

# Effectiveness of a Safe Routes to School Program in Preventing School-Aged Pedestrian Injury



**WHAT'S KNOWN ON THIS SUBJECT:** A number of studies have demonstrated community acceptance of Safe Routes to School interventions as well as their success in addressing perceptions about safety, but little is known about their effectiveness in reducing pedestrian injury risk in school-aged children.



**WHAT THIS STUDY ADDS:** Implementation of a Safe Routes to School program in New York City may have contributed to a substantial reduction in school-aged pedestrian injury rates, with the effects largely limited to school-travel hours in census tracts with these interventions.

## abstract



**BACKGROUND:** In 2005, the US Congress allocated \$612 million for a national Safe Routes to School (SRTS) program to encourage walking and bicycling to schools. We analyzed motor vehicle crash data to assess the effectiveness of SRTS interventions in reducing school-aged pedestrian injury in New York City.

**METHODS:** Using geocoded motor vehicle crash data for 168 806 pedestrian injuries in New York City between 2001 and 2010, annual pedestrian injury rates per 10 000 population were calculated for different age groups and for census tracts with and without SRTS interventions during school-travel hours (defined as 7 AM to 9 AM and 2 PM to 4 PM, Monday through Friday during September through June).

**RESULTS:** During the study period, the annual rate of pedestrian injury decreased 33% (95% confidence interval [CI]: 30 to 36) among school-aged children (5- to 19-year-olds) and 14% (95% CI: 12 to 16) in other age groups. The annual rate of school-aged pedestrian injury during school-travel hours decreased 44% (95% CI: 17 to 65) from 8.0 injuries per 10 000 population in the preintervention period (2001–2008) to 4.4 injuries per 10 000 population in the postintervention period (2009–2010) in census tracts with SRTS interventions. The rate remained virtually unchanged in census tracts without SRTS interventions (0% [95% CI: –8 to 8]).

**CONCLUSIONS:** Implementation of the SRTS program in New York City has contributed to a marked reduction in pedestrian injury in school-aged children. *Pediatrics* 2013;131:290–296

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### KEY WORDS

environment and public health, injuries, motor vehicles, prevention and control

### ABBREVIATIONS

CI—confidence interval  
DOT—Department of Transportation  
SRTS—Safe Routes to School

Dr DiMaggio conceived the study, acquired and had access to the data, obtained institutional review board approval, conducted all analyses, wrote the initial manuscript, interpreted the results, and had final approval of the version to be published; and Dr Li contributed to the study design, statistical analysis, interpretation of the results, drafting of the manuscript, and critical revision of the manuscript for important intellectual content.

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Children are known to be at heightened risk for pedestrian injury.<sup>1</sup> In 2006, 20% to 25% of all children aged <19 years who were killed in motor vehicle crashes were pedestrians, and pedestrian injuries were the most common cause of traumatic brain injury for 5- to 9-year-olds.<sup>2</sup> Pedestrian injury accounts for 31% to 61% of all injury-related hospital admissions (nearly 18 000 each year) in children and requires surgical intervention in 11% of those cases.<sup>3</sup>

The consequences of pediatric pedestrian crashes extend beyond that of the immediate injury. Twenty-three percent of all children struck by cars can be expected to experience some psychological sequelae,<sup>4</sup> and their parents are at increased risk for psychological symptoms.<sup>5</sup> At the societal level, concern about pediatric pedestrian injury has been linked to declines in children's activity and may contribute to childhood obesity.<sup>6,7</sup>

In 2005, to help address the health and societal consequences of the decline in walking and bicycling to school, the US Congress created the federal Safe Routes to School (SRTS) program as part of the federal Safe, Accountable, Flexible, Efficient Transportation Equity Act. The program allocated \$612 million for fiscal years 2005 to 2009 for state departments of transportation to build sidewalks, bicycle lanes, and safe crossings, to improve signage, and make other improvements to the built environment to allow children to more safely travel to school.<sup>8</sup> As of 2010, departments of transportation in all 50 states had introduced safety improvements at 10 400 of the nation's 98 706 elementary and secondary schools. Interventions consist primarily of sidewalk improvements (19%), traffic calming (14%), pedestrian/bicycle access (14%), and education (14%). The distribution of projects mirrored the

