (WC) with Inclusion of Endogenous Variables Using Individual Fixed-Effects by Gender, HILDA 2005-14

Had a WC Last Year with an Inclusion of	Weekly Working Hours		Weekly Wage/Salaries ($)		Overall Job Satisfaction	
	Male (1)	Female (2)	Male (3)	Female (4)	Male (5)	Female (6)
a) Union	-1.975***	0.028	-57.233***	6.127	-0.078	-0.175***
	(0.489)	(0.470)	(20.000)	(13.823)	(0.051)	(0.065)
b) Industry	-1.632***	-0.380	-46.734**	-2.488	-0.080	-0.180***
	(0.421)	(0.378)	(18.931)	(12.741)	(0.051)	(0.065)
c) Occupation	-1.766***	-0.428	-49.755***	-2.320	-0.076	-0.175***
	(0.417)	(0.411)	(18.801)	(13.238)	(0.050)	(0.065)
d) Health	-1.381***	0.091	-48.565**	9.173	-0.060	-0.147**
	(0.532)	(0.502)	(21.482)	(14.944)	(0.053)	(0.069)
All (a) to (d)	-1.260***	-0.662*	-48.245**	-8.821	-0.059	-0.144**
	(0.415)	(0.397)	(19.792)	(13.507)	(0.053)	(0.069)
Max. n	50869	56133	50867	56133	42928	39433

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All reported weekly wages have been inflated to 2014 $AUD. Each estimate represents one separate individual fixed-effects model. A constant term, age in years, age in years squared, married, number of dependents, state, and wave dummies are also included in all individual fixed-effects models, but are not shown. Although not presented, a workplace injury in the last year has no impact on hourly wage despite the selection of endogenous variables.

5.5.3 Do Results Differ with Inclusion of Endogenous Covariates?

As specified in equation (5.1), my individual fixed-effects approach does not control for individual job-related and health characteristics in the estimation, such as union membership, industry, occupation, tenure at current work, employment contract type, and health condition. The exclusion of these covariates is primarily because they may be shifted by an experience of adverse health shock at work, which may in turn affect later labour force outcomes (e.g., hours and wages). In other words, these endogenous factors are potential mediating pathways for how an occupational injury affects return-to-work outcomes and their changes are what my empirical model aims to capture. In this sub-section, I examine if the main results are robust after controlling for these endogenous factors in the estimation equation. Table 5.13 re-estimates equation (5.1) in five extended models, respectively, by including 1) union membership; 2) industry type (classified by ANZSIC 2006); 3) occupation type (ANZSCO 2006); 4) self-reported global 5-point scale in health status;[33] and 5) all four endogenous variables. Overall, my main results are replicated after including these covariates in the estimation. It is noteworthy that health status has stronger confounding effects than job-related characteristics, which explains about 20% of the loss in injured women's job satisfaction (the estimated coefficient drops from -0.177 in Table 6.11 to -0.144 in Table 5.12 column (6)).

5.6 Discussions and Concluding Remarks

Work-related injury is a critical public health challenge in the industrialised world. Although the last three decades have witnessed a global decline in the incidence rates, the economic and wellbeing loss of injured workers are still quite costly. My study extends the empirical literature on this topic in three ways. First, using a detailed longitudinal household survey data spanning over 10 years, my study is the first Australian study investigating short- and long-term outcomes of a workplace health shock. Despite the high prevalence of work-related injury in the Australian labour force and the complexity of workers' compensation programs across different states, little is known about this issue in the Australian context. Second, I have studied the links between work-related injuries and workers' compensation, and found that severity is the most significant predictor of receiving a compensation claim after a work injury. Last and more importantly, I have carefully examined the injury cost on workers' self-reported job satisfaction from different aspects, which has not been researched by early international studies.

My empirical strategy includes two main steps. First, using ABS-WRI 2009-10 cross-sectional data, I carefully examine the associated factors (particularly job- and industry-related characteristics) that predict an individual's probability of having a workplace injury and the probability of receiving a worker's compensation benefit, respectively. My first-step results show two important findings: 1) a work-related injury is strongly selected by a number of job-related factors (not individual-related), which is consistent with the exiting literature in labour economics and industrial relations (Dembe et al., 2007, 2008; Galizzi, 2013;

[33] In the pooled sample (aged 21 to 64), 11.6%, 37.5%, 36.1%, 12.0%, and 2.8% of observations report their own health status as "excellent," "very good," "good," "fair," and "poor," respectively.

Guadalupe, 2003; Hernanz & Toharia, 2006); and 2) among injured workers, injury severity (measured by the number of absent days) is the single dominant predictor of making and receiving a serious claim. This latter finding gives me strong confidence to use a receipt of worker's compensation benefit as a valid indicator for an occupational injury occurrence in the HILDA data. In the second step, exploring the time-variant nature of a workplace injury and the longitudinal richness of the HILDA panel, I employ a range of individual fixed-effects models to estimate the injury impacts on future labour participation, performance, and satisfaction. This approach estimates the economic and psychological cost of an injury using only the association between within-individual changes in injury experience and within-individual changes in labour force outcomes.

