ORIGINAL ARTICLES

An international study of the exposure of children to traffic

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Abstract

***Objectives*—To examine the extent of international differences in children's exposure to traffic as pedestrians or bicyclists.**

***Design*—Children's travel patterns were surveyed using a parent-child administered questionnaire. Children were sampled via primary schools, using a probability cluster sampling design.**

***Setting*—Six cities in five countries: Melbourne and Perth (Australia), Montreal (Canada), Auckland (New Zealand), Umeå (Sweden), and Baltimore (USA).**

***Subjects*—Children aged 6 and 9 years.**

***Main outcome measures*—Modes of travel on the school-home journey, total daily time spent walking, and the average daily number of roads crossed.**

***Main findings*—Responses were obtained from the parents of 13 423 children. There are distinct patterns of children's travel in the six cities studied. Children's travel in the three Australasian cities, Melbourne, Perth and Auckland, is characterised by high car use, low levels of bicycling, and a steep decline in walking with increasing car ownership. In these cities, over a third of the children sampled spent less than five minutes walking per day. In Montreal, walking and public transport were the most common modes of travel. In Umeå, walking and bicycling predominated, with very low use of motorised transport. In comparison with children in the Australasian and North American cities, children in Umeå spend more time walking, with 87% of children walking for more than five minutes per day.**

***Conclusions*—There are large international differences in the extent to which children walk and cycle. These findings would suggest that differences in 'exposure to risk' may be an important contributor to international differences in pedestrian injury rates. There are also substantial differences in pedestrian exposure to risk by levels of car ownership—differences that may explain socioeconomic differentials in pedestrian injury rates.**

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The increase in the use of motorised transport during the second half of the twentieth century has had important implications for child health. In the heavily motorised countries, pedestrian-motor vehicle collisions are a leading cause of death in childhood, and an important cause of acquired disability.[1,2] In addition, the use of car travel for journeys that would previously have been made on foot has provoked concerns about declining levels of physical activity in childhood, and the effect this might have on health in later life.[3,4] A deeper understanding of both these issues requires information about travel patterns in childhood.

The concept of 'exposure to risk' is central to understanding the epidemiology of childhood traffic injuries. 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 injury, an understanding of how pedestrian exposure to risk varies between and within populations may answer some of the most important etiologic questions: why injury rates vary between countries and why some population subgroups have higher injury rates than others.

There are striking international differences in child pedestrian death rates. By comparison with Sweden in 1987, the mortality rate in New Zealand was 2.1 times higher, and in the USA 1.9 times higher.[5] The low death rate in Sweden has been the subject of considerable speculation. It has been suggested that it is the result of urban planning initiatives, taken in the early 1960s, that increased the safety of children as pedestrians.[6] An alternative explanation is that Swedish children walk less, in which case the low injury rate may represent a trade-off between injury risk and the benefits of physical activity. To examine the extent of international differences in child pedestrian exposure to risk, we surveyed the travel patterns of young school aged children in Australia, Canada, New Zealand, Sweden, and the USA.

Methods

Children from six cities in five countries were surveyed: Melbourne and Perth (Australia),

**Editors note:* readers will note that this paper includes several members of the editorial board among its authors. To avoid any conflict of interest, the entire reviewing process was handled by an associate editor — as they say in the judiciary, the editor recused himself from the process from start to finish.

Montreal (Canada), Auckland (New Zealand), Umeå (Sweden), and Baltimore (USA). Study cities were a convenience sample, chosen because they provided a broad geographical coverage and because people with the interest and expertise necessary to conduct the present study were located in them. Subjects were selected using a probability cluster design, except in Umeå, where all children in the desired age range were approached. For the two stage sampling, the sampling frames for the primary sampling units were lists of all primary schools in the sampled cities. Schools were selected with probability proportional to total enrolment in the age groups of interest. Two age groups were selected: 6 year olds and 9 years olds because pedestrian injury rates are highest between these ages. In Melbourne, a single class at each age level was randomly selected, while in the other centres all children in the relevant grades of the selected schools were invited to participate. To account for seasonal differences in children's travel patterns, all surveys were conducted in the spring: September to November 1994 for the southern hemisphere cities, and May to June 1995 for the northern hemisphere cities.