population density of school-aged children across the United States.<sup>9</sup>

New York State received \$31 million dollars from the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act SRTS federal budget allocation. As part of this funding, the New York City Department of Transportation (DOT) introduced safety improvements at 124 schools with the highest injury rates. The work included new traffic and pedestrian signals; the addition of exclusive pedestrian crossing times, speed bumps, speed boards (radar-equipped digital signs that tell drivers how fast they are moving), and high-visibility crosswalks; and new parking regulations. As of 2009, the New York City DOT reported that "100% of the short-term safety improvements...are complete" and that additional longer-term capital improvements had advanced far enough for the DOT to propose expanding the program to an additional group of ~100 schools.<sup>10</sup>

Although a number of studies have assessed programmatic aspects of SRTS programs and evaluated their effect on children's physical activity,<sup>11–13</sup> little is known about the effectiveness of the SRTS program in reducing pedestrian injury risk in school-aged children. We assessed whether the implementation of an SRTS program in New York City was associated with a decrease in school-aged pedestrian injury.

## METHODS

### Data and Variables

Motor vehicle crash data were obtained from the New York City DOT Office of Research, Implementation, and Safety. The data were based on police investigations for all crashes in New York City involving death, personal injury, or property damage to any 1 person in excess of \$1000 for the years 2001 to 2010. The data are entered by an investigating law enforcement officer

onto a form (MV-104AN) and abstracted into a Microsoft Access database by personnel of the New York City DOT. Among the many variables are date of the crash, age, and gender of injured individuals, extent of injury (coded as "possible," "non-incapacitating," "incapacitating," or "killed"), contributing factors, and Global Positioning System-based latitude and longitude of the crash location.

The crash data were in a relational set of Microsoft Access files linked by a unique crash identification number. SQL syntax was used to translate the related files into a single flat text file with 1 observation for each pedestrian crash. Crashes involving pedestrians were identified by using an indicator variable for pedestrians ("Body Type = 35") or bicyclists ("Body Type = 36") and were cross-validated against a variable in a separate linked table that similarly identified pedestrians ("Vehicle Type = 6"). The data were read into the R statistical analysis program<sup>14</sup> and evaluated for outliers, inconsistent values, and missing entries.

Date and time variables were translated into POSIX objects to extract time variables for year, month, day, and hour. A school-travel time indicator variable was created to identify crashes that occurred during days and hours when school-aged children would be expected to be traveling to or from school. We defined this time period as 7 AM to 9 AM or 2 PM to 4 PM, Monday through Friday between September and June. A geographic variable was created by using crash latitude and longitude coordinates, and crashes were assigned to census tracts by using the R *mapproj* package.<sup>15</sup>

SRTS data were similarly obtained from the New York City DOT and consisted of ArcGIS shapefiles for 124 New York City schools selected by the DOT for SRTS interventions. These schools were selected from the city's 1471 schools

because they had the highest rates of pedestrian injury. As of January 2009, twelve schools had completed short-term intervention measures such as new crosswalk markings and had replaced or improved signage and completed capital construction projects. Eighteen schools had completed short-term interventions and had capital construction underway. Ninety-four schools had either started or planned to start interventions but had not yet begun capital construction projects at the time the study was conducted.

We extracted dBase (.dbf) files from the ArcGIS shapefiles that contained the SRTS school intervention information and read them into the R statistical analysis program. We combined the 12 schools that had completed both short-term measures and capital construction by 2009 and the 18 schools that had completed short-term interventions and had capital construction projects ongoing by 2009 into a group of 30 schools located within 30 intervention census tracts. The comparison nonintervention census tracts were defined as those containing schools that were not included as 1 of the 124 SRTS schools. Because there was insufficient information to accurately classify them as SRTS intervention sites, we excluded the 94 census tracts that contained schools that may or may not have started short-term interventions and had not yet started capital construction projects at the time the study was conducted. To account for changes in census tracts between 2000 and 2010, we confirmed that all census tracts which contained intervention sites were present in both the 2000 and 2010 data files.

