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Original article

National Safe Routes to School program and risk of school-age pedestrian and bicyclist injury

Charles DiMaggio PhD, MPH [a,b,*], Spiros Frangos MD, MPH [a], Guohua Li MD, DrPH [b,c,d]

[a] Department of Surgery, New York University School of Medicine, New York
[b] Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, New York
[c] Department of Anesthesiology, College of Physicians and Surgeons, Columbia University, New York, New York
[d] Center for Injury Epidemiology and Prevention at Columbia University Medical Center, New York, New York

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ABSTRACT

Purpose: Safe Routes to School (SRTS) was a federally funded transportation program for facilitating physically active commuting to and from school in children through improvements of the built environment. There is evidence that SRTS programs increase walking and bicycling in school-age children, but their impact on pedestrian and bicyclist safety has not been adequately examined. We investigate the impact and effects of the SRTS program on school-age pedestrian and bicyclist injuries in a nationwide sample in the United States.

Methods: Data were crash records for school-age children (5–19 years) and adults (30–64 years), in 18 U.S. states for a 16-year period (1995–2010). Multilevel negative binomial models were used to examine the association between SRTS intervention and the risk of pedestrian and bicyclist injury in children aged 5–19 years.

Results: SRTS was associated with an approximately 23% reduction (incidence rate ratio = 0.77, 95% confidence interval = 0.65–0.92) in pedestrian/bicyclist injury risk and a 20% reduction in pedestrian/bicyclist fatality risk (incidence rate ratio = 0.80, 95% confidence interval = 0.68–0.94) in school-age children compared to adults aged 30–64 years.

Conclusions: Implementation of the SRTS program appears to have contributed to improving traffic safety for school-age children in the United States.

Introduction

Motor vehicle crashes are a major source of injury mortality. Although rates and frequencies of motor-vehicle occupant deaths have decreased markedly in recent years, similar declines have not occurred in pedestrian and bicyclist fatalities [1,2]. Children are at particularly heightened risk of significant harm and are subject to more severe injuries after a collision as a result of anatomic factors [3]. In 2011, pedestrians accounted for nearly 20% of traffic injury fatalities in children aged 5 to 9 years compared to 5% in adults [4]. Pedestrian injury is the leading cause of traumatic brain injury for 5 to 9-year olds [5] and contributes to over half of all trauma-related hospital admissions for children in the United States [6]. In addition, an estimated 23% of children struck by motor vehicles will suffer psychological sequelae [7].

Concern about the potential dangers of walking and biking may contribute to childhood obesity and its attendant morbidities [8,9]. In response to these concerns, the U.S. Congress funded the federal Safe Routes to School (SRTS) program in 2005 as part of the federal Safe, Accountable, Flexible and Efficient Transportation Equity Act. The program was intended to encourage children to walk and bike to school and was allocated $612 million for fiscal years 2005 to 2009 for state departments of transportation to build sidewalks, bicycle lanes, and safe crossings and to improve the built environment to allow children to more safely travel to school. Legislation requires that the majority (70%–90%) of funds be used for engineering and infrastructure projects (e.g., sidewalk construction, traffic calming measures, and capital improvements) for pedestrian and bicycle access and the remaining 10% to 30% be used for education, encouragement, and enforcement activities [10,11]. As of 2012, departments of transportation in all 50 states and the District of Columbia had introduced safety improvements at 10,400 of the

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* Corresponding author. New York University School of Medicine, Division of Trauma and Acute Care Surgery, Department of Surgery, 550 First Avenue, New York, NY, 10016. Tel.: +1-212-263-3202; fax: +1-212-263-8216.
E-mail address: Charles.DiMaggio@nyumc.org (C. DiMaggio).

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nation's 98,706 elementary and secondary schools for a total cost of $1.12 billion with nearly half of all available funds allocated [12].

The distribution of projects mirrors the population density of school-age children across the United States [13]. Although schools which received SRTS funds were more likely to be located in dense urban environments with a higher proportions of disadvantaged and Latino students, 20% of SRTS schools were located in rural areas indicating attention to geographic equity in funding [14]. State departments of transportations have generally adhered to federal administrative guidance on the type and scope of interventions intended by the original legislation, with the large majority of proposed projects involving capital construction and engineering interventions [12].

SRTS programs have had a demonstrable positive effect on travel behavior as measured by both self-report and socioecological models of public health interventions [10,15]. In the relatively few states that have laws requiring traffic calming, there has been an increase in active travel to school [15]. Another study that looked at pre-project and post-project active school-travel survey data at 53 schools in Mississippi, Wisconsin, Florida, and Washington found statistically significant increases in walking (9.8% in the preproject period vs. 14.2% in the postproject period). Although there were relatively smaller increases in bicycling (2.5% preproject vs. 3.0% postproject), the researchers concluded that the projects were especially effective at introducing bicycling to those communities where it had been rare [16].

