Driveway-Related Child Pedestrian Injuries: A Case-Control Study

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ABSTRACT. *Objectives.* To examine risk factors for driveway-related child pedestrian injuries.

Design. A community based case-control study.

Setting. The Auckland region of New Zealand.

Participants. Cases (n = 53) were children killed or hospitalized as a result of a driveway-related pedestrian injury, in the Auckland region over a period of 2 years and 2 months. Controls (n = 159) were an age-matched random sample of the child population of the Auckland region.

Results. The absence of physical separation of the driveway from the children's play area was associated with a threefold increase in the risk of driveway-related child pedestrian injury (OR = 3.50; 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 the absence of physical separation of the driveway from the children's play area was 50.0% (95%CI 24.7, 75.3).

Conclusion. The fencing of residential driveways as a strategy for the prevention of driveway-related child pedestrian injuries deserves further attention. *Pediatrics* 1995;95:405–408; *pedestrian, injury, case-control, nontraffic, driveway.*

Pedestrian injuries are an important cause of death and disability in childhood.[1,2] The majority of child pedestrian injuries are sustained when a child is struck by a rapidly moving vehicle on a public road. However for children younger than 5 years, nontraffic pedestrian injuries, most often involving a child reversed over in a residential driveway, account for the majority of pedestrian deaths.[3] To date, there have been no etiological epidemiologic studies of driveway-related child pedestrian injuries, and as a result there are few well established countermeasures. In this paper we report the results of a case-control study aimed at the identification of risk factors for driveway-related child pedestrian injuries.

METHODS

Cases in the study were all children younger than 15 years, normally resident within the Auckland region of New Zealand, who were killed or admitted to hospital as a result of a driveway-related pedestrian injury between 1 January 1992 and 24 February 1994. The Auckland region has a predominantly urban population of 936 981 of whom approximately 213 177 are under 15 years.[4]

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Children resident outside of the Auckland region, who were transferred to Auckland for hospital care, were excluded from the study. Children resident within the Auckland region are very unlikely to be transferred out of the region for hospital care. Hospitalized cases were identified through a monitoring system established at both of the hospitals in the region which admit injured children. Fatal cases were identified by regular surveillance of the records of the coroner's pathologist. In Auckland, all children whose deaths have resulted from injury are subject to a coroner's postmortem.

Three controls were selected for each case. Controls were frequency-matched to cases by age and were selected in a one or two stage process, depending on the age of the case. Controls for school-aged cases were selected in the following way. First a school was randomly selected from a list of all schools in the study region, with a sampling probability in proportion to the number of children on the school roll. In New Zealand all children begin school on their fifth birthday, and school attendance is compulsory until the age of 15 years. The selected school was then visited by the study staff who randomly selected a child from the school roll. The parents of the selected school child were provided with information about the study and invited to participate.

Controls for cases younger than 5 years (preschool) were selected by first selecting a school-aged child using the method described above. Then, using the street address of the selected school child as the starting point, homes were successively visited in a predetermined direction until a home with a preschool child was found. The parents of this child were provided with information about the study and invited to participate. If a home was visited when the occupants were out, the neighbors were contacted and asked if a preschool child lived in the selected home. If so, repeated calls were made, at different times of the day, until either the family of the eligible child was contacted or four separate visits were made, when the next household was visited. If an eligible child was located, but the family could not be contacted, a nonresponse was recorded.

After each subject was identified, an interview was scheduled with one or both parents. Parents of hospitalized cases were mostly interviewed in hospital, at a time determined in consultation with the nursing staff. Parents of fatal cases and parents of controls were interviewed in their own homes. Parents of cases and controls completed an interviewer-administered questionnaire that included questions about sociodemographic and familial characteristics and aspects of the home environment. Socioeconomic position was classified using the New Zealand-based Elley Irving scale.[5] Both maternal and paternal occupations were classified, with the highest level of the two being chosen as the value of the socioeconomic position variable for the child. If neither parent had undertaken paid employment, the child was classified as "other" and included with the lowest socioeconomic group.

On completion of the questionnaire, parents of cases and controls were asked if a research officer could visit the home to measure aspects of the driveway environment. During this visit the presence or absence of a fence separating the driveway from the children's play area was ascertained. Specifically the research officer determined whether the children's play area was completely separated from the driveway by a physical barrier such as a fence and a gate. Driveways were counted as fenced regardless of whether the gate was open or closed at the time of observation. Other measurements included driveway length, width, and gradient. The study was approved by the University of Auckland Ethics Committee.

Relative risks were estimated by calculation of odds ratios (OR). Univariate odds ratios have confidence intervals calculated by Cornfield's method except for the socioeconomic position variable where the exact method was used because cell numbers were small.[6] Multivariate odds ratios were calculated by unconditional logistic regression. Population attributable risks were calculated to estimate the proportion of cases explained by exposure to particular risk factors.[7]

RESULTS

Over the study period, a total of 55 children who had been injured as pedestrians in a residential driveway were identified. Fifty-three children were identified during hospital surveillance, and two children were identified during surveillance at the coroner's pathologist. Of the 55 cases identified, the parents of 53 (96%) agreed to participate in the study.

