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Title and Subtitle

Driveway deaths: fatalities of young children in Australia as a result of low-speed motor vehicle impacts

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Abstract

Using information extracted from coronial records, this report summarises the characteristics of 36 events that occurred between 1996 and 1998 involving fatalities of young children in Australia as a result of impacts with low-speed motor vehicles. Summary accounts of other studies are also provided. Most of the cases involved young toddlers who had positioned themselves close by stationary vehicles in the driveways of suburban residences. They were old enough to be mobile but too small to be easily visible from the driving position. The vehicles tended to be large, the majority being large 4WD passenger vehicles, large utility vehicles, delivery vans or heavy trucks, although either a sedan or a station wagon was involved in about one-fifth of the cases. The development of a preventative strategy will need to consider how to increase public awareness, encourage modification of high risk driveway environments, and equip vehicles with devices to enhance object detection.

Keywords

Driveway, Motor vehicle, Pedestrian, Childhood injuries

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Executive Summary

This report summarises the incidence and characteristics of events involving fatalities of young children in Australia as a result of low-speed motor vehicle impacts during 1996, 1997 and 1998 (the latest years for which full records are available).

These low-speed events are of a different character to pedestrian deaths occurring at normal traffic speeds. They typically involve very young children - mainly toddlers - in private driveways or other private property, and require their own set of safety countermeasures.

The report was initiated in response to a request from the Parliamentary Secretary to the Minister for Transport and Regional Services, Senator Ron Boswell. This followed studies in New South Wales that indicated a significant number of driveway fatalities of young children in that State. It was decided to conduct a closer examination of all recent cases across Australia using available coronial information together with a review of the published literature.

Based on the 36 cases identified from information on death summaries held by the Australian Bureau of Statistics, deaths of young children from low-speed motor vehicle impacts averaged 12 annually throughout Australia during the study period, with some year-to-year variation. There were 17 deaths in 1996, ten in 1997 and nine in 1998. Whereas this type of low-speed accident is primarily a non-traffic phenomenon, the scope of the report was not restricted to events on private property. A number of the accidents included within the report occurred on the street.

The report summarises information extracted from coronial records about each of the cases. Details of the age, height and sex of the deceased child, the circumstances leading up to the accident and the vehicle and driver characteristics are summarised to identify patterns in accident circumstances that may facilitate an understanding of how future accidents might be avoided.

Several common threads run across the cases. Most of the cases involved young toddlers who had positioned themselves close by a stationary vehicle. These children were old enough to be mobile, but too small to be easily visible from the driving position when close to the vehicle. Less commonly, the child had been unseen for reasons not associated with close proximity to the front or rear of the vehicle. These cases often involved children who had positioned themselves partially or fully underneath stationary heavy trucks.

Most of the accidents occurred at or near the child's home, where both the parent and the child may have felt that the child was safe. The immediate location was most commonly the driveway of a suburban residence. The driver of the vehicle was most likely to be a man and was generally a family member or a friend of the family. None of the cases involved a shared driveway.

The vehicles tended to be large, the majority being large 4WD passenger vehicles, large utility vehicles, delivery vans or heavy trucks, although either a sedan or a station wagon was involved in one-fifth of the cases. The predominance of large vehicles in these accidents contrasts with the fact that sedans and station wagons account for about two out of every three pedestrian traffic deaths in Australia. This is unlikely to be attributable solely to the fact that a low-speed collision involving a heavy vehicle is more likely to result in a fatality than one involving a sedan.

The accidents involving passenger vehicles predominantly entailed vehicles reversing in driveways. More than half of the passenger vehicles were large 4WDs, but the reason for this over-representation remains unclear. The relatively high sitting position of the driver in large 4WDs tends to counteract any reduction in the driver's field of view resulting from the high

window sills in such vehicles, but that benefit is significantly compromised in some models by the fitment of a spare wheel high on the rear door.

Commercial vehicles also featured prominently. Heavy trucks, large utilities and delivery vans were over-represented. The accidents involving these vehicles took place in a wide variety of locations, not just driveways, and entailed forward-moving vehicles as often as rearward-moving ones. The driver's all-round field of view is clearly an issue with heavy trucks being manoeuvred in places frequented by young children. Given that some of the truck accidents involved children who had positioned themselves underneath the truck or between the truck and its trailer, counter-measures directed at these vehicles will need to address more than just the forward and rearward vision from the driving position. The reason for the over-representation of large utilities and delivery vans is less clear. Little information is available to indicate whether or not the driver's field of view had been affected by possible blind spots or objects carried in the vehicles.

There is little to indicate that these types of deaths would be avoided by enhancements in medical intervention. The solution lies in the avoidance of such accidents. The development of counter-measures can be broadly classified under increasing public awareness, modifying the driveway environment and enhancing motor vehicle safety.

Increasing public awareness on how these tragic accidents may occur is a priority. Families with small children need to be particularly mindful of the dangers of slow-moving vehicles. The considerable variation in the particular circumstances of each of the cases studied indicates that care should be taken in every circumstance in which there is a possibility of young children being nearby. Given that many of the cases involved a child who, without being seen, had followed an adult from a house, an important specific message for parents is to be vigilant about the adequacy and use of door catches as soon as children become mobile.

Targeting families with small children is possible through early childhood centres and hospitals. Specific attention is warranted for rural Australia, where a large proportion of the accidents occurred and where there may be less scope to provide information via early childhood centres. Targeted material may need to counter possible perceptions that motor vehicles pose minimal dangers in low traffic areas.

Given that a number of the cases involved heavy trucks that were generally garaged at home, there is also a need to stress additional care by those who drive large vehicles for a living and park their vehicles at home.

Modifying the driveway environment and creating safe play areas for children is an important priority although the implementation of any plan that targets families most at risk may not be straightforward. Further research in this area is warranted.

Enhancing motor vehicle safety is another important component of a comprehensive preventative strategy. Attention needs to be directed towards improving the driver's visual ergonomics in all types of vehicles, including sedans, and eliminating objects fitted to the interior or exterior of vehicles that are responsible for significant blind spots in the driver's field of view. There is also a potential role for technological measures to enhance object detection. Such measures include proximity sensors, additional mirrors, wide-angles lenses and video systems. Whereas it is unlikely that a proximity sensor could be developed that would work as a stand-alone measure, it may be feasible to develop a viable countermeasure of moderate cost based on a combination of proximity sensor and a wide-angle video camera system. Such measures will nevertheless rely critically upon increased awareness and care on the driver's part.

1. Introduction

Background

This report summarises the incidence and characteristics of events involving fatalities of young children in Australia as a result of low-speed motor vehicle impacts during 1996, 1997 and 1998 (the latest years for which full records are available).

These low-speed events are of a different character to pedestrian deaths occurring at normal traffic speeds. They typically involve very young children - mainly toddlers - in private driveways or other private property, and require their own set of safety countermeasures.

The report was initiated in response to a request from the Parliamentary Secretary to the Minister for Transport and Regional Services, Senator Ron Boswell. This followed studies in New South Wales [8, 11] that indicated a significant number of driveway fatalities of young children in that State. This type of accident was also identified as significant and not uncommon among child accidental deaths in Victoria, accounting for 16% of pedestrian paediatric fatalities in a study covering an 11-year period 1985-1995 [18].

It was decided to conduct a closer examination of all recent cases throughout Australia. Information was extracted from coronial records about each of the cases identified for the study. Details of the age, height and sex of the deceased child, the circumstances leading up to the accident and the vehicle and driver characteristics were summarised to identify patterns in accident circumstances that may facilitate an understanding of how future accidents might be avoided.

This report also includes summary accounts of published literature on Australian and overseas studies of such events, including comparisons with the findings of our study.

Scope of the report

The report is restricted to deaths of children registered during 1996, 1997 and 1998 that stemmed from low-speed impacts with motorised road vehicles that were under driver control.

It was decided at the outset to restrict the search for cases of interest to solely those involving children aged no older than seven years. It transpired that all but three of the deaths within this age range that occurred during the study period in fact involved children below four years of age and none involved a child older than six years of age.

Whereas this type of low-speed accident is primarily a non-traffic phenomenon, the scope of the report has not been restricted to events on private property. A number of the accidents included in the report occurred on the street.

Excluded from the scope of the report are events involving non-road vehicles, eg agricultural vehicles.

2. Data Sources

Because of privacy constraints, it was not possible to identify the cases of interest by reference to listings maintained by State and Territory agencies. The cases were instead identified from information on death summaries held by the Australian Bureau of Statistics (ABS) after requisite confidentiality undertakings were put in place with State and Territory Registrars of Births, Deaths and Marriages.

The ABS maintains a statistical record of each death in Australia, based on information routinely provided to it by the State and Territory Registrars of Births, Deaths and Marriages, and its staff classify the cause of death of each individual by reference to the International Classification of Diseases (ICD). An External Cause of Injury code (ie E-code) is also allocated in the case of each accidental death. The death registration number and date of death were sought from the ABS for each death of a child aged seven or less that was registered during 1996, 1997 and 1998 and classified with an E-code of the ICD (version 9) that was within the range 810 to 829 (ie traffic accidents, non-traffic accidents or other road vehicle accidents) and for which the E-code included a fourth digit that identified the type of person as being either a pedestrian (ie code 7) or an 'unspecified person' (ie code 9).

By reference to the death registration numbers, the names of the deceased children were then obtained from the State and Territory Registrars of Births, Deaths and Marriages. As stated above, this required confidentiality undertakings to be put in place in a number of jurisdictions. Coronial reports pertaining to these names were then sought from the State and Territory Coroners.

