

**ANALYSIS OF MOTOR VEHICLE-RELATED FATALITIES INVOLVING
CHILDREN UNDER THE AGE OF SIX YEARS (1995-2000)**

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Executive Summary

Between 15 and 16 children under the age of 6 years were killed each year due to motor vehicle crashes based on this study of coroners records in NSW over a six year period. Around half of these children were passengers in vehicles at the time and half were pedestrians. Overall, two year olds were the single most vulnerable age group, accounting for just over one-quarter of cases. Males were slightly more likely to be involved in crashes than females (57% of cases were male). Most crashes occurred in metropolitan regions. Passenger crashes and pedestrian crashes had different characteristics. To a large extent these differences reflect the degree to which the child played a role in the crash.

Characteristics of passenger fatalities versus pedestrian fatalities

- Passenger crashes were fairly evenly spread across all age groups and between males and females. In contrast, pedestrian crashes were much more likely to involve males and children in the 1 to 2 year age group. In addition, babies under the age of 12 months were much more likely to be involved in crashes as passengers than as pedestrians off-road.
- Most passenger crashes occurred over the weekend or on Thursdays, and the most common time for crashes was between 9am and 3pm with a peak at around 10am. Pedestrian crashes on the other hand were fairly equally likely on any day of the week and were most common between 3pm to 9pm.

Passenger fatalities

The even distribution of age group and gender among passenger fatalities, and the restriction of the involvement of most small children to crashes in the daytime when it is more likely that babies and small children will be travelling, clearly reflects the likelihood of being in a vehicle that is involved in a crash.

While young children as passengers do not play a role in causing the crash, factors like use of personal protective equipment and seating position in the vehicle can modify the likelihood of a fatality.

- Around one in five passenger fatalities in this study were not using any form of restraint and a further 25 percent were using inappropriate or sub-optimal protection.
- Girls were slightly less likely to be using some form of restraint, but most strikingly, nearly three-quarters of 1 to 2 year olds were not wearing protection or wearing it inappropriately.
- For all other age groups the majority of children were using the appropriate personal protection.

Clearly usage of appropriate personal protective equipment for the 1 to 2 year old age group when passengers is an issue.

Pedestrian fatalities

In contrast to passenger fatalities, the characteristics of pedestrian crashes reflect the involvement of the most vulnerable groups of children, in particular male children around the age of one to two years. Five year olds were also more vulnerable for

pedestrian crashes although they accounted for a much smaller percentage of the motor vehicle crashes in this study.

The characteristics of the pedestrian fatalities differed for on-road and off-road crashes.

- Just over one-third of pedestrian fatalities occurred off-road, and about half of these occurred in driveways.
- Males were considerably more likely to be involved in on-road than in off-road pedestrian fatalities.
- While 1 to 2 year olds were most commonly involved in both on-road and off-road pedestrian fatalities, 3 to 5 year olds accounted for a significant percentage of pedestrian on-road cases, but very few off-road cases.
- On and off-road pedestrian fatalities also differed in the time they occurred. On-road fatalities were more common in the evening with approaching half occurring between 6.30pm and 8.30pm whereas off-road fatalities occurred earlier, mainly in the afternoon between 3pm and 6pm. This time difference may reflect differences in the age distributions of on-road and off-road cases as the majority of off-road cases tended to be younger.
- Around one in five pedestrian fatalities involved no, or inappropriate, use of other forms of safety equipment (e.g. doors without locking devices, doors being left open) and there were no strong age or gender differences in their use. The use of other forms of safety equipment was however a factor in a higher proportion of off-road than on-road pedestrian fatalities.

Characteristics of off-road pedestrian fatalities

Off-road pedestrian fatalities fell into two main groups; those occurring in driveways and those occurring in other off-road areas.

- For both types of fatalities, 1 to 2 year olds were involved most often, but whereas males accounted for most driveway fatalities, the gender distribution for other off-road fatalities was equal.
- Driveway fatal crashes tended to occur mainly on weekdays in the early morning, between 6.30 and 9.30am, and the late afternoon, between 4pm and 6pm, whereas other off-road fatalities occurred more mainly in the late afternoon and early evening and were spread evenly across the week.
- All driveway fatal crashes occurred in metropolitan areas, all but one involved large vehicles such as 4 wheel drives which in most cases were slowly reversing.
- A small number of other off-road fatal crashes occurred in rural areas, most involved cars rather than large vehicles and most were moving forward slowly at the time of the crash.
- For both types of off-road pedestrian crashes, the child was, in most cases, in a place they knew well (such as their home or the home of a relative) and the crash involved a person they knew.
- Driveway fatalities, however, were more likely to involve a parent driving.
- In a notable group of other off-road crashes, the crash occurred at least partly because the driver mistook the accelerator for the brake pedal.

The main patterns of the circumstances off-road pedestrian fatalities

Three main patterns accounted for all off-road pedestrian fatalities.

1. The first main pattern accounted for well over half of all off-road pedestrian fatal crashes and two-thirds of all driveway crashes. This pattern involved an unsupervised child being left in a location that the supervisor thought was safe, then finding their way outside and into the path of a vehicle. In this pattern, the vehicle was almost always large (4 wheel drive, van or truck), and the driver was unaware of the location of the child with respect to the vehicle. Equal numbers of cases involved reversing and forward moving vehicles. In this pattern, the child played the major active role in the crash, but almost all of these children were very young, aged between 1 and 2 years, most were male and all occurred in the early morning or late afternoon.
2. The next most common pattern accounted for five cases, only one of which was a driveway fatality. The main feature of this pattern was that it involved the behaviour of an adult. In three of these cases, the adult was the driver of the vehicle who made an error operating the accelerator pedal of the vehicle, and the remainder involved an unsafe decision by the child's carer. In each of these cases the child was outside in the vicinity of the slow-moving vehicle at the time and being supervised by a carer. As might be expected, both genders were equally likely to be involved in these crashes, and three of five cases involving 3 to 5 year old children showed this pattern. Most occurred in other off-road situations and there was no tendency for the vehicle to be reversing or moving forward.
3. The third pattern accounted for four cases and again involved a child outside and under adult supervision. In these cases, however, the child played a major role in the crash by running out into the path of the slow-moving vehicle. Mostly these cases involved younger children, but there were no other clear distinguishing features of these cases, although the number was small.

