

# Active and safe transportation of elementary-school students: comparative analysis of the risks of injury associated with children travelling by car, walking and cycling between home and school

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## Abstract

**Introduction:** Elementary school active transportation programs aim to address physical inactivity in children by prompting a modal shift from travel by car to walking or cycling among children living a distance from school conducive to walking or cycling. The objectives of this study are to evaluate the risk of injury related to walking, cycling and travelling by car between home and school among elementary-school students in the Montréal area and to evaluate the impact on number of injuries of a modal shift from travel by car to walking or cycling.

**Methods:** The risk of injury was estimated for the 2003–2007 period by calculating the average annual rate of injury in children aged 5 to 12 years walking, cycling or being driven in a car, per 100 million kms travelled during the normal hours of travel between home and school. The impact of a modal shift from travel by car was evaluated for children living a distance from school conducive to walking and cycling (under 1.6 km), that is, the targets of active transportation programs. This evaluation was done using the regional rate of injury calculated for each travel mode.

**Results:** Between 2003 and 2007, an average of 168 children aged 5 to 12 years were injured each year while walking ( $n = 64$ ), cycling ( $n = 28$ ) and being driven in a car ( $n = 76$ ) during the normal hours of travel between home and school in the Montréal area. The rate of injury was 69 children injured per 100 million kms for travel by car (reference group), 314 pedestrians (relative risk [RR] = 4.6; 95% confidence interval [CI]: 4.3–5.1) and 1519 cyclists (RR = 22.2; 95% CI: 14.3–30.0). A shift of 20% in the distance travelled by car to walking by children living less than 1.6 km from their school is estimated to result in an increase of 2.2% ( $n = 3.7$ ) in the number of children injured each year in the area. In the case of a shift to cycling, the number of resulting injuries is estimated to be 24.4, an increase of 14.5%.

**Conclusion:** The risk of injury among elementary-school students during the normal hours of travel between home and school is higher for walking and cycling than for travel by car, and cyclists are at greater risk of injury than pedestrians. A modal shift from travel by car would increase the number of children injured in the area (minor injuries, for the most part) if no action were taken to reduce the risk of injury to pedestrians and cyclists.

**Keywords:** *active transportation, elementary school, injury, pedestrians, cyclists, travel, trips, risks*

## Introduction

Over the past few years, many industrialized countries have initiated programs to promote active transportation among school-age children, one of the best known being the Safe Routes to School<sup>1</sup> program. In Quebec, promotion of active transportation among elementary-school students mainly takes the form of implementing the Mon école à pied, à vélo<sup>2</sup> program. Overall, the main objective of these programs is to reduce physical inactivity, as well as the associated health problems, among children by prompting a shift from travelling to school by car to walking or cycling. This type of program usually leads to a shift of 20% or less away from travel by car in the targeted clientele.<sup>3</sup>

Road safety is an important aspect of the programs that promote active transportation among elementary-school students. Children of this age do not always have the cognitive and psychomotor skills required to walk or cycle safely.<sup>4</sup> Also, unsafe roads are one of the main reasons parents give for preferring that their children be driven to and from school.<sup>5–7</sup>

A study in the United States showed that children aged 5 to 13 years who walk or cycle to school are at greater risk of injury than those who are driven by car.<sup>8</sup> A study conducted in New Zealand revealed the same trends.<sup>9</sup> The results of these studies suggest that a modal shift as a result of programs to promote active transportation could lead to an increase in the number of child pedestrians or cyclists injured, but

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such an effect has not been scientifically documented.

The objective of this study is to evaluate the risk of injury related to walking, cycling and travelling by car between home and school for elementary-school students in the Montréal area, as well as to evaluate the impact on the number of children injured of a modal shift from travel by car to walking or cycling between home and school in this area. The Montréal area is of special interest for this type of evaluation because active transportation can be easily promoted in this urban setting, as about half of the elementary-school age children in Quebec live here. In addition, Montréal is one of the areas for which data on travel by children between home and school are available.