After removal of extraneous cases (mainly those that had occurred at normal traffic speeds), a total of 36 cases were identified as being within the scope of the report. Thirty-five of these had been identified from the ABS records. Validation of case totals was undertaken for the State of Queensland [1] and this indicated a shortfall of one case in that State. Coronial documentation was subsequently sought and obtained for that additional death.

The fact that the additional Queensland event had not been identifiable from the group of E-codes interrogated in the ABS records indicates that caution should be exercised in assuming that each and every Australian occurrence during 1996-1998 has been reported here.

[1] This validation was done for the ATSB by the Mater Hospital Clinical Epidemiology Centre through reference to its records of child deaths in Queensland. The validation was done without compromising the confidentiality of the names and other personal information held by the Centre.

3. Related Studies

Other case studies

Appended to this report are summary accounts of peer-reviewed published studies about injuries and deaths of young children in non-traffic or low-speed impacts with motor vehicles. Comparisons of the findings of these studies with the data extracted for this report can be found within the following Results section.

The following is a list of the most directly relevant of these studies. The populations studied in these articles included children in Australia, New Zealand, Europe and the United States of America. Some of the articles reviewed a wider scope of injury and fatality data than that obtained for this study, and to facilitate comparisons only the component of each article that fell more or less within the scope of this study has been summarised below.

Country	Years covered	Number of children	Type of data	Data source	Age group studied	Information collected
USA [3]	1979-1983	41	Deaths	Coroner reports, police records	< 5 years	Age, sex of child, types of injuries, vehicle type, direction of motion, time of accident, driver's relation to child
USA [4]	Oct 1995-Oct 2000	421	Injuries	National Pediatric Trauma Registry	< 20 years	Age, sex of child, severity of injuries
UK [6]	1995-1999	4	Injuries	Regional pediatric surgical centre	<5 years	Case reports
NSW [8]	Injuries: Nov 1995-Feb 2000 Deaths: Jan 1988-Dec 1999	42, 14	Injuries, deaths	Hospital records, NSW Pediatric Trauma Death Registry	< 16 years	Age, sex of child, types of injuries, vehicle type, direction of motion, time of accident, driver's relation to child, access restrictions to driveway
Austria [9]	Apr 1993-Apr 2001	32	Injuries	Hospital records	< 15 years	Age, sex of child, types of injuries, driver's relation to child
USA [10]	May 1986-Aug 1999	44	Injuries	Hospital records	< 18 years	Age, sex , weight of child, types of injuries, patient outcome, vehicle type, direction of motion, time of accident
NSW [11]	Jan 1996-June 1999	17	Deaths	Child Death Register	< 18 years	Sex of child. Age range, summary of general pattern of accident circumstances
USA [13]	Jan 1991-Dec 1996	51	Injuries, deaths	Two urban trauma centres	< 18 years	Age, sex of child, types of injuries, circumstances of accident, driver's relation to child
New Zealand [15]	1986-1990	91, 8	Injuries, deaths	Coroner and hospital records	< 15 years	Age, sex of child, direction and motion of vehicle, time and location of accident
New Zealand [17]	Jan 1992-Jan 1993	25	Injuries, deaths	Coroner and hospital records	< 15 years	Age, sex of child, time of accident, type of dwelling, presence of fences
Victoria [18]	1985-1995	25	Deaths	Consultative Council on Obstetric and Pediatric Morbidity and Mortality	< 15 years	Age, sex of child, vehicle type, direction of motion, time of accident, child's relationship to driver, activity involved
USA [19]	Mar 1990-Oct 1994	26	Injuries	Urban trauma centre	< 16 years	Age, sex of child, types and severity of injuries

The incidence of events from the fatality studies is consistent with that seen in our study. It is to be expected that the number of incidents is related to the time period under investigation, the

scope of the study, and the area and density of the population in the reporting area. Most of the studies covered a multiple year period in a single metropolitan area and environs. In such a setting, there were typically a dozen of so fatalities reported over a five-year period.

Some of these studies reviewed pedestrian injuries as well as fatalities. The non-traffic child pedestrian deaths identified in the studies accounted for between 8% [15] and 20% [13] of all non-traffic child pedestrian injuries from motor vehicles. Nadler et al [10] report a mortality rate of 9% (4/44) and a 'poor outcome' rate (rehabilitation or death) of 18% (8/44). There was a consistent finding that toddlers have poorer outcomes than older children.

One small study in the United Kingdom [6] failed to identify any fatalities among the reviewed cases of child pedestrian driveway injury. The authors found only few similarities between driveway accident patterns in the United Kingdom and those reported in the literature in the USA. They suggested that these differences perhaps reflect the differing proportion of residences with cars and driveways.

Towards a prevention strategy

The above case studies offered possible strategies for preventing accidents of this type. Such strategies included developing greater public awareness of the issue, creating a secure separation between the driveway and children's play areas, and developing better visual and sensory devices for cars and commercial vehicles.

None of these discussions was as thorough or as well considered as that appearing in Henderson [7] in his response to the New South Wales Child Death Review Team Report 1998-99 [11]. He offered a series of fairly specific recommendations for developing public awareness, modifying human behaviour and environmental risks, and finding practicable ways to equip vehicles to improve visual fields. For the NSW policy analyst interested in developing a countermeasure framework, this article offers clear guidance on creating an effective multi-faceted strategy making use of existing resources in the NSW community.

Henderson pointed out, for example, that parents of toddlers can be targeted through early childhood centres and early childhood education centres. He reported that the Early Childhood Road Safety Program at Macquarie University provides professional development workshops on road safety education. A key element in road safety education, he found, is the maintenance of a strong partnership between the Roads and Traffic Authority of New South Wales and these education providers.

In addition, he considered that creating a safer home environment for toddlers and their families is possible through public education and possibly through developing building standards focused on driveway safety. He stressed the importance of targeting the households most likely at risk.

Finally, he discussed the use of sensory and visual devices for vehicles to enhance object detection. A more comprehensive assessment of these devices appears in a later report, described below.

Device studies

In a recent review of possible technological measures for reducing the risk of driveway injuries and fatalities, Paine and Henderson [12] discussed the present limitations of rear vision for a

sample of passenger and commercial vehicles, the essential requirements of effective sensory and visual aid systems, and the current technology and its limitations.

These authors found that limitations on a driver's rear field of view depended upon driver size, in particular eye height when seated, and that the relatively high sitting position of the driver in large 4WDs or commercial vans tended to counteract the high window sills of those vehicles. The driver's rearward field of view amongst their limited sample of large 4WDs and empty commercial vans was better than that in some sedans and worse than that in others. The authors also demonstrated that various types of objects fitted to the interior or exterior of vehicles sometimes create significant blind spots for drivers of both sedans and large 4WDs.

The authors observed that the effectiveness of any proximity sensor is highly dependent upon the initial speed of the vehicle, the sensory detection range, the duration from detection to alarm activation, the driver reaction time and the braking distance of the vehicle. They used a stochastic model of driver reaction times to estimate the probability of avoiding a collision under a range of scenarios assuming estimated reaction times for 'alert' drivers, a sensor reaction time of 0.2 seconds, an average deceleration of 5 m/s^2, and a detection device that is 100 per cent accurate. A subset of these estimates is reproduced in the table below:

Table 1 Estimated percentage of collisions avoided by a proximity sensor device

	Detection distance of proximity sensor device (m)				
	1.0	1.5	2.0	3.0	4.0
Vehicle speed (km/h)					
2	98%	100%	100%	100%	100%
4	47%	84%	97%	100%	100%
6	3%	39%	72%	96%	100%
8	0%	4%	31%	79%	95%
10	0%	0%	4%	48%	81%

Three out of the four sensory devices reviewed in this article had a detection range of no more than 1.5 metres. With these devices, a collision would be avoided in only 39% of cases involving a vehicle travelling at 6 km/h and in only 4% of cases involving a vehicle travelling at 8 km/h. These probabilities further reduce when one considers less optimistic reaction times and less accurate detection.

The authors regarded it as unlikely that a proximity sensor could be developed that would work as a stand-alone measure, and that a combination of proximity sensor and visual aid would be needed to cover all rear blind spots. They found that wide-angle lenses and auxiliary mirrors would not provide sufficient coverage or clear enough images, and considered that video cameras provide the best opportunity for technological improvement. They considered it probably feasible to develop a viable countermeasure of moderate cost based on a combination of short-range (and low cost) proximity sensor and a wide-angle video camera system.

The authors emphasised that no visual or sensory technology is effective if the driver is not alert and sensitive to potential hazards.

4. Results

Overall incidence

Based on the 36 cases identified from the ABS records, deaths of young children from low-speed motor vehicle impacts averaged 12 annually throughout Australia during the study period, with some year-to-year variation. There were 17 deaths in 1996, ten in 1997 and nine in 1998. The majority of the cases were reported in NSW and Queensland, although there was at least one case reported in each state.

