Understanding the determinants of active transportation to school among children: Evidence of environmental injustice from the Quebec longitudinal study of child development

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A B S T R A C T
Purpose: To examine the combined influence of poverty and dangerousness of the neighborhood on active transportation (AT) to school among a cohort of children followed throughout the early school years.

Methods: Growth curve modeling was used to identify determinants of AT to school among 710 children participating in the Quebec Longitudinal Study of Child Development from 2003 through 2006. Parent-reported dangerousness and pedestrian–vehicle collision data were merged with travel mode and health data.

Results: At age 6 years, insufficient household income, having an older sibling, and living in a neighborhood that is not excellent for raising children, or characterized with high decay were predictive of greater likelihood of using AT and remained unchanged as children progressed from kindergarten through grade 2.

Conclusion: A public health concern is children experiencing environmental injustice. Since AT is most likely to be adopted by those living in poverty and because it is also associated with unsafe environments, some children are experiencing environmental injustice in relation to AT. Interventions may be implemented to reduce environmental injustice through improvements in road safety.

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1. Introduction

Physical activity is needed for healthy growth and development and can track into adulthood thus preventing chronic diseases (Malina et al., 2004; Story and Neumark-Sztainer, 1999). Secular trends of declining physical activity among youth (Anderssen et al., 1996; Dollman et al., 2005) highlight the need for opportunities for children to be more physically active (Barnett et al., 2006; Malina et al., 2004). Active transportation (AT) to/from school, such as walking and cycling, is one potential opportunity for children to be physically active (Heelan et al., 2005; Sirard et al., 2005; Tudor-Locke et al., 2001). AT to/from school has been shown to be related to higher levels of physical activity (Chillon et al., 2010; Cooper et al., 2003, 2005; Saksvig et al., 2007) and may contribute to preventing excess weight gain (Pabayo et al., 2010; Rosenberg et al., 2006; Veugelers and Fitzgerald, 2005).

However, in keeping with population estimates observed for physical activity, the prevalence of AT to/from school (Ham et al., 2008; McDonald, 2007; van der Ploeg et al., 2008) has also declined while concurrent increases in proportions of children being driven in cars (Ham et al., 2008; McDonald, 2007; van der Ploeg et al., 2008) have occurred. In a population-based repeated cross-sectional survey in Australia, the prevalence of walking to school among 5–9 year olds and 10–14 year olds declined from 62.6% and 44.2%, respectively, in 1971 to 29.4% and 32.7% (van der Ploeg et al., 2008). Similarly in the United States, among 5–18 year olds, the prevalence of AT to school declined from 42% in...
1969 to 16.2% in 2001 (Ham et al., 2008). Canadian data shows similar trends. In the Greater Toronto Area, between 1986 and 2006, walking to school declined from 53.0% to 42.0% and from 38.6% to 30.7% among 11–13 and 14–15 year olds, respectively (Buliung et al., 2009).

