Accident Analysis and Prevention 98 (2017) 252–258

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

School environments and social risk factors for child pedestrian-motor vehicle collisions: A case-control study

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ARTICLE INFO

Article history:
Received 15 June 2016
Received in revised form 5 October 2016
Accepted 13 October 2016
Available online 19 October 2016

Keywords:
Schools
Pedestrian collisions
Children
Built environment
Prevention
Injuries

ABSTRACT

Background: Child pedestrian-motor vehicle collisions (PMVCs) have decreased in Canada in the past 20 years. Many believe this trend is explained by the rise in automobile use for all travel. Initiatives to increase walking to school need to consider PMVC risk. Potential risk factors related to walking to school, the built environment and social factors were examined for schools with historically high child PMVC rates.
Methods: Child PMVCs (age 4–12 years) from 2000 to 2013 and built environment features were mapped within school attendance boundaries in the City of Toronto, Canada. Case and control schools were in the highest and lowest PMVC quartiles respectively. Observational counts of travel mode to school were conducted. Logistic regression evaluated walking to school, built environment and social risk factors for higher PMVC rates, stratified by geographic location (downtown vs. inner suburbs).
Results: The mean PMVC rates were 18.8/10,000/year (cases) and 2.5/10,000/year (controls). One-way street density (OR = 4.00), school crossing guard presence (OR = 3.65) and higher social disadvantage (OR = 1.37) were associated with higher PMVCs. Higher residential land use density had a protective effect (OR = 0.56). More walking was not a risk factor. While several built environment risk factors were identified for the inner suburbs; only social disadvantage was a risk factor within older urban neighbourhoods.
Conclusions: Several modifiable environmental risk factors were identified for child PMVCs. More walking to school was not associated with increased PMVCs after controlling for the environment. School social disadvantage was associated with higher PMVCs with differences by geographic location. These results have important implications for the design of roadways around schools.

1. Introduction

Road traffic injuries are a leading cause of preventable child death in Canada. Motor vehicle fatalities are six times more common than any other unintentional injuries, and are the leading cause of unintentional injury death in those ages 0–24 (Public Health Agency of Canada, 2012). Hospitalization because of motor vehicle injuries ranks 2nd (after falls) for all injury admissions (ages 0–24) in Canada (Public Health Agency of Canada, 2012; Transport Canada, 2015). Road traffic injuries in children 0–14 years, resulted in 70 deaths and 9000 reported injuries in 2013 and cost the Canadian health care system 60 million dollars annually (Transport Canada, 2015; Parachute, 2015).

Although child pedestrian hospitalizations and deaths in Canada have declined over the past 20 years, the burden remains high (Safe Kids Canada, 2007; CIHI, 2008). Child pedestrians are overrepresented in road user fatalities, with 33% being pedestrian deaths (ages 0–14), as opposed to 13% in adults (Transport Canada, 2013). Many believe the decline in child pedestrian-motor vehicle collisions (PMVCs) is due to children walking less, thereby reducing

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http://dx.doi.org/10.1016/j.aap.2016.10.017

their exposure to motor vehicles (Roberts, 1993; Unicef, 2001; DiGuiseppi et al., 1997). In the 2004 Canadian National Transportation Survey, 50% of children reported never walking to school (Cragg et al., 2006). From 1986–2011, walking mode share for trips to school in 11–13 year olds in the City of Toronto decreased from 59% to 45%, with auto mode share increasing from 12% to 29% (Smart Commute School Travel in the City of Toronto, 2015). The 2013 Active Healthy Kids Canada Report Card on Physical Activity for Children and Youth indicated 24% of Canadians 5–17 years use active school transportation only (AST, i.e. walking, cycling, scooters etc.) and 14% use a combination of active and inactive modes (e.g. vehicles) for transportation (Active Healthy Kids Canada, 2013).

Almost 40% of pedestrian-motor vehicle collisions involving children ages 4–12 years in Toronto occur during school travel times (Warsh et al., 2009; Rothman et al., 2015a). More than 1/3 of collisions have been found to be within 300 m of a school, with the highest density of collisions among children occurring within 150 m of a school (Warsh et al., 2009). Peak times for child pedestrian-motor vehicle collisions appear to be in the morning (7:00–9:00) and the afternoon (15:00–18:00); school start and finish times and also peak times for overall traffic volume (Yiannakoulias et al., 2002).

