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TITLE

Transportation of children with bicycle seats, trailers, and other carriers: considerations for safety

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ABSTRACT

With plans to increase cycling participation and the increase in use of child carriers and cargo bikes in Australia, there is a need for research to support evidence-based safety improvements for cyclists and their passengers. Currently, very little is known about the safety of the increasing yet vulnerable road user group: child passengers on bicycles. The purpose of this study is to obtain a better understanding of the safety implications of transporting children by bicycle. This research is the first of its kind to explore issues relevant to child passenger safety in detail, including cycling behaviours when carrying children; safety concerns and the strategies used to mitigate them; factors contributing to crash and non-crash events; and injury characteristics including mechanisms, nature, and treatment. This study includes the analysis of hospital injury data, a detailed national survey of cyclists, and discussions with cycling stakeholders. Several recommendations for enhancing the safety of child passengers are discussed and an example of a resource to educate and inform those who are considering transporting their children by bicycle is provided.

KEYWORDS

Cycling, Children, Passenger, Bicycle

Summary

With plans to increase cycling participation and the increase in use of child carriers and cargo bikes in Australia, there is a need for research to support evidence-based safety improvements for cyclists and their passengers. While there is an increasing amount of research investigating the safety of adult cyclists, very little is known about the safety of children transported as the passenger on an adult's bicycle. This research addresses a significant gap in current knowledge by investigating the safety of an increasing yet vulnerable road user group: child passengers on bicycles. In order to obtain a better understanding of the safety implications of transporting children by bicycle, this study specifically examined:

- the characteristics of people who transport children, the types of carriers used and the factors influencing their use
- the type, nature and mechanisms of child carrier related injuries
- measures and initiatives that have the potential to reduce the incidence and severity of child carrier injuries.

Three research activities were undertaken to explore these issues in detail: an analysis of hospital injury data, a comprehensive national survey of cyclists, and discussions with cycling stakeholders.

Hospital injury data

Hospital injury data was extracted from the Victorian Admitted Episodes Dataset and Victorian Emergency Minimum Dataset from 1999 to 2014. A total of 17,859 emergency department presentations and 4,794 hospitalisations were identified for child cyclists, including passengers, under the age of 10 years. They were classified into three age groups representing children most likely to be injured as a passenger on a bicycle (0-3 years), children transitioning between passengers and riders (4-6 years) and children who are most likely to be injured while riding a bicycle (7-10 years).

For emergency department presentations, the most commonly injured body parts included the head (35%) and wrist and hands (16%). For hospital admissions, the head was also the most commonly injured body region (37%) followed by the elbow and forearm (27%). Comparisons of injured body regions between age groups revealed that children under the age of four years were statistically significantly more likely to sustain injuries to the head and neck that required hospital admissions, or presentation to an emergency department compared to older age groups.

For emergency department presentations the most common injury types included open wounds (30%), fractures (19%) and superficial injuries (18%). Fractures were the most common injury requiring hospitalisation (47%), followed by open wounds (28%). Compared to older children, children under the age of three had a statistically significantly higher number of open wound injuries that required presentation to an emergency department or hospital admission. Children under the age of three were significantly more likely to require a hospital stay of less than two days than older children.

Survey

A national online survey was undertaken of cyclists who were the parent of a child aged five years or younger. The survey collected information on: demographics, cycling behaviour, crash history, near misses, non-crash incidents, child transportation practices and experience, injuries to child passengers in crash and non-crash incidents, risk management, and other transport use.

A sample of 100 participants (74% male) aged 24 to 58 years completed the survey. The majority of the sample (94%) reported transporting at least one child aged up to five years by bicycle. There were

12 reported cases of child passengers involved in a crash; none of the children were injured. There were eight cases in which child passengers were injured in a non-crash incident, most commonly involving the bicycle tipping over due to the passenger's negative effect on the bicycle's balance. All injuries were minor and none required treatment at a hospital.

The most common types of carrier used by participants were seats attached either in front of or behind the rider. Common practices adopted by participants when transporting children included using different routes compared to when riding alone, modifying a usual route to reduce the risk of a crash, riding at times when there is less traffic and riding more often on the footpath and main roads with bike lanes. Survey participants suggested the best means to reduce the risk of injury when transporting children was to improve cycling infrastructure.

Stakeholder discussions

In order to gain some understanding of the availability and use of carriers, consultations with relevant stakeholders were undertaken. A number of cycling agencies and organisations were contacted to seek their knowledge of child transportation practices and types of carriers, safety concerns associated with child carriers, and the suitability of infrastructure when transporting children. Two organisations participated in this process. Findings from these discussions included:

- Concerns for the safety of child passengers due to their increased vulnerability.
- Concerns about rider experience and their ability to carry child passengers, particularly due to increased weight and changes to the balance and handling characteristics of the bicycle.
- Some cycling infrastructure (i.e. lane width) is not suitable for wider carriers (e.g., trailers, tricycles).

Conclusion

The findings from this study demonstrate that there is a real risk of injury to child passengers, although there are a number of strategies that can be employed by cyclists, road managers, and society to mitigate these risks. A lack of data precluded any analysis of differences in safety performance of different types of carriers. With an expected increase in the number of cyclists and the variety of child carriers in use, this research offers practical advice to enable parents and caregivers to make informed choices regarding the carriers they use and other strategies they can employ to enhance their safety when transporting child passengers.

Contents

1 Introduction

The predominant focus of cycling safety research has been on those who ride and control the bicycle, the majority of whom are adult cyclists. A group that has been largely overlooked until now has been the young children who are transported as passengers on bicycles. This research addresses a significant gap in current knowledge by investigating the safety of an increasing yet vulnerable road user group: child passengers on bicycles.

The importance of cycling to achieve sustainable transport and national health goals is well recognised by governments nationally and internationally (Australian Bicycle Council, 2010; Department of Transport, 2009; Department of Transport Western Australia, 2009). Cycling is an environmentally sustainable transport mode with a range of benefits, including reduced congestion, reduced vehicle emissions, and improved health. People who regularly cycle are less likely to be overweight, less likely to suffer from obesity-related diseases including heart disease, diabetes and stroke and have improved mental health (Oja et al., 2011). Currently, inactivity related health issues in Australia are estimated to cost $13.8 billion. An increase in everyday cycling for commuting and local trips can help achieve the recommended activity levels and reduce this cost (Australian Bicycle Council and Cycling Promotion Fund, 2012). Cycling is also known to have several economic benefits. Compared to non-cyclists, regular cyclists take one less sick day per year. This equates to $61.9 million saved by businesses per year (Australian Bicycle Council and Cycling Promotion Fund, 2012). In addition to health-related cost savings, the Federal Government forecast that $13 billion congestion-related costs would be saved if bicycle use were to double by 2020 (DOIT, 2013). In Australia commuting by bicycle for 20 minutes has been estimated to save the economy over $14 per trip (DOIT, 2013).

In recognition of these benefits the *National Cycling Strategy 2011-2016* (NCS) has prioritised the promotion of cycling as a safe, viable, enjoyable mode of transport and recreation, with the ultimate aim to enable people to cycle safely (Australian Bicycle Council, 2010). The NCS also identifies the need for continued development of road safety educational programmes to minimise the risks of cycling, and the importance of targeting children to ensure generational change.

According to the 2013 national cycling participation survey (Munro, 2013) 87,000 residents of Canberra ride in a typical week and 169,000 ride at least once a year; in Canberra, residents' use of bicycles for commuting (to work or education) and shopping is higher than the national average and there has been an increase in cycling participation. Although statistics tracking the transportation of young children by bicycle are not recorded anywhere, it is possible that this will increase in line with general increases in cycling participation. Anecdotally, the transportation of children as bicycle passengers is increasing and the introduction of European-style cargo bikes and other specialised carriers has led to greater variety in the types of carriers being used (e.g., Carroll, 2014).

The increase in use of carriers that are new to Australia has raised questions regarding their safety (Carroll, 2014). These questions are primarily related to design standards, which consider aspects such as protrusions, sharp edges, shields to protect from entanglement in wheel spokes, and the presence of safety harnesses. Consequently, the Australian design standards for child carriers have undergone review in order to address these concerns. While the focus on design standards is important, consideration of occupant protection from injuries sustained in collisions or falls has been largely overlooked. Given the variety of carriers now available, comparisons of child carriers in terms of occupant safety may be an important consideration for parents contemplating transporting children by bicycle. While such information is available for cars and child restraints (i.e., car seats), no such information is available for child carriers attached to bicycles.

1.1 Current state of knowledge

While understanding of the numerous aspects of cyclist safety for adult cyclists continues to improve, the safety of child bicycle passengers has been largely overlooked by the scientific community. The following presents a summary of the current state of knowledge regarding the safety of transporting children by bicycle.

Research conducted in the US in the late 1980s estimated that injuries to bicycle passengers represent 97-99% of all bicycle-related injuries for children aged up to three years old. This would suggest that this is the age group most likely to be transported as a child passenger. In general, the number of injuries associated with child carriers is low with fewer injuries observed for trailers compared to bicycle-mounted seats (Powell & Tanz, 2000). It has been noted that the use of bicycle-mounted seats can alter the stability of the bicycle, while falls can be particularly dangerous for children as their physical stature and development is not sufficient to cope with the adult-level forces imposed by the speed and height of the bicycle in falls (Murray & Ryan-Krause, 2009). These risks are somewhat reduced by trailers.

Trailers have a number of features that reduce the likelihood of injuries. Due to a wide wheel-base and low centre of gravity trailers are generally quite stable. They are mounted to an adult's bicycle using universal mechanisms, which reduce the likelihood of the trailer tipping over, even when the bike to which it is attached tips over (Murray & Ryan-Krause, 2009; Powell & Tanz, 2000), although instances of trailers tipping over have been recorded (Powell & Tanz, 2000). While being low to the ground is good for stability and reduces the height at which passengers fall in the event of a tip over, it has been noted that trailers may be susceptible to tipping due to bumps, and the low stature may increase the risk of collision with a motor vehicle. Another potential source of injury is the rear wheel of the adult's bicycle should the trailer or passenger be propelled forward in some manner –at least one such injury has been recorded (Powel & Tanz, 2000). The use of adequate restraints can prevent child passengers falling from the trailer. Trailers also provide protection from the elements (rain and sunshine), and have roll-bars that prevent the trailer from collapsing during rollovers and collisions (Murray & Ryan-Krause, 2009).

While it is possible that trailers are indeed safer than seats, the lower injury numbers in available research may also be attributed to the greater popularity of bicycle-mounted seats in the market. Seats are more commonly used as they are less expensive, and easier to install and position children in than trailers (Murray & Ryan-Krause, 2009).

The incidents most often leading to the injury of child passengers are falls while a bicycle is either stationary or in motion (Hagel et al., 2015; Murray & Ryan-Krause, 2009; Powell & Tanz, 2000; Sargent et al., 1988; Tanz & Christoffel, 1991). The child falling from the seat and the seat (and child) becoming detached and falling from the bicycle are the most common mechanisms of injury, while the entanglement of extremities (usually legs or feet) in the spokes has also been identified as an issue of some concern (Bruggers & Mulder, 1995; Powell & Tanz, 2000; Sargent et al., 1988; Tanz & Christoffel, 1991). A small proportion of injuries involve collisions with motor vehicles (Hagel et al., 2015; Tanz & Christoffel, 1991).

A study investigating the causes of injuries arising from objects or bicycle parts becoming entangled in the wheels of a bicycle found that those most likely to be injured are small children who are passengers (Bruggers & Mulder, 1995). This study also found that there was an increased risk of an injury due to wheel entanglement when carrying inexperienced or multiple passengers, and when passengers sit backwards. These findings suggest that transporting passengers without the use of appropriate or correctly installed carriers increases the risk of this type of injury.

Further to the mechanisms that lead to the injury of child passengers, a number of studies have also considered the nature and severity of injuries. Head injuries are the most commonly reported injury for child passengers followed by the face and lower extremities (Sargent et al., 1988; Tanz & Christoffel, 1991). Another study examining paediatric bicycle injuries, which, although not generally identified, includes injuries to child passengers, has found multiple injuries to be common, followed by head injuries, abdomen/genitalia, and extremities (Teisch et al, 2015). Teisch and colleagues (2015) found internal injuries to be most common, accounting for around one half of all injuries, followed by fractures (one in five) and contusions (around one in eight). Although the findings apply to all paediatric bicycle injuries, including older children riding their own bicycles, injuries to child passengers may follow a similar pattern. Other studies examining cycling-related injuries in general (i.e., samples include all cyclists with no specific focus on children or child passengers) show that while most cycling-related injuries are minor (i.e., not requiring follow-up treatment or admission to hospital), injuries sustained in crashes with motor vehicles are generally more severe and involve a greater likelihood of admission to hospital (Bilston & Brown, 2005; Ng et al., 2001).

1.2 Gaps in knowledge

The safety of child passengers has received little attention, with much of the research that has been done focussing on injuries sustained in either rear-mounted seats or towed trailers, and being limited to studies undertaken in the USA and Japan. While these studies provide some insight into this issue there are a number of important questions that remain unanswered. First, there are currently more types of child carriers available than at any time previously, some of which offer different methods for transporting children. At present there is no information regarding the safety performance of carriers other than rear-mounted seats and trailers. As such it is necessary to investigate the safety performance of other types of carriers; it is possible that some types perform differently to others.

While a little is known about the types of injuries sustained by child passengers, this information is again limited to rear-mounted seats and trailers, and knowledge regarding the causes and mechanisms of injuries associated with all carriers is limited. Little is known about the injury outcomes associated with different types of incidents or mechanisms.

The largest gap in knowledge is that nothing is known about the actual practice of child transportation by bicycle. There is no information regarding the prevalence of child transportation or characteristics of the cyclists who transport or the children they transport. There is no information about the types of carriers in use and why they are used. There is no information regarding whether cyclists and their passengers are exposed to the same types of risks associated with cycling in general when transporting child passengers, nor regarding the strategies or behaviours that transporting cyclists adopt to reduce these risks.

This project seeks to address some of these gaps by being the first of its kind to undertake a comprehensive examination of the practice of transporting child passengers by bicycle.

1.3 Aims

As described above, there is a global lack of knowledge regarding the safety of children transported as the passenger on a bicycle. In order to address this problem, the research undertaken as part of this project was designed to provide answers to the following research questions:

Research Question One: What is the nature and extent of the problem?

Addressing this question requires consideration of three key issues:

a) Characteristics of people who transport children and the children they transport
b) The types of carriers that people use
c) The factors influencing the use of child carriers

Research Question Two: What are the key safety issues?

In order to answer this question the research focussed on two issues:

a) The causes and mechanisms of child carrier injuries
b) The potential differences in injury types and severity for different carriers

Research Question Three: What measures and initiatives have the potential to reduce the incidence and severity of bike carrier injuries?