Although these trends in AT to/from school provide evidence of widespread declines, little is known about the predictors of this behavior across the early school years. Recent systematic reviews (Davison et al., 2008; Pont et al., 2009) have identified several correlates of greater likelihood of AT to/from school such as shorter distance to school (within 1 mile or 1.6 km) (Babey et al., 2009; Bere et al., 2008; Bringolf-Iserl et al., 2008; Cole et al., 2007; DiGuiseppi et al., 1998; Ewing et al., 2004; Gilhooly and Low, 2005; Gray and Kelly, 2005; Harten and Olds, 2004; Larsen et al., 2009; McDonald, 2007, 2008; Merom et al., 2006; Nelson et al., 2008; Panter et al., 2009b; Rodriguez and Vogt, 2009; Schlossberg et al., 2006; Wen et al., 2008; Yelavich et al., 2008; Zhu and Lee, 2009), male gender (Babey et al., 2009; Buliung et al., 2009; Larsen et al., 2009; Merom et al., 2006; Pabayo and Gauvin, 2008; Robertson-Wilson et al., 2008; Yelavich et al., 2008), lower socio-economic status (Babey et al., 2009; Butler et al., 2007; Chillon et al., 2009; Cole et al., 2007; Evenson et al., 2008; Mota et al., 2007; Pabayo and Gauvin, 2008; Pabayo et al., 2011b; Spallek et al., 2006; Yelavich et al., 2008), no parental car ownership (Buliung et al., 2009; Carlin et al., 1997; Cole et al., 2007; DiGuiseppi et al., 1998; Ewing et al., 2004; Panter et al., 2009a; Rodriguez and Vogt, 2009; Wen et al., 2008; Yelavich et al., 2008; Zhu and Lee, 2009), unfavorable neighborhood characteristics (Alhport et al., 2008; Bringolf-Iserl et al., 2008; Carver et al., 2005; Fulton et al., 2005; Harten and Olds, 2004; Merom et al., 2006; Panter et al., 2009a; Voorhees et al., 2010), and non-white ethnicity (Babey et al., 2009; Bere et al., 2008; Braze et al., 2004; Fulton et al., 2005; Martin et al., 2007; McDonald, 2007). Almost all of these investigations utilized a cross-sectional study design; longitudinal studies are needed to help researchers and practitioners gain better insight into predictors and the natural history of AT to/from school across the early school years.

To our knowledge, only a few longitudinal studies that identify the predictors of AT to/from school have been published. Hume et al. (2009) conducted a longitudinal study among 121 children aged 9 years and 188 adolescents aged 14 years. They observed that children of parents who reported that their child had many friends in their area were more than twice as likely to increase their active commuting over 2 years in comparison to other children. Among parents of adolescents, those who reported that there were no traffic lights or crossings available were significantly less likely to increase their AT to school in comparison to others. Also, those who reported that they were satisfied with the number of pedestrian crossings in their neighborhood were twice as likely to increase AT to/from school. Although this was the first longitudinal investigation of the predictors of AT to/from school, it comprised a small sample of 309 participants. Furthermore, the researchers only used parental or self-reported data to assess environmental features. Measures from other sources (e.g., community surveys, crime data) are required to tap into neighborhood safety in order to gain further insight into neighborhood safety. In our own work, although we identified socio-demographic determinants of AT to school from 1996 to 2001 among children aged 6 through 16 years in a large population-based cohort, we did not investigate the role of the environment as a determinant of this behavior (Pabayo et al., 2011b).

Social inequalities have also been implicated in AT to/from school. Children from low socio-economic status (SES) backgrounds assessed by household income, education, or lack of access to a motor vehicle are more likely to use AT to/from school (Chillon et al., 2009; Davison et al., 2008; Larsen et al., 2009; Martin et al., 2007; Pabayo and Gauvin, 2008; Pont et al., 2009; Spallek et al., 2006; Zhu and Lee, 2009). Furthermore, numerous cross-sectional studies have also identified features of the neighborhood such as higher perceived safety and the presence of other children in the neighborhood as being significantly positively associated with AT to/from school (Salmon et al., 2007; Timperio et al., 2004, 2006).

Although the phenomenon of children from low SES backgrounds participating to a greater extent in AT to/from school appears beneficial from a cardiovascular health perspective, they are also more likely to be exposed to danger and more likely to be harmed while walking to school (Carlin et al., 1997; Posner et al., 2002; Rao et al., 1997; Roberts et al., 1996, 1997). This social inequality can be regarded as a form of environmental injustice, which is defined as the disproportionate exposure to and burden of harmful environmental conditions experienced by low-income populations (Taylor et al., 2006).

Historically, although environmental injustice originally referred to the disproportionate exposure to toxic environments whereby African Americans and people living in low-income communities were exposed to large hazardous waste landfills (Taylor et al., 2006), environmental injustice has been used also in research investigating inequalities in physical activity and obesity among different populations (Drewnowski, 2004, 2009; Taylor et al., 2006). For example, researchers have observed that economically disadvantaged populations must overcome greater environmental barriers in order to be physically active (Pabayo et al., 2011a; Singh et al., 2008). In addition, the term "Deprivation Amplification" has been used to describe a pattern related to features of the local environment where people from deprived families and households have fewer personal resources and the local facilities that enable people to lead healthy lives are meeker in comparison to non-impoverished and non-socially deprived areas (Macintyre et al., 1993, 2007).

