Child pedestrian injury rates: the importance of "exposure to risk" relating to socioeconomic and ethnic differences, in Auckland, New Zealand

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Study objective – To examine how child pedestrian exposure to risk, as measured by the mean number of streets crossed, varies according to indices of material disadvantage and ethnic group.

Design – A questionnaire on pedestrian exposure to risk was distributed to children for completion by parents and return to school. Children from 40 schools were selected using a probability cluster design.

Setting – The Auckland region of New Zealand.

Subjects – Questionnaires were distributed to 3388 pupils of whom 2873 (85%) completed and returned the questionnaire.

Results – The mean number of streets crossed was 2.19 (95% confidence interval 1.82, 2.56) at age 6 years and 2.80 (2.42, 3.17) at age 9 years. The mean number of streets crossed for boys (2.57 (2.15, 2.98)) was similar to that for girls (2.38 (2.05, 2.72)). The mean number of streets crossed by Pacific Island children was 4.87 (4.01, 5.73), more than twice the number crossed by children of predominantly European origin (1.90 (1.65, 2.15)). Children from families without a car crossed an average of 5.34 (4.35, 6.34) streets, compared with 2.90 (2.50, 3.31) streets for children from families with one car, and 1.97 (1.65, 2.29) streets for children from families with two or more cars.

Conclusion – There are large differences in pedestrian exposure to risk in relation to ethnic group and levels of car ownership. These differences may explain ethnic and socioeconomic differentials in child pedestrian injury rates.

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The concept of "exposure to risk" is central to understanding the epidemiology of childhood traffic injuries.¹ The concept is straightforward. Children who are driven to school are exposed to the risk of vehicle occupant injury, but are not exposed to the risk of pedestrian injury on that particular journey. For child pedestrian injuries, an understanding of how pedestrian exposure to risk varies within and between populations may answer several of the most important aetiologic questions: why some population subgroups have higher injury rates than others, why injury rates vary between

countries and why injury rates change over time.¹ In New Zealand, nearly all child pedestrian injuries occur on public roads. Children are thus exposed to the risk of pedestrian injury predominantly while crossing roads. Within a population the amount of road crossing by children will vary. Some children make many road crossings each day while others make few or none. Like most population variate values, the number of roads crossed will cluster around a central value, with the probability of finding more extreme values decreasing towards the tails of the distribution. The mean number of roads crossed can be used to locate a population along an axis of pedestrian exposure to risk.

There are steep social class gradients in child pedestrian death rates. In Britain, the pedestrian death rate for children in social class V is almost five times that of children in social class I.² Strong socioeconomic gradients also exist for non-fatal child pedestrian injury.³ In New Zealand, pedestrian injury rates also vary considerably in relation to ethnic group. The rate for Maori and Pacific Island children is over twice that of children of European origin. These ethnic differences persisted, although somewhat attenuated, after controlling for neighbourhood environmental characteristics.³ The socioeconomic and ethnic differences may be due to differences in exposure to risk. A study of the travel patterns of British school-children found that poor children were considerably less likely to travel to school by car and were more likely to walk.⁴

Pedestrian exposure to risk may also explain international differences in death rates. In 1987 and in comparison with Sweden, the child pedestrian death rate in England and Wales was 2.3 times higher, in New Zealand was 2.1 times higher, and in the USA was 1.9 times higher.⁵ Although it has been suggested that Sweden's low injury rates are the result of the greater emphasis on environmental approaches to prevention, without internationally comparable data on pedestrian exposure to risk, it cannot be assumed that road crossing is safer in Sweden.

Answering these questions has implications for prevention. If socioeconomic, ethnic, and international differences in injury rates can be explained in terms of variations in pedestrian exposure to risk, then perhaps greater effort should be directed towards understanding and controlling the determinants of the population mean pedestrian exposure to risk. In this paper

we report the results of a study of child pedestrian exposure to risk that was conducted in Auckland, New Zealand. The study was conducted as part of "INSECT," (an international study of the exposure of children to traffic). INSECT involves data collection in a number of urban centres internationally, using the same methodology and survey instrument. In this study we use Auckland data to examine how pedestrian exposure to risk varies within a population according to indices of material deprivation and ethnic group.