Recommendations

By looking for the common features across each of these descriptions, it is possible to make suggestions about additional strategies that could be implemented to prevent motor vehicle crashes for this age group. The main recommendations are as follows:

For passenger crashes:

1. The personal protective equipment used, such as capsules, car seats and seat belts should be appropriate to the child's age and size.

For off-road crashes:

2. Information and educational approaches are needed to increase the awareness parents and supervisors of the characteristics of children particularly at more vulnerable developmental stages and also to provide guidance on ways of focusing supervision of children to be especially watchful in specific situations and times of the day and on the problems of using driveways and places where vehicles are parked as play areas for children.

3. Environmental modifications should be considered where possible to reduce the child's access to the path of vehicles. These include secure fences, appropriate security locks and provision of safe play areas.
4. The design of vehicles should be addressed including improvements to the driver's vision and consideration given to improving the location of foot pedals to reduce the likelihood of pedal errors.

4. In depth analysis of driveway and other off-road vehicle-related fatalities

4.1 Number of incidents in driveways and percentage of all vehicle-related fatalities

Nine out of 93 incidents, or 9.7% of all vehicle-related incidences, occurred in driveways (Table 4.1). An additional 10 pedestrian fatalities (10.8%) occurred off-road and were considered to be similar to driveway fatalities with respect to the surrounding circumstances. As such, they are included as a separate category for in depth analysis in this section.

Table 4.1: Number and proportion of fatalities by road user grouping

Road user grouping	Frequency	Percent
Driveway	9	9.7
Pedestrian off-road	10	10.8
Pedestrian on-road	30	32.3
Passenger	44	47.3
Total	93	100.0

4.2 Age and gender

Figure 4.1 shows the number of children involved in driveway, other off-road pedestrian fatalities and all vehicle-related fatalities by age group. The majority of both driveway and other off-road pedestrian fatalities involved children in the 1 to 2 year old age group. Relative to their involvement in all vehicle related fatalities, the 1 to 2 year old age group was over-represented in both driveway and other off-road pedestrian fatalities. Children in the 3 to 4 years age groups were proportionately much less involved in driveway and other off-road pedestrian fatalities than in all vehicle-related fatalities, as were babies less than 12 months of age and 5 year old children. For the remainder of this section any babies less than 12 months are included in the 1-2 year age group, and any children aged 5 years are included in the 3-4 year age group.

Figure 4.2 shows the proportion of driveway, other off-road pedestrian, and all vehicle-related fatalities involving male and female children. Males were involved in a higher proportion of driveway fatalities than females (66.7% were male), but there was no gender difference for other off-road pedestrian fatalities (50.0% were male) and little difference between genders for all vehicle-related fatalities (57.0% were male).

Examination of the relationship between age and gender showed a proportionately higher representation of males in the 1 to 2 year old age group amongst the driveway fatalities compared to their involvement in all vehicle-related fatalities. Male children in the 1 to 2 years age group accounted for more than half of all children killed in driveways (55.6%) compared to only around one-quarter of all vehicle-related fatalities involving under six year olds (25.8%).

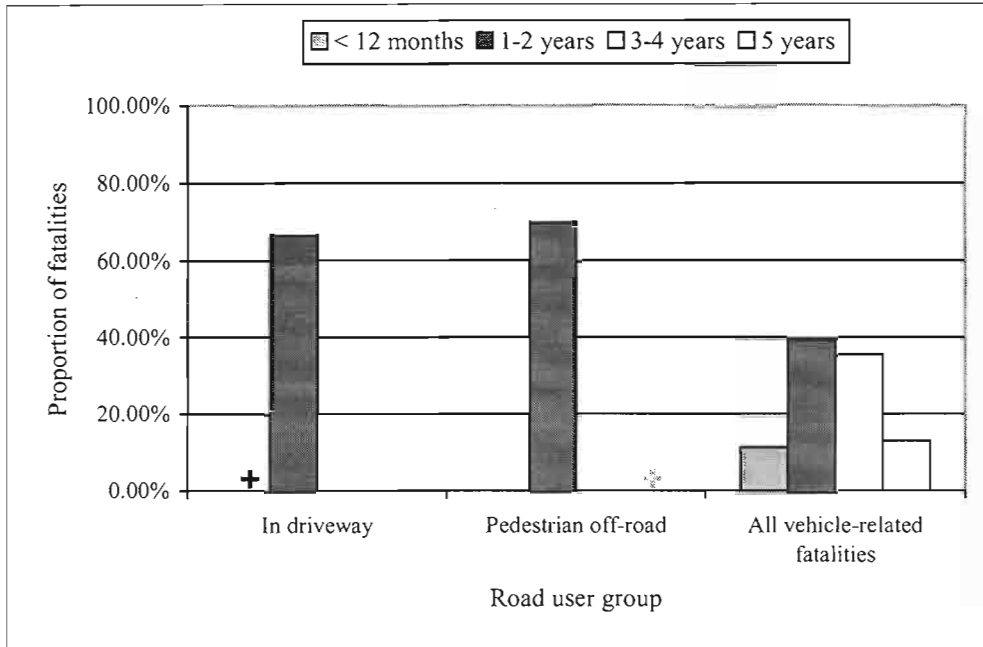


Figure 4.1: Proportion of driveway, other off-road pedestrian fatalities and all vehicle-related fatalities by age group (+ indicates cell size less than 5)

