The Prevalence and Characteristics of Paediatric Driveway Accidents in Queensland

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Abstract

Objectives: This study was designed to investigate the incidence and characteristics of non-traffic child pedestrian accidents in Queensland to which the Queensland Ambulance Service (QAS) responded between January 1998 and December 2000.

Method: Both quantitative and qualitative data from ambulance report forms were utilised in the analyses. Cases were selected on the basis of the child's age (up to 15 years) and the location of the incident (non-traffic areas). The main outcome measures were the child's Glasgow Coma Scale (GCS) score, respiratory rate and ambulance dispatch code (life-threatening or non life-threatening) recorded on arrival by the paramedics.

Results: In total, 76 driveway incidents out of a total of 1105 paediatric accidents were identified over the three-year period. The incidents predominantly involved vehicles reversing at low speed out of driveways, often with a parent driving. Four-wheel drive (4WD) and heavy vehicles were over-represented in the statistics and were associated with more severe injuries to the child. Peak times for the incidents were afternoons and during holiday months, when children were more likely to be playing around non-traffic areas. The incidents were also more likely to involve males (57%) and 51% involved children under the age of four years. In regards to severity, one child was deceased and six were unconscious on arrival of the ambulance.

Conclusions: Non-traffic pedestrian accidents in Queensland remain a considerable risk for children under four years of age. A number of strategies may prove effective at reducing this risk, however greater driver awareness in non-traffic locations and the use of methods to enhance driver visibility when reversing may prove to be important factors in preventing these accidents.

Keywords: paediatric, pedestrian, drive-way, injuries.

Introduction

Paediatric pedestrian injuries and deaths

Pedestrian incidents represent a major cause of injury and death among Queensland children [1]. Such incidents usually involve a moving vehicle striking an individual either on a public road or private property. Pedestrian fatalities are most often classified into either traffic or non-traffic categories under the International Classification of Diseases coding ICD-9-CM [2]. Traffic pedestrian accidents are usually defined as those that occur on a public street or highway, while non-traffic pedestrian accidents are defined as those that occur in driveways, parking lots, and laneways [3]. It is this latter accident type that remains a considerable risk to young children, as previous research has reported a higher paediatric mortality rate for this form of accident [4]. Furthermore, 1 in 4 child pedestrian hospitalisations result from injuries sustained on home driveways [5], and paediatric pedestrian accident rates have remained relatively stable over the past decade [6].

Circumstances of the injuries and deaths

The elevated risk of a young child being struck by a vehicle may be explained by the corresponding developmental stage, as young children are more likely to experience difficulty in recognising environmental hazards [4], and are relatively small size in comparison to the vehicles. Furthermore, current research has demonstrated a clear relationship between the child' s age (e.g., developmental stage) and the likely location of an accident. Infants and toddlers are more likely to be struck in driveways while older pre-school and school-aged children tend to be struck when they run out in front of vehicles in traffic locations [7,8,9,10]. For example, a Californian study reported a median age of two years for driveway injuries, four years for parking lot injuries, six years for mid-block injuries and 10 years for intersection injuries [11]. Similarly, two New Zealand studies have observed that a majority of driveway injuries occurred at homes where there were no physical separations between the driveway and children' s play areas [5, 12].

Although boys are at a higher risk of traffic pedestrian accidents than girls [6,13], there appears to be a relatively equal gender distribution in driveway pedestrian incidents [4,8]. Research has continually demonstrated that a parent or older sibling of the child is most likely the driver of the vehicle in driveway accidents [4,5,6,8,9,14,15,16,17]. Typically the vehicle is moving in reverse at low speed and the driver is unaware that the child is present. Commercial utilities and 4WD vehicles are over-represented in the data on driveway accidents, particularly in the more severe and fatal accidents [18,8,5,17]. Research has suggested that this is probably due to the height of the vehicles, which often results in poor driver

visibility when reversing [4].

Children injured in driveway accidents typically sustain soft-tissue injuries to the head, neck, torso, or limbs as well as fractures to the pelvis and limbs [6,8,15]. In addition, reported mortality rates vary between 6% [8], 10% [12] and 16% [4], although fatalities are more common in children under the age of five years [4].