My individual fixed-effects results in the second step overall suggest that a receipt of workers' compensation benefit (indicator for a serious workplace injury) has weak but significant contemporary impacts on weekly working hours and wages in Australia, and it reduces an individual's long-term labour force participation (especially for females after two years)—these results overall correspond to the primary findings from earlier international studies (Dong et al., 2015a; Galizzi & Zagorsky, 2009; Woock, 2009). Moreover, injured workers report lower job satisfaction, particularly on security, flexibility, freedom, stress, and difficulty at work. These reductions in job satisfaction are much stronger in some subgroups, including female, younger (aged 21 to 40), unmarried, non-office-based, and less educated workers.

My empirical strategy, however, is not without any limitations. First, this chapter only focuses on the severe injury that causes a receipt of workers' compensation benefit (it is most likely a physical injury). Thus, injured workers who do not receive serious claims are treated as "non-injured" workers. Woock (2009) stresses that this classification of injured and non-injured groups may overstate the earning loss. Second, measurement error may plague the empirical estimation. The occurrence of a compensated work-related injury is likely to be reported with error in HILDA, because injured workers may not receive a benefit for different reasons (Bolduc et al., 2002; Du & Leigh, 2011; Galizzi et al., 2010). For instance, workers with mental health illness may seek other financial assistance, due to longer processing time and higher barriers to workers' compensation for mental health issues (Lane et al., 2016). Omission of these uncompensated injured workers may under-estimate the cost of a severe work-related injury. Further, previous studies on self-reported health problems suggest that the bias caused by measurement errors will be exacerbated by using fixed-effects methods (Butler et al., 1987). Due to these two limitations, the main estimated results in this chapter should be interpreted as the job-related impacts of having a physical, and compensated, work injury.

5.7 Appendices

Figure 5A Conceptual Framework: How Does a Work-Related Injury Affect Later Job Satisfaction?

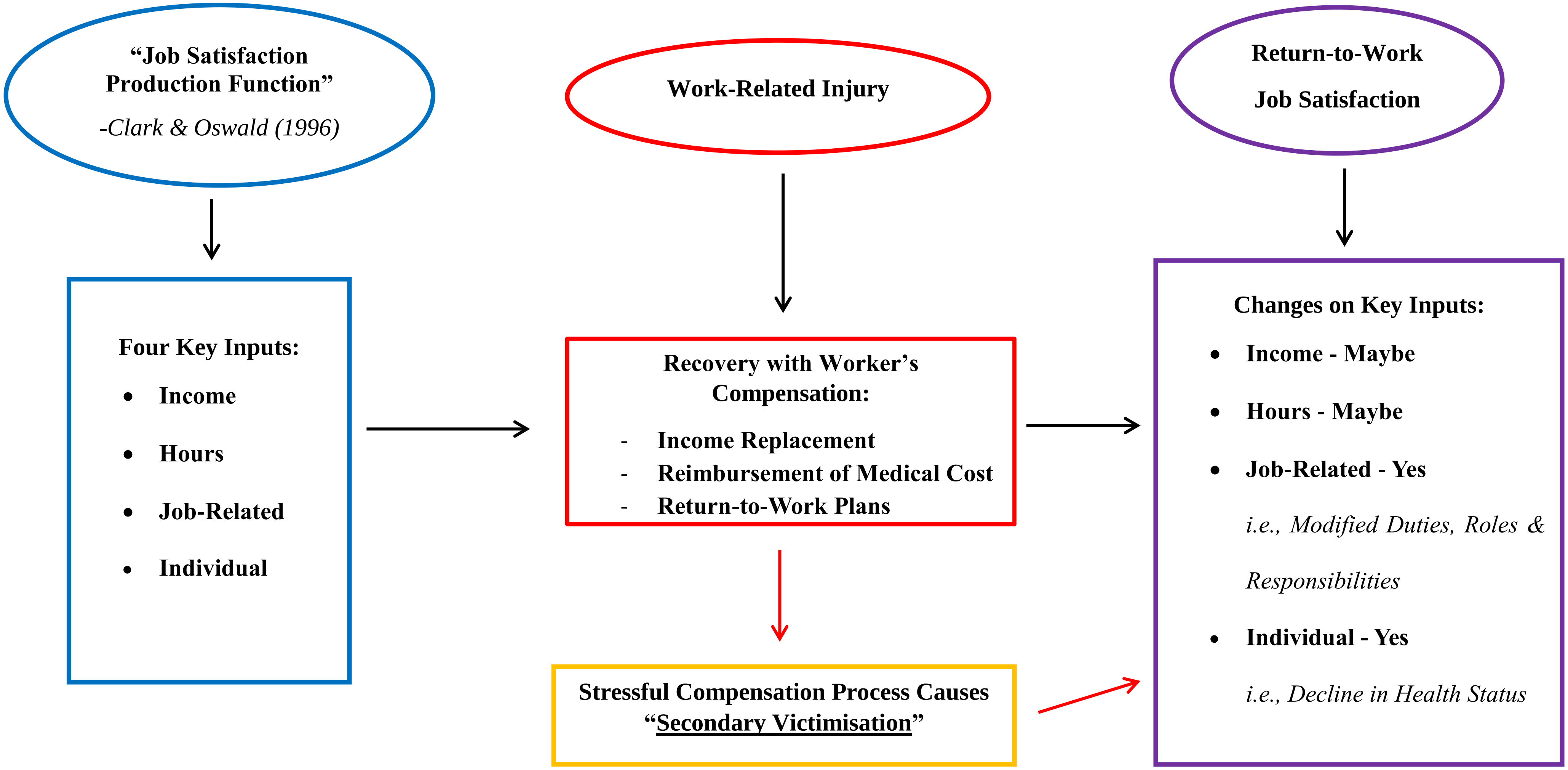


Table 5A: Job-Related Factors Associated with Having Work-Related Injury, Applying for and Receiving Workers' Compensation Benefit in ABS WRI Data 2009-10