Answering this question requires consideration of the knowledge obtained when addressing research questions one and two.

1.4 Structure of the report

In order to answer these questions three different approaches were adopted. The methodology and results of each approach are contained in separate sections of the report as follows:

- Section 2 describes the analysis of official hospital injury data. This approach examined the prevalence, nature, and outcomes of injuries to children transported by bicycle. This section addresses research questions one and two.
- Section 3 describes the findings of a comprehensive self-report survey of adult cyclists. This survey investigated child transportation practices and the incidents leading to, and mechanisms of, injuries sustained by child passengers. This question addresses research questions one, two, and three.
- Section 4 describes several key issues identified during discussions held with key cycling stakeholders. This section addresses research questions one and three.
- Section 5 is a discussion providing a synthesis of the findings of these research activities and includes recommendations to improve safety for child passengers.
- Finally, an example of an educational resource regarding the transportation of child passengers drawing on the evidence produced by this project and other relevant works is provided in Appendix A.

2 Injury data

In general, bicycle crashes are under-reported to police (Boufous et al., 2013; Sikic et al., 2009). Evidence also indicates that many injuries associated with child bike carriers involve falls while stationary and other non-traffic incidents (Tanz & Christoffel, 1991). As such it is likely that many child carrier related injuries are not reported to police. Therefore, the best information sources regarding injuries while being transported in a child carrier are hospital emergency department presentation and hospital admission data.

2.1 Method

To undertake an analysis of the nature and prevalence of child carrier-related injuries, and injury outcomes, data were extracted from the Victorian Admitted Episodes Dataset (VAED) and Victorian Emergency Minimum Dataset (VEMD) from 1999 to 2014. The datasets, held by the Victorian Injury Surveillance Unit (VISU), were supplied by the Department of Health as de-identified subsets of injury admissions and emergency department (ED) presentations, respectively. The VAED were obtained from all Victorian public and private hospitals and the VEMD were collated from all Victorian public hospitals with 24-hour Emergency Departments.

Cases in the VAED were selected if the patient was aged 10 years or younger and the external cause codes were in the range of 'V10'–'V1999' which represents pedal cyclists, including passengers of pedal cyclists, injured in transport collisions according to the International Classifications of Diseases 10 – Australian Modification (ICD 10-AM) manual (ICD-10-AM, 2008). The variables identified for the VAED include rider/passenger characteristics (age, sex and activity), injury cause and body region, nature of main injury, location, length of hospital stay and separation type. As each record in the dataset represents an episode of care, transfers between and within hospital for various episodes of care relating to injuries arising from one or more incidents are reported as more than one record. Data regarding such cases as well as identifiable re-admissions to the same hospital within 30 days were excluded.

Cases in the VEMD were selected if the age of patients were less than or equal to 10, and injury cause was equal to 5 (Pedal cyclist – rider or passenger). The variables identified include passenger characteristics (age, sex and activity), injury characteristics (cause, body region and nature of main injury), location and departure status. Other collected variables include a 250 character text description of the injury event.

A text search in the description of event variable for the terms 'passenger', 'dink' and 'rider' enabled the identification of passengers and riders. A search of the text narrative including the terms bicycle, child, seat, passenger, trailer and carrier and their synonyms and derivatives was also conducted. Relevant cases were ultimately selected through a manual check. Each record in the VEMD represents the first presentation for treatment of injuries arising from an incident.

Pedal cyclists were classified into three groups: 0-3 years of age, 4-6 years of age and 7-10 years of age. These age groups were selected as they represented children most likely to be injured as a passenger on a bicycle (0-3 years), children transitioning between passengers and riders (4-6 years) and children who are most likely to be injured while riding a bicycle (7-10 years).

Statistical analysis was undertaken using STATA 13. Aggregate analyses were undertaken focussing on frequencies and cross-tabulations. Chi-squared tests were applied with post hoc testing of adjusted standardised residuals used to identify associations between variables of interest. In cases for which a significant relationship was observed, Cramer's V (φ_c) was used as a measure of the effect size. A φ_c

of 0.1 is considered to be a small effect, 0.3 medium, and 0.5 large. Trend data was analysed using log-linear regression model to assess estimated annual percentage change and 95% confidence intervals.

2.2 Results

During the fifteen year study period between July 1999 and June of 2014, a total of 17,859 emergency department presentations and 4,794 hospitalisations were reported for children pedal cyclists, including passengers, under the age of 10 years. A summary of the number of hospitalisations and emergency department presentations for each age group is presented in Table 2.1.

Table 2.1
Child cyclist hosptial admissions and emergency department presentations

Age Group	Emergency department presentations	Hospital admissions	Total
0-3 years	2,491	515	3,006
4-6 years	4,988	1,384	6,372
7- 10 years	10,380	2,895	13,275
Total	17,859	4,794	22,653

Overall there has been a slight reduction in the absolute number of child pedal cyclist injuries over the past 15 years. The number of emergency department presentations remained relatively stable over the period with 1,170 presentations in 1999/2000 and 1,168 in 2013/14. Over the same time period hospitalisations fell from 363 in 1999/2000 to 239 in 2013/14, representing an estimated annual reduction of 3.9% (-5.2% to -2.6%). While these figures represent only a modest reduction in the overall number of child pedal cyclist injuries, over the study period the population of children under the age of 10 increased by 15.3% in Victoria (ABS, 2014). As such, when adjusted for age, the rate of emergency department presentations reduced from 52.2 presentations per 100,000 residents in 1999/2000 to 29.8 per 100,000 in 2013/14 and the rate of hospital presentations fell from 168.2 per 100,000 in 1999/2000 to 145.5 in 2013/14, representing estimated reductions of 1.5% (-2.8% to -0.2%) and 5.0% (-6.5% to -3.4%) respectively.

Overall, the drop in the number and rate of child pedal cyclist injuries was largely due to reductions in the rate of injuries to children aged four years and older with the rate of hospital admissions for children between the ages of four and 10 years falling from 73.9 per 100,000 to 40.6 per 100,000 over the 15 year study period. This represents an estimated reduction of 4.8% (-6.4% to -3.3%). The rate of emergency department presentations for children aged 4-10 years also fell from 230 per 100,000 to 194 per 100,000, an estimated reduction of 1.6% (-2.9% to -0.2%). Conversely, the rates of pedal cycle hospitalisations and emergency department presentations has remained steady for children below four years of age.

Comparison of gender of injured cyclists revealed that males were involved in approximately 69% of hospital admissions and 66% of emergency department presentations. No significant sex differences were observed between the three different age groups.

Analyses were undertaken to examine body regions injured amongst child cyclists. For emergency department presentations, the most commonly injured body parts included the head (34.9%), elbows and forearms (14.6%) and wrist and hands (16.3%). For hospital admissions, the head was again the most commonly injured body region (36.5%), followed by the elbow and forearm (26.7%) and shoulder and upper arm (9.1%) (Table 2.2).

Comparisons of injured body regions between age groups revealed that children under the age of four years were significantly more likely to sustain injuries to the head and neck that required hospital admissions ($\chi^2_{(2)}$=258, p<0.01 φ_c= .232), or presentation to an emergency department ($\chi^2_{(2)}$=1785, p<0.01 φ_c= .316) compared to older age groups. In contrast, older children, between the ages of seven and 10 years, were significantly more likely to sustain injuries to either the arms, wrists and hands for both emergency department presentations ($\chi^2_{(2)}$=560, p<0.01 , φ_c= .177) and hospital admissions ($\chi^2_{(2)}$=78, p<0.01 , φ_c= .128).

Table 2.2
Child cyclist hosptial admissions and emergency department by body region

Body region	Emergency Department Presentations			Hospital Admissions		
	0-3 years	4-6 years	7-10 years	0-3 years	4-6 years	7-10 years
Head	1,459	2,475	2,303	299	652	797
Neck	5	38	77	-	14	30
Thorax	-	-	131	-	5	17
Abdomen, lower back, lumbar spine & pelvis	35	163	395	12	74	267
Shoulder & upper arm	53	159	473	52	147	236
Elbow & forearm	274	568	1,774	93	243	942
Wrist & hand	245	508	2,162	18	65	171
Hip & thigh	8	59	299	13	42	113
Knee & lower leg	85	294	1,218	18	97	241
Ankle & foot	230	427	890	7	37	67
Other	97	297	658	3	8	14
Total	2,491	4,988	10,380	515	1,384	2,895

For emergency department presentations the most common injury types included open wounds (30%), fractures (19%), superficial injuries (18%) and dislocations and sprains (14%). Fractures were the most common injury requiring hospitalisation (47%), followed by open wound (28%). Analysis of the nature of injury also revealed a small proportion of very serious injuries including 786 intracranial injuries, 109 injuries to internal organs, 39 traumatic amputations, and 14 injuries resulting in nerve or spinal cord damage (Table 2.3).

Table 2.3
Child cyclist hosptial admissions and emergency department by nature of injury

Nature Of Injury	Emergency Department Presentations			Hospital Admissions		
	0-3 years	4-6 years	7-10 years	0-3 years	4-6 years	7-10 years
Fracture	315	759	2,373	201	573	1,462
Open Wound	993	1,863	2,546	197	498	643
Intracranial Injury	91	142	226	27	78	222
Superficial Injury	472	1,019	1,791	16	63	167
Injury To Internal Organs	*	*	27	*	*	82
Dislocation, Sprain & Strain	229	459	1,874	23	31	53
Injury To Muscle & Tendon	34	95	365	*	*	18
Traumatic Amputation	9	6	10	*	*	14
Injury To Nerves & Spinal Cord	*	0	*	*	0	*
Injury To Blood Vessels	*	*	20	0	0	5
Crushing Injury	40	40	53	0	*	*
Burns	6	6	10	*	*	0
Eye Injury- Excl. Foreign Body	20	26	28	*	*	0
Other & Unspecified Injury	282	573	1,057	42	93	221
Total	2,491	4,988	10,380	515	1,384	2,895

Note. Cells with values less than 5 have been replaced by an asterisk (*) as a privacy protection measure.

Further analysis of the nature of injury revealed that, compared to older children, children under the age of three had a significantly higher number of open wound injuries that required presentation to an emergency department ($\chi^2_{(2)}$=389, p<0.01 , φ_c= .148) or hospital admission ($\chi^2_{(2)}$=118, p<0.01 , φ_c= .158). Children over the age of three presented to the emergency department with significantly more fracture injuries ($\chi^2_{(2)}$=208, p<0.01 , φ_c= .108). This trend was also seen for injuries requiring hospitalisation ($\chi^2_{(2)}$=44.5, p<0.01 , φ_c= .096).

For hospital admitted patients, analysis of the duration of hospital stay revealed that the majority of child pedal cyclists were admitted to hospital for less than two days (84.7%). Children under the age of three were significantly more likely to require a hospital stay of less than two days ($\chi^2_{(2)}$=28.1, p<0.01 , φ_c= .077), compared to children over the age of two years, who were more likely to require a hospital stay between two and seven days. Approximately 92% of children were discharged to a private residence following their hospital stay with 8% requiring transfer to an acute hospital care or extended care facility. There were no significant differences between the three age groups for separation type ($\chi^2_{(2)}$=.36, p=.835).

3 Survey

3.1 Method

The self-report survey was conducted as an on-line survey using the Survey Monkey platform. Participants were recruited via online cycling forums, social media sites of cycling organisations or cycling interest groups (e.g., Facebook), and cycling advocacy groups from some states also promoted the survey among members (e.g., through email or regular newsletters). The survey was distributed nationally in order to maximise the sample.

3.1.1 Participants

To be eligible for the study, participants had to be a cyclist and the parent of a child aged five years or younger. Non-cyclists and cyclists with children older than 5 years were excluded. A sample of 100 participants (74% male) aged 24 to 58 (M=39.46, SD=6.35) completed the survey. The majority of the sample (94%) reported transporting at least one child aged up to five years by bicycle. Of these most transported one (69%) or two (29%) children with the remainder transporting three (1%) and six (1%) children, respectively. Approximately half (52%) of the sample reported riding a bicycle five or more days per week in the past 12 months. The number of bicycles a person owns can also provide an indication of how involved in cycling a person is. In the present sample, the number of bikes owned ranged from one to 13, with 80% owning more than one bicycle. Two bikes was most common (27%) followed by one (20%), three (20%), and four (16%). In terms of trip type, 94% reported participating in recreational cycling, 92% commuting/utility, and 59% sport/exercise. The pattern of trip type frequency was largely as expected, with commuting/utility occurring multiple days per week, and recreational and sport/exercise cycling occurring less frequently.

3.1.2 Measures

The survey was developed to capture a range of information regarding the transportation of child passengers. Survey development was informed by discussions with three child-transporting cyclists recruited via posts on a local cycling on-line forum in Adelaide, South Australia. These discussions helped identify response options, particularly regarding the identification of risks and the strategies employed to help reduce these.

The survey was divided into several sections obtaining information in the following areas:

1. Participant demographics including age, sex, education, state of residence, number of children, and age and sex of children under five years of age. Responses were made via a combination of multiple choice and free-text entry.
2. Cycling characteristics: annual riding frequency (including frequency of three different trip types - see definitions below), number of bicycles owned, and riding behaviours such as helmet and light use, conspicuity of clothing, and use of different types of infrastructure. Responses to these items involved a combination of likert scales, multiple-choice, and free-text entry.
3. Crash history details of most recent crash for trips when riding alone (i.e., without child passenger). Details included age, day, time, trip purpose, helmet use, clothing type and colour, infrastructure used, and counterpart in the crash (if any). Where participants were involved in a crash information regarding injuries to self and child passengers was also obtained. This covered body location of injury, nature of injury, and medical treatment received. Participants were able to provide details of the most significant injury, other

significant injury and three other injuries. Responses were made using multiple choice and free-text entry.

