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Driveway-related motor vehicle injuries in the paediatric population: a preventable tragedy

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Abstract

Aim To describe the incidence and demographics of children injured by slow-moving vehicles in Auckland driveways in order to develop preventative strategies.

Methods We retrospectively reviewed all children less than 15 years, 76 in total, who were injured by a vehicle in a driveway within Auckland between January 1998 and October 2001. Patient demographics and risk factors were identified by clinical note review, contacting the parents, and inspecting the driveways involved.

Results These injuries occur most commonly in children less than 4 years old (86%), usually boys (58%), who are reversed over by a relative (68%) at the home driveway (71%). There were six deaths within the study period. Head and thoracic injuries predominated and were typically associated with lower limb injuries. Maori and Pacific Island children represented 74% of all the cases. Nineteen drivers saw the child immediately prior to reversal in a presumed safe position. None of the driveways had any fencing to separate the driveway from rest of the property.

Conclusions A combination of targeted public health messages to increase awareness, safer driveway design and the fencing of domestic rental properties will prevent these injuries.

Vehicles striking children on driveways are a predominant cause of non-traffic-related injuries and account for one quarter of all reported paediatric pedestrian injuries requiring admission to hospital in the Auckland region. These accidents occur most commonly to children less than four years old, who are reversed over in their own driveway by a car driven by their parent. Although driveway-related injuries had previously been studied in Auckland, we believed that there was still limited public awareness and that overall incidence had remained unchanged.¹⁻³ We also suspected that the children involved belonged to a clearly defined demographic group not previously described. Our objectives were to assess the incidence of the events, describe the nature of the injuries, identify at-risk groups and develop definitive methods of prevention.

Methods

A retrospective review was performed of all patients less than 15 years old, who were admitted to Starship Children's Hospital due to a driveway injury over a 45-month period from January 1998 to October 2001. Starship Children's Hospital is the tertiary referral centre for all paediatric patients in Auckland and receives all children requiring paediatric surgical care. Only children from the Greater Auckland region (a population of approximately 250 000 children less than 15 years old) were included.⁴ Cases were identified via an admission and discharge trauma monitoring system. Fatalities at the scene were reviewed along with mortality information from the coroner's office. Data were collected on the:

gender, age and ethnicity of the child; date, time and site of the accident; vehicle type and driver; events leading up to and including the accident; description of the accident site; the number of children in the household; the initial medical assessment; injuries sustained; intensive care admission; length of stay; operative procedures; medical management; discharge; complications; and the resulting outcome. Outpatient review and telephone consultations were performed. The accident site was visited in 43 cases to ensure accuracy of the collected data. All other cases were investigated by telephone interview and 10 of these cases were inspected to ensure accuracy.

Results

A total of 77 separate driveway accidents occurred, involving 76 patients. Two children were involved in more than one accident. One was reversed over twice on two separate occasions during the period and another was struck by a car driven by his other parent prior to the commencement of the study in January 1998. One accident involved two children being reversed over. Patient demographics and characteristics are summarised in Table 1.

Table 1. Characteristics of driveway accidents

| Characteristic | Number in study | % in study | |
|------------------------------|-----------------|------------|-----------------------------|
| Ethnicity of patients | | | Census data 1996 (%) |
| NZ European | 16 | 21 | 49 |
| NZ Maori | 24 | 31 | 19 |
| Samoan | 12 | 16 | 8 |
| Cook Islander | 10 | 13 | 3 |
| Tongan | 5 | 6 | 4 |
| Asian | 2 | 3 | 7 |
| Other | 8 | 10 | 10 |
| Vehicle type | | | LTSA* (%) |
| Car | 55 | 71 | 94 |
| Van/light truck | 16 | 20 | 2 |
| Four wheel drive | 6 | 8 | 4 |
| Unknown | 1 | 1 | |
| Driver identity | | | |
| Father | 15 | 19 | |
| Mother | 15 | 19 | |
| Extended family | 22 | 30 | |
| Neighbour/friend | 14 | 18 | |
| Commercial | 4 | 5 | |
| Other/unknown | 7 | 9 | |
| Location of driveway | | | |
| Home | 55 | 71 | |
| Relative | 16 | 21 | |
| Neighbour | 6 | 8 | |

* Land Transport Safety Authority

A number of key factors are evident. The median age for the studied group was 23 months, ranging from 12 to 138 months. The majority 45 (58%) of the children were male.

The family home was the most common site for the accidents 55 (71 %). The second most common site was the home of the daytime child carer, whose role is often held by the extended family in the study population. In total, 16 accidents occurred at relatives' homes, with 12 vehicles being driven by a relative. Only six accidents occurred while the child was playing in neighbouring driveways, three of which involved commercial vehicles. In the eight children older than five years, the incident most often

occurred (n=6) while they were playing at a neighbour's or relative's home.