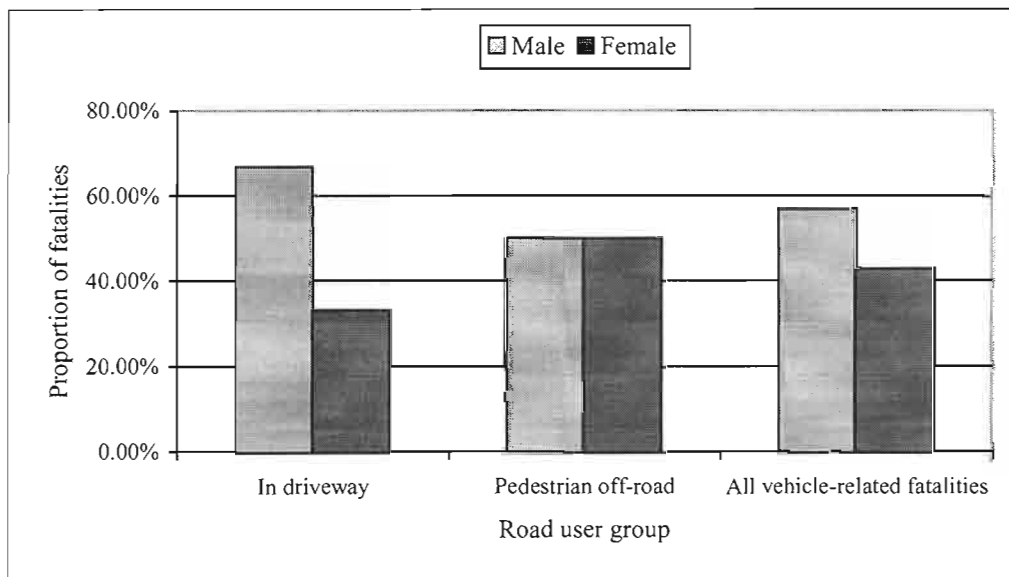


Figure 4.2: Proportion of driveway, other off-road pedestrian, and all vehicle-related fatalities by gender

4.3 Timing and trends

Analysis of patterns of off-road fatalities over the period 1995 to 2000 shows that incidents of pedestrian off-road fatalities were fairly evenly spread across all years, but there were no driveway fatalities in the years 1995 and 2000.

Driveway fatalities occurred mainly in the late afternoon, especially between 4pm and 6pm (4 cases), in the morning between 6.30am and 9.30am(3 cases), or around 12 noon (2 cases). Other off-road pedestrian fatalities also occurred in the late afternoon to early evening, between 4pm and 6pm (3 cases) and between 6pm to 9pm (2 cases) and were fairly evenly spread across the remainder of the day; 8am-9am (2 cases), 10.30am-3:30pm (3 cases).

Across all pedestrian off-road fatalities (including driveways), the most common time of the day was between 3pm and 6pm. In contrast, passenger fatalities most commonly occurred between 9am and 3pm. Pedestrian on-road fatalities occurred commonly between 3pm and 6pm but were also common between 6pm and 9pm.

When the number of fatalities were examined by the day of the week of the incident, the majority of driveway fatalities occurred during the week (8 of 9). This was in contrast to other off-road pedestrian fatalities (4 of 10 occurred during the week) and all vehicle-related fatalities (61.3% occurred during the week). When the average number of fatalities were analysed by the type of day (weekday vs. weekend) on which they occurred, driveway fatalities were more common on week days (1.6 versus 0.5), whereas the average number of other off-road pedestrian fatalities, like all vehicle-related fatalities, was somewhat higher on weekend days (1.0 vs. 2.0, and 11.4 vs. 15.0 respectively).

Analysis of off-road pedestrian fatalities by the time of the year during which they occurred, showed that 6 of the 19 occurred during Summer (December through to February), and 6 in Winter (June to August). There was a slight tendency for more fatalities to occur over the warmer months of the year, in the 6 month period from November to April inclusive (11 incidences occurred over this period accounting for 57.9% of off-road fatalities). For driveway fatalities, five of the nine cases occurred over the November to April period.

4.4 Location

All driveway fatalities occurred within metropolitan or suburban areas and on residential properties (e.g. 7 occurred in single homes, 2 in units or townhouses). The majority of pedestrian off-road fatalities also mainly occurred in metropolitan or suburban areas, with only three of the ten cases occurring in rural areas. Pedestrian off-road cases in metropolitan areas occurred in a broad range of areas including the yards of single homes (3), carpark of a unit/townhouse property, supermarket and a childcare centre, and at a petrol station. In rural areas, other off-road pedestrian fatalities occurred on farms (2) and in a yard. Whilst the number occurring on rural properties was small, they represented a higher proportion of other off-road pedestrian fatalities (30.0%) than the proportion of all vehicle-related fatalities occurring in rural locations (6.5%).

4.5 Relationship of child to property owner

All driveway fatalities occurred in places in which the child was known and might be expected to be in. Five out of nine driveway fatalities occurred within the child's own home, with other incidences occurring at the home of the child's grandparents (2 cases) and people they were visiting (2 cases). Like driveway fatalities, the largest number of other off-road pedestrian fatalities also occurred within the grounds of the child's own home (4 cases), as well as at neighbours, grandparents property or on a property the child was visiting (1 case each). In three cases, the accident occurred in incidental locations.

4.6 Vehicle type

Of driveway fatalities, eight out of nine cases involved four wheel drives or other large vehicles (e.g. vans, trucks). When compared to their involvement in all vehicle-related fatalities, 4WD's and other large vehicles were over-represented in driveway fatalities (88.9% versus 35.5%). In contrast, half of the other off-road pedestrian cases involved cars (5 of 10), and this was consistent with the involvement of cars in all vehicle-related fatalities (51.6%).