4. Near misses: participants indicated the frequency with which they experienced 15 types of near-miss incidents when riding alone. These questions were also duplicated in a section concerned with riding with child passengers. Responses were made on a five point likert scale ranging from Never (0) to Every time (4).
5. Non-crash incidents were also examined, with participants reporting details of any incident in which they or their child passengers sustained an injury. Responses were made using a combination of multiple choice and free-text entry.
6. Perceived risks: participants reported the extent to which various cycling behaviours increased or reduced safety when riding a bicycle. Responses to these questions were made on a seven point likert scale ranging from Significant reduction in crash risk (1) to Significant increase in crash risk (7).
7. Child transportation data: experience transporting children (i.e., how long the participant had been transporting child passengers), age and sex of children, frequency of transporting children, trip purpose, child carrier(s) used (including reasons for use, and other carriers considered). Responses to these questions utilised a combination of multiple choice, likert scales, and free-text entry.
8. Crash history when transporting child passengers. These questions were identical to those asked for solo crash history with the inclusion of additional questions to determine characteristics of the child passenger(s) (age and sex), types of carriers used, child helmet use, and child injuries. Participants were able to provide injury details for up to seven child passengers, which was the maximum number of passengers considered possible based on: a cargo trike (4), seat behind rider (1) and a towed trailer (2). Responses to these questions were made via multiple choice or free-text.
9. Injuries to child passengers due to non-crash incidents: Incident data was the same as that recorded for crash history. Responses to these items were made using multiple choice and free-text entry.
10. Risk management when transporting children: participants identified up to five main risks when transporting children by bicycle and described up to five corresponding strategies (if any) employed to reduce these risks. Responses to these items were made using free-text entry.
11. Rider injuries caused by a carrier. These questions included details of the incident and injury details were recorded using the same set of questions for crash and non-crash injuries. Responses were made using multiple choice and free-text entry.
12. Other transport use: whether the participant drives, owns a car, how often they drive, how often they drive with child passengers, main mode of transport for five different activity types (commuting, shopping, attending appointments, attending events, visiting friends/family), circumstances when not transporting children by bike, and transport used in such cases. Responses to these items were made using a combination of multiple choice, likert scales, and free-text entry.
13. Transporting parents were also asked whether their child liked being a passenger on their bicycle. All participants were also provided the opportunity for further comments regarding the safety of transporting children by bicycle. Responses were made using multiple choice and free-text entry.

The survey questions for non-transporting parents were similar although any questions regarding child passengers (e.g., crashes when transporting, injuries due to child carrier, risks to safety when transporting, risk management when transporting children, rider injuries caused by a carrier) were excluded. Non-transporting parents were asked why they did not transport children and also reported other transport use.

3.1.3 Definitions

To ensure consistency in responses, it was necessary to provide definitions of several key concepts. Participation in three different trip types were explored. *Commuting/utility cycling* was defined as cycling trips taken to get to place of employment/study, shopping trips, travel to appointments, visit friends or travel to sport/concerts/other events, etc. *Recreational cycling* was defined as riding for leisure in spare time and may be a social ride with friends. *Sport/exercise cycling* was defined as riding as part of an organised competition, in organised group/bunch rides, or for exercise, either as part of a group or alone. The group ride may be social but the core aim of the ride in this case is fitness.

A crash was defined as any incident in which the participant had fallen off their bicycle due to loss of control, collision with another road user (pedestrian, motor vehicle, another cyclist, or animal), collision with an object (e.g., tree, kerb, sign post, etc.), or something entangled in the wheel spokes causing them to fall. The rider did not need to sustain an injury for an incident to be classified as a crash.

Non-crash incidents were defined as any incident resulting in injury where a collision with another road user or object did not lead to the injury. Examples of non-crash incidents include a fall due to not removing feet from pedals fast enough, a bike tipping over while loading/unloading a child, or loss of balance when stationary.

3.2 Findings

3.2.1 Types of carriers used to transport child passengers

Regarding the transportation of children by bike, participants' experience ranged from .01 to 27 years (M=3.58, SD=3.66). The number of children transported ranged from one to six, with most participants transporting one (69%) or two (29%) children.

The types of carriers used are shown in Table 3.1. Among the 94 transporting parents a total of 154 carriers were used. The most common type of carrier in use is a child seat behind the rider. Seats mounted behind the rider account for about one third of all carriers used but were used by half of transporting parents.

Table 3.1
Types of carriers used to transport children

Type of carrier	N	Proportion of carriers	Proportion of participants using type of carrier[a]
Seat behind rider	47	29%	50%
Trailer	29	18%	31%
Seat in front of rider	27	17%	29%
Cargo bike	18	11%	19%
Trail-a-bike or similar	16	10%	17%
Long-tail cargo bike - platform only	14	9%	15%
Cargo trike	5	3%	5%
Tandem	4	3%	4%
Total	159	100%	

[a]Total is greater than 100% due to use of multiple carriers

The reasons reported for using different options are provided in Table 3.2. In order to identify the benefits associated with each type of carrier more clearly, the proportion of participants who used a specific option who endorsed each of the reasons for using or purchasing that carrier type is provided in Table 3.3.

Table 3.2
Reasons for using/purchasing different child carriers: number of users endorsing reason

Type of carrier	Reason for use							
	1	2	3	4	5	6	7	8
Seat behind rider	2	-	4	6	6	13	38	18
Seat in front of rider	1	2	2	1	2	11	20	18
Trailer	-	13	16	2	3	17	23	23
Trail-a-bike	-	2	3	-	2	3	9	6
Long-tail cargo - platform only	-	7	11	-	2	6	11	8
Cargo trike	-	3	4	-	1	3	3	3
Cargo bike	1	7	7	1	2	7	11	11

Note. 1 = Only carrier available in shop, 2 = Need to carry other gear, 3 = Need to transport more than one child, 4 = Cheapest available, 5 = Value for money, 6 = Safety features, 7 = Practicality/ease of use, 8 = Comfort of child.

Table 3.3
Reasons for using/purchasing different child carriers: proportion of users endorsing reason

Type of carrier	Reason for use							
	1	2	3	4	5	6	7	8
Seat behind rider	4%	-	9%	13%	13%	28%	81%	38%
Seat in front of rider	4%	7%	7%	4%	7%	41%	74%	67%
Trailer	-	45%	55%	7%	10%	59%	79%	79%
Trail-a-bike	-	13%	19%	-	13%	19%	56%	38%
Long-tail cargo - platform only	-	50%	79%	-	14%	43%	79%	57%
Cargo trike	-	60%	80%	-	20%	60%	60%	60%
Cargo bike	6%	39%	39%	6%	11%	39%	61%	61%

Note. 1 = Only carrier available in shop, 2 = Need to carry other gear, 3 = Need to transport more than one child, 4 = Cheapest available, 5 = Value for money, 6 = Safety features, 7 = Practicality/ease of use, 8 = Comfort of child.

The main reasons reported for using most of the carrier options were practicality of use and comfort of child followed by safety features. Larger carriers such as trailers and cargo bikes/trikes were considered to be good options for carrying multiple children and other gear, a capability found lacking for seat attachments.

3.2.2 Incidents and injuries

Three separate types of incidents and associated injuries were explored. First were crashes while transporting child passengers, including injuries to both the adult rider and child passenger(s). Second were injuries to riders and passengers arising from non-crash incidents. Finally, we examined the potential for rider injuries caused by the child carrier (e.g., being struck by the carrier).

Crashes while transporting child passengers

A crash was defined as any incident in which the participant had fallen off their bicycle due to loss of control, collision with another road user, or something entangled in the wheel spokes causing the rider to fall.

Eleven instances of a crash when transporting a child were reported. Cyclist characteristics included five male riders and six female riders aged 33 to 49 years (*M*=38.64, *SD*=4.5). Experience transporting children at the time of the crash ranged from 0.5 to 12 years (*M*=3.41, *SD*=3.40 years) with around two thirds (63.6%) of parents having two years or less of experience transporting child passengers. The majority of cases involved only one child passenger but two cases involved two child passengers. In total there were 10 male and four female child passengers involved ranging in age from less than one year to five years of age (*M*=3.0, *SD*=1.3 years).

Examination of injuries found that four of the adult cyclists sustained minor injuries in the crash, the remainder reporting no injury. The nature and treatment of injuries sustained by adult cyclists are displayed in Figure 3.1. No injuries to child passengers were reported.

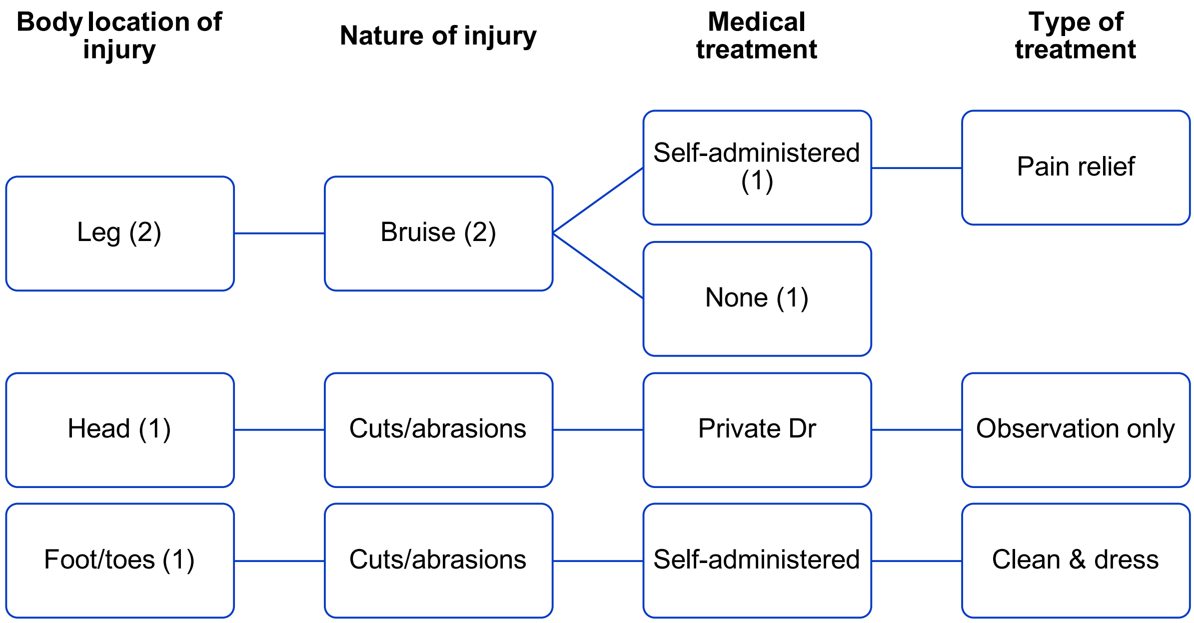

Figure 3.1
Nature and treatment of injuries sustained by adult cyclist in crashes when transporting children (n=4)

Analysis of the crash details revealed that in nine cases the trip type was commuting/utility while two cases were recreational trips. Five of the reported incidents occurred on a footpath, with one each on the following: shared path, cycle path, pedestrian crossing, road with bike lane, road without bike lane, and car park. No other road user was involved in eight cases, two involved motor vehicles identified as a car, ute, van, or 4WD, and one involved another cyclist. The presence of a child passenger was reported to contribute to the incident in four cases, two due to altered balance of the bicycle and two due to the presence of the child and carrier (i.e., because they were transporting the child the carrier was present: in both cases it was a towed attachment striking something that caused the crash). The infrastructure present, other road users involved, and a short description of incidents are provided in Table 3.4.

Table 3.4
Infrastructure, other road users involved, and brief description of crashes occurring when transporting child passengers

Infrastructure	Other road user	Description of incident
Footpath		
	None	Misjudgment on narrow footpath resulted in clipping a fence and causing the bike to tip over.
	None	Accidentally rode onto the nature strip, bike tipped as a result.
	None	Lost balance and tipped over when performing slow turn manoeuvre due to being clipped into pedals .
	None	Focused on carefully passing disabled pedestrian, going slow, tyre slipped off footpath and bike fell. Pedestrian not hit.
	None	Cycling on footpath and the trailer wheel hit the kerb causing trailer to tip over.
Shared path		
	Cyclist	Involved in a collision with another cyclist.
Cycle path		
	None	Training wheels on trail-a-bike caught in tram tracks.
Pedestrian crossing		
	Car, ute, van, or 4WD	Crossing road using pedestrian crossing, motor vehicle failed to stop for red light. Lost balance when stopped suddenly - van stopped without contacting cyclist.
Road with bike lane		
	Car, ute, van, or 4WD	Stopped at red light. When it changed to green commenced travelling straight, car along side turned left in front.
Road without bike lane		
	None	Stopping for red light, skidded on something on road surface, cargo trike overturned and wheel came off.
Car park		
	None	Chain slipped off and brake jammed.

Non-crash incidents

A non-crash incident included any incident resulting in injury in which a collision with another road user or object did not lead to the injury.

Eight child passengers were injured in non-crash incidents. The incident and treatment of associated injuries are displayed in Figure 3.2. These primarily involved stationary or very slow moving bicycles falling over: three incidents involved a stationary bike tipping over while loading or unloading a passenger, while a fourth incident involved a bike tipping over while performing a very slow (almost stopped) turn manoeuvre. One incident resulting in injury was caused by a bicycle trailer tipping over when the bicycle to which it was attached tipped over. The non-crash incident and associated injuries and treatment were unknown in two cases due to missing data. In all known cases the child passenger received minor injuries the treatment for which was most commonly administered at home and involved observation of the child, pain management, or cleaning and dressing a wound.

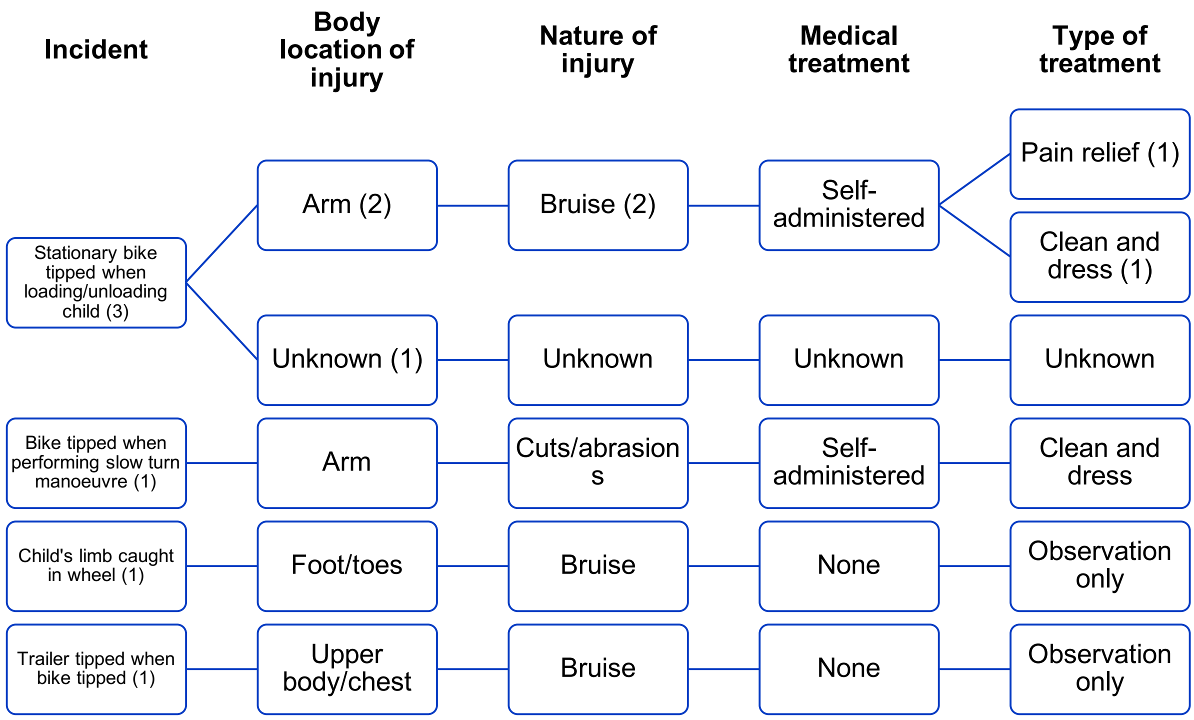

Figure 3.2
Nature and treatment of injuries to child passengers sustained in non-crash incidents (excludes unknown cases, n=2)

In six of the incidents the presence of a child passenger was reported to contribute to the incident. In the three incidents of a stationary bike tipping over, changes to the balance of the bike with the presence of a child passenger was reported as the contributing factor in two cases. In the remaining incident the child sitting in a rear-mounted seat pushed against the object on which the bike was leaning, tipping it over. In the incident involving the child's limb caught in the wheel, the incident could not have occurred if a child passenger was not present. While the presence of a child passenger was reported to contribute to the incident in which the trail-a-bike attached to an adult's bicycle tipped over when the adult's bicycle tipped, the reason for this was not provided. The presence of a child passenger was not reported to contribute to the incident in which the bike tipped during a slow turning manoeuvre. A summary of the types of carriers used, the involvement of child passengers, and the reasons for the incident are provided in Figure 3.3.