Population data were based on age-stratified US Census files from both the 2000 and 2010 decennial census at the tract level.<sup>16</sup> School-aged children were defined as those aged 5 to 19

years. This definition was intended to capture data on children who could be enrolled in an intervention or non-intervention New York City school. We defined 4 comparison age groups who would not be enrolled in an intervention or nonintervention school: children aged <5 years, young adults aged 20 to 29 years, adults aged 30 to 64 years, and the elderly aged  $\geq 65$  years. Populations at the census tract level were extrapolated over time by using linear interpolation and combined for age groups and intervention versus nonintervention census tracts to make comparisons.

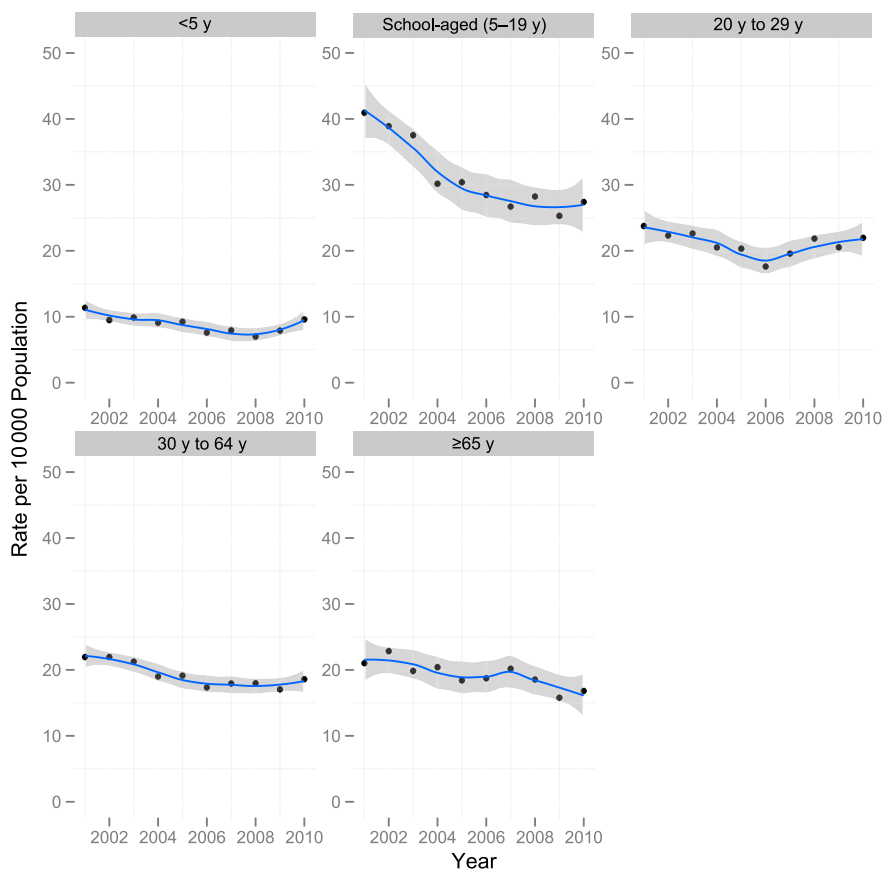
The preintervention period was defined as the 8 years from 2001 to 2008, and the intervention period as the 2 years from 2009 to 2010. We based this definition on a conservative estimate that by 2009, the intervention school sites

had completed all short-term measures and had either completed or nearly completed capital construction.

### Analysis

Rates per 10 000 population for pedestrian injuries were calculated and percent changes in pedestrian injury rates during school-travel hours were compared among different age groups and between census tracts with and without SRTS interventions. This calculation was exclusive of the 94 census tracts where short-term intermediate SRTS interventions or planned capital constructions had not been completed by 2010.

We calculated rate differences and proportion changes with 95% confidence intervals (CIs) by using the epitools package in the R statistical analysis program.<sup>17</sup> Graphical results



**FIGURE 1** Pedestrian crashes per 10 000 population according to age group, New York City, 2001–2010.

were plotted with smoothed loess curves and 95% confidence bands by using the R ggplot2 package.<sup>18</sup>

The study protocol was approved by the Columbia University Medical Center institutional review board.