	All Work-Related Injuries					
	Have a Work-Related Injury (Cond. on Labour Force)		Apply for Workers' Compensation Benefit (Cond. on Work-Related Injury)		Receive Workers' Compensation Benefit (Cond. on Apply)	
Job-Related Factors	N	Row %	N	Row %	N	Row %
Total	**1012**	**5.34**	**422**	**41.70**	**369**	**87.44**
Employment Type						
Casual [REF]	185	6.21	60	32.43	48	80.00
Fixed-Term Contract	52	4.89	12	23.08	12	100.00*
Permanent	699	6.09	345	**49.36**	304	88.12*
Self-Employed	76	**3.74**	5	**6.58**	5	100.00
Occupation						
Managers [REF]	116	4.50	29	25.00	26	89.66
Professionals	170	4.18	62	**36.47**	52	83.87
Technicians & Trades	184	**7.75**	84	**45.65**	76	90.48
Community & Personal Service	132	**8.43**	60	**45.45**	55	91.67
Clerical & Admin	92	**3.38**	37	**40.22**	27	72.97
Sales Workers	63	4.33	27	**42.86**	22	81.48
Machinery Operators	103	**9.61**	52	**50.49**	46	88.46
Labourers	151	**8.92**	71	**47.02**	65	91.55
Industry						
Manufacturing [REF]	101	6.70	52	51.49	45	86.54
Healthcare & Social Ass	138	**6.72**	63	45.65	50	79.37
Retail Trade	89	5.05	39	**43.82**	38	**97.44**
Education & Training	92	**6.22**	42	45.65	35	83.33
Construction	88	5.99	30	**34.09**	27	90.00
Public Admin & Safety	89	6.35	36	40.45	31	86.11
Prof, Scientific & Tech.	35	**2.59**	11	**31.43**	10	90.91
Accomm'n & Food Services	82	**8.29**	22	**26.83**	22	100.00
Transport & Warehousing	67	7.57	35	52.24	30	85.71
Financial & Ins Services	16	3.56	7	43.75	6	85.71
Wholesale Trade	32	4.87	14	45.16	10	71.43
Admin and Support Service	30	4.99	12	40.00	10	83.33
Agriculture, Forestry & Fish	41	**6.96**	9	**21.95**	9	100.00
Information Media & Telecom	12	3.56	6	50.00	6	**100.00**
Arts & Recreation Services	24	**8.16**	9	37.50	9	100.00
Mining	15	**5.23**	4	**13.33**	4	100.00
Rental, Hiring & Real Estate	14	5.04	8	57.14	7	87.50
Elec, Gas, Water & Waste	14	6.51	9	**64.29**	7	77.78
Other Job-related						
Weekly Hours ⩾ 38	495	**6.18**	206	41.62	184	89.32
Tenure ⩽ 1 Year	137	**4.59**	47	34.31	41	87.23
Shift Work	261	**9.70**	113	43.30	103	91.15
OHS Training	791	**6.02**	340	42.98	300	88.24

Notes: n=18,941 in labour force. Industries are defined by ANZSIC 2006 and ranked by descending orders. Bold figures indicate that sample means are statistically different to those in the reference category at the 5% level.

Figure 5B Injury Types Associated with the Number of Absent Workings Days in ABS WRI Data 2009-10