Despite the importance of traffic safety in child health and the potential impact of SRTS programs in reducing injury risk, few studies have assessed these programs from the perspective of injury control and prevention. Studies examining the impact of SRTS on pedestrian injury have often been based on behaviors and perceptions linked to pedestrian safety [17] or have been based on literature reviews [18]. There is a need for additional studies based on data analysis of crash and injury records. As part of a series of studies aimed at closing this research gap, our group has documented the safety benefit and cost effectiveness of the SRTS program in New York City (NYC) [19–21]. However, the effectiveness of SRTS in reducing school-age pedestrian injury in NYC may not be generalizable to other geographic regions. The objective of this study is to extend our investigations of the effects of the SRTS program on school-age pedestrian and bicyclist injuries to a nationwide sample which includes distinct traffic environments, travel patterns, population densities, and demographic characteristics.

Methods

Individual-level pedestrian and bicyclist injury data for a 16-year period (1995–2010) were obtained from the U.S. Department of Transportation National Highway and Traffic Administration State Data System [22] for 18 states: Arkansas, California, Connecticut, Florida, Illinois, Kansas, Kentucky, Maryland, Michigan, Missouri, Nebraska, New Mexico, New York, Ohio, Pennsylvania, South Carolina, Virginia, and Washington. States were chosen based on their participation in State Data System and their consent to share data. The analysis accounts for approximately 55% of the nation's 62 million school-age children. The inclusion of both pedestrians and bicyclists was based on the intent of the SRTS program to encourage both forms of active travel. Data on SRTS funding allocations were obtained from the National Center for Safe Routes to School [23]. Data on the number of roadway miles in each state were obtained from the U.S. Department of Transportation Federal Highway Administration [24]. The most recent data on roadways were from 2008 and contained variables on types of roads categorized by rural versus urban. Population data were obtained from the U.S. Census [25].

Initial descriptive statistics of all-age, all-hour pedestrian and bicyclist injuries and fatalities were conducted. Data were then restricted to a school-age group (5–19 years) and an adult group (30–64 years) for weekdays during school-travel hours (7AM–9AM and 2PM–4PM) throughout the year. The time of injury was based on the police report and reflects the time at which the injury occurred. The decision to include the full year was purposeful and intended to capture all possible school terms. Summary quarterly counts of pedestrian injuries and fatalities for each state, classified by school-age versus adult groups were calculated. Based on previous studies of NYC [19–21] and changepoint analyses of pedestrian and bicyclist injury rates and funding allocations (See Appendix), an indicator variable for whether the injury or fatality occurred before or after an estimated 2008 SRTS intervention changepoint year was created. State-level variables on per student SRTS spending and total number of roadway miles in a state were merged to the injury and fatality files.

After descriptive statistics were assessed, data were modeled using a negative binomial formulation that followed an approach taken from our study of Texas state-level data [26]. Eleven models were fit to assess the effect of an indicator variable for the post-SRTS intervention time period on the risk of pedestrian and bicyclist injury in school-age children:

$$\log(InjCounti) = \beta_0 + \beta_1 * agegroup + \beta_2 * SRTS + \beta_3 * agegroup * SRTS + \beta_i * VAR_i + \log(population)$$

where,

$InjCount_i$ is the count of pedestrian and bicyclist injury in quarter i, age group is a binary variable (1 for ages 5–19 years and 0 for ages 30–64 years), SRTS is an indicator of whether the injury occurred before or after the SRTS program was implemented (0 for before January 2008, 1 for after), and population is an offset variable based on yearly state-level census data and allows the exponentiated coefficients to be interpreted as incidence rate ratios. $V AR_i$ represents a vector of additional explanatory variables, that is, state-level SRTS allocation per student, and number and type of roadway miles in a state.

In the interpretation of this model, β_0 is the intercept; β_1 is the logarithm of the estimated incidence rate ratio (IRR) of pedestrian and bicyclist injury in school-age children versus adults before implementation of the SRTS program (January 2008–December 2010); β_2 is the logarithm of the estimated IRR of pedestrian and bicyclist injury in adults after versus before implementation of the SRTS program; $\beta_1 + \beta_3$ is the logarithm of the estimated IRR of pedestrian and bicyclist injury in school-age children versus adults after implementation of the SRTS program (January 2008–December 2010); and $\beta_2 + \beta_3$ is the logarithm of the estimated IRR of pedestrian and bicyclist injury in school-age children after versus before implementation of the SRTS program. The regression coefficient for the interaction term, β_3, is the linear contrast of $(\beta_2 + \beta_3) - \beta_2$ and thus can be interpreted as the net effect of the SRTS program on the risk of pedestrian and bicyclist injury in school-age children.

After an approach described by Gelman and Hill [27], the modeling procedure consisted of evaluating completely pooled models of injury risk that ignored state grouping and treated the data as arising from a single population or process, followed by completely unpooled analysis of each individual state, proceeding to a series of multilevel models that incorporate variation at both the national and state levels. We evaluated multilevel models with