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Paediatric driveway run-over injuries: time to redesign?

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Abstract

Aims To investigate the demographic, accident, and environmental characteristics associated with driveway run-over injuries in order to identify potentially modifiable factors and prevention strategies.

Methods Retrospective review of all children less than 15 years old who were hospitalised or killed due to a driveway run-over injury in the Auckland region of New Zealand over the 50-month period, November 2001 to December 2005. Data was collected on the demographics, accident and environmental characteristics, and parental awareness. Data was obtained from clinical records and telephone interviews with parents.

Results A total of 93 cases were identified, including 9 fatalities. The median age was 2 years with 73% under 5 years old. Children of Pacific Island and Māori ethnicity comprised 43% and 25% of cases respectively. Injuries occurred predominately on the child's home driveway (80% of cases). In 64% the driveway was the usual play area for the child. Only 13% of driveways were fenced. 51% were long driveways extending through the section, and 51% were shared with other properties. 51% of properties were rented and of these 57% were government houses.

Conclusion The absence of physical separation between driveways and children's play and living areas may predispose to driveway injuries. Further research is needed to investigate the ideal way to implement such separation in current properties and future property developments.

A significant and often overlooked proportion of child pedestrian injuries occur on domestic driveways.1–3 These injuries typically involve young children and most commonly occur in the child's own home driveway.1 Adding to the tragedy is the fact that the driver of the vehicle is most often a parent or close relative.1
Driveway injuries appear to be associated with higher mortality and less favourable outcomes than other types of child pedestrian trauma.4,5 In fatal cases, death usually occurs at the scene of the accident.4
Given the severity of injuries and high mortality rate, primary prevention would be desirable. Various prevention strategies have been suggested including fencing, proximity sensors, visual aid devices and public education.1,4,6–11
The purpose of the present study is to investigate the demographic, accident and environmental characteristics associated with driveway injuries in order to identify potentially modifiable factors and prevention strategies that could lead to a safer driveway environment for children.

Materials and Methods

A retrospective review was undertaken of all children less than 15 years old who were hospitalised or killed due to a driveway injury in the Auckland region during the 50-month period from November 2001 to December 2005. Driveway injury was defined as an injury caused by contact with a non-stationary motor vehicle occurring on a driveway. A driveway was defined as any passageway providing vehicle access between the road and the adjoining property. This definition of 'driveway' excludes injuries occurring in other off-road locations such as carparks, parks, reserves and farms. Also excluded were cases transferred from outside the Auckland region and cases not admitted into hospital, that is, cases seen only in the Emergency Department then discharged.

Cases were identified from three sources: Starship Children's Hospital Trauma Registry, Middlemore Hospital Trauma Registry and the Auckland City Coroner's database. Starship Children's Hospital is the tertiary referral hospital and the paediatric trauma centre for the region. Middlemore Hospital admits paediatric orthopaedic and burns cases. These two units are responsible for all paediatric trauma admissions within the greater Auckland region.

Data was collected on the demographics, accident and environmental characteristics, and parental awareness. Data was obtained from clinical records and telephone interviews with parents. Parents/caregivers of the children in the identified cases were approached with an initial introductory letter and after obtaining verbal consent, a structured telephone interview was conducted. In selected cases where consent was granted, injury sites were visited by the primary investigator to clarify the property characteristics and driveway layout. Population data for the Auckland region was obtained from Statistics New Zealand.12

Statistical analysis was performed using the Pearson's Chi-square test or Fisher's exact test for categorical variables and the Mann-Whitney U test for continuous variables.

The study received ethical approval from the Auckland Regional Ethics Committee.

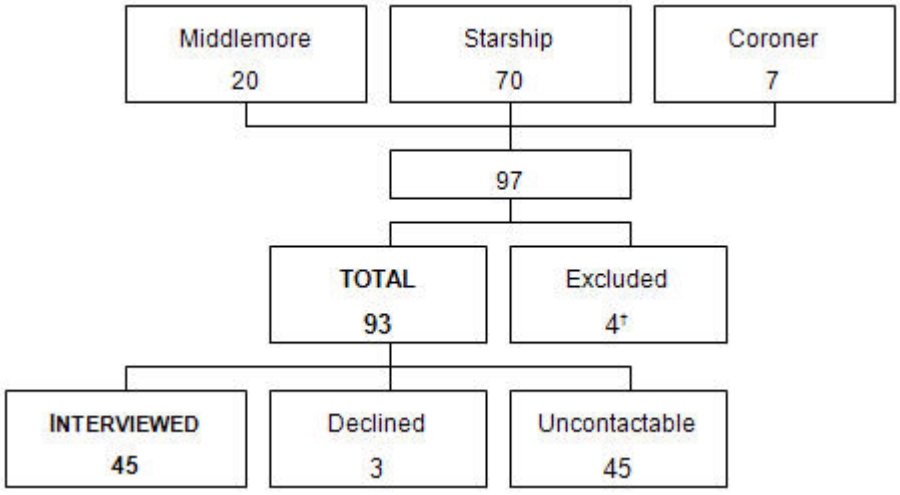
Results

A total of 93 children were injured or killed over the 50-month period (Figure 1). Fifty-eight children initially presented to Middlemore Hospital Emergency Department, but of these, 37 were transferred to Starship Hospital for admission and one fatal case went to the coroner. Of the 93 cases, 7 were fatal. This equates to a mortality rate of 0.63/100 000 children per year, and an injury rate of 8.4.