4.7 Driver age, gender, and relationship to child

In two-thirds of driveway fatalities and 60% of other off-road fatalities the driver of the vehicle was male. These figures are slightly higher than those seen in all vehicle related fatalities which showed a reasonably even gender balance with male drivers accounting for 55.9% of cases. In contrast though, more than three-quarters of drivers involved in pedestrian on-road fatalities were male (76.7%).

Where the age of drivers involved in driveway fatalities was known (7 cases), they were aged between 21 and 59 years. The age range of drivers in other off-road pedestrian fatalities was much broader and ranged from less than 16 years through to 79 years where known (9 cases). When driveway and other off-road pedestrian fatalities are combined, 47.4% (9 out of 19) of cases involved drivers aged between 26 and 39 years, which is proportionately higher than found for drivers in this age group across all vehicle-related fatalities (35.5%).

In the majority of driveway and other off-road fatalities the driver knew the child or the family (8 of 9 driveway fatalities, and 7 of 10 other off-road pedestrian fatalities). In 9 of these 15 cases the driver was either the child's mother or father. Other drivers' known to the child in off-road cases included neighbours, grandparents, family friends and siblings. People known to the family were over represented as drivers in all crashes in this study (62.4% of all crashes), but this finding was more pronounced for driveway and other off-road pedestrian fatalities (88.9% and 70.0% respectively). In particular, parents were most likely to be involved in driveway fatalities (66.7%), compared to other off-road fatalities (30%) and all vehicle-related fatalities (36.6%).

4.8 Access to driveways and other locations associated with fatalities

When driveway and other off-road pedestrian fatalities were examined in terms of how children came to be in the location associated with their death, some commonalities amongst the 19 cases emerged. In eight cases (42.1%), children were inside the home and exited the house through either an open door or gate or through one which they managed to open or unlock. For two of these cases, the exact mode of exit was unknown. In one additional case, the child was inside a non-residential building. Six of these nine cases resulted in crashes in driveways. In the remaining 10 cases (52.6%), children were outside already, with 7 of these being within the property of the home (e.g. in front yard), and 2 in parking areas. Seven of these cases resulted in other off-road fatalities.

4.9 Speed of vehicle and vehicle movement

The approximate speed of the vehicle was known in almost all driveway fatalities (8 of 9), and for half of the other off-road pedestrian fatalities (5 of 10). For almost all driveway fatalities the vehicle was travelling 5kph or less (7 of 8), with the highest known speed being 10kmh (1 case). The vehicle speed was not known for half of the other off-road pedestrian fatalities, but where the speed was known, it involved vehicles travelling less than 5kph (2 cases), 10kph (2 cases), and 20kph (1 case).

The majority of driveway fatalities involved vehicles reversing (6 of 9). In other off-road pedestrian fatalities, most vehicles were moving forward (7 of 10) and only three cases involved a reversing vehicle. Indeed, all fatalities involving reversing vehicles occurred in driveways or other-off-road locations. Amongst the off-road pedestrian fatalities, three cases involved unintended acceleration on the drivers behalf, with two drivers mistaking the accelerator for the brake.

When the behaviour of the driver was examined, it was found that 5 of the 9 driveway fatalities were known to occur when the driver was leaving the property, as was the case for 6 of the 10 other off-road pedestrian fatalities.

4.10 Involvement of alcohol and other drugs

Alcohol was involved in 2 of the 19 off-road pedestrian fatalities, with one driver having an illegal BAC of 0.06, and the other being within the legal range (0.01).

When all vehicle-related fatalities were examined, alcohol and other drugs were involved in an additional 4 passenger fatalities, and in a further 3 cases of passenger fatalities the relevance of alcohol or other drugs was not able to be determined.

4.11 Description of individual factors and events involved in driveway and other off-road fatalities

Contributing factors

A number of factors emerged that contributed to the off-road fatalities. These included the nature of supervision of the child, weather or other environmental conditions, the role of safety equipment including doors and gates, the vehicle type involved, the location of children prior to the accident and the driver's awareness of the child's position. These factors are described briefly below.

Across all off-road pedestrian fatalities, in 11 of the 19 total cases the child was not being supervised at the time of the crash, having been left alone for some time or due to a temporary disruption in supervision. For 4 of the 19 cases, the supervision was classified as indirect as the carer was in the vicinity of the child, but was occupied with activities other than direct supervision. For the remaining four cases, an adult was directly supervising the child at the time of the incident. Most of the driveway cases involved no supervision at the time of the crash (6 of 9 cases), with two involving indirect supervision and only one child being directly supervised at the time. For the other off-road crashes, more cases involved direct supervision, with 3 cases out of 10 directly supervised, two cases indirectly supervised and five cases with no supervision at the time.

In 10 cases the child's location, being outdoors and in the vicinity of vehicles for some time prior to the accident, was a contributing factor as it led to the child being in the position where the incident occurred. For the remaining 9 cases where the child had been left in a safe place (usually a house), breaches of safety equipment in the form of open doors and gates played a role all but one of these cases. This case occurred in a petrol station where the door did not serve as a safety barrier. For six of the nine driveway cases, the child had been left inside the house and the safety barriers had been breached, whereas this occurred in only two of the other off-road cases.

The vehicle type was included as a contributing factor, as due to their size and structure, large vehicles such as 4WDs, vans and trucks, may prevent driver's being able to see children. Whilst the height of the vehicle was cited in the coroners records as obscuring vision in only three cases, a further 10 fatalities involved large vehicles.

