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Investigating Active Transportation to and from School: Identification of Predictors and Health Benefits

par

Roman Pabayo

Secteur de la santé publique

Faculté de médecine

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présentée par :

Roman Pabayo

a été évaluée par un jury composé des personnes suivantes :

Jennifer O'Loughlin
présidente-rapporteuse

Lise Gauvin
directrice de recherche

Tracie A. Barnett
codirectrice

Yan Kestens
membre du jury

Jim Dunn
examinateur externe

Josette Noel
représentant du doyen de la FESP

Résumé

Contexte : Les données probantes rapportées au cours des 20 dernières années indiquent un déclin important de la pratique d'activités physiques. Les chercheurs considèrent que la diminution de l'activité physique est un facteur clé de l'augmentation du surpoids et de l'obésité chez les enfants. Les transport actifs (TA), à savoir les modes de transport non motorisés tels la marche ou le vélo pour aller à l'école ou en revenir, pourraient constituer une opportunité de pratique d'activité physique.

Objective : Cette thèse vise à identifier les déterminants individuels et écologiques du TA et d'en évaluer les retombées de santé possibles. Quatre études visant les objectifs suivants ont été réalisés: (1) Parmi un échantillon d'enfants et d'adolescents québécois, décrire la proportion d'enfants qui utilisent la marche, le transport en commun, le véhicule familial, l'autobus scolaire ou une combinaison de modes de déplacement pour se déplacer vers l'école. (2) Identifier les facteurs associés au TA pour se déplacer vers l'école parmi un échantillon d'enfants et d'adolescents québécois. (3) Parmi des échantillons de jeunes québécois et canadiens, identifier les déterminants individuels et écologiques du TA pour se déplacer vers l'école. (4) Examiner l'association entre le TA pour se déplacer vers l'école et les changements d'indice de masse corporelle (IMC) entre la maternelle et la 2^{e} année du primaire.

Méthodologie : Trois bases de données avec échantillonnage de type populationnel ont été utilisées pour répondre à ces objectifs de recherche, soit l'Enquête Sociale et de Santé auprès des Enfants et Adolescents québécois (ESSEA), l'Étude Longitudinale Nationale des Enfants et des Jeunes du Canada (ELNEJ) l'Étude Longitudinale sur le Développement des Enfants du Québec (ELDEQ). Des analyses statistiques pour données longitudinales ont été appliquées.

Résultats : Les analyses ont mis en lumière quatre résultats importants. 1) Les données de l'ESSEA indiquent que les enfants de 9 ans vivant en milieu urbain et provenant de familles ayant de faibles revenus avaient une probabilité significativement plus élevée d'utiliser le TA pour se déplacer vers l'école. 2) Les données de l'ELNEJ indiquent que certains facteurs sociodémographiques qui changent à travers le temps sont associés à une probabilité plus élevée d'utiliser le TA pour se déplacer vers l'école dont : le fait de vivre

dans un ménage ayant un revenu insuffisant, de vivre dans un ménage avec un seul parent, d'avoir un frère ou une sœur plus âgé/e dans le ménage et de vivre dans un milieu urbain. 3) L'exploitation des données de l'ELDEQ démontre que certaines variables associées à l'utilisation de TA pour se déplacer vers l'école sont le fait d'être un enfant provenant d'un ménage aux revenus insuffisants, de résider dans des quartiers pauvres et de vivre dans des quartiers perçus comme étant moyens, mauvais ou très mauvais pour élever des enfants. Ces résultats suggèrent que les enfants qui sont les moins favorisés sont les plus exposés à des environnements défavorables au TA et donc sont exposés à une forme d'injustice environnementale. 4) Enfin, l'IMC des enfants qui adoptent systématiquement la pratique du TA pour se déplacer vers l'école entre la maternelle à la 2^{e} année du primaire suit une trajectoire plus saine que celle des enfants qui n'ont pas maintenu ce mode de TA.

Conclusion: Bien que l'utilisation du TA pour se déplacer vers l'école puisse s'avérer favorable à la santé des enfants et des jeunes tel que démontré par l'évolution favorable de l'IMC des enfants adoptant cette pratique à plus long terme, la sécurité des routes menant vers l'école doit être améliorée pour permettre aux enfants de bénéficier de retombées positives de cette habitude de vie. Afin d'approfondir les connaissances dans ce domaine, il serait opportun de reproduire ces résultats avec des données issues de mesures de la dangerosité du quartier obtenues par des moyens autres que les questionnaires auto-rapportés de même que des données provenant d'études avec des devis quasi-expérimentaux ou expérimentaux qui ont recours à de grands échantillons représentatifs dans les zones urbaines où le TA pour se rendre et revenir de l'école est le plus probable.

Les mots clés: transport actif vers l'école, marche, cyclisme, injustice environnementale, analyse longitudinale, cohorte populationnelle.

Summary

Rationale: Evidence from the past 20 years points to important secular declines in physical activity. Researchers point to this decline as a factor in the increase in overweight and obesity among children. Active transportation (AT), defined as non-motorized modes of transportation such as walking or cycling to/from school, is one potential opportunity for physical activity. Previous studies have conceptual and methodological shortcomings thus limiting our understanding of the phenomenon.