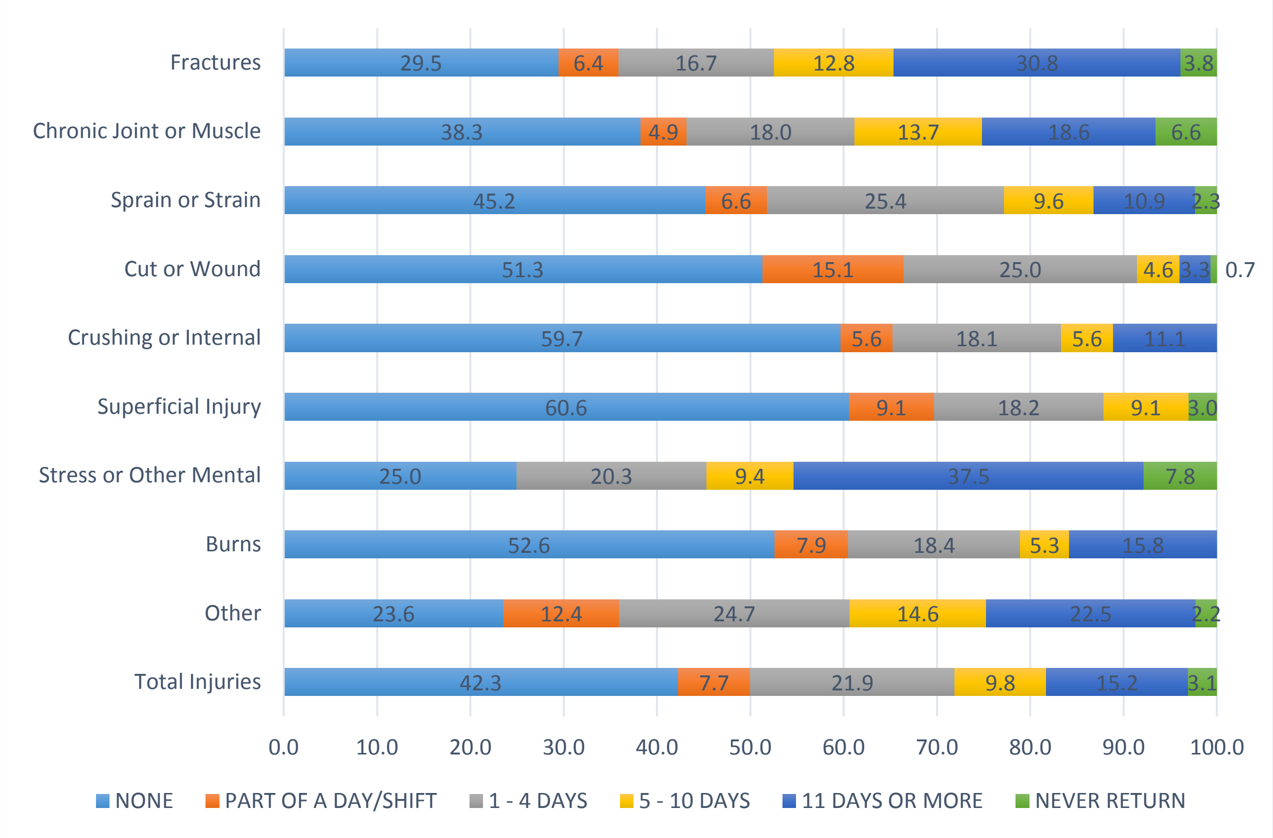


Figure 5C Occupations Associated with the Number of Absent Workings Days in ABS WRI Data 2009-10

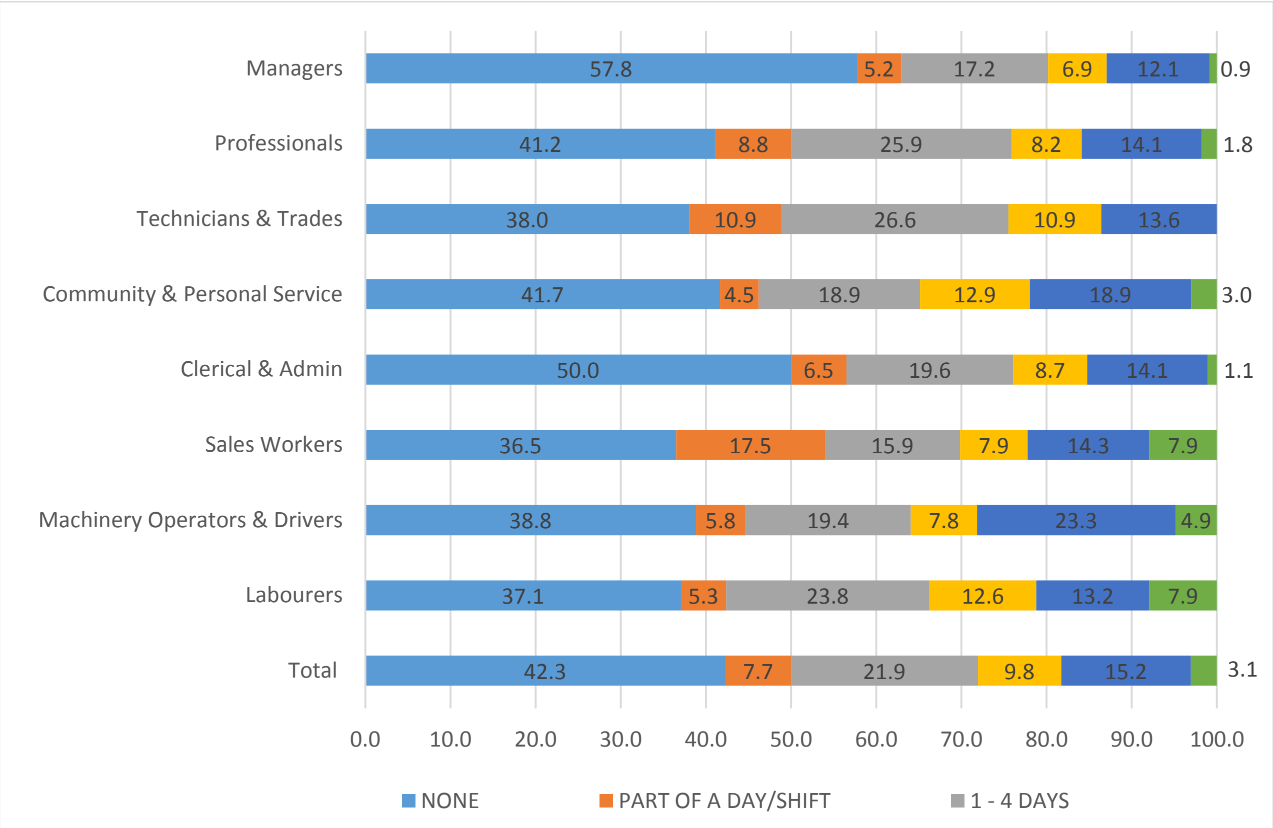


Table 5B Summary Statistics in HILDA, 2005-14 (10 waves, n=107,082)