## Methods

The study population comprises children aged 5 to 12 years living in the area covered by the 2003 Montréal-area Origin-Destination Survey, the most recent survey of this type and in this area at the time of our study. The Montréal area covers 5500 km<sup>2</sup> and 88 municipalities, including Montréal, Longueuil and Laval. In 2003, 52.3% of all Quebec children aged 5 to 12 years lived in this area.<sup>10</sup>

### *Risk of injury*

Risk of injury was estimated for the 2003–2007 period by calculating the average annual rate of injury among children aged 5 to 12 years who were pedestrians, cyclists or occupants of a car, per 100 million kms travelled during the normal hours of travel between home and school while school was in session. Here, the term “car” is used to denote the motor vehicle normally used by caregivers to transport children between home and school. This term includes cars, pickup trucks and sport utility vehicles. Excluded are buses, heavy trucks, commercial vehicles and all-terrain vehicles.

### *Data sources*

We obtained data on the number of injured (the numerator of the rate) from Road Vehicle Accident Reports completed

and filed by police officers.<sup>11</sup> This file includes data on all Quebec pedestrians, cyclists or occupants of a motor vehicle injured in a collision involving a motor vehicle travelling on a public roadway. The victims are classified according to the severity of their injuries (i.e. fatal, serious or minor) on the basis of the data recorded by the police officers. The data on kilometres travelled by type of travel (denominator of the rate) are from the Origin-Destination Survey in the Montréal area in 2003.<sup>12</sup> That survey, carried out from 2 September, 2003, to 20 December, 2003, was of a representative sample of households in any of the 88 municipalities in the area covered by the survey. The households were randomly sampled from all the geographical strata in this area (and not one municipality after another) for the entire duration of the survey, to ensure good distribution, by survey period and according to their composition (household with a child or not). The data were gathered on a weekday, except Monday, by means of a telephone interview of an adult member of the sampled household. The interviewee was questioned about all the travel done by each member of their household in the day before the interview. The data gathered described, among other things, the mode of transportation used (e.g. walking, bicycle or motor vehicle) and the distance travelled each trip (as the crow flies, i.e. the length of a straight line drawn between the point of departure and the point of arrival).

### *Numerator of the rate of injury*

We determined the number of accident victims (pedestrians, cyclists or car occupants, aged 5 to 12 years, injured while travelling between home and school while school was in session) in the area covered by the survey through the municipal code of the place where the injury-causing accident occurred. This information is included in each Road Vehicle Accident Report. The normal hours of travel by children between home and school were defined as 7:00 a.m. to 8:59 a.m., 11:00 a.m. to 12:59 a.m., and 3:00 p.m. to 4:29 p.m. The third time slot ends at 4:29 p.m., rather than 6:00 p.m., to exclude those children injured after their return home, while playing on the street, for example. School

was considered to have been in session for 200 days a year; this excludes the period of summer vacation (June 24 to August 31), the festive season (December 24 to January 2), all Saturdays and Sundays, and local statutory holidays (Good Friday, Easter Monday, Labour Day, Thanksgiving and Patriots’ Day). Children injured as occupants of a car were identified using the category “injured in a car or pickup truck” in the Road Vehicle Accident Report; this category includes cars, light trucks and sport utility vehicles.

### *Denominator of the rate of injury*

We determined the number of kilometres travelled by estimating the total number of kilometres travelled in one year by all children 5 to 12 years old in the area selected for the survey, during the normal hours of travel between home and school while school was in session. This estimate was obtained by calculating the number of kilometres travelled in a day on foot, on a bicycle or in a car by the children aged 5 to 12 who participated in the survey (the sample), during the normal hours of travel between home and school while school was in session. Travel by car was identified using the category “passenger cars”; this category includes cars, pickup trucks and sport utility vehicles (as for the numerator). In some cases, the distance travelled in one trip was an extreme value (i.e. unusually big value). To minimize the impact of these extreme values on the total number of kilometres travelled, travel on foot for more than 4 km was adjusted down to 4 km, travel by bicycle for more than 8 km was adjusted down to 8 km and travel by car for more than 50 km was adjusted down to 50 km. A total of 13 extreme values were adjusted for travel on foot, 14 for travel by bicycle and 22 for travel by car, accounting for 0.15%, 4.3% and 0.26%, respectively, of all travel on foot, by bicycle and by car. Then, because Origin-Destination Surveys provide data on travel that takes place in a single day of the week, the data on kilometres travelled calculated for the sample were multiplied by 200 to obtain values for a 200-day period (as for the numerator). Finally, a survey weight was applied in order to infer the total number of kilometres travelled, estimated through the sample,

to the entire population of children 5 to 12 years old living in the area of the survey.