In Canada, environmental injustice has been observed in disadvantaged areas of cities in regards to poorer access to healthy and affordable food (Larsen and Gilliland, 2008). More specifically, residents of inner-city neighborhoods of low socio-economic status have the poorest access to supermarkets (Larsen and Gilliland, 2008). These results imply that families from disadvantaged backgrounds are more likely to experience negative health consequences. Similarly, environmental injustice applies to the context of AT to/from school. Previous cross-sectional studies indicate that children from deprived backgrounds are disproportionately more likely to use AT to/from school and are more likely to be exposed to high traffic in comparison to children living in more wealthy areas (Carlin et al., 1997; Posner et al., 2002; Rao et al., 1997; Roberts et al., 1996, 1997). Further studies are required to replicate and extend this finding.

Furthermore, two theoretical frameworks describing conceptualizations of the determinants of AT to/from school have been published (McMillan, 2005; Sirard and Slater, 2008). The McMillan framework asserts that parents make a decision to allow their children to use AT to/from school based on their perception of the built environment. If parents perceive that it is safe to walk, then they are more likely to allow their children to use AT to/from school. The ecological and cognitive active commuting (ECAC) framework goes beyond the built environment to assess safety and takes into account variables at different levels of influence including policy, neighborhood, and parent/family variables and thus is more encompassing. For example, distance from school, omnipresence of crime as well as parent perceptions are incorporated as determinants of AT to/from school. Overall, these frameworks are restricted to explaining AT in elementary school.
children and start from the premise that younger children play a lesser part in the decision-making process as parents decide whether or not their younger children can use AT to/from school.

However, these frameworks assume that all parents have a choice in whether their children may use AT to/from school. Families from low-income backgrounds may have limited resources that may restrict the mode of transportation to/from school to walking or cycling. Therefore, further research is needed to determine if these frameworks are applicable to all families from varying socio-economic backgrounds.

In the current investigation, we examined the combined influence of poverty and dangerousness of the neighborhood on active transportation (AT) to school among a cohort of children followed throughout the early school years. Although there are studies investigating the association of socio-economic position and neighborhood safety separately, none of the previously existing studies examines both factors simultaneously.

2. Methods

Data on AT to/from school for this study were from the Québec Longitudinal Study of Child Development (QLSCD), a birth cohort coordinated by the Direction Santé Québec of the Institut de la statistique du Québec since 1998 (Jetté and DesGroseillers, 2000). Participants were drawn from the Québec live birth registry. The sampling design followed a three-stage strategy (Jetté and DesGroseillers, 2000). The resulting sample was representative of singleton live births registered in the Québec live birth registry in 1997–1998 with the exception on the Cree and Inuit territories, on Aboriginal reservations, or in the Northern region of Québec (2.1% of live births). Infants born before 24 or after 42 weeks gestation (0.1%) and those with unknown gestational age (1.3%) were excluded. A random sample of 2940 singleton live-born babies was initially selected. Parents of 2675 children were reachable and 83.1% consented to participate (Jetté and DesGroseillers, 2000). The baseline data collected at 5 months of age included 2223 children, of whom 2120 were resurveyed annually. On a yearly basis, data were collected through structured interviews in the home with the person most knowledgeable about the child’s health (the mother for almost 98% of participants). The current analyses are based on data collected when the children were in kindergarten, grade 1, and grade 2, or when the children were aged approximately 6, 7, and 8 years, respectively. A flow chart illustrating the number of participants throughout the QLSCD study can be found in Fig. 1. By kindergarten, 1492 children (67.1% of the initial cohort) remained in the study. Children lost to follow-up were more likely to have mothers who were immigrants, have insufficient family income in kindergarten, be from urban regions, and be boys. Children attending public schools are often enrolled in a school located in the residential neighborhood. Children attending private schools (n=74, 5.0%) and children in rural areas (n=281, 18.8%) were excluded from the sample since they were not as likely to attend a school within 1.6 km (1.0 miles) of their home. Children who moved out of the neighborhood (n=126, 8.4%) were not included because the neighborhood variables were collected at age 6 years only. Students attending private schools were less likely to have mothers who are non-European immigrants and to have the mother perceive the health of their children to be unfavorable. Children from rural areas were less likely to have mothers who were non-European immigrants and to live in neighborhoods with high social cohesion. When comparing the students who moved and those that stayed in the same neighborhood, movers were less likely to be from sufficient income households, to have mothers reporting that their child’s health is excellent, to live in neighborhoods with high social cohesion, to live in an area with low neighborhood decay, and to live in a neighborhood that is perceived to be favorable.