Children's travel patterns were determined using a questionnaire that was distributed in the classroom, to be completed at home with their parents. This questionnaire included questions about each part of the day (before school, going to school, returning from school, and after school) to determine the mode of travel used, the number and type of streets crossed on foot, and the total time spent walking. Identical questions were asked at each site. We also asked about home and car ownership as indicators of socioeconomic position. Children were asked to complete the questionnaire with their parents in the evening, by systematically reviewing their travel patterns for that day. Before the main survey, the questionnaire was pilot tested in Melbourne, Perth, Auckland, and Seattle. 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 statistical software package Stata (Stata Corporation, College Station, Texas) was used to analyse the data. To ensure that intraschool correlations were adequately controlled for, and to compensate for differences in response rates between schools, analyses were based on cluster specific means.[7] Total population means were estimated as the means of the cluster means. To account for the varying numbers in subcategories (age, sex, and other covariates of interest), mean values within population subcategories were estimated using the means of the mean values obtained within each school, weighted proportionately to the sample number and inverse proportionately to the cluster size.

Ethics committee approval was obtained at each site.

Results

A total of 13 423 completed questionnaires were returned. The number of children surveyed and the response rates for the individual sites are shown in table 1. There were large differences in travel patterns between the study cities. For example, for the journey to school (table 2), car travel was the predominant mode of travel in Melbourne (61%), Perth (62%), and Auckland (55%), while walking was the predominant mode of travel in Montreal (48%), Umeå (41%), and Baltimore (55%). The use of public transport ranged from 36% in Montreal to 1% in Perth. The proportion of children who bicycled to school ranged from 31% in Umeå to 0% in Baltimore. Apart from Baltimore, where there was no bicycling, there was an increase in bicycle use with age, and more boys than girls bicycled to school. In all six cities, there was a steep decline in the extent to which children walk to school with increasing car ownership.

Details of the mode of travel from school are shown in table 3. In every city, a smaller proportion of children were driven home from school than were driven to school, and there was a small increase in the proportion who walked. Car travel predominated in Melbourne and Perth, but more children walked than were driven in Auckland. Walking was the most common mode of travel from school in Montreal, Umeå, and Baltimore. Patterns of bicycling and public transport use were similar to that for the journey to school.

Table 4 gives the mean daily number of streets crossed on foot by age, sex, and car ownership. The mean number of streets crossed on foot ranged from 5.1 streets per day in Montreal to 2.3 in Perth. The number of streets crossed by boys was similar to that for girls, but there was an increase in street crossings with increasing age. The number of streets crossed was also strongly related to car ownership, with children from families without a car crossing the greatest number of streets.

The proportions of children who walk for less than five and less than 15 minutes per day are shown in table 5. In Perth, 52% of children spent less than five minutes walking and 76% spent less than 15 minutes. In contrast in Umeå, 13% of children walked for less than five minutes and 45% walked for less than 15 minutes. There was an increase in the proportions of children who walked for less than five and 15 minutes per day with increasing car ownership.

In Melbourne and Montreal, data were available on the response rate for each indivi-

Table 1 Numbers sampled and response rates

Site	Schools	Children	Response rate (%)
Melbourne	72	3198	82
Perth	48	2781	65
Auckland	40	2871	85
Montreal	43	2501	61
Baltimore	24	861	29
Umeå	43	1211	46

Table 2 Mode of travel to school (values are percentages using particular mode)

Site	Total	Boys 6 years	Boys 9 years	Girls 6 years	Girls 9 years	Car ownership No car	Car ownership One car	Car ownership Two cars
Melbourne								
Walked	35	35	36	30	38	81	42	27
Car	61	63	56	68	57	11	52	69
Public transport	2	1	2	1	3	6	2	1
Bicycle	3	1	6	1	3	2	4	3
Perth								
Walked	31	31	30	29	35	59	37	26
Car	62	66	57	69	58	20	55	68
Public transport	1	1	1	1	2	7	1	1
Bicycle	6	3	13	2	6	14	6	5
Auckland								
Walked	40	37	41	37	43	80	50	28
Car	55	58	52	56	52	16	45	65
Public transport	5	4	5	7	5	3	4	7
Bicycle	1	1	2	0	1	1	1	1
Montreal								
Walked	48	46	46	53	46	60	51	32
Car	14	16	14	14	14	2	13	27
Public transport	36	37	35	33	39	35	35	40
Bicycle	2	1	6	0	2	2	2	2
Baltimore								
Walked	55	47	62	53	61	88	48	39
Car	38	45	35	40	34	6	44	59
Public transport	6	8	3	8	5	6	8	3
Bicycle	0	0	0	0	0	0	0	0
Umeå								
Walked	41	35	46	40	43	67	44	30
Car	18	30	5	27	5	2	17	23
Public transport	10	11	10	10	10	4	5	24
Bicycle	31	24	39	23	41	27	35	24