### **Relative risk**

We calculated the relative risk (RR) of injury during the normal hours of travel between home and school by comparing the rate of injury when travelling on foot and by bicycle to the rate of injury for occupants of a car. The calculation of the standard errors of the estimates for the number of kilometres travelled takes into account weighting as well as the design effects due to the complex sampling in Origin–Destination Surveys. For example, trips by children aged 5 to 12 years from the same household or the same neighbourhood cannot be considered independent and form observation clusters. Using specialized software (SUDAAN)<sup>13</sup> and specifying the parameters of the sample design, it was possible to correct the standard errors of the population estimates and, consequently, the rate ratios. The confidence intervals can thus be determined with a significance level of 95% both for injury rates and for relative risk.

### **Impact of modal shift**

We evaluated the impact of a modal shift from travel by car to travel on foot or by bicycle on the number of children injured during the normal hours of travel between home and school on the basis of the injury rate related to each travel mode. We considered only children travelling by car between home and school who lived less than 1.6 km from school (reasonable walking and cycling distance), that is, the target clientele of the programs that promote active transportation among elementary-school children. In 2003, the number of Montréal-area children aged 5 to 12 years who met these two conditions was estimated at 68 900, and this accounted for 57.5% of all children travelling by car between home and school in this area. In 2003, these 68 900 children travelled 8 815 400 km by car to and from school. The impact of a modal shift from travel by car on the number of children injured was evaluated by assuming that 10%, 20%, 30%, 40% and 50% of the kilometres travelled by these children would be

travelled on foot or by bicycle, rather than in a car. We evaluated the impact by comparing the number of children likely to be injured as pedestrians, cyclists or occupants of a car while travelling the number of kilometres associated with each of these 5 shift scenarios (a 10% shift corresponded to 881 540 kms). The potential number of children injured as pedestrians, cyclists or occupants of a car was estimated using the corresponding injury rates between 2003 and 2007. For this estimate, we assumed that the modal shift from travel by car would be entirely either to travel on foot or to travel by bicycle. The observed gap for a given shift scenario between the number of children injured as pedestrians and as occupants of a car was expressed as the number of additional injured children and as a percentage of the average number of children injured during the normal hours of travel between home and school annually. The same procedure was followed for the scenarios involving a shift from travel by car to travel by bicycle.

## **Results**

### **Number of children injured**

Between 2003 and 2007, a total of 957 children aged 5 to 12 years were injured while walking, cycling or being driven in a motor vehicle (including car but also heavy trucks and other types of road vehicles) in the Montréal area, equivalent to 46.8% (957/2044) of all cases in Quebec (Figure 1). Of these 957 children, 178 (18.6%) were injured during the normal hours of travel between home and school while school was in session; those injured included 64 pedestrians, 28 cyclists and 76 occupants of cars, pickup trucks and sport utility vehicles. In most cases, the injuries were minor (89.1% of the pedestrians, 97.1% of the cyclists and 97.6% of the occupants of a car – data not shown).

### **Modal shares and kilometres travelled**

In 2003, a total of 12 799 children aged 5 to 12 years participated in the Origin–Destination Survey in the Montréal area (Table 1). These children (the sample) made 22 819 trips between home and

school on an ordinary weekday, including 29.6% in a car, 32.5% on foot and 1.4% by bicycle. (The remaining travel was mainly by school bus.) Almost all (98.1%) of the travel on foot and 86.1% of the travel by bicycle involved distances shorter than 1.6 kms to school, compared with 57.5% of the travel by car. After taking weighting into account, we estimated about 332 700 children aged 5 to 12 years travelled between home and school in the Montréal area in 2003 (the population). Overall, these children were associated with 588 800 trips, including 29.2% by car, 33.8% on foot and 1.3% by bicycle.