Table 2 Number of child pedestrian fatalities resulting from low-speed motor vehicle impacts in Australia during 1996-1998, by State/Territory and year

	Australian total	State/Territory NSW	Vic	Qld	SA	WA	Tas	NT	ACT
Year of accident									
1996	17	4	3	6	0	2	1	1	0
1997	10	4	1	2	1	2	0	0	0
1998	9	5	1	3	0	0	0	0	0
Total	36	13	5	11	1	4	1	1	0

The children

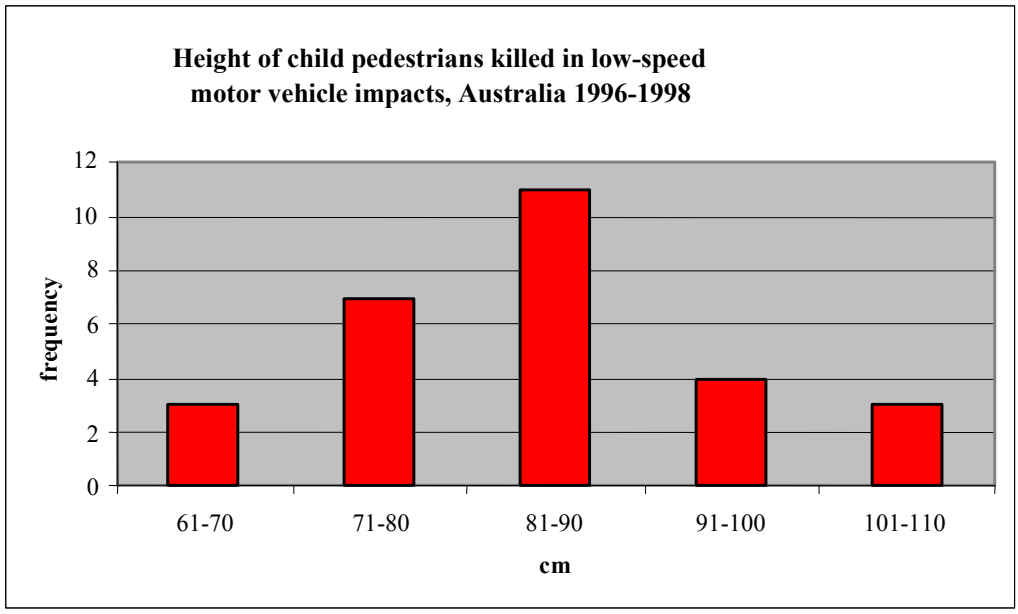
The majority of accidents involved children who were in their second year of life. The median age was 20 months and just over 60% of the children were between 13 and 24 months of age. The oldest child was six years old. As with most other childhood injuries, the child was more likely to be a boy. Thirteen of the fatalities were girls and 23 were boys.

Other studies have reported that young children aged between one and two years are a high-risk group compared with children of other ages. A review of pedestrian injuries between January 1992 and January 1993 at Auckland, New Zealand [17] reported a median age of 18 months for 25 children injured in residential driveways. A review of coroners' reports and police records for Washington State in 1979-1983 [3] identified 41 children aged less than five years who had died in non-traffic collisions with vehicles, the highest risk group being children between one and two

years of age. In a retrospective case series of driveway injuries during the 1990s in New South Wales [8] the median age among the survivors was 23 months and the median age among the deceased was 18 months. In a US study undertaken at the Denver Health Medical Centre [13] that reviewed the period 1990 to 1996, the average age of a child involved in a driveway injury was 3.4 years. The incidence was concentrated in the 0-4 age group, accounting for 41 of the 51 reported accidents. The eight reported fatalities belonged to this age group.

Children ranged in height from 66 to 104 centimetres, with a median height of 86 centimetres.[2] It appears that in most cases the child had been very close to the vehicle immediately prior to the driver setting off, and this together with short stature might have been a significant contributor in most of the events. In a recent study of visual ergonomics for a wide range of vehicle types, it was found that even amongst vehicles with a wide visual coverage, a 60 centimeter test cylinder was visible in the driver's rear mirror only when it was more than three metres from the rear of the vehicle [12]. More commonly, it was necessary to place the cylinder between five and ten metres behind a vehicle before it was detectable.

Less commonly, the child had been unseen for reasons probably not associated with close proximity to the front or rear of the vehicle. In two cases, the child had been a considerable distance from the vehicle prior to it moving towards the child. In five cases, the child had been positioned partially or fully underneath a stationary heavy truck or between a truck and its trailer.



Accident conditions

Thirty-two of the events (89%) occurred during daylight hours, most often in the morning between 8 am and 10 am or in the late afternoon between 4 pm and 6 pm. No day of the week stood out as higher risk than the others, and these accidents were as likely to occur on a weekday (25 cases) as on a weekend (11 cases). The weather was generally reported to be fine and clear.

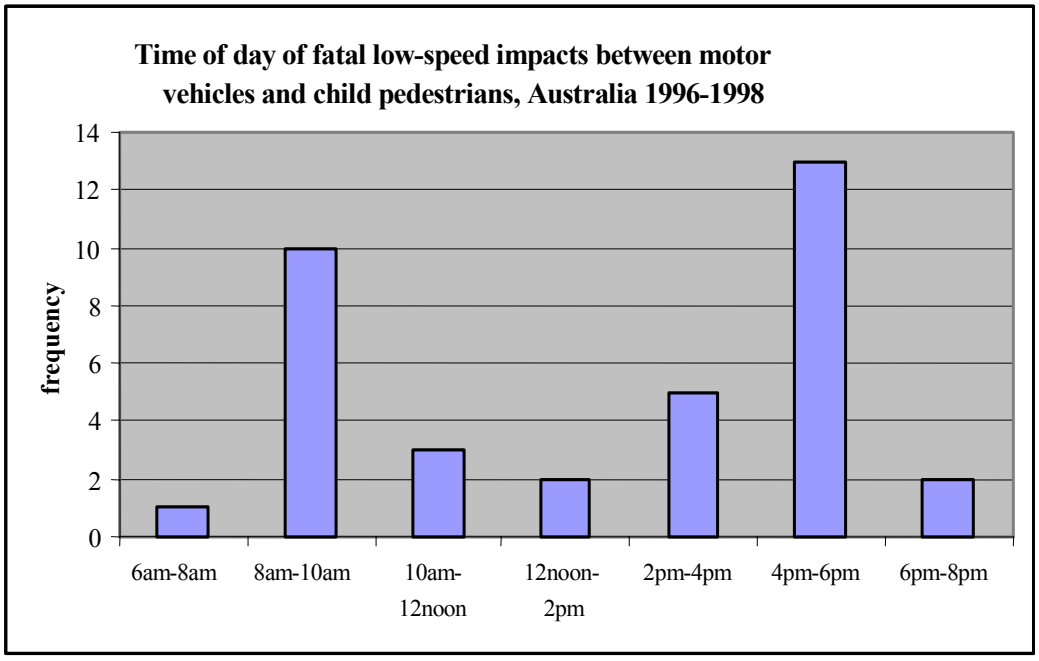
Other studies corroborated the general finding that these accidents occur predominantly during daytime in fine weather. The differences from this series and other studies lay only in the fine detail. In the Auckland study [17], driveway injury times were evenly distributed throughout the daylight hours, and 25% of the cases occurred on Sunday. In the five-year case series covering

[2] Heights for 8 children were not available

1979 to 1983 in Washington State [3], it was reported that 71% of the non-traffic related fatalities occurred between noon and 7 pm. The Australian retrospective review of hospital records and death registry [8] reported that 82% of injuries occurred in the afternoon or evening, whereas 43% of the fatalities occurred in the morning.

Table 3 Environmental conditions of fatal low-speed impacts between motor vehicles and child pedestrians, Australia 1996-98

Environmental condition	frequency	%
Weekday	25	69
Weekend	11	31
Natural light		
Day	32	89
Night	1	3
Dawn	1	3
Dusk	2	6
Lighting		
Daytime	32	89
Dawn or dusk, with unknown lighting	3	8
Night-time, with inadequate lighting	1	3
Weather		
Fine	30	83
Rain	1	3
Unknown	5	14



Accident location

A disproportionately large number of these accidents occurred in rural Australia. Whereas less than one-third of Australians live outside major urban centres having over 100,000 population, almost two-thirds (23/36) of the accidents occurred outside a major urban centre. Of these, fifteen occurred in country and coastal towns and eight occurred in small rural localities or other rural areas.

Most of the accidents (28 or 78%) occurred in the immediate vicinity of the child's home, usually a single-family residence. Another 4 (11%) accidents occurred at the home of a friend or relative. The remaining 4 accidents (11%) occurred either on commercial property or in a camping area.

A residential driveway was the most common location for these accidents. Twenty-three of the accidents occurred there, and two additional accidents occurred on the street as the vehicle was backing into or out of the driveway. Those two street accidents involved children between one and two years of age. There were three other street accidents, all of which involved older boys being run over by trucks, and with indications that the boys took an active interest in the trucks.

While a 1995 New Zealand study [16] found that a shared driveway was a significant risk factor for driveway-related child pedestrian injuries, none of the cases reviewed in this ATSB report involved a shared driveway.

Two accidents occurring in the yard in front of a house. These followed the same pattern as the driveway accidents. In both cases the vehicle was leaving the premises, moving forward slowly.

Table 4 Location of fatal low-speed impacts between motor vehicles and child pedestrians, Australia 1996-98

Location	frequency	%
Geographic region		
Major urban centre over 100,000 population	13	36
Town of 1,000–99,999 population	15	42
Rural locality of 200-999 population	4	11
Other rural area	4	11
Neighbourhood		
At child's residence	28	78
At relative/friend's residence	4	11
At other location	4	11
Immediate area		
Residential driveway	23	64
Street adjacent to house	5	14
Yard at front of house	2	6
Caravan park or camping ground [(a)]	3	8
Paddock on farm	1	3
Service station	1	3
Workshop	1	3

a. In one case, this was the child's long-term residence.

The events preceding the accidents covered a wide range of circumstances. Fourteen of the cases occurred immediately after a child, without being seen, had followed an adult from the house. The child left by the front door in six of these cases, by the rear door in five cases and by an internal door to the garage in three cases. In another 16 cases the child had been engaged in activities outside the house for some time prior to the accident, generally in the company of one or both parents.