Table 3 Mode of travel from school (values are percentages using particular mode)

Site	Total	Boys 6 years	Boys 9 years	Girls 6 years	Girls 9 years	Car ownership No car	Car ownership One car	Car ownership Two cars
Melbourne								
Walked	40	40	43	34	43	82	46	34
Car	55	58	49	63	52	9	47	62
Public transport	2	2	2	2	2	8	2	2
Bicycle	3	1	6	3	3	1	4	3
Perth								
Walked	33	32	33	31	38	59	40	29
Car	59	65	53	66	53	23	52	64
Public transport	2	1	2	2	3	7	2	2
Bicycle	6	3	12	2	6	11	6	5
Auckland								
Walked	49	44	53	46	55	84	60	40
Car	44	50	39	47	38	12	35	53
Public transport	6	5	6	6	6	3	4	7
Bicycle	1	1	2	0	0	2	1	1
Montreal								
Walked	50	47	50	54	48	62	53	34
Car	13	14	10	14	14	2	11	25
Public transport	36	38	35	32	37	35	34	39
Bicycle	2	1	5	0	2	1	2	2
Baltimore								
Walked	69	63	76	68	70	90	69	52
Car	25	30	21	24	25	3	24	44
Public transport	6	7	3	8	5	6	7	5
Bicycle	0	0	0	0	0	0	0	0
Umeå								
Walked	43	37	46	45	45	67	46	32
Car	15	26	4	22	4	4	12	22
Public transport	10	12	9	9	10	4	5	21
Bicycle	32	25	41	24	41	25	36	26

Table 4 Average (daily) number of streets crossed by foot

Site	Total	Boys 6 years	Boys 9 years	Girls 6 years	Girls 9 years	Car ownership No car	Car ownership One car	Car ownership Two cars
Melbourne	3.6	3.4	3.9	2.8	3.9	8.8	4.3	2.8
Perth	2.3	2.2	2.5	1.9	2.7	4.8	2.8	1.9
Auckland	2.5	2.4	2.8	2.1	2.9	5.3	3.0	2.0
Montreal	5.1	4.3	6.0	5.1	4.9	5.9	5.4	3.9
Baltimore	3.9	4.0	4.5	3.3	4.2	5.7	3.8	2.8
Umeå	4.1	3.7	5.0	3.3	4.5	4.5	4.3	3.7

Table 5 Percentages of children who spend less than five and less than 15 minutes walking per day (before school, to school, from school, and after school)

		Boys		Girls		Car ownership		
Site (time in mins)	*Total*	*6 years*	*9 years*	*6 years*	*9 years*	*No car*	*One car*	*Two cars*
Melbourne								
<5	44	45	41	50	40	11	39	49
<15	72	74	68	78	70	34	67	77
Perth								
<5	52	54	49	57	48	44	46	56
<15	76	76	75	79	75	58	71	80
Auckland								
<5	40	45	36	43	35	15	31	48
<15	69	71	64	74	65	39	62	76
Montreal								
<5	30	35	24	29	31	18	27	44
<15	66	67	60	68	70	58	64	77
Baltimore								
<5	31	37	24	33	27	9	29	50
<15	62	62	66	66	55	32	67	78
Umeå								
<5	13	17	9	17	7	6	10	21
<15	45	47	45	45	43	44	42	52

Table 6 Proportions walking to school and total streets crossed on foot by tertiles of school based response rate

Response tertile	*Schools*	*% Walk to school (95% CI)*	*Total streets crossed (95% CI)*
Melbourne			
<78%	24	37 (31 to 43)	4.1 (3.1 to 5.1)
78–90%	24	33 (25 to 40)	3.2 (2.8 to 3.6)
>90%	24	34 (28 to 40)	3.5 (2.9 to 4.0)
Montreal			
<51%	14	46 (28 to 63)	5.4 (4.1 to 6.8)
<51–69%	15	46 (30 to 63)	4.8 (3.9 to 5.6)
>69%	14	51 (34 to 69)	5.2 (4.4 to 6.0)

CI=confidence interval.

dual school. Table 6 shows the proportions of children who walk to school and total streets crossed by response rate tertiles. In both cities, there was no clear relationship between pedestrian activity and response rate.