Table 2 shows the data for the sample by survey month: 53.9% of travel by any mode (94.2% by bicycle) was done in September and October, and 46.1% (5.8% by bicycle) in November and December. Table 3 shows the distances travelled in a year for each travel mode by the population (column: distance travelled).

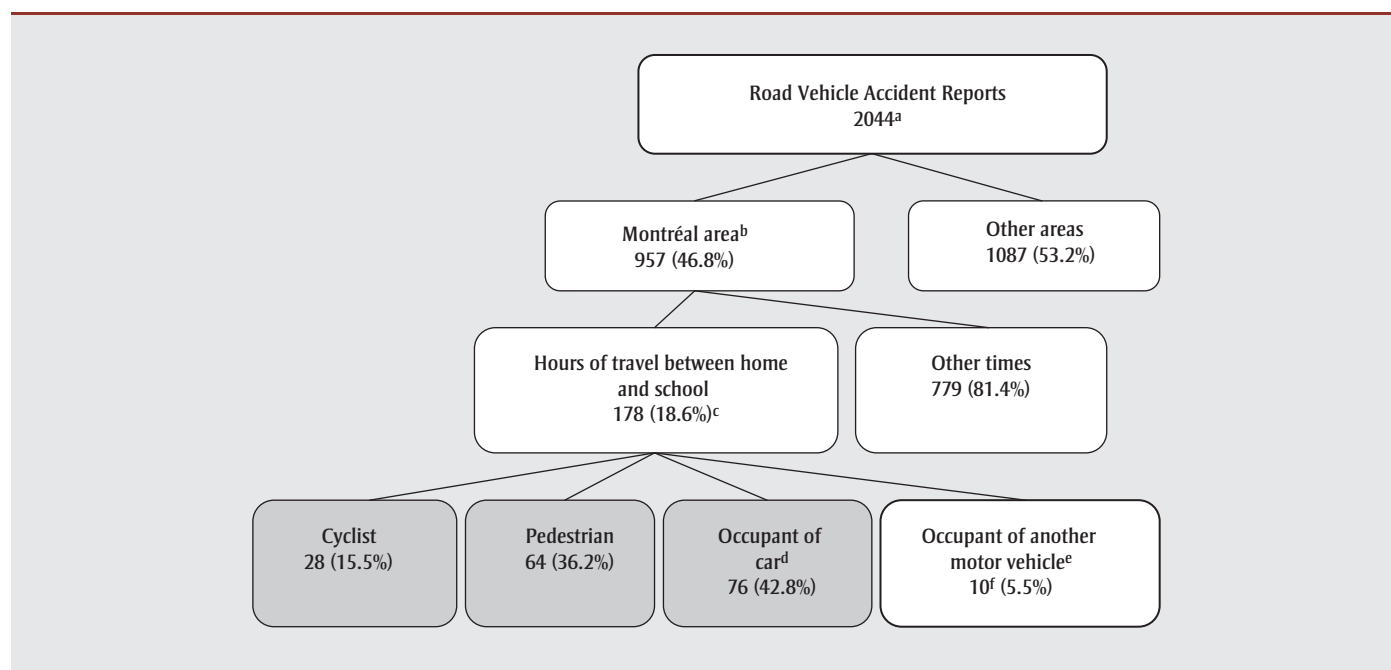
### **Risk of injury**

Between 2003 and 2007, the average annual rate of injury among children aged 5 to 12 years old during the normal hours of travel between home and school in the Montréal area was 69 injured children per 100 million kms travelled by car (including pickup trucks and sport utility vehicles), compared with 314 for travel on foot and 1519 for travel by bicycle (Table 3). During this period, the relative risk of injury was higher for travel on foot (RR = 4.6; 95% CI: 4.3–5.1) and by bicycle (RR = 22.2; 95% CI: 14.3–30.0) than for travel by car (reference group). The risk of injury related to travel by bicycle was significantly higher than that related to travel on foot. Similar trends were observed for children aged 5 to 8 years as for those aged 9 to 12 years.