Environmental factors were only noted in two cases; both involving driveway fatalities. For one case, the crash occurred in the dark or reduced lighting and in the other it was thought that rain had encouraged the child to shelter near the rear wheel of a tow truck.

In more than half of the cases (10 of 19), the driver was unaware that a child was in the vicinity of their vehicle and in a further five cases the driver was unaware, but due to the circumstances leading to the crash may have been possible to see the child and so avoid the crash. In all of the driveway fatalities, the driver was unaware of the position of the child. In three cases of other off-road pedestrian fatalities, the driver was definitely aware of the child position of the child, and in a further five cases it may have been possible for the driver to see the child.

Table 4.2: Number of pedestrian off-road cases in which various factors were seen to contribute to the fatality

Contributing Factor	Number of cases	Percentage
Supervision		
No supervision at time	11	57.9%
Indirect supervision	4	21.1%
Direct supervision	4	21.1%
Other safety equipment		
Doors / gates	8	42.1%
Use of rear vision mirrors	+	+
Vehicle type		
Large eg van, truck, 4WD	13	68.4%
Location of child		
Outdoors	10	57.9%
Extreme weather conditions	+	+
Driver awareness of child		
Unaware	10	57.9%
Could possibly have been aware	6	26.3%
Aware	3	21.1%

NB: + indicates cell size less than 4.

Precursor events

For all cases, up to three precursor events were coded leading up to the fatal crash. The coding of these related to events associated with the environment or the location at the time of the crash, any equipment breakages or failures, and the behaviour of children, drivers and others leading up to the accident.

In the greater majority of cases (14 of the 19 cases), the child performed one or two behaviours which led directly to the fatal crash. Typically these involved the child placing themselves in front of, behind or between a vehicle(s) and 10 of these cases involved two behaviours, where the first behavioural event involved the child recently moving from a safe place to the vicinity of the vehicle. In at least 7 of the 14 cases, the vehicle was moving at the time.

In eight cases, behaviours by adults played a role either alone (four cases) or in combination with behaviour by the child. These behaviours by adults ranged from leaving the door or gate open or unlocked, leaving keys in vehicles, placing children, in some cases accidentally, in dangerous locations, to adult drivers making mistakes in driving such as hitting the accelerator instead of the brake pedal. In four cases the behaviour was due to the driver of the vehicle and in four cases to the supervisor of the child.

Table 4.3: Number of cases involving each type of precursor event in off-road pedestrian fatal crashes.

Precursor events	Number of cases	Percentage
Behavioural Events – Child	15	78.9%
<i>One</i>	3	15.8%
<i>Two or more</i>	12	63.2%
Behavioural events – Adult	8	42.1%
<i>One</i>	5	26.3%
<i>Two</i>	3	15.8%
<i>As driver</i>	4	21.1%
<i>As supervisor</i>	4	21.1%

Table 4.4 illustrates the relationships between types of precursor events and contributing factors for off-road pedestrian fatalities.

Table 4.4: Relationships between types of events and contributing factors for off-road pedestrian fatalities

Case No.	Type vehicle	Environ factors	Safety devices	Super-vision	Location of child	PE 3	PE2	PE1	Driver aware	Driver/supervisor
<i>Driveway fatalities</i>										
1	1	-	Door	1	Inside	-	BC	BC	DU	NS
2	1	-	Door	1	Inside	-	BC	BC	DU	NS
3	1	-	-	2	Outside	-	-	BA	DU	NS
4	2	-	-	2	Outside	-	-	BC	DU	NS
5	1	✓	-	3	Outside	-	-	BC	DU/DP	NS
6	1	✓	Door	1	Inside	-	BC	BC	DU	NS
7	1	-	Door	1	Inside	-	BC	BC	DU	NS
8	1	-	Door	1	Inside	BA	BC	BC	DU	NS
9	1	-	Door	1	Inside	BA	BC	BC	DU	S
<i>Other off-road pedestrian fatalities</i>										
1	2	-	-	2	Outside	-	BC	BC	DU	NS
2	2	-	-	3	Outside	-	-	BA	DA	NS
3	1	-	Door	1	Inside	-	BC	BC	DU	S
4	1	-	-	3	Outside	-	-	BC	DU/DP	NS
5	1	-	-	1	Inside	-	BC	BC	DA/DP	NS
6	2	-	Door	1	Inside	-	BC	-	DA/DP	NS
7	2	-	-	3	Outside	-	BA	BA	DA	NS
8	1	-	-	1	Outside	BA	BC	BC(Other)	DA/DP	NS
9	1	-	-	1	Outside	-	BA	BA	DU/DP	NS
10	2	-	-	2	Outside	BC	BA	BA	DA	S

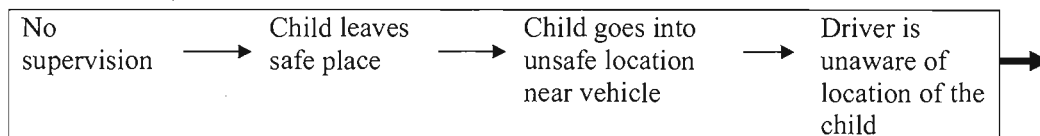
KEY: Vehicle type (1=large, 2= car)
 Safety devices (Door=Door/gate able to be breached by child)
 Supervision (1=No supervision, 2=Indirect supervision, 3=Direct supervision)
 Location of child (Inside=in safe location away from path of vehicles, Outside=outside a secure environment and near path of vehicles)
 Precursors 1 to 3 (PE1 to PE3) (BA=behaviour due to adult, BC=behaviour due to child, BC(other) = Behaviour due to another child)
 Driver awareness (DA=driver aware of location of child, DP=driver might have been aware of child, DU=driver could not have known the location of child)
 Driver supervisor (S=driver was child's supervisor, NS=driver was not child's supervisor)

4.12 Interaction of contributing factors and precursory events

There were a number of common patterns of the circumstances of these fatal crashes.