## RESULTS

The data consisted of 168 806 pedestrian crashes from 2001 through 2010. During the study period, the total annual number of pedestrian crashes for all age groups decreased 14.4% from 18 961 in 2001 to 16 226 in 2010. When stratified according to age group, the most pronounced reduction in the count of pedestrian crashes was in school-aged children, which declined 38.2% from 5822 injuries in 2001 to 3597 injuries in 2010.

During the study period, annual pedestrian injury rates decreased 33% (40.9 injuries per 10 000 in 2001 to 27.4 per 10 000 in 2010) in school-aged children but remained fairly stable in other age groups (Fig 1, Table 1). Among school-aged children, the 5- to 9-year-old group experienced the largest decline in pedestrian injury rates (42% [95% CI: 37–46]) followed by the 10- to 14-year-olds (35% [95% CI: 31–39]) and the 15- to 19-year-olds (18% [95% CI: 11–24]), respectively (Fig 2).

During the 10-year study period, a total of 4760 school-aged pedestrian injuries occurred during school-travel hours. The rate of school-aged pedestrian injury during school-travel hours in 2001 was 4.4 injuries per 10 000 population, which decreased to 3.8 injuries per 10 000 population in 2010 ( $P = .01$ ). The proportion of school-aged pedestrian injuries in census tracts with SRTS interventions that occurred from 7 AM to 9 AM decreased from 8.2% of all school-aged pedestrian injuries in 2001 to 5.7% in 2010. In census tracts without SRTS interventions, the proportion of school-aged pedestrian

**TABLE 1** Annual Pedestrian Injury Rate per 10 000 Population and Proportion Reduction by Age Group, New York City, 2001 and 2010

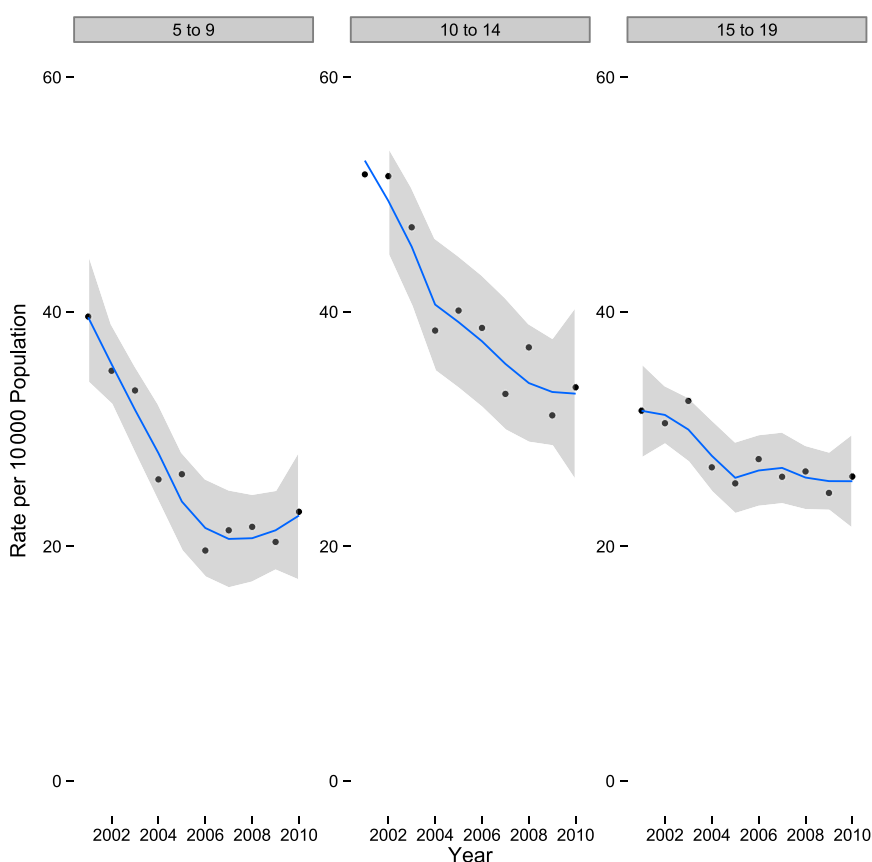
Age Group	2001	2010	Proportion Reduction (95% CI)
<5 y	11.4 (543/477 702)	9.6 (440/458 396)	0.16 (0.26–0.04)
School-aged	41.0 (5822/1 419 315)	27.4 (3597/1 310 700)	0.33 (0.36–0.30)
20–29 y	23.8 (2740/1 152 123)	22.0 (2712/1 232 895)	0.08 (0.12–0.02)
30–64 y	22.0 (7166/3 261 989)	18.6 (6312/3 393 474)	0.15 (0.18–0.12)
≥65 y	21.0 (1752/832 703)	16.8 (1475/876 802)	0.20 (0.25–0.14)