Three controls were selected for each participating case, a total of 159 controls. In order to recruit these 159 controls, the parents of 164 eligible children were invited to participate, a response rate of 97%. The age and sex distribution of cases and controls is shown in Table 1.

Numbers and univariate and multivariate odds ratios for the sociodemographic variables are shown in Table 2. In unadjusted analyses, children from families in the lowest socioeconomic stratum were at greatly increased risk, a risk of injury over five times that of children in the reference category. The risk of driveway-related pedestrian injury for Maori children was close to four times that of children in the reference category. The risk of injury for Pacific Island children was close to three and a half times that of children in the reference category. Children from single parent families were at increased risk, although this did not reach significance at the .05 level. Children from families with more than three children younger than 5 years were also at significantly increased risk. The adjusted odds ratios showed attenuation of risk for all of the variables in Table 2. However strong and significantly increased risks remained for Maori children and for children from families with more than three children under the age of 5 years.

Numbers and univariate and multivariate odds ratios for the environmental variables are presented in Table 3. 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 less than 3 months, and for children from families without access to a car. The risk of injury for children living in homes with shared driveways was over twice that of children from homes where the driveway was not shared. The risk of injury for children from homes where the play area was not fenced off from the driveway was close to three 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 ratios for all of the environmental variables except the variables describing the fencing of the driveway from the children's play area (OR = 3.50; 95%CI 1.38, 8.92) and the shared driveway variable (OR = 3.24; 95%CI 1.22, 8.63).

TABLE 1. Age and Gender Distribution for Cases and Controls

Variable	Cases (%), n = 53	Controls (%), n = 159
Age (years)		
0–3	39 (74)	118 (74)
4–7	11 (21)	40 (25)
8–11	3 (06)	1 (01)
Gender		
Male	33 (62)	84 (53)
Female	20 (38)	75 (47)

Since the study was community-based, the prevalence of unfenced driveways among the controls estimates the prevalence of unfenced driveways in the Auckland population. Population-attributable risk can therefore be estimated. The population-attributable risk associated with an unfenced driveway was 50.0% (95%CI 24.7, 75.3).

DISCUSSION

The typical driveway-related child pedestrian injury involves a 2-year-old child, struck by a vehicle driven by a friend or relative, while reversing out of the driveway.[8,9] This study has shown that, after adjusting for a range of potential confounders, the absence of a fence separating the driveway from the children's play area is associated with a three and a half times increase in the risk of driveway-related child pedestrian injury. It suggests that physical barriers that prevent children from gaining access to the residential driveway have the potential to significantly reduce driveway-related child pedestrian injury rates. The results also demonstrate that children living in homes with shared driveways are also at greatly increased risk. This increased risk is probably related to the increased use of such driveways. Children living in homes with shared driveways thus represent a high risk group to which preventive strategies might be preferentially directed.

Cases in this study were all children killed or hospitalized as a result of a driveway-related pedestrian injury, in the Auckland region, during the study period. While there have been reports of children injured after falling out of a motor vehicle set in motion by an unsupervised child, all of the cases in this study were reversed over by vehicles driven by adults.[10] Controls were a random sample of the child population. Although it is possible that a small number of driveway pedestrian injury cases were missed by our surveillance system, incomplete ascertainment would only introduce selection bias if the risk factor prevalence among those missed was different from among those included. Since there is no reason to suspect this, incomplete ascertainment is unlikely to have resulted in bias in this study. Similarly, in view of the very high response rates for cases and controls, even if the risk factor prevalence among nonrespondents were different from that among respondents, no major bias would be expected.

The presence or absence of physical separation of the driveway from the play area was determined by direct observation rather than by parental report. A previous validation study had shown that parents of children injured in driveways over report the extent to which their driveways are unfenced.[11] As a result, the use of parental reports would have overestimated the risks associated with unfenced driveways.

TABLE 2. Numbers and Univariate and Adjusted Odds Ratios for Sociodemographic Variables

Variable	Cases (%), n = 53	Controls (%), n = 159	OR (95% CI)	Adjusted OR* (95% CI)
Socioeconomic position				
I, II, III	5 (09)	40 (25)	1.00	1.00
IV, V	22 (42)	78 (49)	2.26 (0.75, 8.16)‡	1.65 (0.50, 5.42)
VI and others	26 (49)	41 (26)	5.07 (1.67, 18.36)‡	1.60 (0.42, 6.12)
Ethnic group				
Maori	15 (28)	21 (13)	3.81 (1.57, 9.26)	2.92 (1.02, 8.35)
Pacific Island	17 (32)	26 (16)	3.49 (1.51, 8.07)	1.67 (0.59, 4.71)
Other	21 (40)	112 (70)	1.00	1.00
Responsibility for child				
Sole	13 (25)	28 (18)	1.52 (0.67, 3.40)	0.65 (0.25, 1.67)
Partner	40 (75)	131 (82)	1.00	1.00
Number of children (under 5 years)				
> = 3 children	14 (26)	10 (06)	5.35 (2.04, 14.19)	3.36 (1.19, 9.50)
< = 2 children	39 (74)	149 (94)	1.00	1.00

* Adjusted for age, gender, and all variables in Tables 2 and 3.
‡ Exact confidence interval.