Pattern 1

The most common pattern was seen for 10 cases in total (6 of 9 driveway fatalities and 4 of 10 other off-road fatalities) and involved an unsupervised child getting into a risky location in the path of a vehicle without the driver being aware of it. The pattern is as follows:



For driveway fatalities:

- In one of these cases, the driver was also the child's supervisor
- In all cases a safety device (door) was able to be breached by the child through which the child gained access to the outside environment. In two cases, the supervisor made it possible for the child to leave the safe place by leaving the door open.
- In all cases a 4WD or large vehicle was involved.

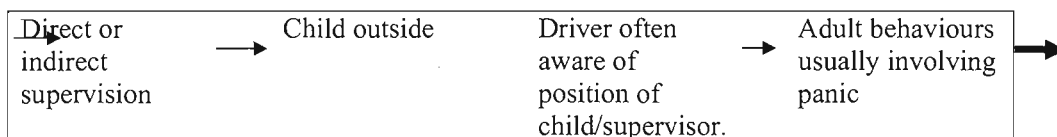
For other off-road fatalities:

- In one case, the driver was also the child's supervisor.
- In one case, the supervisor left keys in the ignition with children in the car.
- In three cases, a safety device (door) was penetrated either by the child or an unknown person allowing the child access to the outside.
- In 3 of 4 cases the driver was definitely unaware of the child's location
- In 3 of 4 cases, a large vehicle was involved

The child involved in these cases was aged 1-2 year in nine cases and male in seven cases. All of these cases occurred in the early morning before 9:10am or between 3.30pm and 6:30pm. The vehicles involved were evenly divided between reversing and forward movement at the time of the crash. Eight drivers were male, and a parent of the child was the driver in five cases.

Pattern 2

The second most common pattern was seen for five cases in total, mainly other off-road fatalities. This pattern involved a child being directly or indirectly supervised outdoors and one or two adult behaviours leading to the fatal crash. In three cases, the driver was aware of the position of the child and in almost all cases a non-supervisory adult was driving.

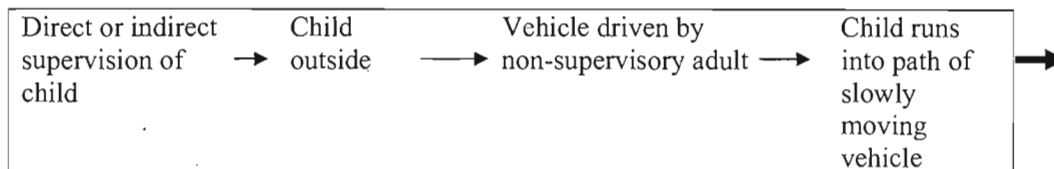


- In four of five cases the driver was not the child's supervisor.
- In three of five cases, the driver was aware of the position of the child.

Fatalities involving 3-5 year old children tended to show this pattern of events (3 of 5 cases). There was no particular pattern of gender and no specific time of day or day of the week on which they occurred. Around half the vehicles involved were reversing at the time of the crash and the remainder were moving forward. The driver of the vehicle was female in 4 of these cases.

Pattern 3

This pattern involved four cases in total with equal numbers of driveway and other off-road fatalities (two of nine driveway fatalities and two of ten other off-road fatalities). In this pattern, the child being either directly or indirectly supervised when they ran out quickly into the path of the vehicle which was moving forward (2 cases) or in reverse (2 cases). In all cases, the driver of the vehicle was not the child's supervisor.



The driver was unaware of the child in two cases and possibly aware in two cases.

The children involved in this pattern tended to be younger, with three of the four children being in the 1 to 2 year old age group. There was no particular pattern for gender, time of day, day of the week or vehicle movement. In three of these cases, the driver was a parent of the child.

These three patterns were distinguished mainly in terms of the level of supervision of the child, whether the child was outside or inside when last supervised, and whether the behavioural events were due to the child or an adult. The patterns also distinguish off-road fatalities occurring in driveways compared to other off-road fatalities. Most of the driveway fatalities occurred following the same overall pattern (Pattern 1) in which a child was left alone inside by a supervisor in a seemingly secure place. The child managed to get out of this secure place and into the path of a large vehicle. In each case the driver was unaware of the location of the child at the time. Three of the other off-road fatalities also showed Pattern 1, but the pattern was not as internally consistent as for the driveway cases.

The second most common pattern was distinguished by involving primarily the behaviour of an adult. In these cases, the child was at least partially supervised, such that the supervisor was completely aware of the child's location, however the fatal crash occurred due to the supervisor's behaviour in three cases and/or the behaviour of another adult driver in two cases. In two cases, the fatality occurred because the driver confused the accelerator for the brake, and in a third case the driver accelerated forward rapidly.

The distinguishing characteristics of the third most common pattern was the child running out into the path of the vehicle, despite the direct or indirect supervision by an adult. In all of these cases, the child was outside with or near an adult, but suddenly ran towards the vehicle. The cases in this pattern were also distinguished by involving light and heavy vehicles driven by a person other than the child's supervisor and by the fact that the vehicle was moving forward or reversing. For the vehicles moving forward, it was judged that the driver could have been aware of the location of the child.

Discussion

This study looked at the circumstances of all fatal motor vehicle crashes involving children under the age of six years reported to the NSW Coroner over the period 1995 to 2000. It therefore provides a useful series of cases for describing the wider circumstances in which these tragic accidents occur. The main purpose of such an analysis is to attempt to understand the main causes of these crashes and to better develop approaches to preventing them.