Demographics—The 0–4 years age group were over-represented, comprising 73% of cases versus 33% of the paediatric population. The Pacific Island and Māori ethnic groups were over-represented: Pacific Islanders represented 43% of driveway run-over cases, significantly higher than their Auckland population of 14%, and Māori represented 25% of cases compared to 10% of the population.

Injury location—The majority of injuries (56%) occurred in South Auckland (which comprises 39% of the paediatric population in the Auckland region).13 The injury occurred at the child's own home in 80% (n=74) of cases.

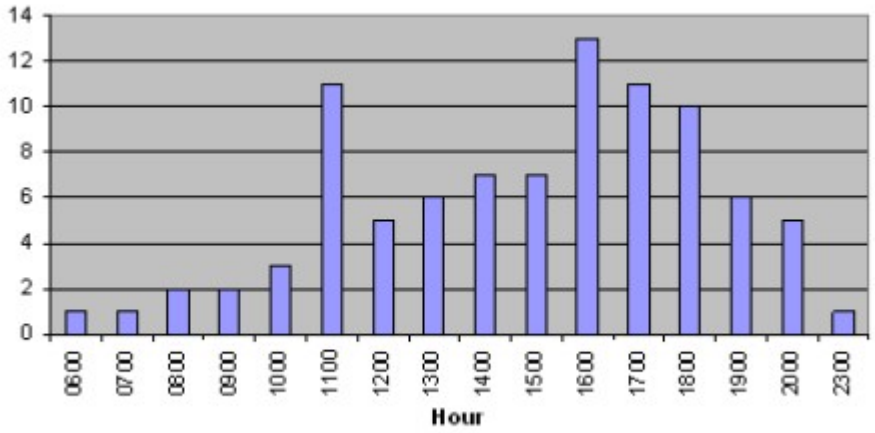
Figure 1. Patient numbers



Middlemore: admissions to Middlemore Hospital; **Starship:** admissions to Starship Children's Hospital; **Coroner:** fatal cases; † Injury occurred outside the Auckland region.

Time: Accidents tended to occur in the afternoon, especially between 4pm and 7pm, 37% (n=34) (Figure 2). There was also a second peak around 11am. 43% (n=40) occurred in the summer months, correlating with better weather and longer daylight hours, with peak frequency in December (n=19).

Figure 2. Number of accidents by hour of day†



† Time of the accident could not be established for two of the cases.

Driver and vehicle characteristics (**Table 1**)**—**In about two-thirds of cases, the driver was related to the child, most commonly the parent, 36% (n=34). The type of vehicle most frequently involved was the car, 65% (n=60). However, vans were over-represented in these accidents.

Table 1. Vehicle and driver characteristics (N=93)

Variables	n	%	LTSA† data (%)
Vehicle type	60	65	77.2
Car	18	19	5.8
Van	9	10	10.1
Four wheel drive/SUV	4	4	6.9
Light truck/Ute	2	2	–
Unknown			
Driver	19	20	–
Father	15	16	–
Mother	17	18	–
Neighbour	24	26	–
Extended family	6	6	–
Friend	1	1	–
Commercial	3	3	–
None	4	4	–
Other	4	4	–
Unknown			

† Relative proportions of each vehicle type registered to the Land Transport Safety Authority (LTSA) of New Zealand in the Auckland region in 2005.

Interviewed subgroup—Of the 93 cases identified, 45 (48%) were able to be contacted and gave consent for interview (Figure 1). The characteristics of the interviewed subgroup did not differ significantly from total study population (Table 2). The remaining results presented below pertain to the interviewed subgroup (N=45).

Home ownership—The properties where injuries occurred were predominantly rental houses (51%), of which 57% were owned by the government housing agency, Housing Corporation New Zealand. Rental accommodation comprises 36% of houses in the Auckland region.12

Table 2. Characteristics of the total study population compared to the interviewed subgroup

Age and gender	Total (N=93)		Interviewed (N=45)		P value
Age in years, median (LQ, UQ)	2 (1, 5)		2 (1,3)		0.7
Gender (female:male)	42:51		20:25		0.9
Ethnicity	**n**	**%**	**n**	**%**	**P value**
Māori	23	25	7	16	0.3
Pacific Island	40	43	22	49	0.6
European	23	25	11	24	1.0
Asian	5	5	4	8	0.5
Other	2	2	1	2	1.0
Injury location	**n**	**%**	**n**	**%**	**P value**
North Auckland	11	12	9	20	0.2
West Auckland	14	15	7	16	1.0
Central Auckland	12	13	6	13	1.0
East Auckland	4	4	1	2	1.0
South Auckland	52	56	22	49	0.5

Age (Mann-Whitney U test); Gender (Pearson Chi-squared test); Ethnicity (Fisher's exact test, two-tailed); Injury location (Fisher's exact test, two-tailed); LQ: lower quartile; UQ: upper quartile.