The driver of the vehicle was usually a parent (39%) or close relative (30%). Friends and neighbours were driving in only 18% of cases. Two separate incidents were reported in which boys had released the car's handbrake and then escaped the vehicle only to be rolled over further down the driveway. One 15-month old was struck by a car whose handbrake had been released by an older sibling. In all other cases the child was reversed over.

Although the accidents occurred from 0700 to 2330 hours, the majority occurred in the afternoon, predominantly between 1600 and 1900 (n=36). A second peak (n=14), occurred in the morning between 1000 and 1200 hours. We found no evidence that improved lighting could prevent the accidents. A preponderance of events, 30 (39%), occurred during the summer months of December to February. The frequency of the events was lowest, 10 (13%), during the spring months of August to October.

Certain ethnic groups, such as Maori and Pacific Island children, were over represented at 66%, as compared with their population size of 34%. The mean number of children in households where these accidents occurred was 3.4, as compared with the mean of 2.4 children in the average Auckland household.⁴ Nineteen drivers reported seeing the child in a safe position either in the house, at the front door, or in the garden away from the rear of the vehicle, prior to them reversing. Despite anecdotal evidence, we could find no correlation between multiple residences using a single driveway and increased frequency of the accidents.¹ Only 16 (21%) events occurred on shared-access driveways. None of the properties had a driveway fenced or separate from the main house. Forty three (56%) of the accident sites were inspected to reveal the driveway was frequently easily accessible from both the front and back of the house. Since the accident, none of the driveways had been fenced.

The residences involved were analysed using the New Zealand deprivation index, which divides the New Zealand population into 10 equal groups. Group 1 represents the wealthiest 10% of the population, and group 10 the poorest 10%. In our study, the higher socioeconomic groups 1 to 3 were all under represented. 47% of the cases occurred in groups 9 and 10, instead of the expected 20%.

The ownership of the property was identified for 50 of the residences where the accident occurred in the home driveway. Forty two (84%) of fifty residences were rented properties, compared with the mean of 38% in Auckland.⁴ Although the government agency Housing New Zealand owns only 8% of rented properties in the Auckland, it owns 38% (n=19) of the homes in our study.

Thirty seven patients (48%) attended Starship Children's Hospital directly and 38 (49%) were transferred from other hospitals. The median length of stay was two days. Seventeen patients (22 %) required admission to paediatric intensive care with a median length of stay of one day, ranging from one to nine days. Seventy patients were discharged home and two went to rehabilitation centres.

Driveway accidents produce a distinct pattern of injury, typically involving the head, chest and lower limbs. Thirty seven (48%) children sustained a minor head trauma while 17 (22%) sustained a major injury such as base of skull fracture and intracranial haemorrhage. Twenty three (29%) suffered major thorax injuries and 9 (12%) suffered lower limb fractures. Lower limb abrasions and lacerations were associated with a head injury in 21 (28%) patients. The severity of the injury increased with the size of the vehicle, the weight of the vehicle and the effect of reversing and then driving forward again. Upper limb fractures, 3 (4%), and intra-abdominal injuries, 9 (12%), were relatively less common.

Long-term complications were identified at follow up at a median of 12 months, ranging from 6 to 30 months, occurred in 8 (11%) of survivors, and ranged from mental handicap, hemiparesis, ataxia and third nerve palsy, to marked speech and learning difficulties. There were 6 (8%) fatalities over the 45-month period. Four children who died at the scene were identified via the coroner's office. Within the fatalities, both genders were equally represented, the mean age was 30 months and the majority of the accidents (n=5) occurred at home. Vans or trunks struck three of the six fatally injured children. Four sustained massive basal skull fractures. One died from multiple injuries, including pulmonary lacerations and a ruptured inferior vena cava. Only one boy aged 32 months survived longer than 24 hours. He sustained a closed head injury, bilateral pulmonary contusions and a left-sided first rib fracture. Echocardiography on day two was normal. Thirteen days after discharge a fatal left ventricular aneurysm rupture occurred.

Discussion

The most common paediatric pedestrian injury occurs when a child is struck by a vehicle while crossing the road.⁵ However, from 1986 to 1995 throughout all New Zealand, there were 39 non-traffic pedestrian deaths. The majority of these were driveway-related events, occurring in children less than four years,⁶

and in domestic driveways in urban centres.⁷

A total of 71 non-fatal driveway related accidents occurred during our study period, producing a non-traffic pedestrian injury rate of 7.6/100 000 children per year. There were six fatalities over the 45-month period, resulting in a fatality rate of 0.64/100 000 children per year.⁴ The overall incidence has remained significantly unchanged over the last 15 years.² A review of the literature reveals that driveway-related injuries are uncommon in Europe and have a much higher incidence in New Zealand, Australia and North America.^{7–9} We believe this is due to the longer driveways and the frequency of subdivided properties in these countries.