Overall two major groups of crashes emerged from the analysis; crashes where children were involved as passengers and crashes where children were involved as pedestrians. The pedestrian crashes could be grouped further into crashes occurring on-road and crashes occurring off-road. Each group of crashes was distinguished by different causal factors and to a large extent these differences were due to the role the child played in the circumstances of the crash. For example, where the child played little or no role in the crash, such as passenger crashes, there was fairly even distribution of age and gender amongst the children involved. In contrast, pedestrian crashes were much more likely to involve boys and to involve the one to two year old age group. In addition, the timing of passenger crashes involving small children seemed to reflect the time that babies and young children are likely to be travelling, for example, travelling in the middle of the day and on weekends. The timing of pedestrian crashes on the other hand were more like general traffic patterns, occurring mainly in the late afternoon and early evening and were evenly spread across days of the week.

Whilst the full range of road safety strategies are needed to reduce passenger fatalities, for fatalities in children of this age group the use of child restraints and seating position of children are two practices highlighted in this analysis. A failure to employ appropriate personal protective equipment (PPE) such as seatbelts, employing equipment not suited to the child's age, or failing to properly secure capsules or child seats, was a factor in almost half the fatalities. In particular, the failure to employ PPE was most evident in female fatalities, and those involving 1 to 2 year old children. Indeed, nearly three-quarters of 1 to 2 year olds in passenger crashes were not in or wearing a correctly fitted car restraint. Previous research has demonstrated the effectiveness of restraint use in preventing injuries in children and seating children in the rear of vehicles provides an additive and independent protective effect to that offered by restraints (Berg, Cook, Corneli, Vernon and Dean, 2000). Whilst this analysis showed that the majority of children were seated in the rear, 1 in 4 were seated in the front passenger seat.

Within the group of pedestrian crashes patterns of occurrence depended on where the crashes occurred; on or off-road and within the off-road group, whether they occurred in driveways or in other off-road areas. Different characteristics of crashes were seen for on-road and off-road crashes and for the different types of off-road crashes in terms of age, gender, timing and use of other safety equipment. For example, toddlers in the 1 to 2 year old age group accounted for the largest group of crashes for all locations, on-road and for both types of off-road pedestrian fatalities. In contrast, older children in the 3 to 4 and 5 years age groups accounted for a relatively large percentage of on-road cases, but very few off-road cases. Similarly, males had higher representation in on-road than in off-road pedestrian fatalities and within the group of

off-road crashes they were more common in driveway crashes than in other off-road pedestrian crashes.

This analysis highlighted the vulnerability of two groups in particular; 1 to 2 year old children and boys. These groups present important targets for reducing crashes involving under six year olds. Toddlers in the 1 to 2 years age group are clearly at increased risk for pedestrian crashes overall and for off-road pedestrian crashes in particular.

These results lead inevitably to the question; why would 1 to 2 year olds be so vulnerable? The most likely answer lies in the developmental stage of children in this age group. The transition from babyhood to fully functioning child is overall a gradual one in which the child's physical and mental processes develop but may progress in fits and starts. In the period roughly between around one and a half to around two years corresponds to considerable developmental change (e.g. Piaget and Inhelder, 1973). The child is becoming increasingly more mobile and curious with an emerging independence but is still not capable of understanding the concepts of rules and risks in their behaviour. They are discovering new behaviours which could include how to open a door and refining their abilities to imitate the behaviour of others which could include copying a parent leaving the house. This was particularly evident in patterns of events in off-road pedestrian crashes, with 9 of the 10 children who managed to get from a seemingly safe indoor area outdoors and in the path of a vehicle being in the 1 to 2 year age group. As a consequence, strategies to reduce the toddler's vulnerability that focus on the child him/herself, for example setting a rule for a 1 or 2 year old or telling the child to stay in a secure place, are unlikely to be successful. Rather, strategies need to focus on the circumstances in which the child becomes vulnerable.

The second vulnerable group, boys, are also more highly represented but only in on-road pedestrian crashes and off-road pedestrian crashes in driveways. One of the most common findings in the research on injury is that males have higher risk of injury than females, although not for all types of injury (Schmertmann and Williamson, 2002). The greater involvement of males in injury is often attributed to their supposed higher propensity to risk taking compared to females (Vavrck, 1997). This is consistent with the higher representation of male children in on-road pedestrian crashes because this type of crash is most likely to result from risky, adventurous or curiosity behaviour which results in the child coming into contact with the road environment. In contrast, as off-road crashes occur in places often frequented by the child, a child can come into contact with a vehicle off-road without exhibiting these sorts of behaviours. Males were however involved in 7 of the 10 cases in which children managed to get outdoors from seemingly safe locations. The finding of this study also suggests that gender differences in behaviour are exhibited very early. For this vulnerable group as well, the most effective crash prevention strategies are likely to focus on the circumstances in which the child becomes vulnerable, rather than on modifying the child's behaviour.

The characteristics of off-road pedestrian crashes identified in this study are similar to those found in previous studies. For example, a number of studies have found that children around the age of two years and boys are over-represented in these kinds of crashes (Brison et al., 1988; Roberts et al., 1993; Roberts et al., 1995; Robinson and

Nolan, 1997). Other studies have also found more off-road pedestrian crashes for this age group particularly in the late afternoon which were defined as times of high family activity (Roberts et al., 1993). Also consistent is the finding of a high representation of larger vehicles (Brisson, 1988; Agran et al., 1994; Robinson and Nolan, 1997) and that driveway crashes with young children typically involve a reversing vehicle (Agran et al., 1994, Roberts et al., 1993; Robinson and Nolan, 1997).

A major aim of this study was to look in depth at off-road crashes and driveway crashes in particular. This analysis revealed some common patterns of occurrence of crashes which help to refine our understanding of how the crashes occur and point to common features between crashes and more specific targets for preventive action in the circumstances in which the fatal crashes occur. For example, the most common pattern in off-road pedestrian crashes established the role of a number of factors that could be modified. These factors include; temporary periods of no supervision of a child, the child having access to the outside and consequently to be in the path of a vehicle, the driver being unaware of the proximity of the child when they started to move the vehicle and the role of large vehicles.