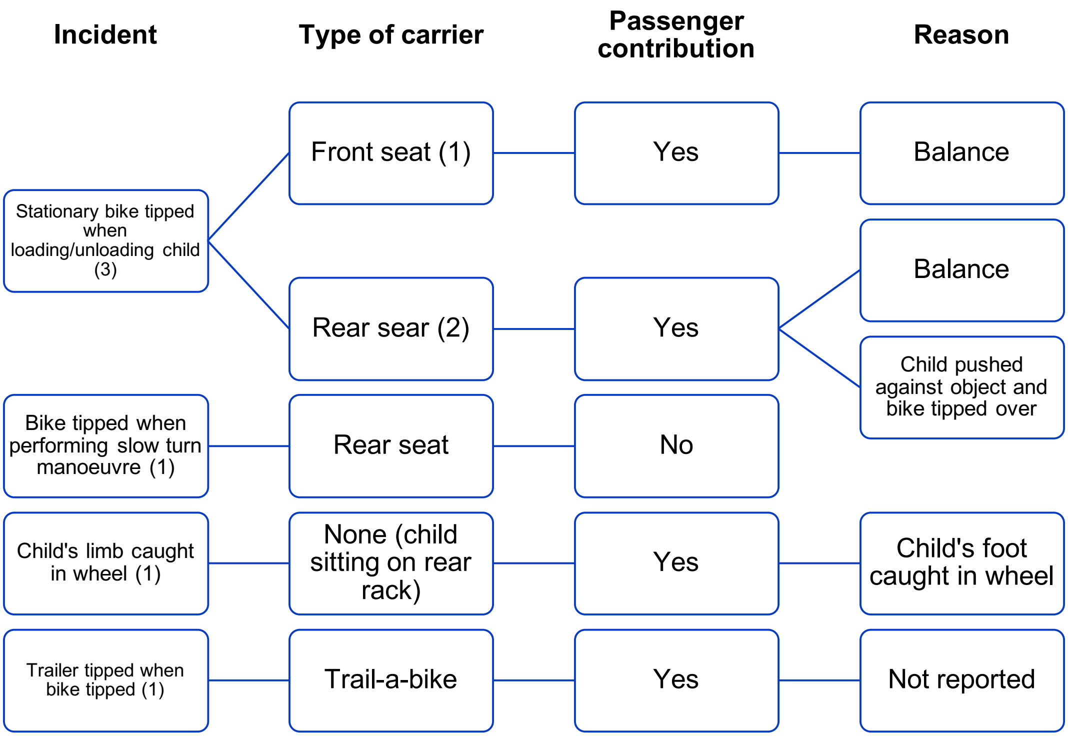

Figure 3.3
Type of carrier and passenger contribution for non-crash incidents in which a child passenger was injured (excludes unknown cases, n=2)

Adult cyclist injuries caused by a carrier

No participant reported being injured by any child carrier. While the potential for such injuries cannot be ruled out by this study, the potential for injuries arising in this manner would appear to be very small. Alternatively, it is possible that injuries caused by carriers were very minor and not considered by participants to be injuries at all or worth reporting (e.g., skin pinched in restraint buckle).

3.2.3 Reasons why some parents do not transport their children by bicycle

Comparison of transporting participants (n=94) with non-transporting participants (n=6) revealed that two thirds of the former and about three quarters of the latter had been involved in a crash as a single cyclist. It was thought that involvement in a crash might influence people's decisions to transport their children but this does not appear to be the case. When examining the reasons for not transporting the majority of participants indicated the reason for this was their child being too young (n=4). One participant reported not having the need to and that the number of children was more than they would be able to transport. Only one respondent suggested they chose not to transport because they felt child seats and other options do not offer suitable protection for children or may be difficult for drivers to see (and thus avoid), or would reduce stability of the bicycle.

At the outset of this project it was our intention to compare transporters to non-transporters to see if there were any differences between these groups but the small sample of non-transporting participants made this infeasible.

3.2.4 Near misses, perceived risks, and risk management

This section addresses participants experiences of near misses, riding behaviour, perceived risk, and risk management when riding alone and when transporting children.

Near misses

Participants' self-reported experiences of near misses when riding alone were compared with those experienced when riding with child passengers using paired-samples *t*-tests; the results are provided in Table 3.5. When transporting child passengers cyclists experienced near misses significantly less often than when riding alone for almost every type of near miss described. There were no significant differences in the experience of mechanical faults, falling when mounting or dismounting, or from a problem clipping into or out of pedals; such events were extremely rare when riding alone or with passengers.

Figures 3.4 and 3.5 respectively provide the self reported frequencies for which near misses were experienced when riding alone and when transporting children. It should be noted that experience of many near miss types were infrequent. Figure 3.5 also includes the frequency of near misses arising from tip overs when loading or unloading a passenger (a situation not present when riding alone). Another point of interest observable in both Figures is that near misses that are attributable to the actions of other road users (e.g., vehicle passing within 1m, vehicles failing to give way, etc.) are more common than those over which the cyclist has most control (e.g., loss of control on a slippery surface, misjudge the speed of an approaching vehicle, problem unclipping from pedals, etc.).

Table 3.5
Comparison of near misses when riding alone versus transporting children

Type of near miss	Riding alone		Transporting children		$t(df)^a$	p	Cohen's d
	M	SD	M	SD			
Vehicle passing within 1m	2.56	1.02	1.65	1.13	7.029 (71)	<.001	0.83
Cut off by a vehicle turning left or right	1.72	1.00	1.20	1.05	4.115 (70)	<.001	0.49
A vehicle failed to give way at a T-junction	1.50	0.99	1.01	1.06	4.415 (71)	<.001	0.52
A vehicle failed to give way at a cross road	1.58	0.93	1.04	1.04	4.772 (71)	<.001	0.56
A vehicle failed to give way at or on a roundabout	1.68	1.05	0.96	1.00	5.554 (71)	<.001	0.65
Swerve to avoid suddenly open car door	1.37	0.98	0.82	0.95	6.275 (72)	<.001	0.73
Motor vehicle stopped suddenly in your lane of travel	1.13	0.92	0.72	0.76	4.02 (71)	<.001	0.47
A vehicle turning through a gap in traffic nearly hit you	1.36	1.03	0.58	0.77	7.402 (71)	<.001	0.87
Run off the road by another vehicle	0.86	0.91	0.40	0.60	4.736 (71)	<.001	0.56
A pedestrian or animal unexpectedly stepping into your path	1.44	0.82	0.89	0.90	4.974 (71)	<.001	0.59
Loss of control on slippery, uneven, or damaged (pothole) surface	0.94	0.63	0.50	0.58	5.313 (71)	<.001	0.63
Misjudged the speed of an approaching vehicle	0.57	0.67	0.32	0.55	3.855 (71)	<.001	0.45
Mechanical fault of bike resulted in a near miss	0.25	0.44	0.21	0.44	0.652 (71)	.516	0.08
Nearly fell off while mounting or dismounting	0.49	0.69	0.44	0.69	0.491 (71)	.625	0.06
Problem clipping in or unclipping from pedals resulted in a near miss	0.20	0.47	0.11	0.36	1.622 (70)	.109	0.19

Note. Significance value is two-tailed.
[a]Sample sizes differ due to missing data.

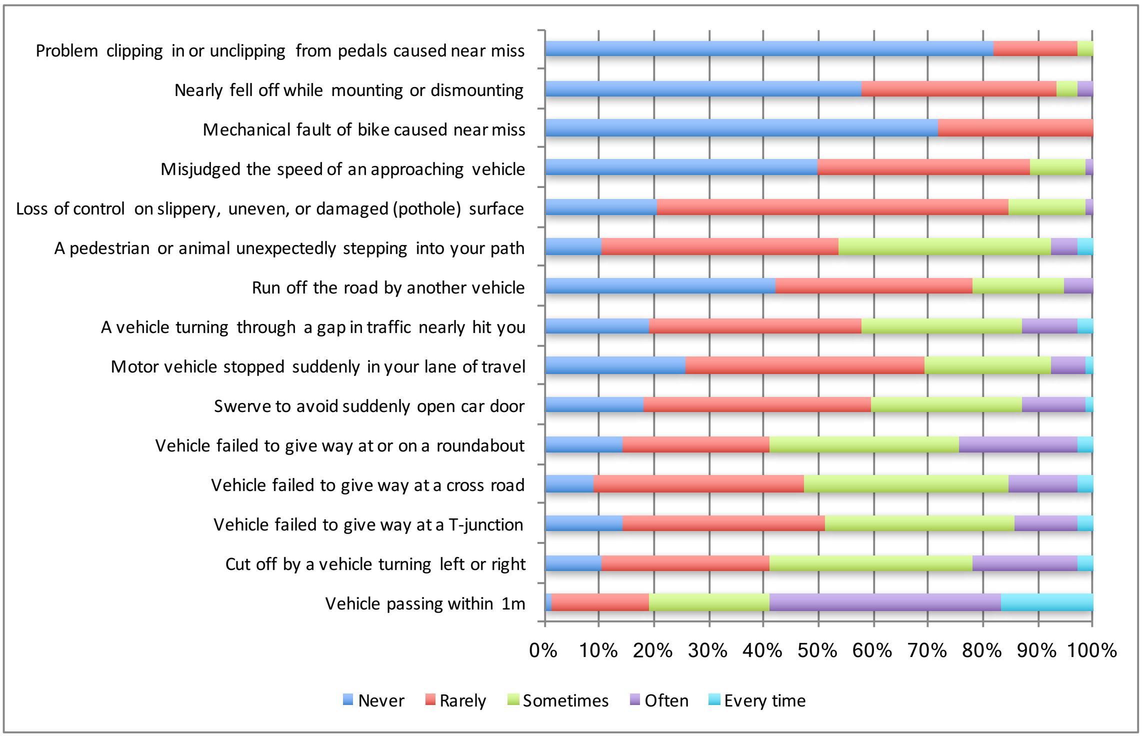

Figure 3.4
Transporting parents' experience of near misses when riding alone

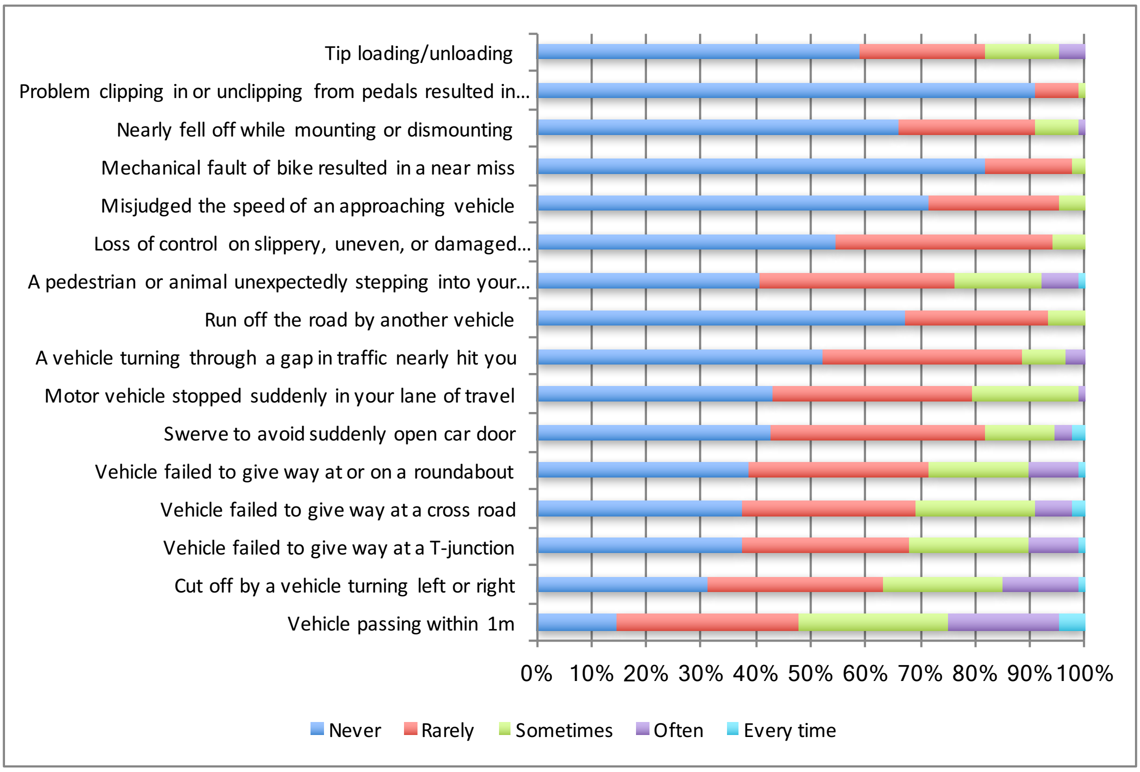

Figure 3.5
Transporting parents' experience of near misses when carrying child passengers

Riding behaviour

In order to determine whether parents adopt different riding behaviours when transporting children riding practices when alone (i.e., no child passengers) were compared to self-reported riding practices when transporting child passengers using paired-samples t-tests. The results are presented in Table 3.6. When transporting children, participants were significantly more likely to use off-road bike paths and footpaths, and were significantly less likely to use main roads with or without bike lanes. No significant differences were observed in the use of safety equipment such as helmets, lights (during the day or night), and high-visibility clothing.

Figure 3.6 shows the responses to questions addressing additional facets of riding behaviour when transporting child passengers. In support of the above findings about 75% of parents used a different route at least half of the time when transporting passengers and a similar number modified their usual route.