injuries that occurred from 7 AM to 9 AM increased from 6.6% of all school-aged pedestrian injuries in 2001 to 7.9% in 2010.

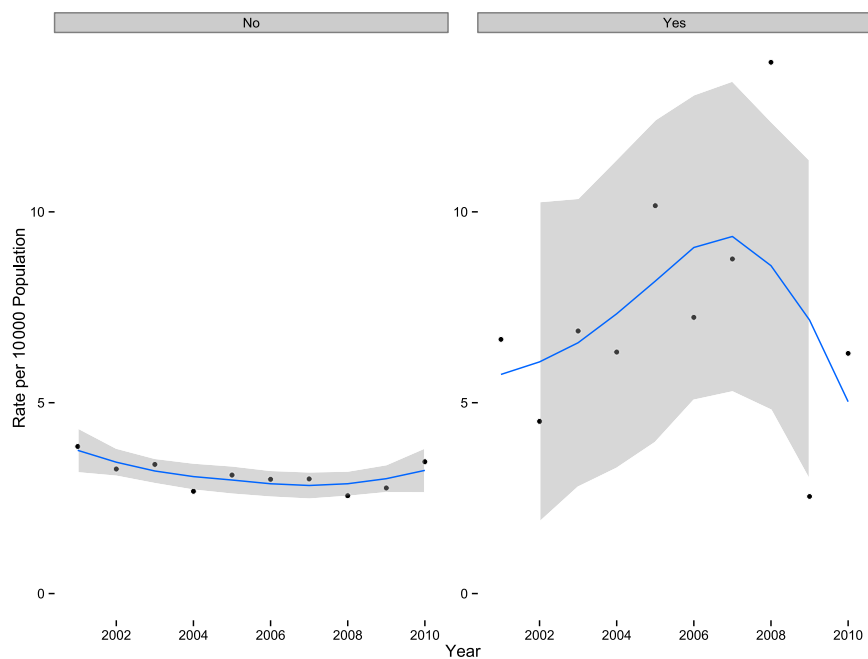
There was a 44% (95% CI: 0.17–0.65) reduction in school-aged pedestrian injury rates between preintervention and postintervention periods in census tracts with SRTS interventions sites compared with no change in census tracts without SRTS interventions (0% [95% CI: –0.08 to 0.08]). The rate of school-aged pedestrian injury during

school-travel hours in census tracts with SRTS interventions was nearly halved, from 8.0 per 10 000 population per year during 2001–2008 to 4.4 per 10 000 population per year during 2009–2010; the rate in census tracts without SRTS interventions remained at 3.1 pedestrian injuries per 10 000 population per year in both time periods (Fig 3).

During the study period, there was little change in the rates of pedestrian injuries among adults aged 29 to 64 years



**FIGURE 2** Pedestrian crashes per 10 000 population according to school-aged group, New York City, 2001–2010.



**FIGURE 3**

School-aged pedestrian crashes per 10 000 population during school-travel (to and from) hours: SRTS intervention census tracts (yes) versus nonintervention census tracts (no), New York City, 2001–2010.

during school-travel hours. In 2001, there were 768 pedestrian injuries in this age group during school-travel hours, for a rate of 6.7 per 10 000 population. This rate remained steady throughout the study period (Fig 4).