Table 5 Prior locations of children involved in fatal low-speed impacts with motor vehicles, Australia 1996-98

Prior location of child	frequency	%
Child had followed an adult from house		
Via a closed door	5	14
Via an open door	3	8
Unstated if door closed or open	6	17
Subtotal	**14**	**39**
Child had already been outside house		
Accompanying parents in yard activities or arrival/departure activities	8	22
In company of parents seeing off visitors	2	6
With permission to play in front yard unsupervised by parents	4	11
Prior supervision unstated	2	6
Subtotal	**16**	**44**
Accident occurred at commercial premises, caravan park, camping ground or paddock	**6**	**17**
Total cases	**36**	**100**

In each case the vehicle was moving slowly at impact and the driver was not aware that the child was in the immediate vicinity of the vehicle. It appeared that in most cases the child had been very close to the vehicle immediately prior to the driver setting off. It was commonly reported by the drivers involved in these accidents that their vehicle had travelled a very short distance before they became aware of an impact.

The vehicles

The vehicles involved in these fatal accidents were mostly large (29 of 36 cases).

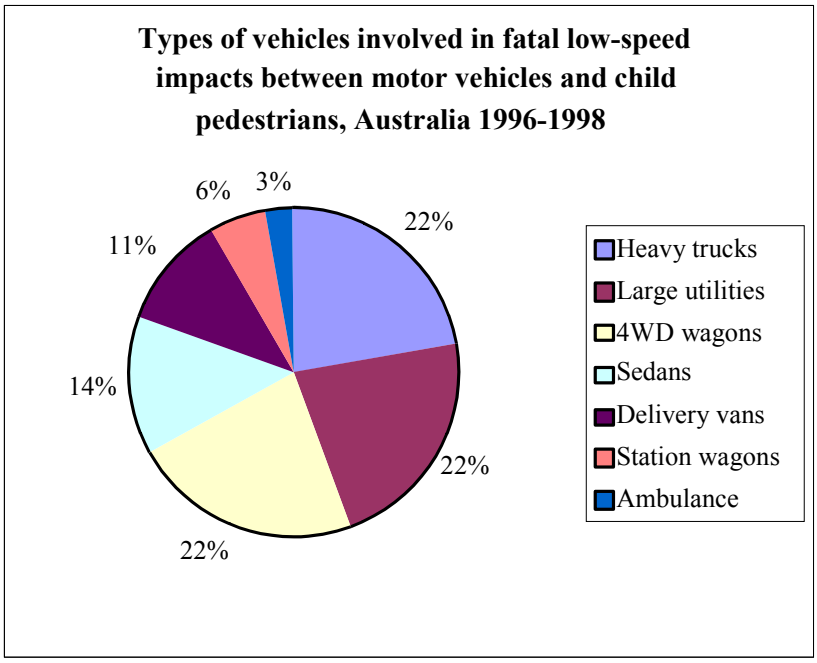
Eight of the vehicles (22%) were heavy trucks; of these two were semi-trailers and one was a prime mover without trailer. Three of these accidents involved vehicles that were generally garaged at home and the accident occurred whilst the vehicle was leaving for or returning from the working day.

There was a strong association between age of child and vehicle type. Of the eight cases involving a heavy truck, only one involved a child under two years of age. Conversely, a heavy truck was involved in all six accidents involving children aged three years or older. Of these, five were boys and one was a girl. There are indications that in some of these cases the child had a particular interest in the truck.

Large utilities were involved in another eight accidents (22 %). The children involved in collisions with these vehicles ranged in age from 14 months to 30 months.

Eight of the vehicles (22%) were large 4WD passenger vehicles, four (11%) were delivery vans and one was an ambulance. All but one of the children involved in collisions with these vehicles were of two years of age or less.

Sedans and station wagons comprised the remaining seven cases (19%). All of the children involved in collisions with these vehicles were of two years of age or less.



These findings are broadly comparable with other recent studies of children injured by motor vehicles in driveways. Holland et al [8] reported that 4WDs and light commercial vehicles were involved in about 50% (23/45) of reviewed cases. A similar case study by Nadler et al [10] of driveway injuries in the USA reported that a sports utility vehicle or truck was the responsible vehicle in 64% (28/44) of cases in which a driver had been involved. In an earlier USA study (1988), Brison et al [3] reported that nearly 60% (22/37) of the known involved vehicles were trucks or jeeps.

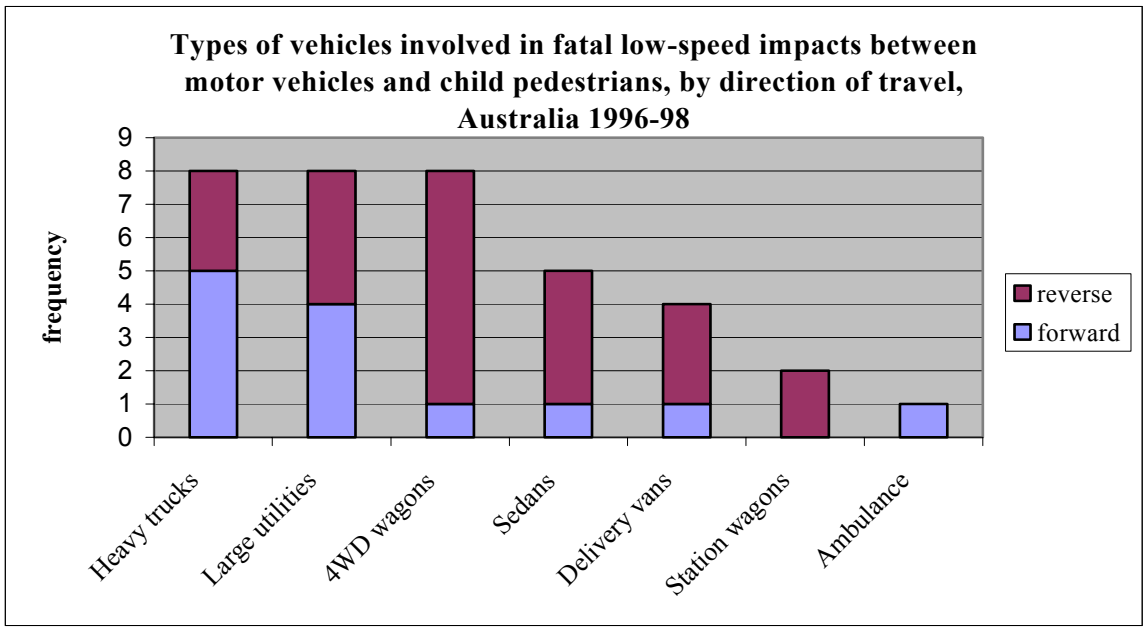
The predominance of large vehicles in this specific type of accident contrasts with the fact that sedans and station wagons account for about two out of every three pedestrian traffic deaths in Australia. It would seem unlikely for such a disparity to be solely attributable to the fact that a low-speed collision involving a heavy vehicle is more likely to result in a fatality than a low-speed collision involving a sedan. The pattern of movement of each vehicle involved in these accidents was examined to assess the presence of other factors such as reduced field of view for drivers of large vehicles.

The accidents involving passenger vehicles (large 4WD passenger vehicles, sedans and station wagons) took place predominantly in driveways (13 of 15 accidents). A reversing vehicle was involved in 13 of the cases, as might be expected from the fact that vehicles are most commonly driven forward into driveways and reversed out of them. More than half of the passenger vehicles were large 4WDs (8 of 15), but the reason for this over-representation remains unclear. The relatively high sitting position of the driver in large 4WDs tends to counteract any reduction in the driver's field of view resulting from the high window sills in such vehicles, but that benefit is significantly compromised in some models by the fitment of a spare wheel high on the rear door [12].

Heavy trucks and large utilities were both over-represented. The accidents involving these vehicles took place in a wide variety of locations, not just driveways, and entailed forward-moving vehicles as much as rearward-moving ones. The driver's all-round field of view is clearly an issue with heavy trucks being manoeuvred in places frequented by young children. Given that some of the truck accidents involved children who had positioned themselves underneath the truck or between the truck and its trailer, countermeasures directed at these vehicles will need to

address more than just the forward and rearward vision from the driving position. The reason for the over-representation of large utilities is less clear. Little information was available to indicate whether or not the driver's rear field of view had been affected by possible blind spots or objects carried in the vehicles.

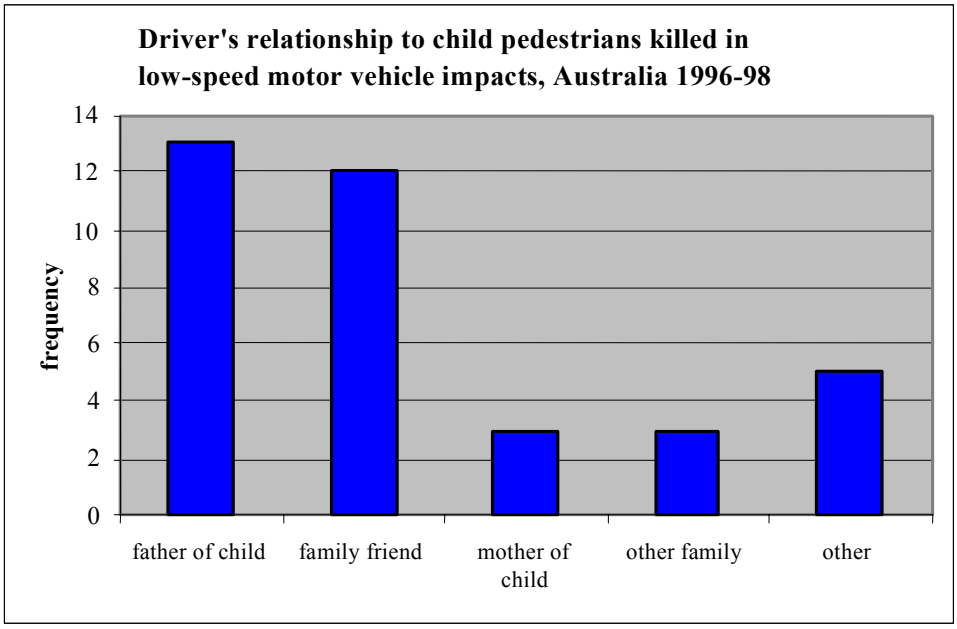
Delivery vans were likewise over-represented. Three of the four accidents involving these vehicles entailed vans being reversed in a variety of locations. Amongst a limited sample of empty commercial vans, Paine and Henderson [12] found the driver's rearward field of view to be comparable to that in many sedans. For the accidents in question, however, no information is available on the extent to which the driver's rear field of view may have been compromised by objects carried in the vans.