The next most common pattern involved a considerably smaller number of cases, but pointed out the role of adult behaviour in a subgroup of off-road pedestrian crashes. Adult behaviours seen in these off-road crashes took three main forms. One form was the adult failing to ensure or maintain the security of the child's surroundings by failing to install locks on doors or gates or leaving them open. This first form of error is most likely due to underestimating the risk involved in failing to install the safety equipment and the second is most likely due to a lapse of memory or temporarily not paying attention to this aspect of the child's safety. The absentminded and lapse types of errors are very common in everyday life (Reason, 1990). Another adult behaviour that was involved in off-road crashes was poor judgement or poor hazard awareness on the part of the adult about the riskiness of their behaviour at the time, such as leaving a child in a potentially vulnerable place. The third type of adult behaviour seen in these off-road crashes involved a driver error in unintended acceleration or inappropriately judged acceleration. This type of driver error has been recognised in previous research and found to be responsible for a small but significant number of crashes involving injuries and fatalities (Schmidt, 1989).

Aside from the involvement of adults in specific behaviours, one of the main ways in which adults were involved in almost all of these crashes was in the supervision of the young child. While it seems self-evident that supervision should play a role in the circumstances of pedestrian crashes involving young children, few of the previous studies of off-road pedestrian crashes included the role of supervision as a factor, focusing rather on environmental and other external causes. Pedestrian crashes occurred in some cases in this study even though the child was being directly supervised, indicating that active adult supervision alone will not prevent off-road crashes. Nevertheless, for most of the driveway fatalities the sequence of events leading to the fatal crash would not have started if the child had not been left alone and unsupervised.

Strategies for overcoming lapses in supervision are difficult, however. Clearly, simply telling supervisors to be more careful and active in their supervision is not the

only answer and may be an unreasonable expectation of the carer who cannot be with the child for every minute of the day. Rather, this study has suggested some specific characteristics of off-road pedestrian crashes which point to periods and circumstances to which carers could be alerted. For example, as discussed above, there are clearly vulnerable characteristics of children and from the research, there are vulnerable times of the day such as late afternoon and early morning, and instances in which parent/s or others are leaving the property. These are situations when a parent or carer might be advised to pay particular attention to the security of the child.

The study findings also suggest that passive or indirect supervision is insufficient and that even active, direct supervision may not suffice when a child is in close vicinity of a vehicle. In these situations, more uncompromising strategies need to be taken to keep a 1 to 2 year old child safe. These could include keeping physical contact with the child or even putting the child into the slowly moving vehicle while it is being manoeuvred by the driver. In addition it is essential to ensure that the driver is aware of the location of the child.

Recommendations

The results of this study suggest a number of recommendations for strategies to reduce the involvement of under six year old children in motor vehicle crashes. These recommendations relate mainly to pedestrian crashes.

The recommendations are as follows:

1. Road safety strategies need to highlight the significantly greater vulnerability of toddlers in the 1 to 2 year old age group. This should include educational strategies to alert parents and carers on the implications of day to day supervision of this group of children. To attempt to assist the supervision responsibility for parents and carers, advice should be provided about the factors that increase the risk of off-road pedestrian crashes. This could include such factors as the riskier times of the day when vehicle movements are more likely, the large number and range of vehicles which limit adequate vision around them and the need for effective safety devices on access points to areas where vehicles are likely to be located.
2. Educational strategies should also focus on appropriate modifications to increase the security of this age children in places where they are most likely to be, such as inside the home and in the outdoor environs of the home. Such modifications may include installation of locks on doors and gates, and barriers in the form of fences to prevent the ease with which young children can access areas where vehicles are found. Parents and carers should also be made aware of the developmental stages of early childhood including new behaviours which their child is likely to engage in, such as opening doors and following them or another parent outdoors, as well as the limited capacity of children of this age to understand rules and risks or danger.
3. Advice should be provided to parents and carers on safety practices when children are in the vicinity of vehicles which may be moved in order to reduce the risk that a child will run into the path of the vehicle. For example, holding the child, not just standing next to them or holding their hand when someone leaves the property, or even placing the child into the vehicle while it is being moved are strategies that could be used. These practices could also include avoiding use of driveways and places where vehicles are parked as play areas for children so that they are not encouraged to use them.
4. With respect to drivers, parents with children under the age of six years are one group to whom strategies designed to increase awareness of the circumstances of such accidents should be directed, particularly for driveway fatalities. At the same time, awareness should also be promoted in all drivers, as around half the drivers in these tragic accidents are not a parent to the child. In addition, strategies targeting drivers should not only focus on owners of 4WD's, but also drivers of other large vehicles, as well as sedans.
5. A small number of off-road pedestrian fatal crashes resulted from a driver making an unintended acceleration. There has been some research conducted on

approaches to reducing this type of foot placement error focusing mainly on redesign of brake and accelerator pedals. Work on vehicle design for reducing off-road pedestrian crashes to date has focused mainly on the driver's vision, but investigation into the need for research into better ways of reducing pedal error may be required.

6. Prevention of crashes involving this age group as passengers needs to be consistent with the full range of road safety strategies because the child plays little role in the causes of these crashes. Based on the findings of this study, the main strategy that is specific to the involvement of babies and young children as passengers is the use of appropriate personal protective equipment, particularly for children in the one to two year age group. This should include educational strategies to alert parents and carers of the need to ensure children are restrained in vehicles with restraints appropriate to the child's age, and that baby capsules and child seats are installed correctly. In addition, parents should be alerted to the additional protection afforded by seating children in the rear of vehicles.