Australian Research

There have been a number of Australian studies that have focused on the prevalence of paediatric pedestrian non-traffic accidents. A nation wide investigation into the incidence of low-speed motor vehicle driveway deaths during 1996 to 1998 indicated 12 deaths on average per year [19]. The study revealed that most incidents resulted from young toddlers positioning themselves behind large stationary vehicles e.g., 4WDs. While most toddlers were old enough to be mobile, they were generally too small to be easily visible. The immediate location of the incidents was usually a residential driveway, although no cases involved shared driveways. A similar Victorian study that examined mortality rates from slow-speed, non-traffic accidents that occurred between 1985 and 1995 identified 28 fatal paediatric pedestrian accidents over this period, with an increase in the rate during the later years of the study e.g., 79% occurred between 1992-1995 [9]. The majority of fatalities involved 4WD and heavy vehicles, 57% of vehicles were in reverse, 79% incidents occurred in driveways, and most resulted in head injuries. Incidents were more common in the morning, on weekends, and during the warmer months (November – April), as children are more likely to be outside playing. Furthermore, relative risk of a driveway fatality was estimated to be greater in rural than in urban areas of the state.

A similar New South Wales study examined the number of paediatric pedestrians admitted to the New Children' s Hospital (Sydney) over the period November 1995 to February 2000, and entries into the NSW paediatric trauma death registry over the 12-year period from January 1988 to December 1999 [15]. The results indicated there were 14 driveway-related deaths over the 12 years, which accounted for 8% of all paediatric pedestrian deaths in that period. Furthermore, there were 42 hospital admissions over the same period of time. Once again, the majority of these incidents involved male children, struck by a reversing vehicle driven by a parent or friend, during the afternoons. Four-wheel drive and light commercial vehicles were responsible for 42% of all incidents, even though they accounted for only 30% of all registered vehicles in New South Wales at the time. A closer examination revealed that driveways not protected or separated by a fence or building from a child' s play area had three times the number of accidents compared to protected driveways [15]. A similar Adelaide study reported emergency department statistics on 35 pedestrian accidents involving one-year-old children and highlighted that 11 of the incidents (30%) involved a reversing vehicle, and a majority of these incidents occurred in driveways and car parks [18].

Many of these trends are consistent across states, although it is noted that past research has demonstrated that Queensland records a significantly higher rate of slow speed runovers than the rest of Australia; 2.4 per 100 000 for children aged one to four years [1]. Between 1994 and 1996 in Queensland, 76% of the pedestrian fatalities involved a truck, utility, or 4WD. The majority (78%) of the vehicles were reversing at the time of the incident and 69% were driven by immediate family members of the victim, with most (67%) of the fatalities occurring in or around the residential driveways.

Present Study

Despite the above statistics, it remains generally difficult to gather accurate and consistent information on non-traffic accidents as they occur on private land and are not always reported to the police. Figures usually vary according to the source and whether the data included all incidents or fatalities only, as research into non-traffic accidents often utilise a variety of information from police data, hospital emergency departments, hospital trauma registries to coroner' s offices.

In regards to the present context, the Queensland Ambulance Service (QAS) is in a unique position to provide state-wide data on non-traffic injuries in children. The QAS responds to approximately 370 paediatric vehicle-related trauma incidents every year [20]. QAS paramedics complete ambulance report forms for each call-out that include information about the date and time of the accident, patient demographics, vehicle details, and the nature and severity of injuries.

The current study has three main aims, which are to:

a) investigate the incidence of driveway-related child pedestrian incidents in Queensland to which the QAS responds;

b) examine the characteristics of these incidents with a view to identifying potential risk factors; and

c) examine the general severity of the injuries and determine the factors, if any, that are associated with the severity of injuries.