Students with missing data due to non-response (n=130/1492, 8.7%) were excluded; complete data were available for 710 (47.6%) students. Children who were excluded were more likely to have mothers who were non-European immigrants.

Ethics approval was obtained from the ethics committees of the Direction Santé Québec of the Institut de la statistique du Québec and of the Faculty of Medicine of the Université de Montréal. Signed informed consent was obtained from the parent.

2.1. Variables

Outcome: Parents were asked how their child usually gets to school. Response options were categorized as school bus, public transit, walking/bicycling, is driven, or uses multiple modes. Usual

![Flow chart of participants from the Quebec Longitudinal Study of Child Development throughout the different set of analyses in this investigation.](chart.png)
mode to school was dichotomized as active (walking/bicycling) or inactive (school bus, public transit, is driven, or multiple modes). Although there has been a lack of studies assessing the validity and reliability of tools used to measure mode of transportation to/from school, one investigation that compared parental report with child report on AT to/from school reported a kappa of 0.80 (95% CI = 0.71, 0.89) and a mean percent agreement of 88.4% (Evenson et al., 2008). Test–retest reliability of the survey indicated almost perfect replicability (98.1%) and the kappa coefficient was 0.80 (95% CI = 0.71, 0.89) (Evenson et al., 2008).

Socio-demographic variables: Data included child’s sex, age, birth rank, mother’s immigrant status, and family income in Canadian dollars (CAD) when children were in kindergarten. Copies of the questionnaires and data collection forms are available on the Internet at www.jesuisjeserai.stat.gouv.qc.ca/outils_collecte_an.htm (E7, E8, E9).

Household income at 6 years of age: Insufficient income was operationalized according to the low income cut-offs (LICO) from Statistics Canada (www12.statcan.ca/english/census06/reference/dictionary/fam019.cfm), which takes into account the number of persons in the household and the area of residence. LICOs are often used to define poverty in Canada (Ross and Roberts, 1999) and have been associated with child health in the QLSCD (Seguin et al., 2003, 2007). The question used to measure total household income in the QLSCD is identical to that used in the 1991 Canadian Census. Mothers reported total family income (before taxes) in the previous 12 months. Income was dichotomized as insufficient (income level below the LICO) or sufficient (income level at or above the LICO).

Mother’s perception of neighborhood quality: Mothers were asked to characterize their neighborhood for raising children as excellent, good, average, bad, or very bad. Responses were dichotomized as favorable (excellent/good) or unfavorable (average/bad/very bad). An explanation of how this variable was derived has been described elsewhere (Jetté and DesGroseillers, 2000).

Having an older sibling: The child’s birth rank was dichotomized as 1st born or higher. Students with a birth rank greater than one were categorized as having an older sibling. This variable was included because children who have other children to commute with, such an older sibling, are more likely to use AT to/from school (McMillan, 2007; Timperio et al., 2006).

Mother’s immigrant status: Mother’s immigrant status was categorized as Canadian/European born, or non-European.

Social cohesion: Parents were asked whether they strongly agreed, agreed, disagreed, or strongly disagreed with each of the following statements: Around here, when there is a problem, the neighbors get together to resolve it; In our neighborhood, there are adults who can serve as a role model for children; People around here are willing to help their neighbors; You can count on adults in the neighborhood to ensure that children are safe and are not in trouble; When I’m away from home, I know my neighbors will keep an eye open to ensure there is no problem. Responses were dichotomized to strongly agree/agree or disagree/strongly disagree. If the parent answered, “disagree” to any of the questions, they were classified as living in an area with low social cohesion. The measure has been used previously in research (Buka et al., 2003; Cradock et al., 2009; Pabayo et al., 2011a; Sampson et al., 1997). The test–retest reliability of this measure is estimated to be 0.80 (Raudenbush, 1999).