## DISCUSSION

The national SRTS program represents a major intervention for improving child pedestrian safety in the United States. Our results indicate that implementation of the SRTS program in New York City may have contributed to a substantial reduction in school-aged pedestrian injuries. Specifically, we found that reductions in pedestrian injury rates in New York City are largely limited to school-aged children during school-travel hours and to census tracts with SRTS interventions.

The finding that implementation of SRTS interventions in New York City was associated with a 44% reduction in the rate of school-aged pedestrian injury during school-travel hours is not

surprising. Researchers have long noted that environmental approaches to injury control are often the most effective.<sup>19</sup> Legislation requires that 70% to 90% of SRTS funds be used for engineering and infrastructure projects (eg, sidewalk construction),<sup>13</sup> and 63% of all SRTS projects nationwide involve some change to the built environment.<sup>9</sup>

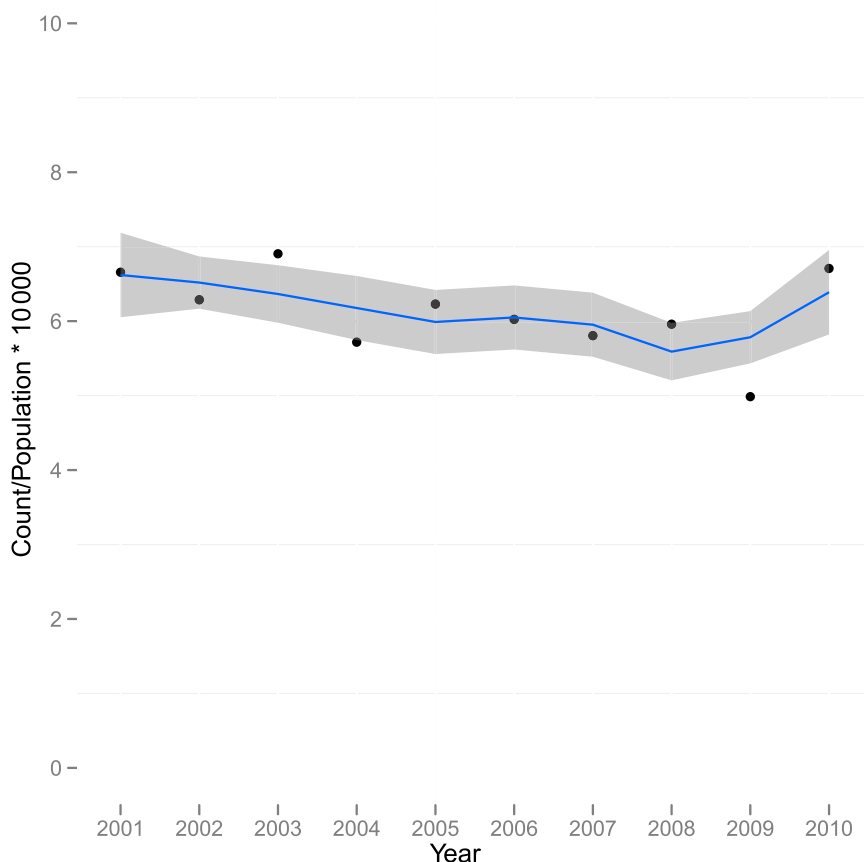
The most commonly reported barriers to active travel to school given by parents and caregivers involve student safety, in particular traffic speeds, traffic volume, and lack of sidewalks.<sup>20–22</sup> A number of studies have demonstrated the programmatic success and community acceptance of SRTS interventions, and SRTS interventions can be successful in addressing perceptions about safety.<sup>11–13</sup> A nationally representative survey concluded that although “relatively few states have laws requiring...traffic calming around schools, when they do, they can help to reduce barriers to and/or facilitate active travel to school.”<sup>12</sup> If SRTS interventions indeed increase walking and

bicycling in school-aged children, the results in our study are likely conservative estimates of the actual effect on pedestrian injury risk.