The drivers

In 31 of the 36 cases (86%) the driver of the vehicle was a family member or a friend of the family. The driver was the father in 13 (36%) of the cases and was the mother in three (8%) of the cases. Thirty (83%) of the 36 drivers were men. Just two of the accidents involved vehicles making deliveries to a private residence.

These findings are consistent with other published case studies that collected information on driver characteristics. In a study covering 1979-1983 in Washington State [3], the involved driver was a parent or family friend in 71% of the 28 cases for which driver information was available. In a combined retrospective review of driveway-related injuries and fatalities from records in the 1990s of a NSW hospital and the NSW Paediatric Trauma Death Registry [8], the involved driver was a relative or family friend in 91% of 54 reviewed cases. In a study covering the period 1985-1995 in Victoria [18], all but one of the 25 drivers was a relative or family friend. In the remaining case, the driver was a tradesman.



The type of driver's licence was known for 30 drivers. Of these, 83% (25/30) carried a normal full licence. Two of the drivers had an initial P-plate licence.

Although drivers were not tested in all cases, there was no evidence that alcohol was a factor in any of the accidents. There was one instance of suspected recreational drug use by the involved driver, but no formal drug test was performed.

Table 6 Characteristics of drivers involved in fatal low-speed impacts between motor vehicles and child pedestrians, Australia 1996-98

Driver characteristic	frequency	%
Age of driver		
17-24	4	11
25-34	14	39
35-44	5	14
45-54	6	17
55-64	2	6
65+	1	3
Unknown	4	11
Sex of driver		
Male	30	83
Female	6	17
Licence type		
Normal full licence	25	69
Initial P-plate licence	2	6
Expired or surrendered licence	1	3
Appropriate licence of unstated category	2	6
Unknown	6	17
Driver's blood alcohol concentration		
Nil	14	39
Not tested / Unknown if tested	22	61
Drug test on driver		
No test / Unknown if tested	36	100

5. Conclusions

Several common threads ran across these reported cases from 1996-98. Most of the cases involved young toddlers who had positioned themselves close by a stationary vehicle. These children were old enough to be mobile, but too small to be easily visible from the driving position. Most of the accidents occurred at or near the child's home, where both the parent and the child may have felt that the child was safe. The immediate location was most commonly the driveway of a suburban residence. The driver of the vehicle was most likely to be a man and was generally a family member or a friend of the family.

The vehicles tended to be large, the majority being large 4WD passenger vehicles, large utility vehicles, delivery vans or heavy trucks, although either a sedan or a station wagon was involved in one-fifth of the cases. The predominance of large vehicles in this specific type of accident contrasts with the fact that sedans and station wagons account for about two out of every three pedestrian traffic deaths in Australia. It would seem unlikely for such a disparity to be solely attributable to the fact that a low-speed collision involving a heavy vehicle is more likely to result in a fatality than one involving a sedan.

The accidents involving passenger vehicles predominantly entailed vehicles reversing in driveways. More than half of the passenger vehicles were large 4WDs, but the reason for this over-representation remains unclear. The relatively high sitting position of the driver in large 4WDs tends to counteract any reduction in the driver's field of view resulting from the high window sills in such vehicles, but that benefit is significantly compromised in some models by the fitment of a spare wheel high on the rear door [12].

Commercial vehicles also featured prominently. Heavy trucks, large utilities and delivery vans were over-represented. The accidents involving these vehicles took place in a wide variety of locations, not just driveways, and entailed forward-moving vehicles as much as rearward-moving ones. The driver's all-round field of view is clearly an issue with heavy trucks being manoeuvred in places frequented by young children. Given that some of the truck accidents involved children who had positioned themselves underneath the truck or between the truck and its trailer, counter-measures directed at these vehicles will need to address more than just the forward and rearward vision from the driving position. The reason for the over-representation of large utilities and delivery vans is less clear. Little information is available to indicate whether or not the driver's field of view had been affected by possible blind spots or objects carried in the vehicles.

There was little to indicate that these types of deaths would have been avoided by enhancements in medical intervention. The solution lies in the avoidance of such accidents. As outlined by Henderson [7] and others, there is a need for a multi-faceted approach targeting households most likely to be at risk and making efficient use of existing resources in partnership. The development of countermeasures can be broadly classified under increasing public awareness with the aim of modifying human behaviour, modifying the driveway environment and creating safe play areas for children, and enhancing motor vehicle safety.

Increasing public awareness on how these tragic accidents may occur is a priority. Families with small children need to be particularly mindful of the dangers of slow-moving vehicles. The considerable variation in the particular circumstances of each of the cases studied indicates that care should be taken in every circumstance in which there is a possibility of young children being nearby. Given that many of the cases involved a child who, without being seen, had followed an adult from a house, an important specific message for parents is to be vigilant about the adequacy and use of door catches as soon as children become mobile.

Targeting families with small children is possible through early childhood centres and hospitals. Working through liaison groups, educators can stay well informed of road safety issues as they emerge from current traffic injury and fatality figures collected and interpreted by government agencies. Specific attention is warranted for rural Australia, where a large proportion of the accidents occurred and where there may be less scope to provide information via early childhood centres. Targeted material may need to counter possible perceptions that motor vehicles pose minimal dangers in low traffic areas.

Given that a number of the cases involved heavy trucks that were generally garaged at home, there is also a need to stress additional care by those who drive large vehicles for a living and park their vehicles at home.

Modifying the driveway environment and creating safe play areas for children is an important priority although the implementation of a plan that targets families most at risk may not be straightforward. Henderson [7] provided some general guidance on how targeted public programs can assist families to create safe play areas for children and how government can work with the construction industry to focus on driveway safety. Further research in this area is warranted.

Enhancing motor vehicle safety is another important component of a comprehensive preventative strategy. Attention needs to be directed towards improving the driver's visual ergonomics in all types of vehicles, including sedans, and eliminating objects fitted to the interior or exterior of vehicles that are responsible for significant blind spots in the driver's field of view. There is also a potential role for technological measures to enhance object detection. Such measures include proximity sensors, additional mirrors, wide-angles lenses and video systems. Whereas it is unlikely that a proximity sensor could be developed that would work as a stand-alone measure, Paine and Henderson [12] consider that it may be feasible to develop a viable countermeasure of moderate cost based on a combination of proximity sensor and a wide-angle video camera system. Such measures will nevertheless rely critically upon increased awareness and care on the driver's part.

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Appendix: Summary Accounts of Other Studies

The following set of summary accounts of studies about injuries and deaths of children in low-speed pedestrian incidents is based on a comprehensive search of the peer-reviewed published literature.

Author	Agran PF, Winn DG and Anderson CL
Year	1994
Title	Differences in child pedestrian injury events by location.
Journal	Pediatrics 93(2):284-288
Country	USA
Abstract	OBJECTIVE. To compare child pedestrian injury events occurring in driveways and parking lots and at midblock and intersections with respect to characteristics and activity of the child, injury outcome measures, and characteristics of the vehicle and roadway. DESIGN. Descriptive case series. SETTING. Data were obtained from a multihospital/coroner monitoring system, during 2 years in an urban county, by record review and interviews. PATIENTS. The sample consisted of 345 pedestrians 0 through 14 years of age treated for injuries at one of the participating facilities. RESULTS. Eleven per cent were injured in driveways, 8% in parking lots, 53% at midblock, and 28% at intersections. Median age was 2 years for driveways, 4 years for parking lots, 6 years for midblock, and 10 years for intersection. Events in driveways and parking lots had significantly more vehicles backing up, fewer automobiles, and more pedestrians with adults. Events at intersections occurred more often on streets with more than two lanes with speed limits > 25 mph, and with moderate or heavy traffic than events mid-block. Sixteen per cent of those injured in driveways and parking lots sustained head injury of moderate or greater severity versus 35% injured in the street. CONCLUSIONS. Interventions to prevent child pedestrian injuries must consider normal child behaviour and driver awareness as it relates to location of the events. Driveway events involve small children, larger vehicles, and backing up. Mid-block events involve children too young to cross even quiet residential streets safely. Traffic controls and safe street crossing skills are measures to consider for intersection events involving older children.

Author	Agran P, Winn D and Castillo D
Year	1991
Title	Unsupervised children in vehicles: a risk for pediatric trauma.
Journal	Pediatrics 87(1):70-3
Country	USA
Abstract	In this study, a series of instances of children injured by a motor vehicle set in motion by an unsupervised child are reviewed. During a 24-month period, nine such children were identified through a multihospital and coroner's office monitoring system in a single urban county. Injuries ranged from multiple abrasions and contusions to serious leg and head injuries. Three children died. The typical circumstance involved a child releasing the brake or placing the vehicle in gear in a private driveway which resulted in the vehicle striking or rolling over the victim. In four of the nine cases, the child who set the vehicle in motion fell or jumped from the vehicle and then became the injured victim. The extent of these unusual motor vehicle-related injuries is unknown because they are unlikely to be reported in official police statistics. According to the study findings, there is a need to educate the public and health professionals about the risks associated with leaving a child unattended in a motor vehicle and the hazardous environment of the private driveway. Preventive measures would include not leaving a child unattended in a vehicle, locking unattended vehicles to prevent access, and redesigning of private driveways.