Scene characteristics (**Table 3):** Shared driveways (51%) and driveways which extended through the length of the property (51%) predominated. A typical driveway led up from the road past the front lawn and side of the house to the garage/carport in the rear section, and was readily accessible from the front lawn, back lawn and house. Only a small minority (13%) of driveways were fenced or physically separated in any other way from the house and lawn.

Table 3. Driveway and property characteristics (N=45)

Characteristic	n	%
Rental property	23	51
Government-owned rental property	13	29
Shared driveway	23	51
Driveway extending through section	23	51
Driveway with blind corner	2	4
Physical separation from house	6	13
Unfenced	39	87
Usual play area of child	29	64
No other play area on property	9	20

Supervision—In nine cases (20%), the driver actively checked that the child was in a safe location and that the driveway was clear prior to moving the vehicle. In these cases the child was able to easily gain access to the driveway and dart out into the path of the moving vehicle: The drivers often reported that the child had suddenly darted out into the path of their vehicle from inside the house or from a location out of the driver's view such as from behind another parked vehicle.

Discussion

Strategies in preventing driveway run-over injuries are numerous, but largely fall into three groups: Modifying behaviour (driver and parental education), modifying vehicles and modifying environment.

Education and public awareness campaigns, with messages promoting awareness of driveway safety, parental supervision and driver care, have been repeatedly suggested and have constituted the major thrust of efforts in prevention.4,6,10,14,15 Further efforts in this approach may yet have benefits, especially awareness campaigns targeted at the high-risk groups, such as parents of preschool children, Māori and Pacific Islanders, South Auckland parents and lower socioeconomic groups. However, education alone has major limitations: Education requires significant resources and sustained efforts to be effective, and the benefits are often short-term. And even with the best parental supervision and driver care, driveway accidents can still occur, as demonstrated by a few of

the cases in our study.

Strategies in the area of vehicular modifications have largely focused on improving the rearward visibility of vehicles. The Motor Accidents Authority (MAA) of New South Wales in Australia has conducted extensive research into the effectiveness of various visual aids and technologies, such as specialized mirrors, proximity sensors and cameras. The MAA reported that any significant improvement to rearward visibility would require the combination of a rear-mounted video camera and short-range proximity sensor.15 Such a combination system is yet to be developed commercially and requires further refinement. Even with currently available technologies, the greatest limitation is the accessibility and affordability in the current markets, particularly for lower socioeconomic groups.

We believe that a more definitive and feasible solution in addressing driveway run-over injuries lies in physical measures and modifications that improve the safety of the driveway environment. The driveways on which run-over injuries occur are characteristically shared, extend through the property and function as a child play area. These factors maximise exposure of children to vehicles.

The absence of physical separation between driveways and children's living areas is associated with a threefold increase in the risk of driveway injuries.9 Physical separation can be achieved through various means, including fencing off the driveway, creating a physically separate outdoor play area and, for future developments, changing the design or configuration of driveways.

Fencing is perhaps the most direct and basic form of physical separation and has been frequently recommended.1,6,7,9,10 Advantages include the relatively low cost and flexibility of design, particularly for existing homes and already developed properties where the options for change are more restricted. However fencing is not always practical and, in some instances, may be ineffective.

We believe that it is important to promote the concept of physical separation in general: "Kids and cars don't mix". This concept allows the flexibility to decide the most preferable means for each property to achieve physical separation.

Who is responsible for ensuring safe driveway environment? Parents, caregivers, landlords, developers and council planners could all contribute. Driveway safety should be incorporated into the planning and design of future residential developments. Placing the garage close to the front of a property for example could limit the driveway's accessibility to children, decrease the driveway's usefulness as a play area, and maximise use of the land area for living purposes rather than for vehicles.

The present study is limited by its retrospective nature, although it is based on two prospectively collected trauma registries and a Coroner's registry. It is an observational study of driveway injuries and the residences at which they occurred but with no control group. It cannot be confidently concluded from the presented data that driveway layout is independently associated with risk of injury.

Further research should include a matched control group for comparison. Investigation into the design aspects of driveways will be beneficial, particularly questions addressing the ideal way to secure existing driveways and the ideal layout for off-road parking for new residences.

Competing interests: None known.

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