Neighborhood decay: Parents were asked: ‘Of each of the following problems in your neighborhood, is it a grave problem, more or less a problem, or not a problem: garbage, trash or broken glass: the sale or consumption of drugs; the presence of alcohol or excessive consumption of alcohol in public; groups of youths causing problems. Students were classified into living in a neighborhood with high or low decay. If the parent answered that it was a grave problem for any of the items, they were classified as living in a high decay neighborhood. The question used is similar to the Neighborhood Safety Subscale (NSS) (Greenberg et al., 1999). This measurement tool has been used previously (Lumeng et al., 2006).

Distance to school: Postal codes of the residence and the school attended by the child were collected. The distance between home and school were approximated by calculating the distance between the postal code of the student’s place of residence and the school’s postal code. The geographic co-ordinates (latitude and longitude) of students’ residences and their schools are derived from the postal codes of households by using the residential version of postal code conversion file plus (PPCF+), a program that converts six character postal codes into mapping units, including latitude and longitude.

Pedestrian–vehicle collisions: Urgences-Santé (the centralized ambulance service on the Island of Montreal) data on pedestrian–vehicle collisions were used to characterize the area of residence of Island of Montreal participants as being dangerous or safe for pedestrians. Methods for data collection have been described elsewhere (Morency and Cloutier, 2006). Briefly, the dataset was extracted from Urgences-santé data files containing incoming calls (geographical coordinates) and pre-hospital intervention reports. Pedestrian–vehicle collisions on the Island of Montreal from 1999–2003 were thus geographically mapped. For every call made to 911 in Montreal, the caller’s location is automatically sent to Urgences-santé and the location of the victim is validated by telephone. This location is instantly mapped in a GIS to dispatch and guide an ambulance (Montreal, 2004). The mapping of all crash sites and the density calculations were performed in ArcGIS (ESRI, 2005). Pedestrian victim density was computed with a pixel size of 10 m and search radius of 500 m (Morency and Cloutier, 2006). The density of pedestrian–vehicle collisions was matched by postal code. Students who lived in an area with 1 or more pedestrian–vehicle collisions were classified as living in an area more dangerous for AT.

Car dependency: Car ownership and mode of transportation to destinations, such as places of work, are indicators of car dependence (Kenworthy et al., 2000). Since car ownership was not collected in the QLSCD interview schedule, an area level variable was used to approximate likelihood of car ownership. The proportion of adults, collected by 2001 Canadian Census, who drive to work in each postal code was extracted from the census and matched to each participant. Participants were then categorized as living in areas in which fewer than 50% of adults drive to work (i.e., ‘car independent’) or areas in which ≥ 50% of adults drive to work (i.e., ‘car-dependent’).

3. Data analysis

Bivariate analyses were conducted to determine if there were associations between household income and social cohesion, presence of neighborhood decay, and perception of the neighborhood for raising children.

Because mode of transportation to/from school was measured yearly for the same individuals, we used growth curve modeling analyses to examine the relationship between socio-demographic and environmental factors and likelihood of AT to/from school across time. Growth curve models are a generalization of the linear model used in traditional regression analysis. Further information regarding the application of this type of analysis in
physical activity research is available (Masse et al., 2002). Several authors (Diez-Roux, 2000; Raudenbush and Bryk, 2002) have shown that ignoring the hierarchical structure of a data set can lead to inferential errors and that estimating random effect coefficients can more adequately model data structures typically obtained in field research. Analyses were performed with SPSS (version 15.0) and HLM 6.04 (Hierarchical Linear Modeling, Scientific Software International, Chicago, IL).