Author	Brison RJ, Wicklund K and Mueller BA
Year	1988
Title	Fatal pedestrian injuries to young children: a different pattern of injury.
Journal	American Journal of Public Health 78(7):793-5
Country	USA
Summary	Washington State Death certificates from 1979-1983 were searched to identify all deaths of children less than 5 years of age coded with pedestrian-motor vehicle collision as the cause of death (ICD9 E codes 814-825). Coroner reports and police records were then accessed for additional information on each case. Data abstracted from death certificates included age and sex of child, types of injuries sustained and date and hour of injury occurrence. The incident site was coded on the death certificate. Additional information from coroner and police records included vehicle type, its direction of travel, the relationship of the driver to the injured child and a more detailed description of the incident site. There were 71 fatal injuries to children <5 years recorded in the 5 year period. Pedestrian fatalities were separated into traffic and non-traffic fatalities by ICD9 coding. Traffic pedestrian collisions (E814.7) occur on a street or highway. Non traffic pedestrian collisions (E822.7) occur away from general traffic (eg driveways). 45 (63%) of deaths occurred in traffic, 26 (37%) were coded as non-traffic. It was evident from police and coroner data that many deaths coded as traffic related were actually non-traffic related. 15 of the 45 (33%) traffic related deaths were recoded as non-traffic related because the site of the incident was either a driveway or a parking lot. After correction for the misclassifications, it was apparent that the majority (41/71 or 58%) of all incidents were non traffic related; 30 had occurred in driveways and 11 in apartment building or store parking lots. The lowest risk for both types of incidents occurred for children less than 1 year of age. From ages 1-4 there was a clear trend of decreasing risk for non traffic related fatality with increasing age. Death rates were higher among males than females for both types of incident; the risk difference was more evident in non traffic injuries. ▪ 71% of non-traffic related fatalities occurred between noon and 7pm. ▪ Injuries to the head and neck were listed as the primary cause of death for 81% of non traffic deaths. ▪ Light trucks or vans was the vehicle most commonly involved in non traffic fatalities – 76% (compared to 14% of traffic fatalities). ▪ For two thirds of non traffic related fatalities, the child was backed over; only one-fourth of them were struck while the vehicle was moving forward. ▪ A family member (most often the father) or a visiting family friend was involved in 71% of non traffic fatalities. ▪ The pattern of non traffic pedestrian injury as it relates to the vehicle type and driver is notable. The typical pattern of injury involved a situation in which a 1-2 year old child was backed over in his home driveway by a light truck or van driven by a family member.

Author	DiScala C, Sege R and Guohua L
Year	2001
Title	Outcomes of pediatric pedestrian injuries by locations of event
Journal	45th Annual Proceedings, Association for the Advancement of Automotive Medicine 241-250
Country	USA
Abstract	Data from the National Pediatric Trauma Registry October 1995-October 2000, containing medical records of children under 20 years old hospitalised for pedestrian injuries, were examined. Demographics and outcome measures (nature and severity of injury, utilisation of resources, deaths and disability at discharge) were compared by location of occurrence. Pediatric pedestrian injuries resulted in severe outcomes whether the events occurred in driveways, public places, or in the road. Off-the-road injuries accounted for a significant proportion (13.2%) of all serious pedestrian injuries and disproportionately affected the youngest children. Prevention should consider the child's age and the location of injury occurrence.

Author	Duhaime AC, Eppley M, Margulies S, Heher KL and Bartlett SP
Year	1995
Title	Crush injuries to the head in children.
Journal	Neurosurgery 37(3):401-6; discussion 407
Country	USA
Abstract	Although the majority of head injuries in children and adults involve dynamic loading conditions, some patients suffer static loading. Static loading occurs when forces are applied slowly to the head, and it produces a much different pattern of injuries. Crush injuries are usually described in the context of industrial accidents, but in our experience, these injuries are not rare in children. We report a series of seven crush injuries in young children admitted during a period of 29 months and describe our experience in the evaluation and treatment of this complex entity. Patient ages ranged from 15 months to 6 years. In four cases, the child's head was run over by a motor vehicle backing up in a driveway or parking lot. In the three other patients, the static loading occurred when the child climbed or pulled on a heavy object, which then fell over with the child and landed on the child's head. One child with cervico-medullary disruption died shortly after his arrival at the hospital. The others showed varying degrees of soft tissue injury to the face and scalp, with Glasgow Coma Scale scores ranging from 7 to 15. Computed tomograms and magnetic resonance images showed multiple and often extensive comminuted calvarial fractures, as well as subarachnoid and parenchymal haemorrhages. All patients had basilar cranial fractures. There was one cervical spine injury but no major vascular injuries. One child had pituitary transection, four had cranial nerve palsies, and another developed a delayed cerebrospinal fluid rhinorrhea 18 months after injury. All children made good cognitive recoveries, with some having relatively mild fixed focal deficits.

Author	Godbole P, Crabbe D and Stringer M
Year	2001
Title	Four children crushed in their driveways
Journal	Journal of the Royal Society of Medicine 2001; 94:294-296
Country	UK
Summary	Case histories for 4 patients are reported. These four cases were seen over a five year period between 1995 and 1999 in a regional paediatric surgical centre. The authors observe that the experience in the UK appears to differ from the experience in the US where this type of injury comprises about 10% of all child pedestrian injuries and is commonly fatal. Brief comparisons to other studies in the literature are made.

Author	Henderson M
Year	2000
Title	Child deaths and injuries in driveways: Response to the recommendations of the child death review team
Journal	Consultant report for the Motor Accidents Authority of NSW
Country	Australia
Summary	This is a consultancy report for the Motor Accidents Authority of NSW. It was prepared in response to the Recommendations of the Child Death Review Team NSW 1998-99. The report begins with a selective review of the literature of child pedestrian deaths on public roads and driveways. There is also a review of the then current Australian data on driveway accidents. The author presents a model for a multi-faceted approach to address this public safety issue which encompasses modifying human behaviour, modifying the driveway environment, and equipping vehicles with better visual and sensory devices. His recommendations to the Motor Accidents Authority include the following: 1. The Motor Accidents Authority will liaise with and encourage all stakeholders in the issue of childhood injuries in driveways to incorporate information and educational materials on the issue in their present activities. 2. The MAA will encourage by all possible means the use of lenses and mirrors that improve rear field vision in vehicles; 3. The MAA will seek samples of electronic sensing devices for testing their effectiveness in preventing driveway accidents; 4. The MAA will contact the Australian Building Codes Authority to possibly initiate standards for the physical protection of driveways where small children may be at risk; 5. The MAA will propose to the Australian Transport Safety Bureau that it undertake a survey of coronial records and prepare a report on the incidence and characteristics of driveway deaths in Australia.

Author	Holland AJA, Liang RWY, Singh SJ, Schell DN, Ross FI and Cass DT
Year	2000
Title	Driveway motor vehicle injuries in children
Journal	Medical Journal of Australia 173: 192-195
Country	Australia
Summary	This paper is a retrospective review of records of children <16 years admitted to the New Children's Hospital (Westmead) or reported to the NSW Paediatric Trauma Death (NPTD) registry with driveway injuries. Data were collected on the age of the child; the date, time and location of the injury; the vehicle type and driver of the vehicle; how the accident occurred, including documented safety features restricting access to the driveway; and the injuries identified, together with the surgical interventions, complications and final outcome. *NCH data:* Collected November 1995 to February 2000. *NPTD Registry:* The NPTD registry records all deaths resulting from trauma of children <16 yrs in NSW that are reported to the coroner. Data available from inception of the database in January 1988 to December 1999. The police statement and coroner's report, together with the post mortem findings were reviewed. *RESULTS* *NCH Admissions* ▪ 42 children were admitted with injuries sustained as a result of a driveway motor vehicle injury, representing 12% of the 354 children admitted to NCH with pedestrian motor vehicle injuries. One child died. 26 (63%) of the children who survived were under three years of age. Boys accounted for 74% of the children admitted *NPTD Registry* ▪ 14 deaths from driveway injuries, including one of the 42 children admitted to NCH, reported over the 12 year period. These deaths represented 8% of the 174 pedestrian motor vehicle deaths reported to the registry over the same time interval. ▪ Boys were over represented (78%) ▪ 41 (82%) of injuries occurred in the afternoon or evening (most between 4 and 7 pm) 6 (43%) of the fatalities occurred in the morning ▪ There was no marked seasonal association, although 30% of the injuries took place in the summer months ▪ A relative of the child or a family friend was the driver in 39 cases, including 12 of the 14 injuries leading to death. ▪ A 4WD or LCV was involved in 34% of the injuries in which the child survived compared with 64% of those with a fatal outcome. Overall these vehicles accounted for 42% of all injuries. They were associated with a 2.5 times greater risk of fatality compared with other motor vehicles ▪ Documentation of access limitation to the driveway was available in only 3 cases; in 2 this involved a front door only and in 1 a fence gate, all of which had been left open.