The mean number of children in affected households was 3.4, while the average for the Greater Auckland region is 2.4. However, the mean number of children per household varies markedly between ethnic groups in Auckland, with Maori and Cook Islanders having larger families – 2.7 and 3.06 children per family respectively.⁴ Their over representation within the study may reflect the perceived increased risk for larger families.

Driveway-related injuries have a distinct injury pattern. The short stature of the child relative to the bumper explains the predominance of injuries to the head and chest. Lower limb injuries occur as the child falls to the ground or is driven over. Driveway-related accidents have a higher incidence of closed head injury and a higher mortality than traffic-related injuries.¹⁰ Major abdominal and upper limb injuries are uncommon. Since the majority of the fatalities sustained untreatable injuries at the scene, the appropriate medical response is to focus on primary prevention.¹¹ Interventions must involve the driveway environment, the driver, the vehicle and the behaviour and supervision of all children.¹²

Vans, four wheel drive vehicles and light trucks account for only 6% of all domestic vehicles in Auckland registered by the Land Transport Safety Authority. However, they were involved in 28% of the accidents reviewed, and the majority were owned and driven by a parent. These vehicles are associated with a higher rate of accidents and more complex injuries than cars. The large size of these vehicles produce a visibility problem that can prevent the child from being seen during reversing.^{7,11}

Larger rear view and “rounded” mirrors have been recommended in order to decrease the “blind spots” in which a child may be missed during reversing.¹⁰ Proximity detectors and warning reversal alerts have also been proposed.¹¹ However, they are expensive and not a standard feature in most family cars and are unlikely to be purchased as a preventive method by parents.¹³

Parental supervision is another key element in the prevention of trauma in the under five age group. Younger children must be discouraged from using the driveway as a safe extension of the house and garden for play. The risks of releasing the handbrake and cycling behind reversing cars must be reiterated for older children. Children should not be allowed to remain unsupervised in any vehicle.¹⁴

The erection and maintenance of fencing and physical barriers have proven successful in preventing accidents. The reduction of child drowning in home swimming pools since the introduction of compulsory fencing is an excellent example. Since the introduction of the uniform pool fencing legislation in New South Wales, Queensland, there has been a reduction of at least 50% in the drowning rate in private swimming pools.^{15,16} Denmark has experienced major decreases in pedestrian mortality by placing greater emphasis on environmentally-based prevention strategies, rather than pedestrian skill courses.¹⁷ Fencing with self-closing gates, which isolate the driveway from the garden and the residence, would prevent children from accessing the area while the vehicle is being reversed. It would also allow the area around the vehicle to be safely inspected for children prior to reversing. The absence of a definitive barrier between the play area and the driveway has been shown to increase the risk of a driveway-related injury by a factor of 3.5.¹ In many instances, children were clearly seen in a perceived safe area of the garden or house prior to the movement of the vehicle. The ability of the child to get from there to the rear of the vehicle demonstrates dramatically the need for definitive separation of the driveway from the house.

The majority, 43 (56%), of the accidents occur in the south of the city within clearly-defined lower socioeconomic areas.^{1,3} In Auckland, 38% of all residential dwellings are rented properties.⁴ Owner-occupiers accounted for only 16% of the residents in the study; a percentage noticeable lower than the mean of 62% in Auckland. Although the number of households involved are small, the high incidence of rental property (84%), and particularly the 38% that were government owned, is a cause for concern.³ Fencing is an expensive preventive method and those in poorer socioeconomic areas are unlikely to have the finances to build fences in order to separate the play area from the driveway. It must be the landlord’s responsibility to provide a safe environment and to build and maintain a fenced driveway.

Imposing compulsory driveway fencing for all properties is undoubtedly difficult. However, in new subdivisions provision must be made for the driveway to be fenced and separated from the house. The possibilities and benefits of fencing should be explained and the building of suitable fences supported. In order to decrease the incidence of driveway-related injuries we need to raise public awareness and create safer driveways. The public health message needs to be correctly targeted at those most at risk, particularly those in lower socioeconomic areas with larger families and those driving four wheel drive vehicles and vans. Future residential building should aim to make both driveways and properties safer. Although an expensive solution, we recommend that all rental properties be required to have a fenced driveway provided by the owner in order to separate it from the garden and the house. Together, these measures would lower the incidence of driveway injuries and thereby significantly reduce paediatric pedestrian trauma in New Zealand.

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