### **Impact of a modal shift**

A modal shift of 10% in the ratio of kilometres travelled by car to those travelled on foot among children living less than 1.6 km from school led to 1.8 more injured children a year in the Montréal area, an increase of 1.1% (1.8/168.2) in the average annual number of

**FIGURE 1**  
Process of identification of children aged 5–12 years injured during the normal hours of travel between home and school (average annual number),  
Montréal area, 2003–2007



<sup>a</sup> Average annual number of children aged 5–12 years injured as pedestrians, cyclists or occupants of a motor vehicle as a result of a collision involving a road vehicle on a public roadway, Quebec, 2003–2007.

<sup>b</sup> Area covered by the 2003 Origin–Destination Survey on the basis of the municipal code.

<sup>c</sup> Distribution of the injured children in the Montréal area during the normal hours of travel between home and school (7 a.m. to 8:59 a.m., 11:00 a.m. to 12:59 p.m., and 3 p.m. to 4:29 p.m.) while school was in session (200 days).

<sup>d</sup> Children injured as an occupant of a car, minivan, pickup truck or sport utility vehicle.

<sup>e</sup> Children injured as an occupant of another type of motor vehicle (school bus, heavy truck, etc.).

<sup>f</sup> Of these 10 injured children, 6 were injured as occupants of a school bus.

**TABLE 1**  
Characteristics of the sample<sup>a</sup> and the population studied by travel mode

Travel mode	Sample <sup>a</sup>				Estimated population <sup>b</sup>		
	Sample, n	Trips			Number, <sup>c</sup> n	Trips <sup>d</sup>	
		n	%	< 1.6 km <sup>e</sup> , %		n	%
Car <sup>f</sup>	4661	6752	29.6	57.5	119 700	172 000	29.2
Walking	3867	7413	32.5	98.1	104 900	199 000	33.8
Cycling	156	325	1.4	86.1	3700	7500	1.3
Other (school bus)	5176 (4637)	8329 (7114)	36.5 (31.2)	40.8 (42.3)	131 400 (113 400)	210 000 (184 500)	35.7 (31.3)
Total <sup>g</sup>	12 799	22 819	100.0	65.6	332 700	588 800	100.0

Source: Montréal-area 2003 Origin–Destination Survey.<sup>12</sup>

<sup>a</sup> Children aged 5–12 years who participated in the Origin–Destination Survey and travel by these participants in one day between home and school.

<sup>b</sup> Number of elementary-school students aged 5–12 years in the Montréal area and travel by these students in one day between home and school.

<sup>c</sup> After weighting for population.

<sup>d</sup> After weighting for travel.

<sup>e</sup> Trips shorter than 1.6 km between home and school.

<sup>f</sup> The type of motor vehicle normally used by caregivers to transport children between home and school, i.e. cars, pickup trucks and sport utility vehicles and not buses, heavy trucks, commercial vehicles and all-terrain vehicles.

<sup>g</sup> The totals for the number of children do not correspond to the sum of the number of children on the basis of travel mode because a given child may use more than one travel mode a day.

**TABLE 2**  
Distribution of the sample<sup>a</sup> by survey month, all travel modes and cycling, Montréal area, 2003

Survey month	Sample <sup>a</sup>		Trips <sup>b</sup>			
	All modes		All modes		Cycling	
	n	%	n	%	n	%
September	2727	21.3	5017	22.0	155	47.7
October	4087	31.9	7277	31.9	151	46.5
November	3332	26.0	5975	26.2	17	5.2
December	2653	20.7	4550	19.9	2	0.6
Total	12 799	100.0	22 819	100.0	325	100.0

Source: Montréal area 2003 Origin–Destination Survey.<sup>12</sup>

<sup>a</sup> Children aged 5–12 years who participated in the Origin–Destination Survey.

<sup>b</sup> Travel by 5–12 year-old participants in the Origin–Destination Survey in one day between home and school.

children injured in this area during travel between home and school on foot, by bicycle and by car in 2003–2007 (Table 4). This increase was 2.2%, 3.3%, 4.3% and 5.5%, respectively, for shifts of 20%, 30%, 40% and 50% (Figure 2). With a shift of 10% in the kilometres travelled by car to those travelled by bicycle, 12.2 more children were injured a year, an increase of 7.3% (12.2/168.2) in the average annual number of children injured in the Montréal area during the normal hours of travel between home and school for 2003–2007. This increase was 14.5%, 21.7%, 29.0% and 36.2%, respectively, for shifts of 20%, 30%, 40% and 50% (Figure 2).