TABLE 3. Numbers and Univariate and Adjusted Odds Ratios for Variables Related to the Home and Driveway Environment

Variable	Cases (%), n = 53	Controls (%), n = 159	OR (95% CI)	Adjusted OR* (95% CI)
Multiple dwelling				
Yes	9 (17)	9 (06)	3.41 (1.15, 10.08)	1.39 (0.38, 5.02)
No	44 (83)	150 (94)	1.00	1.00
Rental accommodation				
Yes	32 (60)	44 (28)	3.98 (1.98, 8.05)	2.59 (1.11, 6.06)
No	21 (40)	115 (72)	1.00	1.00
Resident <3 months				
Yes	5 (09)	3 (02)	5.42 (1.08, 29.87)	2.30 (0.37, 14.50)
No	48 (91)	156 (98)	1.00	
Access to car				
No	16 (30)	22 (14)	2.50 (1.12, 5.58)	1.36 (0.51, 3.67)
Yes	37 (70)	127 (86)	1.00	1.00
Shared driveway				
Yes	19 (36)	33 (21)	2.13 (1.02, 4.44)	3.24 (1.22, 8.63)
No	34 (64)	126 (79)	1.00	1.00
Play area fenced from driveway				
No	42 (79)	93 (58)	2.71 (1.23, 6.05)	3.50 (1.38, 8.92)
Yes	11 (21)	66 (42)	1.00	
Driveway width				
>3.0 m	21 (40)	76 (48)	0.72 (0.36, 1.41)	0.57 (0.24, 1.34)
< = 3.0 m	32 (60)	83 (52)	1.00	1.00
Driveway length				
>20 m	38 (72)	99 (62)	1.54 (0.74, 3.20)	1.41 (0.59, 3.36)
<–20 m	15 (28)	60 (38)	1.00	1.00
Driveway gradient				
Down to road	31 (58)	72 (45)	1.70 (0.87, 3.35)	1.02 (0.43, 2.43)
Up or flat to road	22 (42)	87 (55)	1.00	1.00

* Adjusted for age, gender, and all variables in Tables 2 and 3.

However, by making independent observations, the potential for this type of bias was eliminated. In addition, whenever possible the research officer making the observations was blind to whether the driveway was that of a case or a control, thus minimizing the possibility of "interviewer bias." For cases, environmental measures were made as soon as possible after the injury event, usually within 1 week, so that it is unlikely that fences would have been added following the injury event with consequent exposure misclassification for case subjects.

The potential for confounding was minimized in this study by collecting information on a range of social and environmental factors and adjusting for these by means of multiple logistic regression modelling. Because there was comparatively little previously published information on the interrelationships between variables in this context, all of the social and environmental variables were included in the multivariate model. However, the possibility that parents from homes with fenced driveways are more aware of the problem of driveway-related child pedestrian injury and consequently more cautious while reversing out of the driveway, cannot be completely ruled out in this study. In this situation the fencing may be a manifestation of this increased awareness. The potential for confounding by "cautiousness" therefore remains open to question.

If the association between unfenced driveways and the risk of injury is causal, the population-attributable risk of 50% provides an indication of the proportion of driveway-related child pedestrian injury cases that might be prevented if all driveways were fenced. While the association found in this study was strong, we are unaware of any other published studies which have examined the association between unfenced driveways and the risk of driveway-related child pedestrian injury, so that the often quoted causal criterion of consistency with other studies, cannot be satisfied.[12] However a casual association appears plausible, and the concept that fences prevent children gaining access to the residential driveway is analogous to the argument that fences prevent children gaining access to domestic swimming pools.[13–15] In view of these results, we believe that the fencing of domestic driveways as a strategy for the prevention of driveway-related child pedestrian injuries deserves further attention.

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DOCTORS DENOUNCE US GUIDELINES ON DRUGS TO TREAT HIGH BLOOD PRESSURE

A group of blood pressure experts launched an effort to overturn US guidelines on which drugs doctors should use to treat high blood pressure.

The seven experts attacked the recommendations of a National Institutes of Health advisory panel that doctors should first try treating patients with either a diuretic drug, which rids blood of excess water, or a so-called beta-blocker, which cuts the heart's pumping pressure.

The experts charged the recommendations theaten to hamstring doctors in their choice of drugs for high blood pressure patients, discouraging particularly the use of newer classes of drugs called ACE inhibitors and calcium-channel blockers. These drugs may work better and with fewer side effects and doctors should feel free to tailor their choice of drugs to each patient, they argued.

Four of the seven experts attacked the guidelines at a news conference in Dallas during the annual meeting of the American Heart Association. The news conference, which wasn't part of the meeting, coincided with publication of the October issue of the *American Journal of Hypertension*, edited by Dr. John H. Laragh, head of the cardiovascular center at New York Hospital. The *Journal* carries articles and editorials denouncing the guidelines.

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