Variables	Obs.	Mean	S.D.	Min	Max
i. Labour Force Outcomes					
Weekly Hours	10,7082	29.4	20.5	0	150
Weekly Wages/Salaries ($)	10,7080	827.1	922.3	0	63920
Hourly Wages/Salaries ($)	10,7080	21.8	27.4	0	1784.4
Job Satisfaction – Pay	82,358	6.983	2.066	0	10
Job Satisfaction – Job Security	82,334	7.872	2.102	0	10
Job Satisfaction – Work Itself	82,424	7.625	1.785	0	10
Job Satisfaction – Hours	82,409	7.207	2.025	0	10
Job Satisfaction – Flexibility	82,362	7.478	2.218	0	10
Job Satisfaction – Overall	82,416	7.628	1.646	0	10
ii. Workers' Compensation					
Had a Workers' Compensation Last Year	107,082	.027	.162	0	1
iii. Individual Characteristics					
Female	107,082	.5246	.499	0	1
Age in Years*	107,082	41.47	12.4	21	64
Married*	107,002	.5215	.4995	0	1
No. of Dependent Children*	107,082	.9197	1.165	0	12
Born in Australia	107,049	.784	.411	0	1
Born Overseas – Major English	107,049	.0939	.2917	0	1
Born Overseas – Other	107,049	.1219	.327	0	1
Remoteness – Major Cities	107,078	.667	.471	0	1
Remoteness – Inner Regions	107,078	.209	.4067	0	1
Remoteness – Outer & Remote Area	107,078	.123	.3288	0	1
Not Completed High School	107,082	.2399	.427	0	1
High School	107,082	.1505	.3575	0	1
Diploma/Certificate	107,082	.3334	.4714	0	1
Degree	107,082	.276	.447	0	1
Union Membership	107,082	.127	.333	0	1
iv. State of Residence*					
NSW	107,082	.297	.457	0	1
VIC	107,082	.2468	.4311	0	1
QLD	107,082	.2129	.409	0	1
SA	107,082	.0915	.288	0	1
WA	107,082	.0905	.2868	0	1
TAS	107,082	.031	.1734	0	1
NT	107,082	.008	.0916	0	1
ACT	107,082	.0214	.14472	0	1
v. Participation at Each Wave*					
Wave 5 – 2005	107,082	.087	.2819	0	1
Wave 6 – 2006	107,082	.0875	.2825	0	1
Wave 7 – 2007	107,082	.0859	.280	0	1
Wave 8 – 2008	107,082	.0858	.280	0	1
Wave 9 – 2009	107,082	.0895	.285	0	1
Wave 10 – 2010	107,082	.0905	.2869	0	1
Wave 11 – 2011	107,082	.119	.324	0	1
Wave 12 – 2012	107,082	.118	.323	0	1
Wave 13 – 2013	107,082	.1178	.322	0	1
Wave 14 – 2014	107,082	.118	.3226	0	1

Notes: *Time-variant covariates are used in individual fixed-effects models.

Table 5C Estimated Impacts of Having Workers' Compensation (WC) on Labour Force Outcomes using Pooled OLS, HILDA 2005-14