## Discussion

Between 2003 and 2007, an average of 168 children aged 5 to 12 years

were injured each year while walking (n = 64), cycling (n = 28) and being driven in a car (n = 76) during the normal hours of travel between home and school in the Montréal area. This represents nearly one injured child per school day. In more than 90% of the cases, the injuries were minor.

The average annual rate of injury per 100 million kms travelled was 69 children in the case of occupants of a car, 314 in the case of pedestrians and 1519 in the case of cyclists. These results suggest that children travelling on foot (RR = 4.6) or by bicycle (RR = 22.2) are at greater risk of injury than those travelling by car (reference group), and that the risk of injury associated with travel by bicycle is greater than that associated with travel on foot. The same trends were observed for both age groups studied. The results of addi-

tional analyses of the Québec and Trois-Rivières areas show the same trends (data available on request). A United States study in 1991–1999 found similar trends,<sup>8</sup> with the relative risk (calculated based on the rates for children injured per 100 million kms travelled) of injury associated with travel by car for children aged 5 to 10 years 9.4 times higher for travel on foot and 34 times higher for travel by bicycle. The same trends were observed in a 2003–2005 New Zealand study;<sup>9</sup> the relative risk of injury among children aged 5 to 17 years was 2.2 times higher for travel on foot and 14.6 times higher for travel by bicycle than for travel by car (RRs calculated based on the rates of children injured per million hours of travel). To our knowledge, these two studies are the only ones that have evaluated the risk of injury associated with travel by elementary-school children between home and school while school was in session, with control for exposure (kilometres travelled or hours of travel).

The impact of a modal shift in the ratio of kilometres travelled by car to those travelled on foot or by bicycle on the number of children injured was evaluated for 5 scenarios involving shifts ranging from 10% to 50%. A shift of 20% from travel by car to travel on foot for children living less than 1.6 km from school led to 3.7 more injured children a year, an increase of 2.2% in the average annual number of children injured in this area during the normal hours of travel between home and school. Where the 20% shift

**TABLE 3**  
Estimated risk of injury for children aged 5–12 years travelling between home and school, by age and travel mode, Montréal area, 2003–2007

Age, years	Travel modes	Average annual number of children injured, n	Distance travelled, 1000, km	Rates per 100 million, km	95% CI	RR	95% CI
5–8	Car	36.8	56 705	65	(60–71)	1 (ref.)	—
	Walking	24.0	6 607	321	(298–347)	4.9	(4.7–5.9)
	Cycling	6.6	294	2244	(1451–4957)	34.6	(15.4–53.8)
9–12	Car	39.4	54 409	72	(67–79)	1 (ref.)	—
	Walking	40.4	12 028	311	(294–330)	4.3	(3.8–4.7)
	Cycling	21.0	1 523	1379	(991–2266)	19.0	(11.4–26.7)
5–12	Car	76.2	111 114	69	(64–73)	1 (ref.)	—
	Walking	64.4	18 634	314	(300–330)	4.6	(4.3–5.1)
	Cycling	27.6	1 817	1519	(1129–2319)	22.2	(14.3–30.0)

Abbreviations: CI, confidence interval; ref., reference; RR, relative risk.

**TABLE 4**  
Effect of 5 scenarios for shifts in distance travelled between home and school by car to walking or cycling on the average annual number of children aged 5–12 years injured, Montréal area, 2003–2007

Scenarios for shift in kilometres travelled <sup>a</sup>		Estimated average annual number of children injured related to each shift scenario, by travel mode <sup>b</sup>			Effect of shift on average annual number of children injured in the area <sup>c</sup>			
Proportion of shift	Number of km	Car	Walking	Cycling	Car to walking		Car to cycling	
					Number	(%)	Number	(%)
10%	881 540	0.60	2.44	12.79	+ 1.8	(+ 1.1)	+ 12.2	(+ 7.3)
20%	1 763 080	1.21	4.88	25.57	+ 3.7	(+ 2.2)	+ 24.4	(+ 14.5)
30%	2 644 620	1.81	7.33	38.36	+ 5.5	(+ 3.3)	+ 36.5	(+ 21.7)
40%	3 526 160	2.42	9.77	51.14	+ 7.3	(+ 4.3)	+ 48.7	(+ 29.0)
50%	4 407 700	3.03	12.21	63.93	+ 9.2	(+ 5.5)	+ 60.9	(+ 36.2)

<sup>a</sup> The shift scenarios for kilometres travelled are for children living less than 1.6 km from school.