Author	Mayr JM, Eder C, Wernig J, Zebedin D, Berghold A and Corkum SH
Year	2001
Title	Vehicles reversing or rolling backwards: an underestimated hazard
Journal	Injury Prevention 2001;7:327-328
Country	Austria
Summary	The medical records of children who attended the Department of Pediatric Surgery, Graz between 16 April 1993 and 15 April 2001 were reviewed retrospectively and 32 cases involving an impact by a vehicle reversing or rolling backwards were identified. A questionnaire was sent to the parents inquiring about mode, location of injury and car type involved. From the medical records, age, gender, mechanism, type of injury and injury severity score (ISS) were recorded. RESULTS: The median age was 2.1 years, with range of 1 to 14 years.. Fourteen of the 32 cars were driven by family members, and three were rolling backwards without a driver. The median injury score was 3 (1-27) and the most common injuries were contusions (40.6%), fractures (31.3%) and lacerations/burns (21.9%). Most incidents occurred in the driveways (37.5%) or farmyards (21.9%).

Author	Nadler E, Courcoulas A., Gardner M and Ford H
Year	2001
Title	Driveway injuries in children: risk factors, morbidity, and mortality
Journal	Pediatrics 108(2); 326-328
Country	USA
Summary	A total of 9820 patient records covering the period May 1986 to August 1999 from the Benedum Trauma Program at the Children's Hospital of Pittsburgh were reviewed to identify cases of motor vehicle-related injuries in or around a driveway. A total of 64 cases were identified and divided into two groups based upon the mechanism of injury: Group 1 (44 children) consisted of children who were struck by a vehicle driven by an adult who was unaware of the child's presence in the driveway. Group 2 (20 children) consisted of children who were injured as a result of a vehicle set in motion by a child. The two groups were compared by age, gender, weight, vehicle type, pattern of injuries and outcome measures. Overall patterns of the accident circumstances and consequences for the 64 cases were also characterised. RESULTS: The children in this series were on average less than 4 years old with a near equal gender distribution. The median ISS was 10. The musculoskeletal system was the most common organ system injured (56%), although head and chest injuries occurred in 33% of the cases. Children in group 1 were on average 2 years old, weighed 12 kilograms and had a significantly poorer outcome than children in group 2 who were older and heavier. Sports utility vehicles or trucks were involved in 28 of the 44 cases in group 1.

Author	New South Wales Child Death Review Team
Year	2000
Title	New South Wales Child Death Review Team 1998-1999 Report
Journal	
Country	Australia
Summary	▪ In the reporting period, five toddlers died after being run over in their home driveways by a family member or family friend. Since the commencement of the Child Death Register (January 1996-June 1999), 17 children have died in these circumstances. Of these 17 children, 15 children (including 13 toddlers) were run over by 4WD or large commercial vehicles. *Recommendations* ▪ The MAA in consultation with other relevant agencies, including the RTA, the Institute of Early Childhood at Macquarie University, the NSW Health Injury Prevention Policy Unit, NRMA, the NSW Injury Prevention Forum, the Public Health Unit of the New Children's Hospital Westmead and the Child Death Review Team, ▪ develop targeted strategies including public education programs to reduce the number of child deaths occurring in low speed, reversal incidents on residential property. ▪ commission research to determine the effectiveness of the use of refractive panels and rounded mirrors and the extent to which fenced shared driveways act as protective factors in the prevention of driveway fatalities ▪ upon completion of this research, if appropriate make a case to FORS to make an amendment to the Australian Vehicle Standards, particularly for vehicles in the 4WD and commercial categories, regarding refractive panels and rounded mirrors and makes a case to the Australian Building Standards Board for the inclusion of a requirement for fenced shared driveways in all new multi dwelling structures. ▪ NSW Health instigates a specific variation on the ICD coding system to include an additional code in inpatient data collections specifically for driveway crushing incidents involving motor vehicles. *The Child Death Register* ▪ Register of child deaths in NSW after 1 Jan 1996 ▪ Classifies deaths, according to cause, demographic and other criteria ▪ For the purposes of the Child Death Register and child death reviews, children are aged under 18 years and an infant is aged under 12 months. ▪ 1998-1999 five toddlers (3 male, 2 female) aged between eight months and 3 years were run over in their home driveways. In three of these incidents the vehicles the vehicles were large with poor vision. ▪ 1997-1998 four toddlers (2-4 years old) and 2 older children were killed on residential property when reversed over by large commercial vehicles or 4WDs.

	▪ 1996-1997, six toddlers (14 moths-3 years) were run over in their home driveways by similarly large vehicles. ▪ Figures from the New Children's Hospital, Westmead indicate that between March 1996 and December 1998, 32 children were admitted to that hospital alone having been severely injured when reversed over, usually by a parent, family member or friend. Many of the children who were not killed sustained severe and lasting physical and brain injuries. ▪ Little information to suggest proven effective prevention strategies. ▪ Possible that a public awareness campaign which promotes the use of effective affordable solutions "(eg refractive panels and rounded mirrors) which afford a wider view of the rear of the vehicle would provide an effective public education solution. ▪ Other preventative measures suggested include road safety programs warning of hazards where toddlers have access to driveways and the need for increased supervision ▪ Environmental approaches – separating children's play areas from driveways by fencing or redesign of driveways particularly where domestic driveways are shared. ▪ Technological devices (eg sensing devices) could be employed ▪ Ambiguities in the ICD E codes mean that there are significant problems in reporting major trauma occurring in driveway incidents.

Author	Paine M and Henderson M
Year	2001
Title	Devices to reduce the risk to young pedestrians from reversing motor vehicles
Journal	Report prepared for the Motor Accidents Authority of New South Wales
Country	Australia
Summary	This report describes possible technological measures to reduce the risk of child injuries caused by slowly reversing vehicles. The counter measures fall into two broad categories: • Proximity sensors that alert the driver when an object is close to the rear of the vehicle • Visual aids to improve the driver's rearward field of vision. Using a stochastic model, they provide estimates on the detection distance required for a sensory device to be effective at reducing the risk of impact. They present evaluations of rearward field of vision for several models of vehicle, as well as evaluations of several different detection systems. They review a variety of visual aids, including mirrors, wide-angle lenses, and video systems. They conclude that a technical solution is feasible. A combination of short-range proximity sensor and video camera appears to be a viable countermeasure and will cost approximately $1000. However, they emphasise that drivers must still reverse very carefully.

Author	Partrick DA, Bensard DD, Moore EE, Partington MD and Karrer FM
Year	1998
Title	Driveway crush injuries in young children: a highly lethal devastating and potentially preventable event.
Journal	Journal of Pediatric Surgery 33(11):1712-1715
Country	USA
Summary	This study aims to investigate driveway-related injuries in children, identify associated risk factors and evaluate outcome compared with other mechanisms of blunt trauma. ▪ A review (over a 6 year period) of pediatric (<18 years) pedestrian injuries treated at 2 urban trauma centres was conducted ▪ 527 children injured in pedestrian accidents were identified. ▪ 51 children (10%) sustained traumatic injury as a result of being struck in their driveway, with the car rolling backwards over the child. ▪ Patients in driveway related trauma were significantly younger, had a higher mean ISS, a higher incidence of closed head injury and a higher mortality rate. ▪ The 51 patients sustaining driveway related injuries were evaluated by age group to identify the children most at risk. ▪ Children <5 years accounted for the majority of cases of driveway related trauma (80%). ▪ The youngest age group (0-4 years) contained all of the children who died secondary to their injuries, yielding a mortality rate of 20%. ▪ Severity of injury measured by ISS decreased with increasing age. ▪ Incidence of head injury also decreased as the age group increased. ▪ The mother or the father of the child were the responsible drivers for at least 14 (34%) of the driveway related rollover accidents. Other family members involved were siblings (10%)

Author	Roberts I
Year	1994
Title	Differential recall in a case-control study of child pedestrian injuries
Journal	Epidemiology 5(4); 473-475
Country	New Zealand
Summary	This article reviewed the methodology and results of an earlier paper, "Driveway-related child pedestrian injuries: a case-control study" [16] by the same author. The earlier article examined environmental risk factors such as shared driveways and the absence of physical separation of the driveway from the children's play area using an age-matched random sample of the child population in Auckland. Parents of cases and controls completed an interview-administered questionnaire on aspects of the home environment, and socio-demographic and familial characteristics. Parents of the cases were most often interviewed at the hospital, whereas parents of the controls were interviewed in their own homes. This article reports on a validation study of differential recall between cases and controls. Although there was no evidence of differential recall between cases and controls amongst all child pedestrian injury cases, there were substantial recall differences between cases and controls amongst those injured in residential driveways. For these cases, differential recall had a substantial effect on the magnitude of the odds ratio. The odds ratio (OR=.33) from the original study overestimated the protective effect associated with a fence separating the driveway from the play area when compared with the estimate from the validation study (OR=0.52).

Author	Roberts I, Kolbe A and White J
Year	1993
Title	Non-traffic child pedestrian injuries
Journal	Journal of Paediatrics and Child Health 29(3):233-4
Country	New Zealand
Abstract	All non-traffic child pedestrian deaths and injuries resulting in hospitalisation in the Auckland region over a 5 year period were identified from coroner's and hospital records. There were eight deaths (0.77/100,000 children per year) and 91 hospital admissions (8.7/100,000 children per year). Close to half (48%) of the non-traffic pedestrian injury admissions had been misclassified as traffic pedestrian injuries. Eighty-seven per cent of the non-traffic pedestrian injury deaths and 93% of the injuries occurred in residential driveways, most often involving a child run over by a reversing vehicle. Further studies are required to determine the most effective strategies for the prevention of non-traffic child pedestrian injuries.