Method

Selection of cases

The study comprised of a population-based, retrospective analysis of all childhood non-traffic pedestrian accidents that occurred throughout Queensland over a three-year period from 01/01/1998- 31/12/2000. QAS data were gathered from the ambulance report forms that were fully audited for accuracy, and were stored under secure conditions on the Queensland Ambulance Information Management System (AIMS) database. Cases were primarily selected on the basis of the child' s age (under 15 years), and the corresponding

Note: *** p < .001, ** p < .01, * p < .05, NS = not significant

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criteria regarding the location e.g., non-traffic

Data collection

AIMS data was abstracted from microfilmed ambulance report forms that had been completed by ambulance officers required to attend the scene of an accident. Demographic information included address, age and sex of the patient. The dispatch code designated whether the emergency was of a life-threatening or a non life-threatening nature. The respiratory rate and GCS readings used in the analyses were the first assessments carried out upon arrival of the ambulance. In addition to coded information, notes written by the paramedics on the ambulance report forms were analysed for further details of the incident such as the type of vehicle, section of vehicle in contact with the child, person in control of the vehicle, detailed location of the incident and the severity and location of the injuries sustained.

Variables for investigation

The primary outcome variables for investigation were the respiratory rate, GCS score, and ambulance dispatch code (e.g., life-threatening versus non life-threatening). Respiratory rates were divided into three categories: normal = 10 - 29, absent= 0, or abnormal >29. GCS scores were divided into five categories: 3 (deep coma or death), 4-5, 6-8, 9-12, and 13-15 (neurologically intact). The predictor variables were the age and sex of the child, the type of vehicle, speed, direction of travel, person in control of vehicle, location of incident (e.g., rural versus urban, private versus public, and a more detailed location), time of day, day of week, and month of year.

Results

Overall incidence of paediatric non-traffic accidents

During the data analysis period 01/01/1998 to 31/12/2000, QAS attended 1105 incidents involving a paediatric pedestrian injured by a car, heavy vehicle, bicycle, motorcycle or other vehicle such as skateboard or ride-on mower. Of these incidents, 76 cases were identified as having occurred in a non-traffic area, including educational centres, shopping centres, place of work, recreational and sports centres, parks, campsites and the beach.

Characteristics of the patients and injuries

Of the 76 incidents, 57% involved male victims and 51% involved children under the age of four years. A further 32% were aged between 5 and 10, while 17% were older than 10 years of age. The majority of patients (91%) were conscious at the time of arrival of the paramedic, one victim was deceased while six were unconscious (Table 1). The mean GCS score was 13.7 (3.2). The majority of patients were in the neurologically intact category, six per cent in the deep coma / dead category and 10% in categories with intermediate levels of consciousness (Table 1). The mean respiratory rate was 23.8 (7.4), while respiratory rates were normal for 27% of patients, absent in 3% of cases, and abnormally high in 69% (Table 1). Furthermore, 83% per cent of the patients were treated at hospital, five per cent were treated in non-hospital locations such as a medical clinic, and 12% of patients did not require any further treatment (Table 1). In summary, ambulance dispatch codes indicated that 88% of the incidents were life-threatening, and 12% were non life-threatening.

Impact on child pedestrian	Frequency	Percentage
Status of patient		
Conscious	69	91%
Unconscious	6	8%
Deceased	1	1%
Total	76	100%
Glasgow Coma Scale scores		
3 (deep coma or death)	4	6%
4 - 5	1	1%
6 - 8	1	1%
9 - 12	6	8%
13 - 15 (neurologically intact)	60	83%
Total	72	100%
Respiratory rate		
0 (absent)	2	3%
10 - 29 (normal)	17	27%
> 29 (fast)	43	69%
Total	62	100%
Treatment destination		
Hospital	63	12%
Other medical setting	4	5%
No treatment required	9	12%
Total	76	100%

Table 1. Characteristics of the impact of pediatric pedestrian non-traffic accidents in Qld between January 1998 and December 2000.

Characteristics of the vehicles, locations and times

As depicted in table 2, 61% per cent of the vehicles involved in the incidents were cars, however the ambulance report forms did not indicate whether these cars were large, medium or small. Twenty per cent of the vehicles were 4WDs, utilities or heavy vehicles. In 46% of incidents, the vehicle was in reverse although this figure could be higher due to the fact that the

direction of movement was not recorded in 22% of cases (Table 2). This is consistent with the finding that indicates the rear section of the car hit the patient in 46% of the cases. The vehicle was moving at low speed in 55% of incidents and an unknown speed in 45% of incidents. A parent was in control of the vehicle in 28% of cases, although once again, this figure could be higher as the relationship of the driver was unrecorded in 66% of cases (Table 2). In contrast, an idling car moving out of control caused 5% of the incidents.