<sup>b</sup> The estimates of the average annual number of children injured were arrived at by using the regional injury rate per 100 million kms travelled for travel by car (69), walking (314) and cycling (1519). See Table 3.

<sup>c</sup> The effect of the modal shift is calculated for all children injured in the Montréal area.

was to travel by bicycle, 24.4 more children were injured, an increase of 14.5%. To our knowledge, this type of evaluation has not been previously examined, so we cannot compare results.

### Strengths and limitations of the study

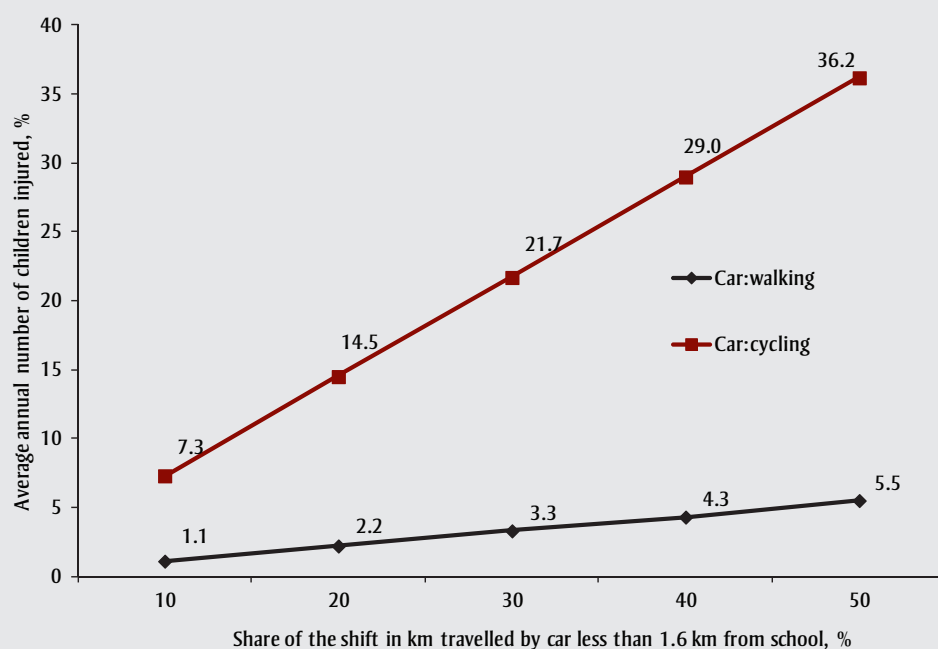
These analyses took into consideration all children aged 5 to 12 years included in the Road Vehicle Accident Reports completed

in 2003 to 2007 (numerator) and all those who participated in the 2003 Montréal-area Origin–Destination Survey (denominator). The rate of injury was evaluated by controlling for the number of kilometres travelled, allowing for comparison of the number of children injured as pedestrians, cyclists or occupants of a car for a given distance travelled. The total number of kilometres travelled during the normal hours of travel between home and school

while school was in session was estimated by multiplying the distance travelled in one day by the number of school days (200). The time of data collection during the year is likely to influence the mode of travel chosen. In that regard, we know that the survey looked at half the children in September and October and half in November and December. We can assume that the interviews conducted in September and October provide informa-