Author	Roberts I, Norton R and Jackson R
Year	1995
Title	Driveway-related child pedestrian injuries: a case-control study
Journal	Pediatrics 3: 405-408
Country	New Zealand
Summary	This paper reports the results of a case control study aimed at the identification of risk factors for driveway related child pedestrian injuries. *Cases:* ▪ n=53, <15 years, children killed or admitted to hospital as a result of driveway related pedestrian injury between 1 January 1992 and 24 February 1994. *Controls:* ▪ n=159 with three controls were for each case. Controls were an age matched random sample of the child population in Auckland. *Results:* ▪ Over the study period a total of 55 children were identified as having been injured as pedestrians in a residential driveway. ▪ 53 identified during hospital surveillance and 2 children were identified through surveillance of coroner's. ▪ Of the 55 cases identified the parents of 53 agreed to participate. ▪ In unadjusted analyses, there were greatly increased risks for children living in multiple dwellings, children living in rental accommodation, children from families having been resident at the current address for < 3 months and for children from families without access to a car. The risk of injury for children from homes where the play area was not fenced off from the driveway was close to 3 times that of children from homes where the driveway was fenced. ▪ Controlling for potential confounders had the effect of reducing the magnitude of the odds ratio for all of the environmental variables except the variables describing the children's play area and the shared driveway variable. ▪ The absence of physical separation of the driveway from the children's play area was associated with a three and a half increase in the risk of driveway related injury (OR = 3.5; 95% CI 1.38, 8.92). ▪ Children living in homes with shared driveways were also at significantly increased risk (OR=3.24; 95% CI 1.22, 8.63) ▪ The population-attributable risk associated with an unfenced driveway was 50.0% (95% CI 24.7, 75.3). Physical barriers that prevent children from gaining access to driveways have the potential to significantly reduce driveway related child pedestrian injury rates. Children living in homes with shared driveways represent a high risk group to which preventative strategies might be directed. All of the cases were reversed over by vehicles driven by adults. The presence/absence of physical separation of the driveway from play area was determined by direct observation rather than parental report. The concept that fence prevent children gaining access to the residential driveway is analogous to the argument that fences prevent children gaining access to swimming pools.

Author	Roberts I, Norton R, Dunn R, Hassall I and Lee-Joe T
Year	1994
Title	Environmental factors and child pedestrian injuries
Journal	Australian Journal of Public Health 18(1):43-46
Country	New Zealand
Summary	▪ All children <15 years of age, killed or hospitalised as a result of pedestrian injury in the Auckland region between 15 January 1992 and 15 January 1993 were identified through a surveillance system established at hospitals which admit injured children and with the Auckland coroner. ▪ A pedestrian injury was defined as an injury sustained in a collision with a motor vehicle by a person who was not at the time of injury riding in or on a motor vehicle, train animal-drawn or other vehicle or on a bicycle or animal. ▪ Both traffic and non-traffic pedestrian injuries were therefore included. ▪ For driveway injuries, site visits were conducted (with the permission of the householder) and information was collected on type and tenure of dwelling and the presence or absence of fences separating the children's play area from the driveway. ▪ Over the one year period a total of 103 injured child pedestrians were identified. 25 of these children were injured in residential driveways. ▪ For the 25 children injured in driveways the median age was 1.5 years (range 0-7). There were 15 males and 10 females (male to female ratio of 1.5:1) ▪ The driveway injury times were evenly distributed throughout the daylight hours. The peak day for injury was Sunday (25%). ▪ Of the 25 driveway sites, site visits were completed in all but one case. ▪ Of the remaining 24 sites, 19 (75%) were associated with single dwellings with private driveways and 5 (21%) were associated with multiple dwellings (flats) with shared driveways. 13 (54%) of the homes were rented, 7 of which were rented from the state, 7 (29%) were owner-occupied homes and for the remaining four cases the parents of the injured child were living with relatives. ▪ There was a fence separating the driveway from the main children's play area in only 6 (25%) of the homes. ▪ The residential driveway was the site of pedestrian injury in 24% of pedestrian injuries in this study compared with only 4% of pedestrian injuries in Perth. The Perth study however was based on police accident reports and the difference is more likely to reflect underreporting of driveway injuries in police accident databases than a real difference in injury occurrence. ▪ As yet there is no information from controlled epidemiologic studies on the magnitude of the risks associated with unfenced driveways.

Author	Robinson P and Nolan T
Year	1997
Title	Paediatric slow-speed non-traffic fatalities: Victoria, Australia, 1985-1995
Journal	Accident Analysis and Prevention 29(6):731-7
Country	Australia
Abstract	An important group of fatal incidents are slow-speed pedestrian non-traffic incidents to children, which account for 14% of accidental deaths from all causes in Victorian children under 5 years of age between 1985 and 1995, and 12% of pedestrian deaths of all ages. In Victoria, Australia, the database of the state Consultative Council on Obstetric and Paediatric Morbidity and Mortality was utilised to identify paediatric slow-speed pedestrian non-traffic-accident deaths in the local population. Additional data relating to the car and its driver, the child, and the circumstances of the incident were abstracted from records kept by the State Coroner and the Victorian compulsory third party traffic injury insurance organisation. Twenty eight Victorian children were identified who had died in one of three types of incident (driverless cars, child interacting with the vehicle and driver, and drivers who were unaware of the child's proximity). These incidents were more common in rural areas compared with urban, usually occurring at the child's home. The child was with or near an adult on all occasions. The vehicle was usually being driven by a relative, and was reversing in a higher proportion of 'unaware' incidents compared with the 'interactive' type. The association of 'off-road' family vehicles and trucks with these incidents appears to be increasing, especially in recent years. These findings suggest some countermeasures, including the separation of vehicle driveways from children's play areas, and object vicinity ultrasonic warning devices for vehicles.

Author	Silen ML, Kokoska ER, Fendya DG, Kurkchubasche AG, Weber TR and Tracy TF
Year	1999
Title	Rollover injuries in residential driveways: age related patterns of injury
Journal	Pediatrics 104(1):e7 (http://www.pediatrics.org/cgi/content/full/104/1/7)
Country	US
Summary	The aim of the study was to determine the severity of non-fatal rollover (wheels of the vehicle roll over the child) injuries sustained by children on residential driveways. Also investigated whether children <24 months demonstrated different patterns of injury and/or worse outcomes. *METHOD:* ▪ Reviewed the medical records of 3971 consecutive admissions to a single trauma service at an urban children's hospital. Only children sustaining injuries associated with a motor vehicle rolling over the child (opposed to a motor vehicle colliding with the child) were included. Children who died were excluded from the study. *RESULTS:* ▪ During the study period 26 (0.7%) of children were injured by motor vehicles in residential driveways. ▪ 18 (69%) injuries resulted from a child being struck by a vehicle that was backed up by an adult. The remaining 8 (31%) of the injuries were caused by either an older child and/or sibling (<16 years) rolling over the child (n=4) or the child engaging the vehicle into gear and then attempting to leave the vehicle (n=4). ▪ 2 patients were excluded as they died after admission. ▪ Among the 24 survivors there were 12 males and 12 females. ▪ Mean patient age 44 months. ▪ The mean ISS and PTS scores were 23 and 6.3 respectively. ▪ Injuries sustained by younger children (<24 months) were more severe. ▪ Younger children had a higher mean ISS (p=0.06) and lower mean PTS score (p=0.006). ▪ Younger children (<24 months) had significantly longer lengths of ICU admission and hospitalisation. ▪ Younger children had a significantly higher rate incidence of both head and neck extremity injury but a similar incidence of chest and abdominal trauma, compared with older children. ▪ The 16 children sustaining injuries as a result of a vehicle driven by an adult were younger (p<0.01), had higher injury severity scores and lower paediatric trauma scores (p<0.01). *DISCUSSION:* ▪ The mechanism of injury is a crushing force by the vehicle rather than a sudden blunt impact or deceleration force. ▪ Younger children sustaining roll over injuries have more severe injuries and worse outcomes. ▪ Public education and injury prevention programs must make drivers aware of the risk of residential driveway events. ▪ Drivers should walk around vehicle before leaving an area in which children may have been.

Author	Stevenson MR, Lo SK, Laing BA and Jamrozik KD
Year	1992
Title	Childhood pedestrian injuries in the Perth Metropolitan area
Journal	Medical Journal of Australia 156:234-238
Country	Australia
Summary	Retrospective study. Studied pedestrian injuries to children aged 1 to 14 years in the Perth Metropolitan area during the period 1 January 1980 to 31 December 1989. Pedestrian defined as a person walking or stationary in a street or driveway. Data for the study was obtained from the Police and Main Roads Departments' ROTARS database which is a record of all reported fatal and nonfatal motor vehicle collisions in the Perth metropolitan area A total of 1282 children aged 14 years and under were reported to have been involved in 1261 pedestrian motor vehicle collisions during the 10 year period. Driveway injuries accounted for only 51 (4%) of the injuries.

Author	Winn DG, Agran PF and Castillo DN
Year	1991
Title	Pedestrian injuries to children younger than 5 years of age.
Journal	Pediatrics 88(4):776-82
Country	USA
Abstract	Historically, research on pediatric pedestrian injuries has analysed children younger than 5 years of age as a single group. However, in this study, these children were divided into two age groups which were reflective of differences in behaviour and development. The data demonstrate differences in the circumstances of the pedestrian injury events between toddlers (0 through 2 years and ambulatory) and preschoolers (3- and 4-year-olds). Toddlers were more likely to be injured in nontraffic events whereas preschoolers were more frequently injured in traffic situations. A high proportion of toddler injuries occurred in residential driveways and were caused by vehicles backing up. The majority of preschoolers, often without supervision, were injured while crossing/darting midblock on residential streets near their homes. Reflecting these differences in circumstances and also developmental differences between toddlers and preschool children, there is a need for age-specific interventions to reduce pedestrian injuries in children younger than 5 years of age.