Characteristics	Frequency	Percentage
Type of vehicle:		
Car	46	61%
Four wheel drive	11	15%
Utility	1	1%
Heavy vehicle	3	4%
Other	5	7%
Unknown	10	13%
Total	76	100%
Direction of Movement:		
Reverse	35	46%
Forward	24	32%
Unknown	17	22%
Total	76	100%
Section of vehicle hitting child:		
Rear	35	46%
Front	24	32%
Side	2	3%
Unknown	15	20%
Total	76	100%
Person in control of vehicle:		
Father	15	20%
Mother	6	8%
Neighbour	1	1%
Idle vehicle	4	5%
Unknown	50	66%
Total	76	100%

Table 2. Characteristics of the vehicles involved in paediatric pedestrian non-traffic accidents in Qld between January 1998 and December 2000.

In regards to accident location, a private or residential area was identified as the location of the accident in 55% of the cases (see Table 3). Precise incident locations were not sighted on arrival by the paramedic in 31% of cases due to the vehicle or the patient being moved to another location, however, a driveway was recorded as the place of incident in 40% of cases. Twenty-nine per cent of incidents occurred in the Brisbane metropolitan area and 52% in other urban areas of the state (Table 3).

An investigation into time of accidents revealed that incidents were most likely to occur between 2 pm and 6 pm (43%), and on Mondays (24%) and Saturdays (21%). The periods of December to January (21%) and July to October (47%) were peak times of year for paediatric pedestrian incidents in Queensland.

Characteristics	Frequency	Percentage
Private vs Public area:		
Private or residential	42	55%
Public area	27	36%
Unknown	7	9%
Total	76	100%
Detailed location:		
Driveway	30	39.5%
Educational setting	6	8%
Sports centre	5	7%
Cinema	1	1%
Shopping centre	8	10%
Beach	2	3%
Unknown	24	31%
Total	76	100%
Regional location:		
Metropolitan	22	29%
Other urban	40	52%
Rural / remote	12	16%
Unknown	2	3%
Total	76	100%

Table 3. Characteristics of the location of paediatric pedestrian non-traffic accidents in Qld between January 1998 and December 2000.

Tests of association

Finally, a series of chi-square analyses indicated that the age of the child was not significantly related to the impact of the accident as measured by GCS, respiratory rate or ambulance dispatch code. However, the sex of the child was related to the dispatch code as, girls were more likely than boys to be placed in the "life-threatening" code $X(1, 76) = 4.34$, $p < .05$.

In regards to vehicle type, there was a significant relationship between the type of vehicle and severity of injury as measured by GCS severity ($p < .001$) as heavy vehicles were more likely to cause more severe injuries. More specifically, of the seven patients with some loss of consciousness (indicated by a GCS rating of less than 13), four were hit by 4WD, two by heavy vehicles, one by an "other" vehicle and one by a car (Table 3). In contrast, measures of the severity of impact (GCS, respiratory rate or dispatch code) were unrelated to the location of the incident, the driver of the vehicle, direction of the vehicle, time of day, day of week or time of year (see table 3).