	Weekly Working Hours		Weekly Wage/Salaries ($)		Overall Job Satisfaction	
	Full Sample (1)	Had a WC (2)	Full Sample (3)	Had a WC (4)	Full Sample (5)	Had a WC (6)
Had a WC Last Year	**1.811*** **	**-2.434*** **	**45.830** **	**-56.384*** **	**-0.357*** **	**-0.193*** **
	(0.557)	**(0.516)**	**(18.217)**	**(16.983)**	**(0.049)**	**(0.047)**
Female	-9.825***	-9.889***	-337.699***	-330.925***	0.133***	0.072
	(0.216)	(0.699)	(9.030)	(26.332)	(0.019)	(0.067)
Age in Years	1.614***	1.979***	49.035***	67.145***	-0.052***	-0.058***
	(0.033)	(0.144)	(1.151)	(4.913)	(0.004)	(0.015)
Age Squared	-0.020***	-0.025***	-0.580***	-0.816***	0.001***	0.001***
	(0.000)	(0.002)	(0.012)	(0.060)	(0.000)	(0.000)
Married	0.500**	1.085	38.500***	46.375*	0.162***	0.084
	(0.242)	(0.705)	(9.404)	(26.506)	(0.022)	(0.068)
No. of Dependents	-0.605***	-0.919***	5.572	3.891	0.030***	0.051
	(0.115)	(0.329)	(4.648)	(12.070)	(0.010)	(0.033)
High School	5.025***	2.910***	144.486***	142.875***	-0.074**	-0.204*
	(0.320)	(1.125)	(11.001)	(38.189)	(0.030)	(0.107)
Diploma/Certificate	7.242***	4.089***	214.219***	200.793***	-0.074***	0.001
	(0.289)	(0.825)	(9.652)	(27.393)	(0.028)	(0.082)
Degree	10.299***	6.866***	579.673***	537.333***	-0.133***	-0.037
	(0.313)	(1.053)	(13.760)	(46.588)	(0.029)	(0.103)
Born Overseas- Eng	-0.807**	-2.426**	-3.756	-34.747	-0.066*	-0.068
	(0.376)	(1.156)	(16.586)	(44.757)	(0.036)	(0.116)
Born Overseas- Other	-4.047***	-4.468***	-183.848***	-206.894***	-0.148***	-0.160
	(0.335)	(1.352)	(13.993)	(53.312)	(0.034)	(0.133)
Inner Regions	-1.117***	-1.137	-114.857***	-98.218***	0.110***	0.118
	(0.272)	(0.855)	(10.119)	(31.022)	(0.024)	(0.077)
Outer or Remote	0.153	1.738	-118.193***	-83.237**	0.173***	0.134
	(0.361)	(1.069)	(12.435)	(37.390)	(0.031)	(0.096)
VIC	0.180	-1.198	-34.697***	-94.440**	0.091***	0.153
	(0.283)	(0.999)	(11.847)	(36.971)	(0.026)	(0.097)
QLD	0.903***	0.705	-8.233	-36.058	0.018	0.125
	(0.299)	(0.871)	(12.029)	(32.954)	(0.027)	(0.083)
SA	-0.719*	-2.165*	-87.148***	-121.353***	-0.010	0.009
	(0.405)	(1.250)	(14.667)	(43.213)	(0.038)	(0.143)
WA	1.160***	1.080	50.749***	69.977	0.095***	0.111
	(0.404)	(1.385)	(17.856)	(58.993)	(0.036)	(0.116)
TAS	-1.062*	-1.128	-14.646	-56.298	0.124**	0.248
	(0.634)	(1.765)	(20.134)	(61.787)	(0.058)	(0.182)
NT	8.605***	2.371	411.425***	313.838***	0.111	0.408
	(1.161)	(2.437)	(53.783)	(91.161)	(0.103)	(0.254)
ACT	1.112	2.163	134.458***	28.505	0.213***	0.207
	(0.715)	(1.647)	(35.985)	(76.713)	(0.058)	(0.174)
Sample Size	106935	12842	106933	12842	94560	11641

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. A constant term and wave dummies are also included in all OLS models, but are not shown. Omitted reference categories are: "not completed high school" for the highest educational attainment, "born in Australia" for the country of birth, New South Wales for the state of residence, and "major cities in Australia" for the remoteness.

Table 5D Estimated Impacts of Having Workers' Compensation (WC) on Significant Job-Related Events Using Individual FE by Gender, HILDA 2005-14

	Significant Job-Related Event					
	Fired or Made Redundant		Change Job		Promotion	
	Male (1)	Female (2)	Male (3)	Female (4)	Male (5)	Female (6)
WC (≤ 12 Mths)	0.020**	0.017*	-0.016	-0.004	-0.008	-0.028***
	(0.010)	(0.010)	(0.014)	(0.016)	(0.010)	(0.010)
WC (12-24 Mths)	0.005	0.022***	0.027*	0.028*	-0.005	-0.012
	(0.010)	(0.008)	(0.014)	(0.016)	(0.010)	(0.011)
WC (>24 Mths)	-0.008	0.020*	0.003	0.026	-0.023*	-0.027*
	(0.012)	(0.011)	(0.020)	(0.019)	(0.014)	(0.015)
Sample Size	36036	41007	36032	41022	35914	40911

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Each column represents one separate model. A constant term, age in years, age in years squared, married, number of dependents, state, and wave dummies are also included in all individual fixed-effects models, but are not shown. All four outcomes are binary in nature.

Table 5E Estimated Impacts of Having Workers' Compensation (WC) on Alternative Self-Reported Job Satisfaction Using Individual Fixed-Effects by Gender, HILDA 2005-14

Had a WC Last Year	Self-Reported Job Satisfaction				
	Freedom & Flexibility (1)	Skills Leaning & Training (2)	Stress & Difficulty (3)	Workload Pressure (4)	Pay & Security (5)
Male (Max. n=35,581)	-0.075***	-0.031	0.055*	0.006	-0.022
	(0.025)	(0.026)	(0.029)	(0.037)	(0.037)
Female (Max. n=33,619)	-0.053**	-0.087***	0.078**	-0.046	-0.062
	(0.027)	(0.031)	(0.035)	(0.041)	(0.039)

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All five outcomes are generalised by factor analysis using 21 self-reported questions in relation to job satisfaction and feelings, at each study round. In addition, all outcomes have been standardised with a mean of 0 and a standard deviation of 1. Notice that "Stress & Difficulty," and "Workload Pressure" are measured in negative forms: higher scores indicate more stress at the job.

Chapter 6

Summary, Policy Implications, and Future Research

This chapter provides a summary of the principal findings of the thesis. It discusses policy implications, and briefly outlines limitations and areas for further research.

6.1 Summary of Findings

Although injury prevention and safety promotion policies have made impressive progress in the developed world over the last half century, injury remains a serious public health concern. Despite its negative impacts on individuals, families, and the community, little empirical research has been undertaken by using the longitudinal data. Longitudinal research on the economic determinants and consequences of injury is important, since it is able to carry out robust analysis by employing rigorous econometric methods (e.g., within-individual fixed-effects models are able to control for unobserved time-invariantt confounders). A better understanding of injury from panel-data research will help to form and target public prevention programs, which in turn helps mitigate injury's short- and long-term negative impacts.