To investigate the potential effect of socio-economic and environmental factors on likelihood of using AT to/from school, we adopted a step-up approach (Raudenbush and Bryk, 2002) and conducted different sets of analyses on different subsets of the dataset. The initial sample \( n = 710 \) was restricted to students who had not moved out of their neighborhoods from kindergarten through grade 1 and grade 2 (Fig. 1). A first set of analyses only included parameters operationalizing time, to explore whether or not the proportion of students who use AT to/from school changed as children progressed from kindergarten through grade 2. Socio-demographic variables were then added to identify significant predictors associated with AT to/from school at each time point. The covariates added included gender, having an older sibling, mother's immigrant status, household income, mother's perception of their child's health, mother's perception of their neighborhood for raising children, neighborhood social cohesion, and the presence of neighborhood decay, all of which were included as moderating variables at kindergarten. Next, interaction terms for the household income variable and each of the neighborhood variables were added to the previous models. Finally, the proportion of adults in the workforce who reported driving to work was added to the models.

### 3.1. Secondary analyses

Since distance to school is an important and consistent factor associated with AT to/from school, we used approximate distance between postal codes of residence and school to restrict the sample to students living within a radius of at most 1.6 km away from school \( n = 436 \). The radius of 1.6 km (1 mile) was chosen as a cut-off because it has been identified as the most feasible distance to walk between home and school within the literature (McMillan, 2005; Schlossberg et al., 2006). The analysis described above was repeated with this sub-sample. To test the sensitivity of the relationship between distance to school and AT to/from school, we re-ran the analysis by using a larger radius (2.0 km cut-off) \( n = 480 \). For these sub-samples, we wanted to determine if the economic and neighborhood perception variables remained significantly associated with AT to/from school as the children aged.

We used vehicle–pedestrian data to determine if dangerousness within a neighborhood was significantly associated with AT to/from school. We also wanted to determine if neighborhood dangerousness had an additive effect, along with socio-economic and the neighborhood perception variables, on the likelihood of using AT to/from school. Household income and vehicle–pedestrian collision rates were not associated. Therefore, any effects of these variables can be considered additive. However, data on pedestrian–vehicle collisions were only available for participants living on the Island of Montreal \( n = 129 \). Models including the pedestrian–vehicle collisions variable should be considered exploratory.

### 4. Results

Characteristics for the 710 students with complete data, attending public schools in urban areas in Quebec, and who did not move out of their neighborhoods during kindergarten to grade 2 in the QLSCD appear in Table 1. Overall, the sample had slightly more girls (51.7%) than boys. About 54.8% of respondents had an older sibling, 4.4% had mothers who were non-European immigrants, 15.8% of students came from families with insufficient income, 24.8% of the participants lived in neighborhoods with low social cohesion, 20.6% of the students lived in areas with high neighborhood decay, 90.0% lived in car-dependent areas, and 17.6% of the mothers perceived the quality of the neighborhood for raising children to be unfavorable.

Growth curve modeling of data pertaining to the likelihood of using AT to/from school showed that there was significant between person variance. That is, the 95% plausible value range established from the null model showed that the percentage of children using AT to/from school from kindergarten to grade 2 varied between 15.2% and 20.4% across the early school years. Addition of the time variable showed the likelihood of using AT to/from school increased from kindergarten to grade 1 (OR = 1.81; 95% CI = 1.32, 2.46). Similarly, at grade 2 (OR = 2.19; 95% CI = 1.61, 2.98), children were more likely to use AT to/from school. Predictors were then tested as moderators of the intercept in the model in order to determine if there were significant differences in likelihood of AT at kindergarten between groups (i.e., between girls and boys). Gender, mother's immigrant status, perception of child's health, and social cohesion were not significantly associated with AT to/from school at baseline nor throughout the early school years. Children with an older sibling (OR = 1.75; 95% CI = 1.19, 2.57), who were from households with insufficient income (OR = 1.80; 95% CI = 1.04, 3.11), who were from a neighborhood that was perceived as unfavorable for raising children (OR = 1.79; 95% CI = 1.11, 2.88), and who lived in neighborhoods with high decay (OR = 2.57; 95% CI = 1.63, 4.05) were more likely to use AT to/from school from kindergarten through grade 2 (Table 2). None of the predictors were associated with change in likelihood of AT across the early school years (i.e., there were no effect modifiers of the change in likelihood of AT across time).