**FIGURE 2**

Effect of 5 scenarios for shifts in distance travelled by car by children living less than 1.6 km from school to travel by walking or cycling on the average number of children aged 5–12 years injured during the normal hours of travel between home and school (as %), Montréal area, 2003–2007



tion on children's exposure during the months of the school year when the weather is milder and therefore more conducive to walking and cycling (September, October, April, May and June), while interviews in November and December provide information on children's exposure during the months when the outdoors temperatures are less comfortable for walking and cycling (November, December, January, February and March). The distribution of the travel by survey month reflects this: most of the travel by bicycle was in September and October, with only a few such trips in November and December. Note that although this estimate of kilometres travelled is during the survey year (2003), we assumed it to be a good indicator of the children's exposure for the entire period studied (2003 to 2007) because it would be unlikely that the modal share for travel on foot, by bicycle and by car changed significantly from year to year during this period. The fact that the kilometres travelled are based on the distance as the crow flies (length of a straight line drawn between the home and the school) is a limitation of this study: this distance would generally be shorter than that actually travelled. Another limitation of the study is that the Road Vehicle Accident Reports are not exhaustive for injuries caused in a collision with a motor vehicle and do not include injuries that do not involve a motor vehicle.<sup>14-17</sup>

The impact of a modal shift from travel by car to active transportation (walking and cycling) on the number of children injured was evaluated for children living less than 1.6 km from their school. This evaluation was done using the regional (Montréal area) rates of injury because the data available in the Road Vehicle Accident Reports do not allow for distributing the numerator (number of injured children) on the basis of the actual distance to the school. That is, it is impossible to calculate the specific rate of injury of children living less than 1.6 km from a given school. For this reason, we assumed that the rate of injury at the regional level is similar to the rate of injury of children living less than 1.6 km from their school. This assumption is fairly plausible for pedestrians and cyclists: 98.1% of the travel on foot and 86.1% of the travel by bicycle in the

Montréal area is done for distances less than 1.6 km from the school. However, it is more difficult to assume this to be the case for children travelling by car because the share of the travel done within this perimeter is smaller (57.5%). In addition, the regional rate (which is, in fact, an average rate) can be used to evaluate the impact of a modal shift only on the regional level (average impact), but the impact may vary from one neighbourhood to another owing to variation in the risk of injury (spatial variation). Finally, note that the impact of a modal shift was evaluated without taking into account the fact that the risk of injury for pedestrians and cyclists could decrease due to the reduction in the number of vehicles on the roads as a result of the transfer. However, the analysis of the available data suggests that this impact would be marginal: a 20% shift from travel by motor vehicle for children living less than 1.6 km from school would be associated with a reduction of 13 780 motor vehicles (20% × 68 900 children), only a very small percentage of the total number of motor vehicles in the area.

## Conclusion

Few studies have evaluated the risk of injury for elementary-school students travelling between home and school, and this study is the first of its kind in Quebec. In addition, to the best of our knowledge, this is the first time that a study has evaluated the impact of a modal shift from travel by car to active transportation (walking and cycling) on the number of injured children.

Overall, our results suggest that programs promoting active transportation among elementary-school students in the Montréal area could, by prompting a shift from travelling by car to walking or cycling, lead to an increase in the number of children injured (although for the most part the injuries would be minor) if no action were taken to increase safety among pedestrians and cyclists. This type of program usually prompts a shift of 20% or less from travel by car among children living a distance from school conducive to walking or cycling.<sup>3</sup> The impact on numbers of injuries of such a shift would be

greater in the case of a complete shift to cycling, but that scenario is unlikely because that mode of travel is less popular than walking.

A number of measures can make travel on foot or by bicycle between home and school safer:<sup>18</sup> adjustment of the road environment (e.g. speed bumps, reduction of road width, curb extensions and pedestrian signals); making school crossing guards available; having adults accompany children to and from school; wearing bicycle helmets and taking road safety courses. However, making the road environment safer should always be the priority, because this has been proven to be effective or promising<sup>19</sup> and because, once in place, the protective effect of a safer road environment is always present, regardless of the child's age, sex or socioeconomic environment. Such measures have the potential to counter the impact of the modal shift resulting from programs promoting active transportation among elementary-school children because they protect new pedestrians and cyclists as well as those children who were walking or cycling to school before the program was implemented (the latter remain the most numerous). The inclusion of safety measures in these programs is important not only to protect children but also to promote active transportation, because lack of road safety is one of the main reasons given by parents for preferring travel by motor vehicle over active travel modes.

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