Methods

Survey subjects were selected using a probability cluster design. The sampling frame for the primary sampling units (primary schools) was a list of all primary schools, including private and special schools, in the Auckland region of New Zealand. The Auckland region has a predominantly urban population of 936 981 of whom approximately 213 177 are under 15 years. Forty schools were randomly sampled from the list with a sampling probability in proportion to the number of children on the school roll. Two age groups were selected for study – 6 year olds and 9 year olds. All children in the relevant grade of the selected schools were invited to participate. The survey was conducted in November 1994.

Pedestrian exposure to risk was determined using a questionnaire that was distributed to children in the classroom, to be completed at home with their parents. The questionnaire included questions about each part of the day (before school, going to school, returning from school, and after school) to determine the number and type of streets crossed and whether the child was alone or accompanied. We asked about home and car ownership and about ethnic group. We asked that children complete the questionnaire with their parents in the evening, by systematically reviewing their road crossings for that day. Parents indicated their consent to participate by ticking the relevant box on the questionnaire. The questionnaire had been pilot tested in Seattle, USA and in Melbourne, Australia. Questionnaires were issued on a second occasion if the first was not returned. Response rates were calculated as the proportion of all first issue questionnaires that were completed and returned.

The SAS statistical software package was used to categorise and analyse the data. Because the cluster design can cause an underestimation of the standard error of the outcome variables if simple random sample methods are used, we adjusted the standard errors for design effects using the sample estimate of the intraclass correlation coefficient.⁶ The study was approved by the University of Auckland Human Subjects Ethics Committee.

Results

Of the 3385 questionnaires that were distributed, 2873 (85%) were completed and returned. Questionnaires were completed by the

parents of 1395 (49%) boys and 1478 (51%) girls. The study sample comprised 1534 (53%) 6 year olds and 1339 (47%) 9 year olds.

Table 1 gives details of the mode of travel to and from school on the day of the survey. For the journey to school at ages 6 and 9 years, most children travelled by car. Almost all of the remaining children walked to school, very few children cycled (0.6%) or used public transport (3%). Nine year olds were more likely to walk to school (43%) than were 6 year olds (38%). There was no substantial sex difference in the modes of travel used. The mode of travel was closely associated with car ownership. The proportion of children who walked to and from school increased as the number of family cars decreased. More children walked home from school than walked to school and more children walked home from school unaccompanied by an adult than walked to school. The mode of travel home from school was also closely related to car ownership.

Table 2 gives the mean number of streets crossed in relation to age, sex, ethnic group, and indices of material deprivation (car and home ownership). There were large differences in the number of streets crossed between ethnic groups and in relation to levels of car ownership. Pacific Island children crossed an average of 4.87 (4.01, 5.73) streets, over two and a half times the number of streets crossed by children of European origin 1.90 (1.65, 2.15). Children from families without a car crossed an average of 5.34 (4.35, 6.34) streets compared with 2.90 (2.50, 3.31) for children from families with one car and 1.97 (1.65, 2.29) for children from families with more than one car.

Table 3 gives the mean number of streets crossed in relation to the level of car ownership, for each ethnic group. The trend of decreasing pedestrian exposure to risk as the number of cars owned increased was evident in all ethnic groups. At each level of car ownership, the number of streets crossed by Pacific Island children was higher than that for Maori and European children.

Discussion

Pedestrian injury has emerged as the contemporary "disease" of childhood poverty. In Britain, socioeconomic gradients in pedestrian injury mortality are steeper than for any other child health problem. Death rates for children in the lowest class are almost five times those of children in social class one.² In New Zealand there are also strong associations between pedestrian injury risk and ethnic group. These may, however, primarily reflect socioeconomic disadvantage, since the ethnic groups with the highest injury rates are also the most disadvantaged. Understanding the reasons for the socioeconomic and ethnic differentials in injury rates has important implications for prevention. Two hypotheses have been proposed to account for them. The first is that poor children live in more dangerous urban traffic environments, with higher traffic volumes and speeds.⁷ However, a New Zealand case-control study found that the associations between pedestrian injury

Table 1 Details of journey to school by 2873 pupils aged 6 and 9 years in Auckland in relation to age, sex, and car ownership. Values are percentages