Table 3.6
Differences in riding behaviour when transporting child passengers

Riding behaviour	Riding alone		Transporting children		*t*(df)[a]	*p*	Cohen's *d*
	M	*SD*	*M*	*SD*			
Use off-road bike paths	1.92	1.17	2.21	1.19	-2.27 (84)	.026	-0.25
Use back streets	2.28	1.08	2.48	1.07	-1.59 (85)	.117	-0.17
Use main roads without bike lanes	1.44	1.10	0.70	0.88	5.74 (86)	<.001	0.62
Use main roads with bike lanes	1.83	1.21	1.22	1.13	4.46 (85)	<.001	0.48
Ride on footpath	1.03	0.90	1.83	1.18	-6.31 (86)	<.001	-0.68
Wear high-visibility vest or top	1.01	1.49	0.86	1.37	1.24 (86)	.219	0.13
Wear light, bright top	1.80	1.37	1.60	1.46	1.75 (86)	.083	0.19
Use lights during day	1.44	1.54	1.26	1.51	1.34 (86)	.185	0.14
Use lights during night	3.77	0.84	3.72	0.95	0.43 (85)	.665	0.05
Wear a helmet	3.63	0.98	3.65	1.00	-0.38 (85)	.708	-0.04

Note. Significance value is two-tailed.
[a]Sample sizes differ due to missing data.

Figures 3.6 and 3.7 show the frequencies of self-reported rider behaviours when riding alone and with a child passenger. Wearing a helmet is very common, with 85% of participants reporting always wearing their helmet when riding alone or with child passengers. The use of lights during the night was also common with over 90% of participants reporting always using lights at night when riding solo or with passengers. The use of lights during the day was a different matter with results showing less frequent use of lights when riding with passengers compared to riding alone: when riding with child passengers 17% report always using daytime lights and 45% never, compared to 19% always and 40% never when riding alone.

An additional four behaviours relating specifically to the transportation of child passengers were also considered, with results also presented in Figure 3.7. Child helmet use was common with 87% reporting always ensuring that child passengers are wearing a helmet. Other findings indicate changes to cycling routes and practices when transporting children with 64% reporting modifying their route most of the time or always while around 50% use a different route most of the time or always. Approximately 45% of participants also reported riding when there is less traffic most of the time or always.

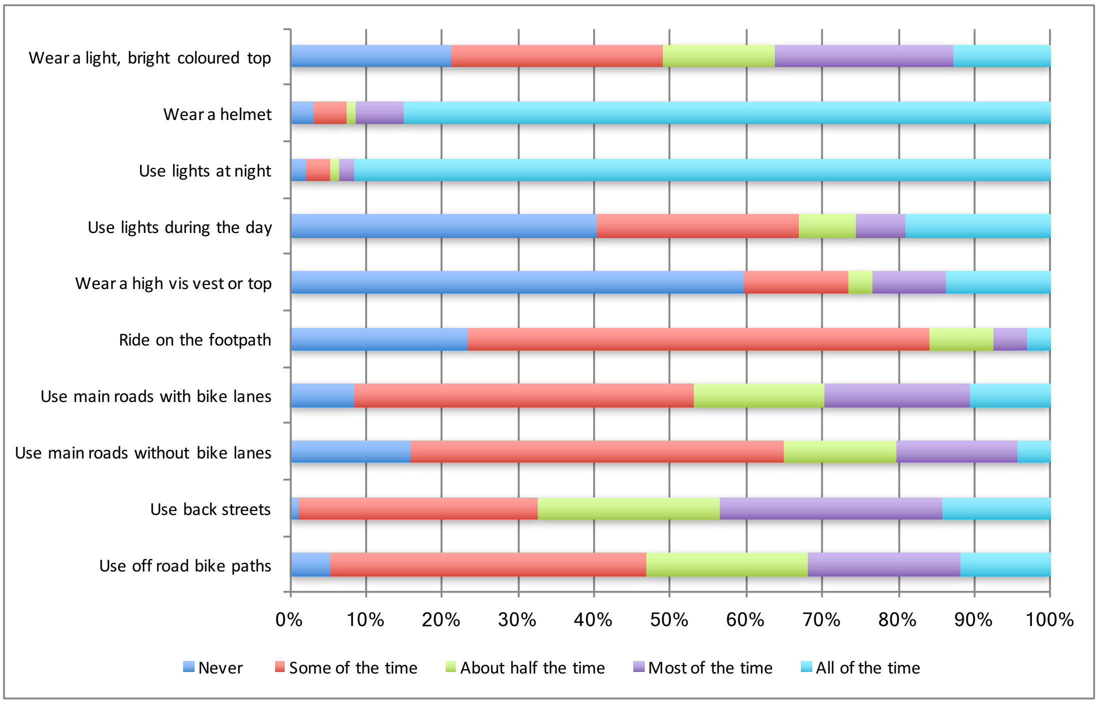

Figure 3.6
Riding behaviours when riding alone

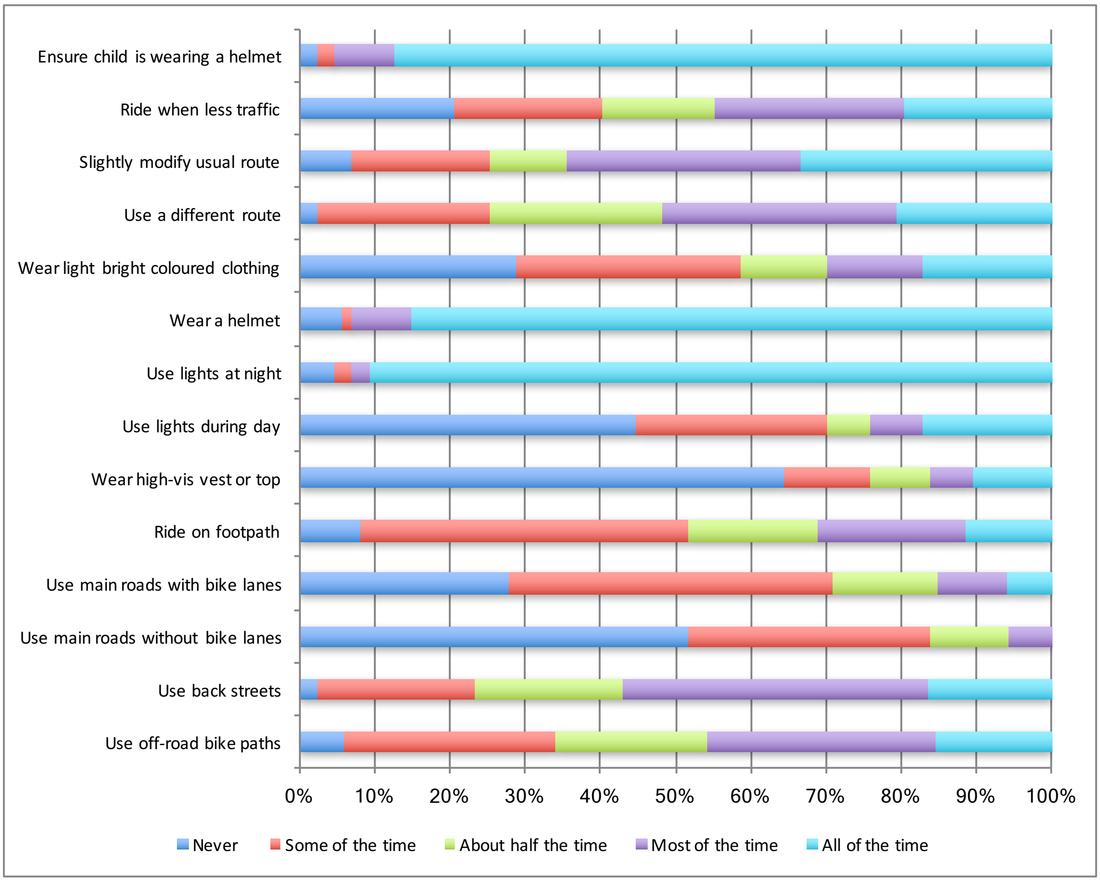

Figure 3.7
Riding behaviour when transporting child passengers

Perceived risks

Participants were asked to identify the top five risks to their safety when transporting a child by bicycle. Answers were in free-text format in order to gauge risks from the participants' perspective. A variety of responses were provided and those that were similar in nature were grouped according to the relevant theme. The themes identified, a description of the theme, and an example from the data are provided in Table 3.7.

Table 3.7
Description and examples of themes regarding risk when transporting child passengers.

Theme	Description	Example
Cars & other motor vehicles/driver behaviour	Risks were perceived as being struck by a motor vehicle, or the behaviour of drivers increasing risks for cyclists.	A car hitting us. Australian motorists. Inattentive car drivers. I live in carville Australia.
Weight/balance/handling of bike	The altered characteristics of the bicycle due to the presence of a child carrier and passenger increase the risk of an incident.	Additional weight changing bike handling characteristics. Reduced braking and handling performance.
Falls/Tipping	Falling or tipping while mounting or riding is considered a risk.	Bike tipping over with child in seat. Bike fall.
Infrastructure	The lack of safe infrastructure or design of the road network contribute to the risk of injury.	Lack of physical separation of infrastructure. Intersections.
Environmental	Exposure to weather.	Sun exposure.
Bike/carrier mechanical fault	A mechanical fault increases the risk of injury due to potential to fall or crash.	Mechanical failure of the bike or trailer.
Animals	The presence of animals is considered a risk.	Dogs off-leash. Animal attack.
Child passenger	The presence of the child passenger may lead to circumstances of increased risk.	Child uncomfortable, getting unruly. Her wiggling around! Child's boredom.
Pedestrians	Collision with a pedestrian, or avoiding errant/unpredictable pedestrian increases risk.	People walking on bike track with mp3 players on. Collision with a pedestrian.
Own behaviour	The cyclists own behaviour may contribute to the risk of injury.	Crashing bike. Me riding inappropriately.
Other cyclists	Collision with other cyclists is a risk of injury.	Collision with another cyclist. Other cyclists. Unpredictability of other riders in an event.
Child carrier	Some aspect of the child carrier may increase the risk of injury.	Passenger restraint. Child falling off platform.
Road safety/culture	Current state of road safety and transport culture increases the risk of injury.	Safety. Culture.
Other	A general category for responses that did not fit with any of the other themes.	Local council.

The frequency of responses observed with each theme are provided in Figure 3.8. The wording of this question asked respondents to report risks ranked in order from greatest concern (Risk 1) to least concern (Risk 5); participants did not need to report five risks. It is clear that other road users, particularly the drivers of motor vehicles, are of the greatest concern for participants. The lack of safe cycling infrastructure was also prominent. Factors over which the cyclist has the greatest control are less concerning for participants.

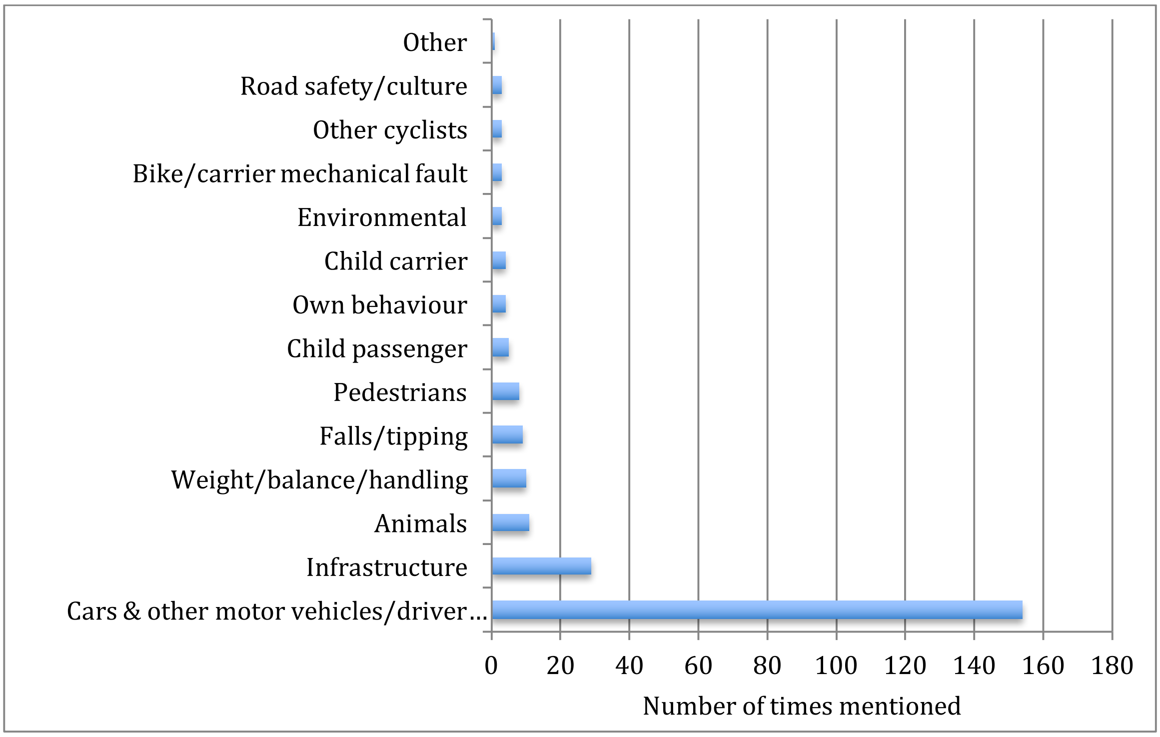

Figure 3.8
Risks to safety – frequency of themes reported

Risk management

Participants were also asked to identify up to five things they do to reduce the likelihood of encountering the risks identified above. While this question asked for things the individual does while riding, a number of responses considered broader solutions. As with risks, responses were grouped based on similar themes, and responses belonging to multiple themes were coded multiple times, once under each relevant theme. For example, the statement "keep to back streets where possible and wear bright clothes and lights if needed" refers to the themes of *route planning* (keep to back streets) and *safety equipment* (bright clothes and lights) and was coded under both themes. The groups/themes identified, a description of the theme, and an example from the data are provided in Table 3.8.

The frequency of responses observed with each theme is provided in Figure 3.9. The main strategies employed by participants were to adopt routes that minimised exposure to drivers and traffic, and to ride in a cautious manner. Better, safer infrastructure was also commonly cited as a solution to some hazards, particularly to reduce exposure to the dangers of motorised traffic. Safety equipment, including helmets, high visibility clothing, and lights, was also used to help reduce risk. Better education for drivers and broader strategic approaches, such as cycling advocacy and legislation to protect vulnerable road users, were also mentioned.