Public health effects are a necessary part of the cost/benefit discussions that inform policy and funding decisions. In February 2012, a coalition of 16 public health organizations, including the American Heart Association and the American Public Health Association, lobbied to urge defeat of H.R. 7, the American Energy and Infrastructure Jobs Act, which would “eliminate dedicated funding for public transportation and key biking and walking programs that promote health and other transportation options for people who can’t or don’t drive.”<sup>23</sup> By May 2012, the coalition had grown to 48 member organizations, including the Safe Routes to School National Partnership, the American Association of Retired Persons, and the National Association of Realtors, urging passage of the US Senate’s Moving Ahead for Progress in the 21st Century national transportation bill, which they state would “improve safety and access for everyone.”<sup>24</sup> Evaluation of programs such as SRTS based on empirical data are imperative for informing the discourse and advancing public policy. Such evaluations should be considered an additional “E” in the classic “education, enforcement, and engineering” approach to injury control and are critical to assuring the expansion and sustainability of programs such as SRTS.

The current study is subject to several limitations. The demonstrated declines cannot be separated completely from underlying secular trends, and indeed declines in overall pedestrian injury rates in school-aged children seem to have begun before the SRTS program was implemented. New York City, through the efforts of the DOT and the Department of Health and Mental





**FIGURE 4**

Pedestrian crashes per 10 000 population, 29 to 64 years old, during school-travel (to and from) hours: New York City, 2001–2010.

Hygiene, has made important strides in making the city safer for all road users, thus making it difficult to tease out the effects of any single program or intervention. The DOT has taken a proactive approach to make the city walkable and safe. Total traffic fatalities decreased 35% between 2001 and 2009, making 2009 the safest year on record in terms of traffic crashes. In 2010, the DOT issued a landmark Pedestrian Safety Study and Action Plan and continues efforts to install 1500 pedestrian signals, re-engineer 60 miles of streets and 20 intersections, evaluate 20 mile-per-hour pedestrian safety zones, and pilot a program to improve left-turn visibility.<sup>25</sup> Therefore, the observed overall decline in school-aged pedestrian injury during the study period cannot solely be attributed

to the SRTS interventions at the relatively small number of 124 schools; the decline is due in part to the improvement of the overall traffic safety environment brought about by other concurrent programs. To help address this issue, we are currently conducting a nationwide evaluation of the effect of SRTS interventions on pediatric pedestrian injuries.

Our study did not control for possible confounding factors. Part of the observed reduction in school-aged pedestrian injury rates might be due to changes in demographic and socioeconomic characteristics. There were important changes in the demographic characteristics and population of New York City from 2000 to 2010. While the city's overall population increased

2.08%, the school-aged population decreased 9.2%.<sup>26–28</sup> These population changes were accompanied by re-configuration of the city's census tracts that resulted in a decrease from 2217 census tracts in 2000 to 2168 census tracts in 2010. There were 288 census tracts in the 2000 data that were not in the 2010 data and, conversely, 239 census tracts in the 2010 data that were not in the 2000 data. To more rigorously assess the effectiveness of SRTS interventions, geographically weighted multivariable analysis would be needed.

## CONCLUSIONS

It is clear that the built environment plays a critical role in the risk of child pedestrian injury independent of and beyond that of such closely related variables as the social, cultural, and economic status of a community and its individual members.<sup>29</sup> Manipulating the built environment has been called a “logical but often overlooked” area of injury control that may result in “the most successful interventions.”<sup>30</sup> These interventions include separating play areas from roadways, improved visibility at intersections, conspicuous stop signs, enhanced pavement markings, and improved lighting.<sup>31</sup> By reducing the risk of injury, SRTS interventions can meet their stated goals of encouraging children to become more active.

In this study, we assessed the effectiveness of SRTS interventions in reducing school-aged pedestrian injury and found compelling evidence that implementation of SRTS in New York City may be attributed to a 44% decrease or 10 fewer school-aged pedestrian injuries during school-travel hours per year in the 30 census tracts with SRTS interventions. If expanded, the program would have the potential of preventing 210 such injuries per year in New York City.

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## **Effectiveness of a Safe Routes to School Program in Preventing School-Aged Pedestrian Injury**

Charles DiMaggio and Guohua Li

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