Discussion

Distinct patterns of children's travel can be discerned in the six cities studied. These findings suggest that differences in 'exposure to risk' are likely to be an important contributor to international differences in injury rates. There are also substantial differences in pedestrian exposure to risk by levels of car ownership. These differences may explain socioeconomic differentials in pedestrian injury rates. However, the extent to which children's travel patterns in the chosen cities represent national travel patterns is open to question. For example, the travel patterns observed in Umeå might not be representative of Sweden more generally. On the other hand, the remarkable similarity in the travel patterns of the two Australian cities does suggest some degree of national homogeneity. Nevertheless, in the light of these considerations, our inferences about the reasons underlying international differences in injury rates are speculative, and are best viewed as pointers for further research.

One of the principal aims of this study was to provide an insight into the very low child pedestrian injury rates in Sweden. It was hypothesised that fewer Swedish children walk to school, so that the low injury rates may have been achieved at the expense of activity levels. This hypothesis was not supported by our data. The proportion of children who walk to and from school in Umeå was similar to that in Auckland. Moreover, children in Umeå cross nearly twice as many streets. Although the degree to which children are accompanied may have an important bearing on the injury risk per unit of exposure, these results do not support the view that Sweden's low injury rates is because fewer children walk to or from school.

In all of the cities surveyed, children in families without a car were substantially more likely to walk to and from school and crossed a greater number of streets, than children in car owning families. In Melbourne, children in families without a car crossed three times more streets than did children in two car families. These gradients are likely to contribute to the steep social class gradients in child pedestrian death rates.[8]

Some methodological limitations may have a bearing on the results. Most important is the potential for bias due to non-response. Response rates in Auckland, Melbourne, Perth and Montreal were reasonably high, but those in Umeå and Baltimore were low. If the travel patterns of non-respondents were substantially different to those of respondents, then non-response may have biased the estimates. Although the effect of non-response is a matter for judgment, it may be appropriate to speculate as to the likely direction of any bias. At each site, including Umeå, children from families without a car were more likely to walk than children in car owning families. If if can be assumed that socioeconomically disadvantaged families are over-represented among non-responders, then the effect of non-response would be to underestimate the amount of walking in Umeå. In this case, non-response bias, if present, would not affect our interpretation of the results.

Alternatively, the impact of non-response can be judged by considering a worst case scenario. In Umeå, 41% of 9 years old bicycled from school. If it is assumed that none of the non-respondent 9 year olds in Umeå bicycled, then the prevalence of bicycling would be 18%, still substantially greater than the other cities. Finally, our analyses of the proportions walking to school and the total streets crossed by tertiles of school based response rates did not show any clear relationship between pedestrian activity and response rates.

Because travel patterns were determined by self report, the validity of these data is open to question. The validity of interview reported pedestrian activity was studied by Routledge *et al* who observed a child's pedestrian activity one day and interviewed the same child the following day.[9] The results showed that pedestrian exposure to risk was slightly under-reported—86% of the number of roads observed to be crossed were reported. Similar results were obtained in a validation study in Perth.[10] Under-reporting of pedestrian activity is probably due to children forgetting road crossings. In our study, we attempted to minimise under-reporting by asking children to complete the questionnaire with their parents in the evening after systemically reviewing their road crossings for that day.

Through its effect on travel patterns, the urban transport infrastructure may influence both injury risk and levels of physical activity. World wide, traffic volume is predicted to increase well into the next century.[11] This study provides a baseline against which future changes in childhood travel patterns can be judged. In cities everywhere, differential exposure to traffic is a major contributor to socioeconomic gradients in childhood mortality.

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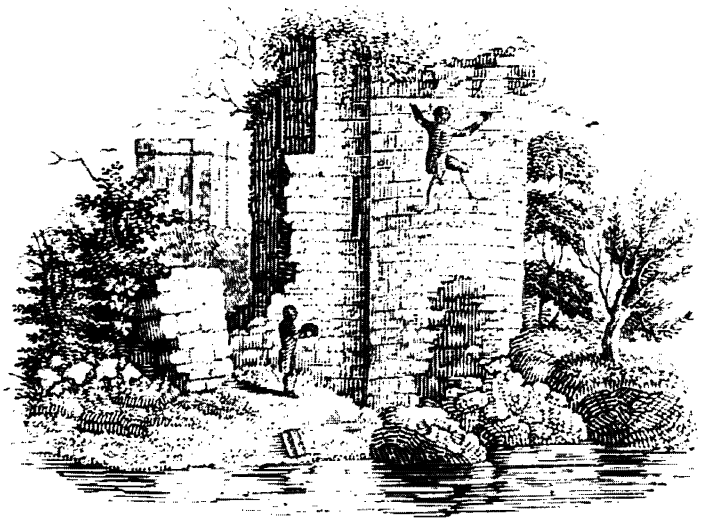

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