There are many initiatives to increase AST in children to combat obesity and other related health conditions throughout Canada and other places in the Global North (Mammen et al., 2014; Buliung et al., 2011). Road traffic exposure; however, remains poorly understood and conflicting evidence exists on pedestrian volume and collisions (Routledge et al., 1974; Rao et al., 1997; Macpherson et al., 1998; Jacobsen, 2003; Rothman et al., 2014). Depending on the mix of walking and driving and environmental conditions, walking promotion could either increase or decrease injury risk. Optimal conditions for safe walking to school must be defined, because if planned poorly, increased walking has the potential to increase injury risk in children. Conversely, injury risk, real or perceived, may be a barrier to successfully increasing children's active transportation.

Previous studies have examined built environment correlates of walking in children and child PMVC separately (Rothman et al., 2013a). These studies are observational, with the majority using a cross-sectional design. Correlates of walking include traffic calming, playgrounds, crosswalks, higher pedestrian volume and population densities, land use mix, urban areas and schools. Correlates of PMVC include crosswalks, higher pedestrian/population volumes, land use mix, urban areas, more schools, higher traffic speeds and crossing busy roadways (Rothman et al., 2013a). It is essential to examine walking and child PMVC together to determine whether there is an increased risk of child PMVC with more walking to school exposure and to identify the effect of the built environment on this relationship. To our knowledge, there is only one previous study examining both walking to school and child PMVC rates together, This cross-sectional study found that there was no relationship between more walking to school and child PMVC once features of the built environment was controlled for (Rothman et al., 2014).

The purpose of this study was to build on the previous cross-sectional study, by using an innovative and more rigorous case control study design and identifying schools as cases and controls based on collision rates. Multivariate logistic regression modelling was utilized to determine if the proportion of children observed walking to school was a potential PMVC risk factor and identify modifiable built environment and social risk factors associated with historically higher child PMVC rates within school attendance boundaries controlling for walking exposure

2. Methods

A case-control study was conducted in the City of Toronto, Canada, in May–June 2015. Cases were identified as kindergarten to grade 6 schools, within the highest quartile of historical child PMVCs within school attendance boundaries. Control schools were those within the lowest quartile of historical child PMVCs. Attendance boundaries were defined by the Toronto District School Board (TDSB) (Toronto District School Board, 2016). Collision rates were calculated from City of Toronto police-reported pedestrian collision data from 2000 to 2013 for children ages 4–12 years. The collision dataset includes location, time of day, date, and child age. Collisions were mapped onto attendance boundaries and PMVC rates were calculated using the 2011 Canadian census population, ages 4–12 years, conflated to each of the school attendance boundaries. Exclusion criteria included schools with: (1) grade combinations that included grades ≥7; (2) special programs that accept children from outside the school's attendance boundaries (e.g., French immersion) and; (3) involvement in other walking studies. Ethics approval was obtained from the TDSB, the Hospital for Sick Children Research Ethics Board and the Toronto District School Board, External Research Review Committee.

2.1. Risk and protective factors

Table 1 presents each of the potential risk and protective factors tested for inclusion in the models by conceptual category (where appropriate) and data source.

2.1.1. Walking to school

Mode of school transportation, including walking, cycling, other active transportation (i.e., scooters, rollerblades, skate-long boards), strollers, wagons and vehicles were counted by trained observers outside of the schools for 20 min before and 5 min after the morning arrival bell on a single day in the spring. The proportion of children walking to school was calculated from the total number of children observed. Children arriving by school bus were excluded as generally they had met TDSB busing eligibility criteria (grades JK-5 living ≥1.6 km, grades 5+ who live ≥ 3.2 km), or had mobility needs related to a medical condition or disability (Toronto District School Board, 2005).

2.1.2. Built environment

Potential built environment risk factors for child pedestrian injury were identified from a literature review and from a previous cross-sectional study (Rothman et al., 2014, 2013a). These factors were organized conceptually according to Cervero and Kockelman's 3 D's, Density (population), Design (roadway) and Diversity (land use) (Cervero and Kockelman, 1997). Density and design environment features were obtained from the City of Toronto, Transportation Services, and the 2006 Canadian census and Toronto Police Services and mapped onto school attendance boundaries. Variables obtained from the 2006 Canadian census were obtained at the Dissemination Area (DA) level of geography. DAs have approximately 400–700 residents, and are the smallest standard geographic area for which all census data are disseminated. DAs were mapped onto school attendance boundaries and census variables for each attendance boundary were estimated using area-weighted proportionate analysis (Braza et al., 2004; Falb et al., 2007). Population and design densities were calculated either per linear kilometer of roadway or per area of school attendance boundary. Two variables were created for crossing guards; the first indicating whether or not a guard was observed at the school site during the transportation mode observations and the other was a density of crossing guards throughout the school attendance boundaries. Only adult crossing guards which are employed