	Age		Sex		No of cars owned		
	6 y (n = 1534)	9 y (n = 1339)	Boys (n = 1395)	Girls (n = 1478)	0 (n = 140)	1 (n = 1045)	>= 2 (n = 1688)
<i>Journey to school</i>							
Walked	38.0	43.4	40.0	41.0	82.8	50.7	30.6
Car	59.3	52.7	56.3	56.2	16.4	47.0	65.3
Public transport	3.0	3.4	3.3	3.2	1.4	1.8	4.3
Bicycle	0.3	1.0	1.0	0.3	0.0	1.0	0.5
Accompanied by (walkers only):							
Alone	12.0	24.1	22.0	14.4	12.1	17.9	19.5
Child same age or younger	48.2	59.4	51.9	55.5	50.0	57.9	50.4
Older child	4.6	2.8	3.4	4.0	6.0	3.8	3.1
Adult	35.2	13.8	22.7	26.1	31.9	20.4	27.0
<i>Journey from school</i>							
Walked	46.9	57.5	51.0	52.7	86.4	61.2	43.2
Car	48.9	37.3	43.8	43.2	12.1	35.4	51.1
Public transport	3.8	4.2	4.2	3.9	1.4	2.3	5.3
Bicycle	0.3	1.0	1.1	0.2	0.0	1.1	0.4
Accompanied by (walkers only):							
Alone	12.9	20.4	18.1	15.6	8.3	17.7	17.5
Child same age or younger	57.1	67.4	63.2	61.7	57.9	62.5	63.0
Older child	1.8	1.8	1.5	2.1	5.0	1.6	1.5
Adult	28.2	10.4	17.2	20.7	28.9	18.3	18.0

and indices of material disadvantage and ethnic group persisted, albeit slightly attenuated, after controlling for traffic volume and speed.³ In this study, it was observed that the risk of injury for children from families without a car was twice that of children from families with a car. This observation suggested a second hypothesis: that poor children cross more roads than more affluent children and are thus exposed to greater risk. The present study aimed to test the latter hypothesis by examining the extent to which child pedestrian exposure to risk varies within a population according to indices of material disadvantage and ethnic group.

The results indicate that there are considerable differences in pedestrian exposure to risk according to car ownership and ethnic group. These differences are large enough to explain the observed ethnic and socioeconomic differentials in pedestrian injury risk. For car ownership, the ratio of the number of roads crossed by children from families without and with a car (2.3) is almost identical to the odds ratio associated with lack of access to a car that was observed in a case-control study in the same population (OR=2.1 95% confidence interval (95% CI) 1.36, 3.10). Because the case-control study included children aged 0–14 years and children who were injured at times other than schooldays, direct comparison of these data sets is not entirely appropriate.

Nevertheless the results support the contention that pedestrian exposure to risk underlies the association with car access. Moreover, the results show a “dose response relation,” with pedestrian exposure increasing as car ownership decreases. This observation underscores the unequal societal distribution of the health advantages and disadvantages of car travel. Children from families without a car receive none of the benefits of car travel but a greater share of the risks. An analogy might be drawn with secondary smoking. Cigarette consumption by smokers adversely effects the health of non-smokers. In the context of pedestrian injury, the volume of road traffic is one of the strongest risk factors for injury. Thus, car travel by more affluent families increases the injury risk for children from families without a car.

The results also indicate that ethnic differences in pedestrian exposure are not entirely attributable to differences in car ownership. Pacific Island children from families who do not own a car cross substantially more roads than do European children from families with no car. Pacific Island children are very much over-represented among the most disadvantaged groups in Auckland so that it is possible that there may be some residual confounding by factors related to socioeconomic deprivation. For example, European children in non-car owning families may have more access to car travel with friends and relatives than would Pacific Island children. Another possible explanation is that Pacific Island children may live further away from schools, because housing situated close to schools may be more expensive. Alternatively the greater pedestrian exposure of Pacific Island children may reflect cultural differences in parental expectations.