Table 3.8
Description and example of themes regarding strategies for improving safety

Theme	Description	Examples
Route planning	Using routes to minimise exposure to other traffic. Includes strategies such as riding on the footpath, using off-road paths, or back streets.	Use alternate routes away from busy roads/intersections. Travel only on few regular routes, not travel on new routes. Ride at quiet times - Sundays.
Rider behaviour/awareness	Strategies focus on the actions and behaviours the cyclist can adopt to improve safety.	Ride slowly and cautiously. Approach roundabouts slowly and make eye contact. Stay alert to all traffic. Ride so no one can hit you. Praying.
Infrastructure	Broader strategies suggesting better, safer infrastructure for cyclists.	Protected bike lanes. Maintenance of roads and paths. Traffic calming measures like speed humps and streets not permeable for through traffic.
Safety equipment	Strategies include the use of equipment, including clothing, lights, and flags, to improve safety. The use of sun protection to protect against sun exposure also falls under this category.	Always wear fluoro vests when transporting children (including for them). Flashing light in the daytime. Ensure trailer has a flag. Sunscreen, hats, etc.
Driver education/training/awareness	Broader strategies suggesting improvements in driver behaviour will improve safety for cyclists.	Better car/van driver training. Education at learning to drive time. Education of drivers.
Strategy/policy/advocacy/law	These are broad measures incorporating elements of transport and safety strategies, policy, cycling advocacy, law, and enforcement.	Cycling advocacy. Encourage more kids to cycle to school. Separate infrastructure, traffic calming, lower speed limits in residential areas, cycle awareness, strict liability laws. Stop lecturing to cyclists about safety and start lecturing drivers about driving safely & courteously. Enforcement of road rules.
Care loading/unloading passenger	Strategies highlighted taking care when loading or unloading child passengers.	Practice technique for removing child. Always hold the bike and don't lean it against anything when the child is on board.
Nothing	Some participants suggested there was nothing they could do to improve safety.	Nothing.
Manage passenger	Managing passengers behaviour to reduce likelihood of passengers contributing to an incident.	Talk with child about waiting for parent to be with them when mounting. Take shorter trips. Take them home if they're not comfortable.
Bicycle/carrier maintenance	Regular maintenance of the bicycle or carrier to reduce the risk of some fault contributing to injury.	Service bike regularly. Check bike and trailer each time thoroughly before riding.
Type of carrier	Selecting a specific type of carrier to reduce some of the risks.	Cargo bike or trailer.
Plan trip (weather)	Planning the trip to avoid inclement weather.	Avoid bad weather conditions. Sun cream, don't ride when it's hot.
Rider training	Improving cyclists' control of the bicycle.	Again practice. Control speed to hold a ling through a corner. Maintain quality of brakes.
Other	A general category for responses that did not fit with any of the other themes.	Wearing normal clothing (not lycra) and not wearing a helmet seems to increase passing distance. Considered getting rear view mirrors.

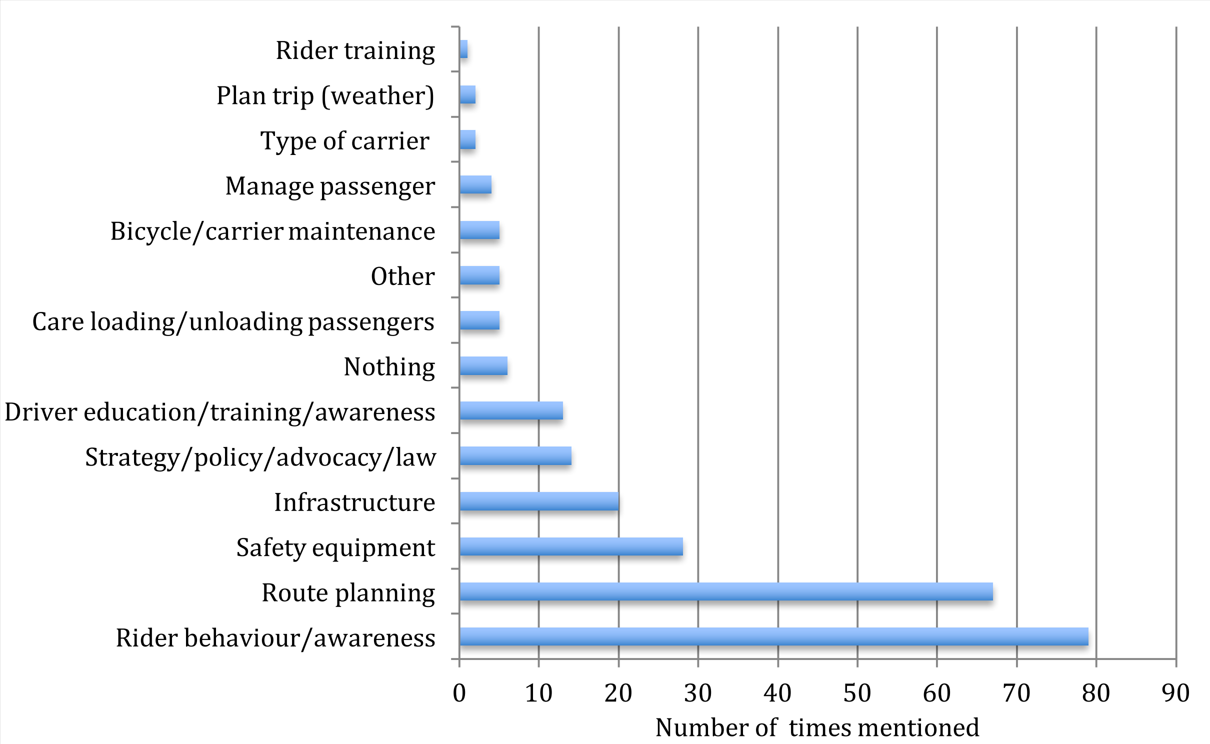

Figure 3.9
Strategies for reducing risk – frequency of themes reported

As with the preceding question regarding risks, the wording of this question asked respondents to identify strategies they adopt to reduce risks such that each response to this question (to a maximum of five) corresponded with the risks identified in the previous question such that *Safety 1* should correspond to *Risk 1*, *Safety 2* with *Risk 2*, and so forth. Table 3.9 shows the safety strategies most often reported for the identified threats for all identified threats and strategies. The most common strategies adopted to address the perceived risks posed by other road users, particularly motorised traffic, were to ride with greater care or caution and planning routes to make use of available cycling infrastructure or use the footpath. Together these account for almost two thirds of the strategies to address this risk. The use of equipment such as high-visibility clothing, helmets, or lights was the third most common strategy adopted to address risks posed by other road users.

As reported above, all child passenger injuries identified in this study were sustained in non-crash incidents, the majority of which involved the bicycle or carrier tipping over. The majority of these incidents occurred while loading or unloading a passenger although some instances of falls when performing a manoeuvre were also reported. The most common strategies to address this risk were taking greater care when riding, exercising caution when loading or unloading passengers, using safety equipment, and managing the child passenger's behaviour while on the bicycle.

Table 3.9
Threats to safety and the strategies adopted to reduce the risk of injury

Threat	Safety Strategy														Total
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
1	41	47	13	17	10	8	-	2	-	1	-		-	2	141
2	-	5	-	-	-	-	-	-	1	1	1	-	1	2	11
3	-	3	-	2	-	-	3	-	1	-	-	-	-	1	10
4	11	5	4	1	3	1	-	-	-	-	-	-	-	1	26
5	-	-	-	2	-	-	-	-	-	-	-	1	-	-	3
6	-	1	-	-	-	-	-	-	-	2	-	-	-	-	3
7	2	5	-	1	-	-	-	1	-	-	-	-	-	-	9
8	-	-	-	-	-	-	1	-	2	-	-	-	-	-	3
9	-	8	-	-	-	-	-	1	-	-	-	-	-	-	9
10	1	2	-	-	-	-	-	-	-	-	-	-	-	-	3
11	2	1	-	-	-	-	-	-	-	-	-	-	-	-	3
12	-	-	-	-	-	-	1	-	1	-	1	-	-	-	3
13	1	-	-	-	-	1	-	-	-	-	-	-	-	-	2
14	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Total	58	77	17	23	13	11	5	4	5	4	2	1	1	6	227

Note. 1 = Cars & other motor vehicles/driver behaviour; 2 = Weight/balance/handling of bike; 3 = Falls/Tipping; 4 = Infrastructure; 5 = Environmental; 6 = Bike/carrier mechanical fault; 7 = Animals; 8 = Child passenger; 9 = Pedestrians; 10 = Own behaviour; 11 = Other cyclists; 12 = Child carrier; 13 = Road safety/culture; 14 = Other; A = Route planning; B = Rider behaviour/awareness; C = Infrastructure; D = Safety equipment; E = Driver education/training/awareness; F = Strategy/policy/advocacy/law; G = Care loading/unloading passenger; H = Nothing; I = Manage passenger; J = Bicycle/carrier maintenance; K = Type of carrier; L = Plan trip (weather); M = Rider training; N = Other.

3.2.5 Other transport use

We were also interested in whether there were situations or circumstances in which transporting parents would not transport their child by bicycle, and whether they have or use alternate transportation on these occasions. Eleven main reasons were identified for not transporting children. These included distance being too great or too short, inclement weather (too hot, cold, or wet), a need to transport more children than able, a need to carry other things, the route being unsafe or difficult (e.g., hilly terrain), parent or child illness, if the purpose of the trip excluded carrying the child (e.g., riding to work), if the trip was to have occurred at night, a need to get somewhere faster than possible by bicycle, or available public transport was considered more viable. An “other” category was also identified, including factors such as the lack of end-of-trip facilities at destination, when consuming alcohol, or if children were sleeping. The frequency with which various reasons were reported and the proportion of participants reporting this reason are provided in Table 3.10.

Participants were also asked to report the alternate mode of transport used under circumstances that preclude transporting children by bike. Table 3.11 shows that driving was the most popular option, with 53% indicating they drive most of the time or always. Participants reported walking or using public transport less frequently than driving, while the use of taxis was least common. Staying at home rather than making a trip was not common, with the majority (77%) reporting they never or rarely chose this option. Some of the other options reported by participants included the use of car share schemes or having the child ride their own bicycle.

Table 3.10
Reasons for not transporting children by bicycle

Reason	Times reported	Proportion of respondents reporting reason
Distance	29	33%
Weather	34	39%
Number of kids	2	2%
Carry things	3	3%
Route	10	11%
Illness	2	2%
Purpose of trip	8	9%
Time of day	2	2%
Time	3	3%
Public transport	2	2%
Other	7	8%
Total	102	

Table 3.11
Frequency of other transport modes used when circumstances prevent transporting by bike

Transport Mode	Frequency of alternate transport use					Total[a]
	Never	Rarely	Some of the time	Most of the time	Always	
Walk	11	14	47	11	-	83
Drive	7	8	25	33	13	86
Public Transport	15	26	34	6	-	81
Taxi	50	23	2	-	-	75
Stay home	29	30	17	1	-	77
Other[b]	27	3	-	-	1	31

[a]Row totals differ due to missing data.
[b]Responses to "Other" were optional.

4 Stakeholder perspectives

In order to gain some understanding of other important issues regarding the availability and use of carriers, consultations with relevant stakeholders were held. A number of agencies and organisations were contacted to seek their knowledge of relevant issues. Two organisations responded to the request and participated in this process. These were Pedal Power ACT, the primary cycling advocacy group in the Australian Capital Territory (ACT), and the Cycling Promotion Fund (CPF) a national organisation established by the Australian Bicycle Industry to promote cycling, including through advocacy.

The topics addressed in the consultations included:

- The prevalence of child transportation
- The identification of issues that impact upon the safety of transporting child passengers
- Advice and assistance for people who want to transport child passengers
- The suitability of current infrastructure with regard to transporting child passengers, including consideration of the cycling network and end of trip facilities
- Concerns of members
- Concerns of the organisation.

Given the CPFs links with the Australian Bicycle Industry they were also able to provide comment on practical aspects, such as sales and design standards and safety.

4.1 Findings

4.1.1 Advocate perceptions

Prevalence of child transportation

The number of cyclists transporting child passengers is very small with a best estimate of about one per cent of ACT cyclists. However, there are reports that transporting children by bike is increasing in popularity. Transportation is most common for recreational trips, although it is also increasing for transport-cycling (e.g., commuting), and sometimes for fitness cycling.

Safety issues that impact transporting child passengers

Several issues regarding the safety of transporting child passengers were raised. One of the main concerns identified was the vulnerability of child passengers and the increased potential for injury should an incident occur. The visibility of towed attachments, particularly trailers, was also highlighted. Trailers are low to the ground and may be below bonnet height, making them difficult for drivers to see. As towed attachments are also behind riders it may be difficult for vehicles approaching from the other direction to see them. It was noted that trailers are generally quite stable and unlikely to tip over, even when the bike to which they are attached tips over, while issues of visibility can be overcome using flags or similar devices.

Another issue for people transporting child passengers, particularly with a trailer or wider carriers, is the lack of accommodation for these in existing infrastructure. Bike lanes and paths are built to the minimum recommended width and have not been constructed with consideration of wider carriers. A carrier may take a whole bike lane or block most of a path, which also makes it difficult to negotiate pedestrians or other obstructions, of for other cyclists to pass. There are also issues with the distance between bollards and other infrastructure, which are designed to allow narrow bikes to pass through but are too narrow for trailers. While not specifically identified by stakeholders, these would also present similar problems for those using wider carriers such as cargo tricycles.

Motorised traffic and the behaviour of drivers were also identified as safety issues, although it was noted that some cyclists use different, comparatively safer routes when transporting child passengers.

Rider experience and ability to carry child passengers, particularly due to increased weight and changes to the balance and handling characteristics that these impose, was also identified as a potential risk to safety. The behaviour of the child passenger also has the potential to cause problems, particularly if they upset the balance or steering by shifting their weight from side to side.

Finally, the quality of the child carrier itself was also considered a risk. It was noted that all carriers meet the appropriate standards but factors such as the quality of construction and materials, particularly for critical components such as couplings, was considered important. In order to meet the international standards carriers should have primary and secondary mechanisms for attaching to the bike.

Advice and assistance

Pedal Power ACT indicated that they do provide advice and assistance regarding the transportation of child passengers although they have no formal program in place. They do not provide advice on individual carriers as they have no preference regarding what people should use and indicated that people tended to purchase the type of carrier that they wanted.

The CPF indicated that while they did not offer such services, there are a number of agencies in every state that are able to provide such advice and support.

Infrastructure

While the issue of infrastructure was identified as a safety concern above, a further question regarding the ability of the existing network to accommodate child transportation was also asked. Following from the issues raised above it was identified that there are a number of deficiencies in the network, particularly regarding land and path width, insufficient space between bollards for trailers and other wider carriers, and general missing links in the network. It was considered that, in general, the network was barely sufficient to accommodate single riders. Other problems identified included trailer susceptibility (i.e., increased risk of tipping) to gutters, kerbs, and potholes. While end of trip facilities, such as bike racks, were available, these are not designed to accommodate trailers.

Member concerns

Pedal Power ACT reported that people want to ride with children but believe that, currently, riding in general is not safe and so will not transport children.