<table>
<thead>
<tr>
<th>Variable</th>
<th>( n = 710 )</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>Male</td>
<td>343</td>
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<tr>
<td>Female</td>
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<tr>
<td>Non-European</td>
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<tr>
<td>Perceived health status of child</td>
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<td>Excellent</td>
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<td>Insufficient</td>
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<td>Low</td>
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<td>Neighborhood decay</td>
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<td>High</td>
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<td>20.6</td>
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<td>Perception of the neighborhood</td>
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</tr>
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<tr>
<td>No</td>
<td>585</td>
<td>82.4</td>
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</table>
were no significant differences in the likelihood of using AT to/from school, children not residing in car-dependent areas were significantly more likely to use AT to/from school (OR = 1.62, 95% CI: 1.28, 2.06; 95% CI: 1.28, 2.06) times more likely to use AT to/from school as they aged in comparison to children from sufficient income households.

When the area-level variable, car dependency was included in the model, having an older sibling (OR = 2.06; 95% CI: 1.28, 3.30) and residing in a neighborhood that is perceived to be unfavorable for raising children (OR = 1.91; 95% CI: 1.04, 3.52) remained significantly associated with AT to and from school (results not shown). Again, this association remained unchanged at grade 1 and grade 2. Although household income and neighborhood decay were no longer significantly associated with AT to/from school, children not residing in car-dependent areas were significantly more likely to use AT to/from school (OR = 6.87; 95% CI: 2.96, 15.94).
4.1. Secondary analysis—children who live within 1.6 km from school

The analysis restricted to students who live within 1.6 km away from school, yielded similar results (results not shown). Having an older sibling (OR = 2.23; 95% CI: 1.39, 3.59) and presence of neighborhood decay (OR = 2.68; 95% CI: 1.54, 4.65) remained significantly associated with AT to/from school in kindergarten and this remained unchanged at grade 1 and grade 2. Similar results were obtained when the sample was restricted to students living within 2.0 km of school; however, perception of the neighborhood being unfavorable for raising children (OR = 1.72; 95% CI: 1.00, 2.96) was also significantly associated with AT to/from school (results not shown). When car dependency was added to the model, having an older sibling and perception of the neighborhood being unfavorable for raising children remained significantly associated with AT to/from school, while household income and the presence of neighborhood decay were no longer significantly associated. Children not residing in car-dependent areas were more likely to use AT to/from school.

4.2. Vehicle–pedestrian collisions

We then included the vehicle–pedestrian collisions variable into the model among students residing on the Island of Montreal. Students living in neighborhoods with high neighborhood decay were more likely (OR = 3.68; 95% CI: 1.16, 11.61) to use AT to/from school (n = 129). Students living in areas with high vehicle–pedestrian collisions were more likely (OR = 3.43; 95% CI: 1.21, 9.73) to use AT to/from school from Kindergarten. These associations remained unchanged across the early school years. Insufficient income and perception of the neighborhood for raising children were not significantly associated with AT to/from school longitudinally.

5. Discussion

This paper examined the combined influence of poverty and dangerousness of the neighborhood environment on the likelihood of AT to/from school among a population-based birth cohort of children followed throughout the early school years. Although AT to/from school may supplement other leisure time and school-based physical activity in order to meet physical activity guidelines, this phenomenon may expose children to other environmental risks. Results indicated that children from disadvantaged backgrounds and areas were significantly more likely to use AT to/from school in kindergarten as well as when they progress through the early school years. These findings show exposure to a form of environmental injustice because children who come from low SES backgrounds are more likely to use AT to/from school. In other words, children from disadvantaged backgrounds appear to be participating in a behavior that is highly acclaimed and encouraged by public health professionals but they are more likely to be exposed to unsafe environments in doing so.