Predictor	(cell size)	GCS 3%	GCS 4– 5 %	GCS 6-8 %	GCS 9-12 %	GCS 13-15 %
Age (years)						
0 to < 2 (17)	0.0	0.0	0.0	17.6	82.4	14.74, NS
2 to <5 (24)	12.5	4.2	4.2	12.5	66.7	
5 to <10 (20)	5.0	0.0	0.0	0.0	95.0	
10 - <15 (13)	0.0	0.0	0.0	0.0	100.0	
Child' s Sex						
Male (41)	7.3	0.0	0.0	7.3	85.4	3.21, NS
Female (33)	3.0	3.0	3.0	9.1	81.8	
Vehicle Type						
Car (45)	0.0	0.0	0.0	0.0	2.2	97.8 52.6***
4WD (10)	10.0	0.0	0.0	30.0	60.0	
Utility (1)	0.0	0.0	0.0	0.0	100.0	
Heavy (3)	66.7	0.0	0.0	0.0	33.3	
Other (5)	0.0	20.0	0.0	0.0	80.0	
Location						
Private (40)	7.5	2.5	0.0	10.0	80.0	5.42, NS
Public (26)	3.8	0.0	3.8	0.0	92.3	
Driver						
Father (15)	6.7	0.0	0.0	13.3	80.0	1.75, NS
Mother (5)	0.0	0.0	0.0	20.0	80.0	
Neighbour (1)	0.0	0.0	0.0	0.0	100.0	
Idle car (4)	0.0	0.0	0.0	0.0	100.0	
Direction						
Reverse (32)	3.1	3.1	3.1	9.4	81.3	3.97, NS
Forward (23)	4.3	0.0	0.0	0.0	95.7	
Time of Day						
MN– 6am (2)	0.0	0.0	0.0	50.0	50.0	16.68, NS
6– 10am (12)	16.7	0.0	0.0	0.0	83.3	
10am– 2pm (15)	0.0	0.0	0.0	13.3	86.7	
2 – 6pm (31)	6.5	3.2	0.0	6.5	83.9	
6pm – MN (12)	0.0	0.0	8.3	8.3	83.3	
Day of Week						
Monday (16)	6.3	0.0	0.0	12.5	81.3	20.38, NS
Tuesday (8)	0.0	0.0	0.0	12.5	87.5	
Wed (11)	18.2	0.0	0.0	9.1	72.7	
Thursday (7)	0.0	14.3	0.0	0.0	85.7	
Friday (8)	0.0	0.0	0.0	0.0	100.0	
Saturday (16)	6.3	0.0	6.3	6.3	81.3	
Sunday (6)	0.0	0.0	0.0	16.7	83.3	
Time of Year						
Summer (19)	10.5	0.0	5.3	10.5	73.7	8.27, NS
Autumn (11)	0.0	0.0	0.0	9.1	90.9	
Winter (23)4.3	0.0	0.0	4.3	91.3		
Spring (19)	5.3	5.3	0.0	10.5	78.9	

Table 3. Tests of association between characteristics of paediatric pedestrian non-traffic accidents and patients' Glasgow Coma Scale score.

Note: *** p < .001, ** p < .01, * p < .05, NS = not significant

Discussion

The present study aimed to report on an investigation into the incidence of paediatric pedestrian non-traffic accidents in Queensland to which the QAS responds. In addition, the study aimed to examine the characteristics of these incidents and the general severity of the injuries.

Firstly, the study revealed that the QAS responded to 76 driveway accidents involving paediatric pedestrians over the three-year study period. A higher percentage of the accidents involved boys than girls, however similar to previous research [4,8], the gender distribution was relatively even. Accidents were also more likely to occur in the warmer months in the afternoon (to late afternoon) when children are likely to be active.

The research findings indicate that non-traffic pedestrian accidents clearly affect preschool-aged children, with over half the accidents involving children under the age of four years. This finding is again consistent with previous studies which have demonstrated that young children are at a heightened risk of being struck by vehicles [8,17, 21], and may suggest that children aged less than five years lack recognition of environmental hazards [9].

An examination into the severity of injuries revealed one patient died and six were unconscious upon arrival of the ambulance. Importantly, analysis of ambulance codes revealed that 88% of the incidents were considered " life threatening" . The average GCS score of 13 was consistent with previous research [8] as less than a third of patients demonstrated respiratory rates within the normal range. Over 80% were treated at hospital and a further 5% received treatment elsewhere. Although this study does not report follow-up information from the hospitals, the apparent mortality rate (1 in three years) is lower than that cited in a previous Victorian study (2.8 per year) [9].