Organisation concerns

The main concerns raised by both organisations include the lack of ability for the current network to accommodate and support transporting children by bicycle. There are a number of barriers that make transporting child passengers harder than it needs to be. Other concerns were based on the ability of riders to carry child passengers safely, particularly for novice riders who may not have the same level of skill or knowledge compared to more experienced riders. It was considered that riding with child passengers was very different to riding alone and required an ability to recognise differences in handling and an ability to judge whether gaps between objects were wide enough to fit through, and the ability to safely steer through these gaps. Recognising the need for an increased turning circle and judging the space and time necessary to make a turn was also considered important.

Other comments

The development of the new safety standards for child carriers was based on international best practice and theoretical research on what is happening around the world. Australia tends to be behind because transporting children by bicycle is not that popular and actual injuries to children as a result of this practice are rare. The recent review of child carrier standards will see the introduction of standards for forward child seats, tag along behind bicycles and single-wheeled trailers, which have previously never had standards. The introduction of these standards was market-driven. One other point is that often transporting children by bicycle can be viewed quite negatively and can be seen as an unsafe and irresponsible activity. More work is needed to change this view towards it being considered more positively and a normal, safe behaviour.

4.1.2 Industry (retail) perceptions

Due to the CPF's links with the Australian bicycle industry their knowledge regarding the sale and installation of, and current design standards for, child carriers was also sought.

Common carriers

The most popular child carriers are seats, with rear seats more popular than front seats. Rear seats are able to accommodate older, heavier children than are front seats. After bicycle-mounted seats, trailers are the next most popular carrier. There is no sales data for child seats and trailers making it difficult to determine the prevalence of different types and brands of carriers in use although for seats Topeak and Yepp are the top selling brands for seats. It was also noted that people generally choose carriers that their friends or family use, or whatever the shop has available.

Installation services

Most bicycle stores offer an installation service for seats. There may be a fee to install a carrier on a bike but when purchasing a bike and seat from a shop, installation is generally free.

Standards for child carriers

Current design standards for child carriers are based on European standards. The Australian standards for child carriers are currently under review, having last been reviewed in 1995. Key elements to the standards are the design, construction, and materials used in the manufacture of the carrier. Safety tests focus on these elements and also consider projections that might cause injury, foot rests, location of the seat (in front or behind rider), weight ratings, and support structures (e.g., racks connecting the seat to the bicycle). Harnesses for seats must have three points of contact; front seats do not meet these standards.

Safety features

The two main safety features of bicycle carriers are they must have guards that prevent feet or fingers getting caught in wheels and they must have a safety harness.

Advice

Generally when considering the use of a carrier it is important to ensure that the bike and brakes are strong enough to handle the additional weight. The rider should be comfortable and confident when riding a bike alone before they start carrying child passengers. Cyclists should always buy bikes and accessories (e.g., child seats) from reputable dealers. If the person is not confident in their ability to install the carrier they should get the shop to fit it for them.

5 Discussion

With plans to increase cycling participation and the increase in use of child carriers and cargo bikes in Australia there is a need for research to support evidence-based safety improvements for cyclists and their passengers. While research investigating the safety of adult cyclists continues apace, very little is known about the safety of children transported as the passenger on an adult's bicycle. This research is the first of its kind to explore issues relevant to child passenger safety in detail, including cycling behaviours, the threats to safety and strategies used to mitigate these, factors contributing to crash and non-crash events, and injury characteristics including mechanisms, nature, and treatment.

One of the questions this report set out to answer was to find out what types of carriers are being used. The most common types of carrier reported by participants in this study were seats attached either in front of or behind the rider. The popularity of rear seats can probably be explained by a few factors. They are among the cheapest options, are readily available from bicycle stores and other retailers, and can be attached to most bicycles. This is also likely true for front-mounted seats and trailers, which were the second and third most used carriers. Other options, particularly the specialised cargo-carrying bicycles (long-tail cargo bikes, cargo bikes and trikes, and tandems), are more expensive than normal bikes and are generally not available at many local bicycle stores. In Australia, some parents may also be unaware of other options such as cargo bikes, and thus may not explore them as a possibility. The main factors reported for using a carrier were practicality and ease of use, comfort of the child, and safety features. More specialised cargo bikes and passenger carriers (e.g., trailers) were considered good options when needing to carry multiple passengers or carry other gear. The manner in which some rear bike seats attach to the bicycle inhibits the use of panniers. Despite often being more expensive, cargo trikes and long-tail cargo bikes were considered by some to be better value for money than other carriers (including cheaper seats), which may be attributable to the versatility of such carriers in terms of passenger and cargo capacity.

One aspect of the survey was to identify cycling behaviours when transporting child passengers. These refer to the use of particular types of roads or infrastructure and the use of safety equipment (e.g., helmets hi-visibility clothing, and lights). Common practices adopted by participants when transporting children included using different routes compared to when riding alone, modifying a usual route to reduce the risk of a crash, and riding at times when there is less traffic. Examination of the types of infrastructure used showed that when transporting children, cyclists more often rode on the footpath and main roads with bike lanes, and less often rode on main roads without bike lanes. This finding may be indicative of the perceived level of safety for the different types of roads. It would appear some cyclists are willing to accept a certain level of risk when riding alone but are less likely to accept it when transporting child passengers. When transporting child passengers it would appear cyclists endeavour to minimise risk to themselves and their passengers by using roads and infrastructure on which they perceive to be safer. While the findings do not indicate this directly, it is also possible that cyclists will use the footpath when no other infrastructure is available. Furthermore, a cyclist's choice of infrastructure is likely determined by what is available on the route that they will take.

Participants also reported significant reduction in several types of near misses, particularly those involving other road users, when transporting child passengers. This may in part be due to differences in riding behaviour as noted above that reduce exposure to motor traffic or increase separation. Another potential explanation is the possibility that drivers take more care if they are aware that a cyclist has a child passenger. While, to the best of our knowledge, this theory has not been empirically tested, the presence of child passengers on a bicycle can be fairly obvious, particularly when carriers are attached to a bicycle.

The most common crash or non-crash incidents reported by survey participants did not directly involve other road users. This supports recent research suggesting the majority of all cyclist crashes are single bike-only crashes (e.g., Biegler et al., 2012; Schepers, 2012;), although it should be noted research has also found crashes involving motor vehicles generally result in more severe injury to cyclists (e.g., Heesch et., 2011). Where reported, injuries to adult cyclists or child passengers arising from such incidents were generally minor in nature and none required treatment at or admission to a hospital. Interestingly, incidents involving a collision with a road user or object, or loss of control (such incidents were classified as a crash in this study) did not result in an injury to child passengers. On the other hand, all reported injuries to child passengers were sustained in non-crash incidents, which most commonly involved the bicycle tipping over due to the passenger's negative effect on the bicycle's balance. Such incidents generally occurred when loading or unloading the passenger into bicycle-mounted seats. Such incidents may be overcome by ensuring bicycles are equipped with a suitable stand, one that is strong enough to handle the additional weight. Conversely, other types of carriers such as cargo bikes/trikes or trailers are either inherently stable (e.g., trailers and trikes) or are equipped with adequate stands.

Being a passenger on an adult's bicycle exposes young passengers to adult-level forces in the event of a crash, bicycle tip over, or falling from a bicycle-mounted seat, which increases their risk of injury. While survey data identified only minor injuries, analysis of hospital injury data demonstrates that child passengers can receive more severe injuries, with children aged three or younger experiencing a significant number of head injuries. The nature of injury for the hospital sample also demonstrates that open wounds, superficial injuries, and fractures are common among this group, while, although somewhat less common, a substantial number of intracranial injuries were also documented. The findings of this study also confirm previous research that has identified head injuries in children are reported as the most prevalent type of injury, and that these are often associated with the characteristics of bicycle child carriers (Corden et al., 2005; Miyamoto & Inoue, 2010; Ng et al., 2001).

Researchers have suggested that aspects of a child's physical and cognitive development may contribute to their risk of injury. The ability of young children to process information and perceive depth and motion are not fully developed, which limits their ability to anticipate a crash or fall. This lack of anticipation for sudden events increases their risk of injury (Tanz & Christoffel, 1991). Furthermore, children lack the physical strength to protect themselves in the event of a collision, which also increases susceptibility to injuries (Murray & Ryan-Krause, 2009). These factors taken in conjunction with the type and severity of injuries observed in the hospital data highlight the importance of protecting young children riding as passengers on a bicycle. Correctly fitted and worn helmets are effective at reducing the severity of head injury (Cripton et al., 2014; Miyamoto & Inoue, 2010). Research has also demonstrated that child seats with higher backs offer greater head protection than seats with lower backs (Miyamoto & Inoue, 2010). In Australia most seats on the market have sufficiently high backs and also come with head supports that may offer further head protection in a fall.

One of the main recommendations made by survey participants to reduce the risk of injury was to improve cycling infrastructure. It is widely recognised that separation of vulnerable road users from motorised traffic is one of the best methods for improving the safety of vulnerable road users (Lydon et al., 2015; Wegman et al., 2012). Traffic calming and reduced speed limits will also improve safety for cyclists and all road users (Fildes et al., 2005; Tingvall & Howarth, 1999; Wegman et al., 2012). Other infrastructure treatments that are not widely used in Australia that may be beneficial include extended traffic signal sequences that allow slower cyclists sufficient time to cross an intersection. Other treatments, such as the installation of expanded storage areas for bicycles and early start/leading interval signals for cyclists at signalised intersections can facilitate safe right turns for cyclists at busy intersections (e.g., Levasseur, 2014). While not specifically required by current Australian traffic management guides, early start or leading interval signals should be available at all intersections where expanded storage areas are utilised, particularly where right turning and through traffic share the same lane. This would ensure cyclists using the storage area are able to clear the intersection without delaying through traffic.

While not directly related to safety, improving existing infrastructure to accommodate larger bikes, such as cargo bikes and trikes, will ensure that cyclists will be able to take full advantage of the safest routes possible. The provision of end of trip facilities (e.g., bike racks) able to cater for non-traditional bikes such as those that are longer and wider than standard bicycles, and bicycles with towed attachments, may also encourage the uptake of bicycles designed for carrying passengers.

Another recommendation was for cyclists to adopt safer behaviours or ride with greater caution when transporting children, and a less common recommendation was training for cyclists.

The goal of this research has been to offer some insight into child transportation so that those currently transporting children, or future transporters are able to make informed decisions regarding the choice of carriers and also on how to transport children safely. To this end, an example of an educational resource drawing on the knowledge gained from this research is provided in Appendix A.

5.1 Limitations

This study is the first of its kind to involve a comprehensive investigation of issues impacting the safety of child passengers transported by bicycle. As with any study, there are a number of limitations to address. First, while this research provides information that has, until now, been lacking, due to difficulties inherent in identifying the population of interest (i.e., child transporting cyclists) an accurate understanding of this activity is difficult to achieve. Further work is needed to confirm and expand upon the findings of the present study.

One limitation was the inability to accurately identify child passengers in the available hospital injury data. While, it is reasonable to assume those aged 0-3 years were most likely passengers it is possible that some may have been riding on their own. It is also possible that young children may be more vulnerable to injuries when riding independently, which may impact hospital emergency department presentations and admissions among this group. As such, the extent to which the data is representative of injuries to child passengers is unclear.

Regarding the survey, the manner in which participants were recruited may have introduced a self-selection bias. It is likely that many respondents were avid cyclists with an interest in cycling issues. It is possible that those who cycle less often and who are not actively interested in cycling issues have a different experience transporting children. Identifying and recruiting such participants would be a difficult task but future research should attempt to address this potential bias. While the study also sought to obtain information from non-transporting cyclists, very few were recruited. Consequently any attempt to investigate differences between the two groups was infeasible.

During the stakeholder consultation phase a number of cycling organisations were contacted to discuss this issue, with two responding. While feedback from a wider range of organisations would be desirable, given the current state of child transportation practices in Australia, it is our opinion that the comments and advice offered by those contacted provide an accurate reflection of the current situation.

5.2 Conclusion

This study involved the most detailed investigation of the various safety issues surrounding the transportation of child passengers by bicycle ever undertaken. The outcomes of this investigation demonstrate that there is a real risk of injury to child passengers although there are a number of strategies that can be employed by both cyclists, road managers, and society to mitigate these risks. A lack of data precluded any analysis of differences in safety performance of different types of carriers. With an expected increase in the number of cyclists on our roads and an increase in the variety of child carriers in use, this research offers practical advice to enable parents and other adults to make informed choices regarding the carriers they use and other strategies they can employ to enhance their safety when transporting child passengers.

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Appendix A – Example of child transportation educational material

General safety

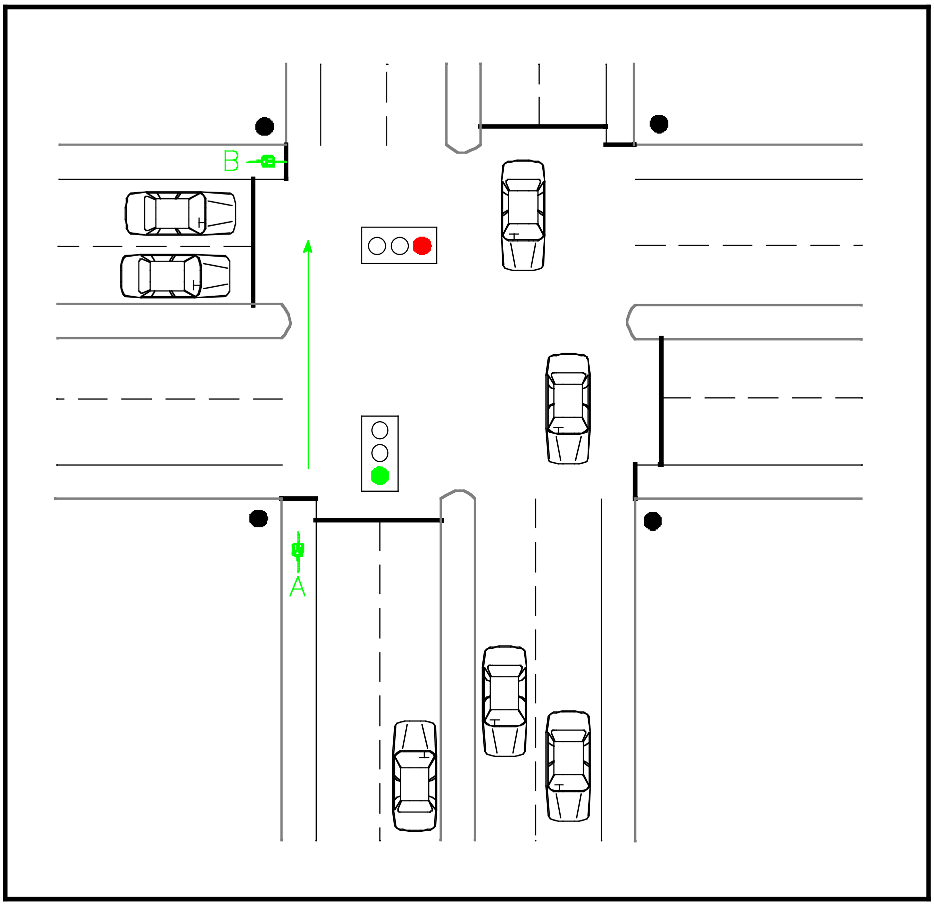
Riding with children can be a fun, enjoyable, and safe experience for everyone. There are a number of things you can do to help stay safe when riding your bike with or without child passengers.