This thesis conducts a thorough empirical investigation into injuries from an economic perspective. Using three detailed nationally-representative longitudinal datasets (LSAC, NLSY-Child, and HILDA) and panel-data econometric techniques, this thesis assesses injuries that occur during childhood and in the workplace. The first is **c**hildhood injury, which is one of the major early-life physical health problems in the developed world. A number of questions in relation to childhood injury are researched in this thesis, including its parental socioeconomic determinants, future cognitive outcomes, medical and pharmaceutical utilisations, and impacts on prevention policies. The second is work-related injury, which is a continuing concern in global industrial relations. In spite of the high prevalence of work-related injuries in the Australian labour force and the complexity of workers' compensation programs across states and territories, limited empirical work has focused on Australian injured workers' recovery and return-to-work outcomes. This thesis fills in this research gap, and estimates the impacts of a severe work-related injury on future labour force participation, performance, and satisfaction in Australia. A summary of the key empirical findings is presented in the following sub-sections.

6.1.1 Parental Socioeconomic Determinants of Childhood Injuries in Australia

A commonly proposed determinant of childhood injury is low SES, a proposition that is strongly supported by a large empirical literature. There is, however, a lack of evidence from longitudinal studies. Due to the existence of unobserved confounders, previous cross-sectional literature may produce biased results. Using a detailed four-wave longitudinal dataset (LSAC) and within-child fixed-effects methods, this thesis estimates SES gradients in childhood injury in Australia. The main results are outlined below:

- **Overall, changes in family SES are not strongly associated with child injury rates in Australia.** The general finding of no SES gradient is inconsistent with most of the earlier international literature, which finds the existence of considerable socioeconomic inequalities in child injuries. This significant difference might be explained by both methodological and contextual factors. On the methodological side, the thesis firstly applies a fixed-effects panel-data method to control for unmeasured confounders, which may play a key role in variations in child injuries, although the main findings are supported by models that exploit cross-sectional variation (random-effects). On the contextual side, Australia has developed a world-leading child safety system. These prevention regulations have reduced child injury rates significantly over the last half century, which may explain the absence of family socioeconomic differentials in child injury risk propensities in Australia.

- **Family income has some unanticipated positive effects.** A child raised in a high-income family is estimated to have slightly higher odds of suffering an injury than a child raised in a low-income family, particularly for those injuries that are potentially caused by sporting and recreational activities (e.g., fracture, dislocation, sprain and strain). This finding may be due to fact that wealthy Australian children may be participating in more expensive and relatively dangerous sporting activities. Participation in such activities is associated with an increased risk of physical injuries, such as fractures and dislocations.

6.1.2 *Impacts of Childhood Injuries in Australia*

Another major contribution of the thesis is to examine how injury, a major source of early-life health concern in the developed world, affects the cognitive development of children. It is well documented that early-life health status plays a key role in child development and future educational attainment. However, to date, little has been found in the economic literature on the schooling effects of childhood injury. This analysis also examines the importance of several potential intermediate pathways, such as absenteeism from school, child health status, and utilisation of medical/pharmaceutical services. The main results are provided as follows:

- **An injured child who stayed at hospital overnight, on average, has more absent school days, more doctors' visits, and more medical/pharmaceutical services than other children.** Having a serious injury significantly causes 0.6 more absent school days, 0.6 more doctors' visits, and 0.7 more medical/pharmaceutical services. In addition, an injured child is 7% less likely to be reported to have "excellent or very good" health status.

- **A severe injury does not strongly affect children's cognitive abilities in Australia.** Given injury occurrence appears to be exogenously determined within-children across time, this analysis treats injury as an exogenous health shock and estimates its effects on children's cognitive skills using individual-level fixed-effects models. Examination of data from the LSAC reveals that having an injury in the last 12 months, regardless of the severity and type, is not strongly predictive of later cognitive test scores.

6.1.3 *Childhood Injuries and Cognitive Achievement in the U.S.*

The thesis re-examines the cognitive impacts of a severe injury requiring hospital admissions, using almost 10,000 U.S. children observed across 13 study rounds of the National Longitudinal Study of Youth-Child Supplement (NLSY-Child) from 1988 to 2012. Cognitive scores are measured from the Peabody Individual Achievement Test (PIAT) and the Peabody Picture Vocabulary Test (PPVT). The purpose of selecting these outcome variables is to investigate if previous results from Australia are replicated in the U.S. context—a country that has substantially larger population, and higher inequality in health and education. The analysis estimates both sibling and individual fixed-effects models. The main finding is as follows:

- **A hospital-treated accidental injury does not strongly impact cognitive development.** This primary finding is insensitive to different injury mechanisms, such as causes of accidents, types of injuries, or time spans of an injury occurrence. The subgroup estimates using individual fixed-effects, however, show some significant associations among girls and children whose mothers are low-educated or full-time working. Overall, the conclusion of no strong cognitive impact of injuries in Australia is replicated in the U.S. context. This interesting finding progresses the existing literature on child health and development, and indicates that childhood physical health problems may be less harmful than childhood mental health issues.