In regards to vehicle type, cars rather than 4WDs had the highest rate of involvement with driveway accidents, although this may be likely to the greater proportion of cars than 4WDs currently being driven. However, accidents involving 4WD and heavier vehicles tended to result in more severe injuries as indicated by the patients' respiratory rate and GCS ratings. This finding is again similar to previous research that has found 4WD and heavier vehicles are over-represented in the statistics for driveway accidents [1,8,9,15,17,22]. Moreover, a reversing vehicle was involved in the majority of the private or residential cases in Queensland. These findings are again consistent with those of previous studies [15,17,22], and suggest that poor driver visibility and lack of awareness are major risk factors in driveway accidents.

Incidents were most common between 2pm and 6pm, which corresponds to the after-school period when children are most likely to be playing and moving about in non-traffic locations. However, there appears to be some level of variability in the peak accident times. For example, a New Zealand study reported the peak time for driveway accidents was between 4pm and 6pm [23], while a Victorian study of fatalities indicated fatalities were most likely to occur in the morning hours [9]. Furthermore, for the current study Saturdays and Mondays were the days when most accidents occurred, while previous research has indicated week days are the highest risk times [9,23]. Taken together, the findings indicate that children are at risk of being injured whenever a motorist moves a vehicle in a driveway, regardless of the time or week of day.

Furthermore, there was no relationship between severity of injury and time, day or season. However, more accidents occurred in the months of July to October, and in December and January (roughly corresponding to winter holidays, 3rd term holiday and summer holiday months in Qld). A Victorian study also noted a peak in driveway accidents in the warmer months [9]. Rather than a direct relationship between season and risk, this pattern may simply reflect a greater frequency of vehicle use while children are at home playing during school holidays.

Limitations

Some limitations of the study were identified. The data presented in the current study is over six years old, however more recent statistics also indicate a similar level of prevalence, and type, of paediatric crashes in Queensland [24]. The severity of injury data was not uniformly collected, and thus questions remain regarding the relationship between injury severity and other environmental factors remain uncertain e.g., such as driving direction & location. Additional missing data regarding vehicle type and driver characteristics for specific incidents make firm conclusions difficult to achieve.

Driveway accident countermeasures

Regardless of the relationship between the driver and victim, the results highlight the importance of being aware of the whereabouts of children before moving a vehicle. Furthermore, the data confirms that children remain at risk of being injured by vehicles on or near property driveways. This study has identified that vehicles moving in reverse out of driveways, in particular higher-set vehicles with poor visibility, pose a high risk for paediatric pedestrian incidents. Children under the age of five are particularly at risk. Such accidents are most likely to occur after school hours and during school holidays, when children are more likely to be playing in non-traffic areas while vehicles are in motion. Since the majority of such accidents cause considerable trauma to both the child and family, the appropriate response is to focus on prevention [6].

Researchers have suggested that interventions should incorporate a holistic approach and involve addressing the driveway environment, the driver and vehicle, as well as the appropriate supervision of children [6,19]. Given the unpredictable nature of children behaviour, special emphasis being placed on environmental controls (e.g., fencing) may prove to be of considerable benefit. While not always feasible, the erection and maintenance of fencing and physical barriers have proven successful in reducing the likelihood of paediatric accidents [6]. For example, a case study reported the absence of barriers between play areas and driveways increases the risk

of driveway-related injuries by a factor of 3.5 [5]. A less expensive option may be to install additional vehicle safety mechanisms on high risk vehicles (e.g., 4WDs) such as extended mirrors to visualise small children. In addition, parental supervision which reinforces children not being permitted to play in the driveway or near cars also has the potential to be a productive prevention mechanism. However, it appears that a combination of well publicised public health campaigns to increase motorists' awareness, as well as safer driveway design and the possible fencing of domestic rental properties have the greatest potential to prevent injuries [6].

Taken together, the process of reducing the high incidence of paediatric driveway injuries is most likely to be found in improving public awareness as well as the safety of driveways. While fencing every driveway may prove an expensive and unrealistic target, raising the publics' perceptions regarding the serious risk of driveways may prove an essential first step in improving child safety. Given that such accidents are often predictable and thus preventable, continued research into effective safety campaigns will only serve to reduce the likelihood of a child sustaining a serious vehicle-related injury in a driveway.

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