Very few children used public transport for the journey to and from school. Only 3% of the Auckland 9 year olds travelled to school by public transport. A British survey of the travel patterns of Newcastle school children found that 34% of 11 year olds travelled to school by public transport.⁴ The results are not directly comparable because of the difference in the

Table 2 Mean number of streets crossed and 95% confidence intervals

Variable	Local streets	Main streets	Total streets
Age:			
6 y	1.77 (1.52, 2.03)	0.42 (0.25, 0.58)	2.19 (1.82, 2.56)
9 y	2.30 (2.03, 2.58)	0.49 (0.34, 0.65)	2.80 (2.42, 3.17)
Sex:			
Male	2.08 (1.80, 2.36)	0.49 (0.31, 0.67)	2.57 (2.15, 2.98)
Female	1.97 (1.71, 2.22)	0.42 (0.27, 0.56)	2.38 (2.05, 2.72)
Ethnic group:			
Maori	2.61 (2.26, 2.95)	0.58 (0.39, 0.77)	3.19 (2.75, 3.63)
Pacific Island	3.66 (3.07, 4.24)	1.21 (0.81, 1.61)	4.87 (4.01, 5.73)
Other	1.62 (1.42, 1.81)	0.29 (0.18, 0.39)	1.90 (1.65, 2.15)
No of cars owned:			
0	3.73 (3.03, 4.43)	1.61 (1.08, 2.15)	5.34 (4.35, 6.34)
1	2.37 (2.07, 2.68)	0.53 (0.36, 0.70)	2.90 (2.50, 3.31)
>= 2	1.66 (1.43, 1.89)	0.31 (0.17, 0.45)	1.97 (1.65, 2.29)
Home owner:			
No	2.44 (2.08, 2.80)	0.84 (0.58, 1.09)	3.28 (2.74, 3.82)
Yes	1.90 (1.66, 2.15)	0.34 (0.21, 0.47)	2.25 (1.92, 2.57)

Table 3 Mean number of streets crossed (95% confidence interval) in relation to car ownership and ethnic group

Variable	Pacific Island	Maori	Other
No car	7.34 (5.35, 9.33)	4.10 (3.10, 5.09)	4.20 (3.17, 5.24)
One car	4.59 (3.27, 5.46)	3.42 (2.86, 3.98)	2.18 (1.86, 2.49)
Two cars (or more)	4.23 (2.78, 5.67)	2.69 (2.14, 3.24)	1.71 (1.47, 1.94)

age of the children surveyed. Nevertheless, greater use of public transport by children would have the potential to reduce exposure to risk by those children who would otherwise walk to and from school.

Some potential limitations of this study may have a bearing on the validity of the results. First, although the response rate was high (85%), it is possible that disadvantaged children with high pedestrian exposure would be over-represented among the non-responders, so that the estimates of pedestrian exposure may be underestimates. Nevertheless, this would not constitute a plausible explanation for the observed patterns of pedestrian exposure by ethnic group and car ownership. Second, pedestrian exposure was determined by self report so that the validity of the data are open to question. The validity of interview reported pedestrian activity was studied by Routledge who observed a child pedestrian’s activity one day and interviewed the same child the following day.⁸ Observers recorded all road crossings and road entries. The results revealed that pedestrian exposure was slightly under reported, 86% of the number of roads observed to be crossed were reported. However, under reporting in this situation is likely to be due to children forgetting road crossings and is likely to be similar for different groups of children. Moreover, in our study we attempted to minimise under reporting by asking children to complete the questionnaire with their parents in the evening, by systematically reviewing their road crossings for that day.

In summary, these results show that car ownership is a key determinant of child pedestrian

exposure to risk. Since car ownership is intimately related to socioeconomic circumstances, this observation provides the most compelling explanation for socioeconomic gradients in pedestrian injury rates. Because car travel contributes to traffic volume it increases the pedestrian injury risk for those without access to a car. In this way, child pedestrian injury might be viewed as a direct consequence of an unequal societal distribution of wealth. Indeed, it is interesting to speculate whether the extraordinarily low child pedestrian injury rate in Sweden is related to its more equitable distribution of income. These results have important implications for public health. They suggest that one approach to the prevention of childhood traffic injury is that of tackling socioeconomic inequality itself. The low use of public transport by children points to another preventive strategy. Strengthening the public provision of alternatives to car travel and encouraging the use of public transport by children might reduce traffic volume and at the same time reduce the exposure to risk of children who are denied the option of car travel. Finally, the wider implementation of traffic calming measures and the provision of safe cycle tracks would reduce the injury risk for children who walk or cycle to school. This strategy might also persuade car owning parents to allow their children to enjoy the health benefits of walking and cycling.

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