6.1.4 Work-Related Injuries, Workers' Compensation, and Labour Force Outcomes in Australia

Work-related injury is a continuing public health challenge in the industrialised world. Over the last three decades, a modest body of international literature in industrial relations has examined its economic consequences. However, very little empirical work has been done in Australia. Furthermore, few studies have examined how work-related injury effects measures of job satisfaction. To fill these research gaps, this thesis investigates the impacts of a severe work injury on future labour force participation, performance, and satisfaction in Australia. The main finding is summarised below:

- **A compensated work-related injury has weak negative impacts on current weekly hours and wages, and substantially reduces a worker's self-reported job satisfaction.** Exploring the time-variant nature of a workplace injury and the longitudinal richness of the HILDA panel, the thesis uses a range of individual fixed-effects models to estimate the impacts of a compensated injury on future labour force participation, performance, and satisfaction. This approach estimates the economic and psychological cost of an injury using only the association between within-individual changes in injury experience and within-individual changes in labour force outcomes. Results suggest that receipt of workers' compensation benefit (which likely indicates a serious workplace injury) has weak to mild contemporary impacts on weekly working hours and wages in Australia, and it reduces an individual's long-term labour force participation (especially for females after two years). These results overall correspond to the primary findings from earlier international studies. Moreover, injured workers report considerably lower job satisfaction, particularly for job security, flexibility, freedom, and stress and difficulty at work. These reductions in subjective work-related wellbeing are found to be stronger in the subgroups of female, young (aged 21 to 40), low-skilled, and low-educated workers.

6.2 Policy Implications

Research plays a vital part in forming injury prevention laws and policies. The correlates of injury, and its consequential harms, are varied, depending on different contexts. Therefore, no single policy will be able to completely curb injury rates or mitigate their cost. Instead, a suite of policies will need to be considered.

6.2.1 Childhood Injury

Like most other high-income countries, Australia has adopted a number of child injury prevention regulations over the past 50 years. For example, in Australia, bicycle helmets, child restraints in vehicles, pool fencing, smoke alarms, safe tap water temperatures, and speed limit control at school zones are all mandatory. These prevention regulations appear to have reduced child injury rates significantly in Australia. For instance, the injury-related deaths of children under the age of 14 years halved over a period of two decades, 1983 to 2003 (AIHW & ABS, 2006). One major empirical finding in this thesis further confirms the success of child injury prevention and safety promotion policies in Australia: an occurrence of childhood injury is not strongly determined by family socioeconomic factors.

6.2.2 Work-Related Injury

While a modest body of literature has assessed international work-related injury prevention and workers' compensation schemes in recent decades, empirical evidence on this field is rather limited in Australia. This thesis has two important findings on the impacts of work injury in the Australian labour market: 1) though compensated during recovery, a work-related injury sustained during the last 12 months has weak negative influences on current weekly hours and wages; and 2) injured workers report substantially lower job satisfaction after they return to work, particularly for job security, flexibility, freedom, and stress and difficulty at work. The policy implications to these findings are two-fold. First, compensation claims have clearly helped Australian injured workers better recover from the accident (e.g., income replacement and reimbursement of medical costs), especially for those who are seriously injured with long durations of time off work. Second, more efforts should be made towards return-to-work plans in the future. Injured workers' current labour participation and wages are not strongly affected in Australia, but their on-the-job duties, roles, and responsibilities are very likely to change after recovery. These important shifts at work may in turn reduce an injured worker's perceived job satisfaction, which is evident in the form of job lower job security and flexibility. This is a particularly difficult challenge for female, young, low-skilled, and low-educated workers.

6.3 Limitations and Future Research

Some limitations are acknowledged in these analyses, which have been discussed in detail in each empirical chapter. A summary of limitations is highlighted below with some avenues for further research.

- **Data issues.** Most variables of main interest explored in this thesis are reliant on self-reported information, including measures of injury occurrences (both childhood injury and work-related injury), parental SES, school absence, cognitive skills, receipt of workers' compensation, weekly hours and wages, and job satisfaction. Therefore, these measures may be subject to reporting error.

- **Measurement issues for severity of injury.** With a lack of linked clinical data, it is difficult to measure precisely the severity of an injury in the thesis. A severe child injury is defined by "staying at hospital overnight" and "requiring hospital admission," respectively, in LSAC and NLSY-Child. In regard to HILDA, the analysis uses a receipt of a compensation benefit as an indicator for a serious workplace injury. Subject to linked clinical data being available in the future, further work can be undertaken to investigate the causes and impacts of sustaining an injury by its severity.

- **Exploring the mechanisms.** The underlying linking mechanisms behind the impact of work-related injury and compensation benefits on job satisfaction remain unclear. Further research, using more on-the-job information and qualitative methods, may provide a better answers to the reasons why certain groups suffer more from a loss of job satisfaction following an injury (for example female, young, low-skilled, and low-educated workers).

- **Limitations to panel-data fixed-effects estimate.** Given the time-variant nature of injury (most likely a one-off health shock), the empirical results in this thesis are mainly estimated by individual fixed-effects models. This approach, however, does not address bias caused by unobserved time-varying confounding characteristics or reverse causality. Moreover, since the main variables of interest are mostly derived from self-reported information, the thesis is not free of measurement errors. Previous study on self-reported health problems suggests that bias caused by measurement errors may be exacerbated by using fixed-effects methods. There is little empirical evidence on the pervasiveness of these issues, and so it is difficult to judge if and to what extent they may be influencing my results. Understanding these potential issues is an important area for future research.

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