This study adds to the literature because it involves a longitudinal design on a large population-based sample. In our previous work, we observed significant associations between socio-demographic factors and AT to school across time among students participating in a large population-based cohort study (Pabayo et al., 2011b). For example, being from an insufficient income household, having an older sibling, and living in an urban setting were significantly associated with AT to school as children were followed from 1996–2001 (Pabayo et al., 2011b). But we could not include environmental predictors of this behavior in the analysis. Researchers in Australia conducted a longitudinal study and identified parental perceptions of the environment as being a determinant of AT to/from school (Hume et al., 2009). However, they found a positive relationship between social cohesion and AT to/from school, while no such association was observed in the current investigation. Differences in sampling may have lead to dissimilar findings. Although the QLSCD used a large population-based sample, Hume et al. (2009) used a small convenience sample.

Two recently published literature reviews have identified correlates of AT to/from school (Davison et al., 2008; Pont et al., 2009). Although previous studies have shown insufficient income as being a correlate of AT to/from school, these investigations used a cross-sectional study design (Chillon et al., 2009; Clifton and Kreamer-Fults, 2007; Larsen et al., 2009; Pabayo and Gauvin, 2008). This study provides evidence that social inequalities persist among children who use AT to/from school as they age. More specifically, children who are from deprived backgrounds are more likely to use AT to/from school and thus more likely to be exposed to neighborhoods not optimal for walking, a situation which persists as they age. These findings are consistent with cross-sectional studies that show that children are more likely to be exposed to traffic and therefore face an increased risk of vehicle–pedestrian collisions (Carlin et al., 1997; Posner et al., 2002; Rao et al., 1997; Roberts et al., 1996, 1997). Interventions such as decreasing traffic volume, lowering the speed limit and implementing programs such as walking school buses may lower risk of vehicle–pedestrian collisions.

Results also indicate that the presence of neighborhood decay modified the relationship between household income and AT to/from school. This disproportionate risk of jointly being exposed to dangerous traffic and unsafe neighborhoods among children from poorer socio-economic backgrounds is a manifestation of environmental injustice. These findings are consistent with previous work that show that children from disadvantaged backgrounds are more likely to be exposed to vehicular traffic and therefore more likely to be injured (Carlin et al., 1997; Posner et al., 2002; Rao et al., 1997; Roberts et al., 1996, 1997). This situation may stem from parents with limited income being unable to afford a vehicle and related expenses, i.e., insurance, fuel, and maintenance, thus removing the option to drive their children to/from school. Hence, AT to/from school may be the
only option for most families with a limited income. The resulting paradoxical situation means that children from poorer backgrounds living in deprived neighborhoods are accumulating more physical activity through AT to/from school, but remain at greater risk for injury.

Findings from this study point to a need for public health practitioners and policy makers to develop and implement interventions to protect children who use AT to/from school. These recommendations are especially relevant for low SES neighborhoods because recent studies have indicated that routes within some of these areas are not safe for AT (Kelly et al., 2007; Lovasi et al., 2009; Neckerman et al., 2009). Intervention targets may include traffic reduction, traffic calming techniques, and crime reduction.

The strengths of the current study include the use of an objective measure of neighborhood safety, density of vehicles-collisions, as a determinant of AT to/from school. In addition, this is one of the few longitudinal studies that involves participants followed during the early school years (from kindergarten) and identifies predictors of AT to/from school. Limitations include a large amount of data with missing postal code; and use of a single item measure of mode of transportation to/from school which pools walking and cycling; however, the prevalence of children cycling to/from school in Canada is typically low. Another limitation is the lack of individual-level variables to account for parental car ownership, which the literature indicates is a strong determinant of AT to/from school. Although the proportion of adults on the workforce who drive to work was used as a proxy for an individual level variable, inferences must be cautious as to avoid the ecological fallacy.

In conclusion, this study illustrates how environmental and individual variables influence AT to/from school among children from kindergarten to grade 2. Findings suggest the existence of environmental injustices: children who use active modes of transportation to/from school are more likely to be exposed to harm. Policies and interventions are needed to make routes to school safer not only to promote adoption among children not using AT to/from school but also to protect children who already practice this behavior.

References