1. Plan your trip. No matter what type of bike you're riding, using off-road paths and quiet back streets is both more enjoyable and will reduce your exposure to other traffic. In some states it is also legal to ride on the footpath, although you are required to give way to pedestrians and should ride at an appropriate speed.

2. Turning right at busy intersections can be tricky. Rather than take your chances with traffic and moving into the right turn lane, consider making a hook turn. These are particularly useful at signalised intersections where you can use the traffic signals to your advantage. When performing a hook turn you must obey all traffic laws, including only proceeding on a green light and giving way to other traffic. The diagrams below shows the steps to follow to perform a hook turn.

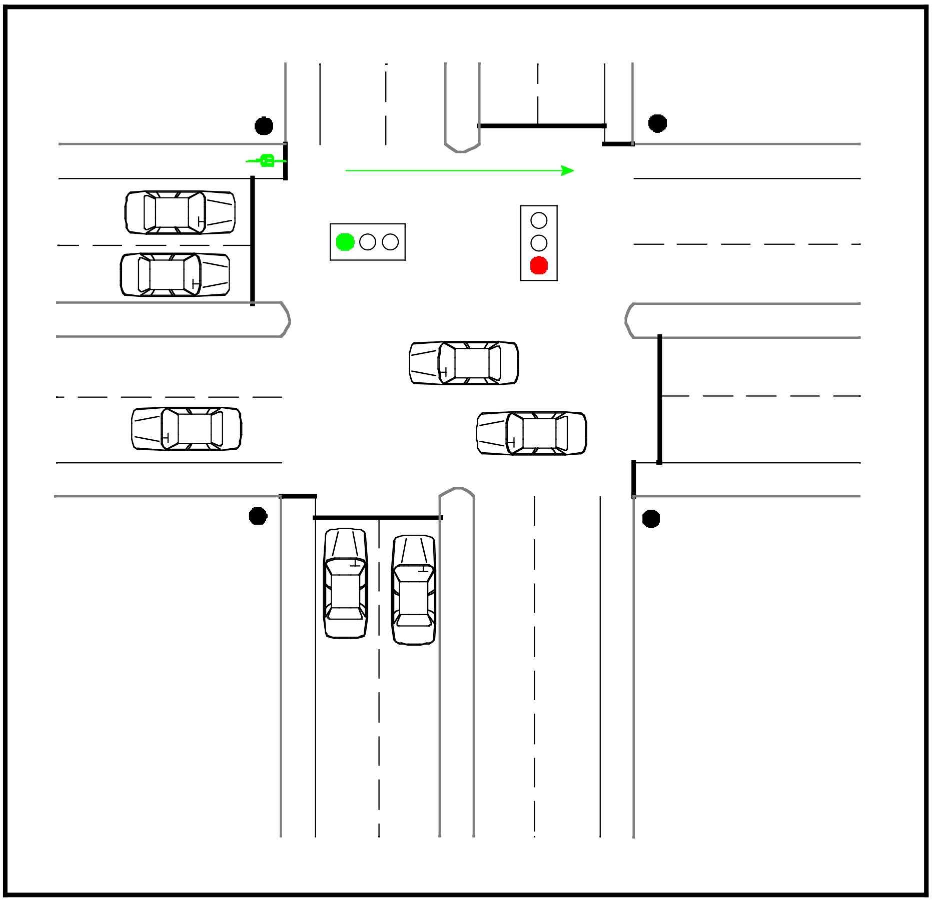
Step 1:

Proceed straight ahead at the intersection in the bike lane (or from the left side of the road) while the light is green and stop at the opposite corner (Point B in the diagram).



Step 2:

When the light changes to green proceed along the road onto which you wished to turn.



3. While it may be tempting, passing some vehicles on the left can be hazardous. Buses may let passengers disembark, which may mean a door flying open or people suddenly appearing in your path. Trucks are large and have significant blind spots which make it harder for the driver to see you, they may not even know you are there. This can be a big problem, especially when they are turning left.

4. Suddenly opening car doors can also be a problem. The only way to avoid these is to leave enough room between you and parked cars to increase the likelihood that the driver will see you in their mirror and give you room and time to avoid the opening door if you need to. There are some hints you can look for: you may see a person sitting in their car, or a car may have pulled into a parking space ahead of you. In some places passengers like to hop out of cars when they are stopped in traffic so you need to be aware of doors opening on the passenger's side too.

5. Roundabouts are particularly problematic for cyclists and there aren't really any designed appropriately for cyclists. If possible try to avoid roundabouts on your route. If you need to, try to ride towards the centre of the lane and ride straight through rather than around the outside. While the law says you need to give way to your right (you should always do this) it is also a good idea for cyclists to check for traffic coming from the left. While they are required to stop and give way, they don't always do this. Be prepared to stop if necessary.

7. Lights – day and night. It is the law at night, but using your light during the day can also be beneficial.

8. Visibility - wear light, bright clothing during the day. While fluoro colours are best, white is a great substitute. At night consider retro-reflective vests to help other road users see you. Remember, they might have seen you but this is no guarantee that they will stop.

9. If you are new to riding or haven't ridden for a while there are a number of organisations that can provide advice on a range of topics from buying and maintaining a bike to planning your route and tips for safer riding. Some also offer courses to teach you how to ride a bike or skills for riding safely in traffic. For more information contact the following organisations:

State or territory	Local bicycling advocacy organisation
ACT	Pedal Power
NSW	Bicycle NSW
Northern Territory	Bicycle NT
Queensland	Bicycle Queensland
South Australia	Bike SA
Tasmania	Bicycle network Tasmania
Western Australia	Bicycling Western Australia
Victoria	Bicycle network

10. Routinely check your bike and child carrier. Make sure everything that should be tight is tight (e.g., wheel nuts, handlebars) and that your child carrier is properly and securely attached to the bicycle.

11. There are a range of child carriers available, which can make choosing the right type of carrier difficult for those who know little about them. The following sections are intended to outline the different types of carriers available and describe the positives and negatives of each. Popular brands for each type of carrier are also identified to help you find the carrier you want. Tips for safe cycling with each type of child carrier are also provided.

Bike seats

Front and rear seats (source: coolbikingkids.com/yepp-mini/, 2016)

Description of carrier: Seats are the most popular child carrier in Australia. They attach to the front or rear of the bicycle. While the weight capacity for seats can vary, front seats can generally be used with children up to 15 kilograms and rear seats are able to accommodate children to 22 kilograms. Always check the product details to ensure the seat is suitable for your needs.

Popular brands: Yepp, Topeak, Bobike, Beto

Positives: Child seats are probably the most affordable child carriers on the market. They can be attached to most bicycles, although it may be necessary to buy racks, mounting brackets, or other adapters if these are not included with the seat. Most seats will come with everything you need for installation. There are a lot of different types of seats available. Having your child in a seat in front of you will allow for a greater level of interaction with your child while riding and they will enjoy being able to see where they are going.

Negatives: Generally, bicycles aren't designed for carrying heavy loads or passengers, as such the addition of a loaded seat behind the rider can have a negative effect on the handling and balance of the bicycle. Seats attached to the rear of the bicycle will make mounting more difficult unless using a step-through frame as shown in the picture above. Children seated in these types of carriers are exposed to the elements. Rear seats may make it difficult to carry other gear as most will not accommodate panniers (bags). Front seats are designed for smaller children so you may need to change to another type of carrier as they get older.

Safety tips: Ensure any child passenger is wearing a helmet that meets Australian standards. Seats with higher backs have also been found to reduce the risk of head injury for children. When buying a seat ensure that the back extends above the child's shoulders. Most seats will have a headrest which is also handy if your child falls asleep on the ride. Lean the bicycle against a stable object or have someone help when loading/unloading the child. Ensure the seat is big enough to provide head support if the child falls asleep. Ensure the seat has guards or other mechanisms to prevent feet or hands getting entangled in wheels. Regularly check the mounting to ensure all bolts, etc. are not loose.

Trailers

Bicycle trailer (source: schwinnbikes.com/int/gear/bike-trailers/trailblazer-trailer, 2016)

Description of carrier: Trailers are the second most common type of carrier in Australia. Trailers are available that can carry one or two children with a little bit of room for extra gear. Trailers attach to the bicycle via a universal joint that prevents the trailer tipping over if the bike falls.

Popular brands: Croozer, Weehoo, Pacific, Thule

Positives: Trailers are stable and offer protection from the elements (sun and rain). They can be attached to most bicycles but if your bike has disk brakes make sure the trailer comes with everything you need to attach it properly. Due to the way they are constructed they have a roll bar that protects children if they do roll over. Some trailers can convert into a stroller.

Negatives: They are more expensive than child seats. They can be susceptible to tip overs due to pot holes, kerbs, and other bumps. Regular bike infrastructure may not support wider trailers, particularly where there are narrow paths and bike lanes, and narrow gaps between bollards. The additional weight of the trailer alters the braking characteristics of the bicycle – it may take longer to stop. Because trailers are lower to the ground they may be difficult for drivers to see (i.e., below the level of the bonnet).

Safety tips: Ensure child passengers are wearing a helmet that meets Australian standards. Increase driver visibility of the trailer using a flag. Attach mudguards to the towing bike to prevent the rear wheel flicking debris or water into the trailer. Give yourself more time to cross busy roads and intersections. Give yourself more time to slow and stop by braking earlier than usual.

Trail-a-bike (or trailer bike)

Trailer bike (source: 99bikes.com.au/trailer-pacific-blue, 2016)

Description of carrier: Trailer bikes (or trail-a-bikes) are essentially a child's bike that attaches to the adults bike. There are a number of different options available ranging from that shown in the image above, to recumbent style seats (e.g., the weehoo igo), or an arm that can attach a normal child's bike to an adults bike.

Popular brands: Pacific, Weehoo, Trail-gator

Positives: Trailer bikes are suitable for older children and may help them learn road safety and how to ride in traffic in relative safety. Because the child also pedals they are helping to push their own weight.

Negatives: One of the most noted risks with these types of carriers is that the child passenger may not hold on with their hands or fall asleep. As these carriers generally do not come with a restraint system this increases the risk that the passenger may fall off. Children are also exposed to the elements.

Safety tips: Ensure child passenger is wearing a helmet that meets Australian standards. Start with trips the child can manage at times when they are less likely to fall asleep. Supervise the child to ensure they are holding on and not falling asleep. Give yourself more time to get across the road or through intersections.

Long tail cargo bikes

Long-tail cargo bike with rail, cargo racks, and panniers (source: xtracycle.com/edgerunner-24d-2016/, 2016)

Description of carrier: Long-tail cargo bikes are similar to regular bikes, but have a longer frame which extends further behind the rider to allow carrying cargo or passengers. Some long-tail cargo bikes come with an electric motor to assist the rider, which can be very handy when carrying passengers and cargo.

Popular brands: Yuba, Surly, Kona

Positives: Designed to carry both cargo and passengers and is able to carry both at the same time. They are more like a traditional bike. Able to carry two (possibly more) children on the rear deck; can attach seats or a rail and hand-holds to help keep kids safe. Most bikes come with a sturdy stand to keep the bike stable when loading and unloading. There is also the option of attaching towed carriers (e.g., trailers or trailer bikes) to increase passenger capacity. It is even possible to transport adult passengers on the rear deck.

Negatives: Available at limited dealers. They are more expensive than a normal bike. Passengers are exposed to sun and rain. Due to the high position of passengers, long-tail cargo bikes may be more prone to tip overs than other types of cargo bikes.

Safety tips: Ensure all passengers wear a helmet that meets Australian standards. Ensure there is adequate guarding to prevent passengers hands, legs, and feet becoming entangled in the wheel. Use a seat for young children. Install a rail and hand holds to help keep children on the deck/rack.

Cargo bikes and trikes

A cargo bike with e-assist (source: dutchcargobike.com.au/wp-content/uploads/product-bakfiets-cargo-electric-granite.jpg, 2016)

A cargo trike with weather canopy (source: dutchcargobike.com.au/wp-content/uploads/product-nihola-family-pink-army-canopy.jpg, 2016)

Description of carrier: Cargo bikes are generally designed to carry passengers and cargo in a box positioned in front of the rider. There are a range of different cargo bikes and trikes available and can vary in size and the number of passengers or amount of cargo that can be carried.

Popular brands: Bakfiets, Christiania, Bullitt, Gazelle, Nihola, Zeitbikes, Workcycles, Babboe

Positives: These bikes are designed to carry passengers and cargo. The position of the cargo box means the weight is distributed between the axles and offers greater stability than other bikes and cargo trikes offer the greatest stability due to having three wheels. Cargo bikes provide the ability to carry up to three (long cargo bike as pictured) or four passengers (cargo trike), with the potential to carry more with the addition of a rear seat and towed attachments (e.g., trailer). Passengers are also in front of the rider allowing for greater interaction with your children and it is also easier to keep an eye on them. Depending on the size of the cargo area there is often room enough to carry other gear. Cargo carrying capacity can be increased using panniers. Most cargo bikes have a range of accessories such as covers and weather canopies that are easy to install and will protect passengers from rain and sun, which means you can ride all year round. Many brands also have an e-bike version with an electric assistance engine that can make carrying heavy loads or riding up hill much easier. Cargo bikes also have a sturdy stand to keep the bike stable while loading and unloading. While they might look awkward cargo bikes are easy to ride: if you can ride a bike, you can ride a cargo bike.

Negatives: Cargo bikes are more expensive than normal bikes (but cheaper than a car) and are available at limited dealers across the country. Generally cycling infrastructure in Australia has not been designed with cargo bikes in mind. While a cargo bike can go most places a normal bike can, there may be some barriers (such as rail crossings) that are difficult to overcome. Cargo trikes are wider than a normal bike and may not fit through narrow gaps (e.g., between bollards). These can be overcome by planning your trip. While very stable, cargo trikes may be vulnerable to tip overs when turning or due to kerbs, potholes, or other significant bumps.

Safety tips: Before carrying passengers or cargo have some practice rides to get used to the handling (particularly turning and stopping) of the bike. When loaded a cargo bike may take longer to stop and also be slower to get going. Give yourself enough time to stop and to clear intersections or cross roads. Ensure that all passengers are wearing a helmet that meets Australian standards. Plan your trip to make best use of available infrastructure and avoid infrastructure that is not suitable.