Objective: The overarching goals of the thesis are to identify individual and ecologic determinants of AT and to evaluate the possible health benefits of AT. Four investigations address the following specific objectives: (1) To describe the proportion of children who walked, used public transit, were driven to school in a school bus or vehicle, or used multiple transportation modes to and from school in a population-based sample of children and adolescents living in Quebec, Canada. (2) To identify correlates of AT to and from school among children and youth in a population-based sample of children and adolescents living in Quebec, Canada. (3) To identify time-varying and time-invariant individual and ecologic determinants of AT to/from school across the school years in population-based samples of Quebec and Canadian children. (4) To examine the relationship between AT to and from school with change in body mass index (BMI) from kindergarten to grade 2 in a population-based sample of Quebec children.

Methods: Three population-based samples of youth were used to address these objectives, including the 1999 Quebec Child and Adolescent Health and Social Survey (QCAHS), the Canadian National Longitudinal Study of Children and Youth (NLSCY), and the Quebec Longitudinal Study of Child Development (QLSCD). Longitudinal analyses techniques were applied.

Results: Analyses show four sets of findings. 1) According to the QCAHS, children who were 9 years old, living in urban areas, and were from low household income families were significantly more likely to use AT to/from school. 2) Findings from the NLSCY study indicated that the time-varying predictors: living in a household with insufficient income, living in a household with only one parent, having an older sibling in the household, and

living in an urban setting were associated with greater likelihood of using AT to/from school. 3) With the use of QLSCD, patterns of AT to/from school across time, were identified including children who were from insufficient income households, and residing in economically deprived neighbourhoods. These results indicate that children who are the most underprivileged and exposed to environments not conducive for AT are those most likely to use AT to/from school suggesting the presence of environmental injustice. 4) Finally, the BMI of children who use AT to/from school consistently from Kindergarten to Grade 2 espoused a more healthy trajectory in comparison to that of children who did not use sustained AT to/from school.

Conclusion: Although AT to/from school may prove to be favourable to the health of children, as manifested through healthful changes in BMI across time, routes to school need to be safe in order for all children to benefit from this behaviour. Replication studies that use measures of neighbourhood dangerosity that go beyond self-report, natural experiments, and inclusion of large representative samples from urban areas are needed.

Key Words: active transportation to/from school, walking, cycling, environmental injustice, longitudinal analysis, population based cohorts.

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LIST OF ABBREVIATIONS

AT	Active Transportation
BMI	Body Mass Index
CI	Confidence Interval
ICC	Intraclass correlation coefficient
OR	Odds Ratio
SEP	Socioeconomic Position
SES	Socioeconomic Status

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Introduction

1.1 Importance of physical activity among children and youth

Physical activity is important for healthy growth and development during childhood and adolescence.[1] Regular physical activity contributes to the development of cardiovascular fitness, strength, flexibility, and bone density.[2] Physical activity during adolescence is essential for bone development since 35-40% of total bone mass is established during adolescence.[3] Moreover, physical activity helps maintain a healthy body weight, and is associated with positive self-esteem, improved academic and cognitive performance, and greater perceived well-being.[4, 5] Physical activity also helps to reduce risk factors for chronic illnesses and conditions later in life such as overweight and stress by establishing positive health behaviors early in childhood and adolescence.[5, 6] Physical activity behavior in childhood and adolescence tracks into adulthood.[7]

1.2 Declining trends in physical activity and the increase in prevalence of overweight and obesity

According to the Canadian Community Health Survey (CCHS), wherein height and weight of respondents were measured, the prevalence of obesity has increased from 3% in 1978/79 to 8% in 2004, corresponding to an estimated 500,000 obese Canadian children aged 5 to 11 years.[8] Among adolescents aged 12 to 17 years, the prevalence of overweight/obesity doubled from 14% to 29% while the prevalence of obesity alone has tripled from 3% to 9% over the span of 25 years.[8] More recently, the Canadian Health Measures Survey has indicated that between 1981 and 2007-2009, the percentage of children aged 15 to 19 years who were classified as being overweight or obese has risen from 14% to 31% among boys, and from 14% to 25% among girls.[9] Secular trends of declining physical activity among

youth over the past 20 years[10, 11] may underlie the recent increased prevalence of overweight and obesity among youth in developed nations.[12] Excess adipose tissue in children increases the risk of cardiovascular disease and diabetes in adulthood.[13] Also, children who are overweight or obese are more likely to experience low self-esteem due to social stigma.[14, 15] In turn, children who are overweight or obese are more likely to be physically inactive, making obesity an inescapable health condition.[16]

1.3 Causes of decline in physical activity across time

The many technological advances that arrived with the modern industrial era have brought about substantial lifestyle changes. Researchers have argued that changes in the environment have resulted in changes in dietary and physical activity behaviours.[17] Time spent on daily activities such as cooking, cleaning, making repairs, and childcare have decreased due to inventions and services created to make life more convenient.[17] This has led to an increase of an average of 4.9 hours for women and 4.7 hours for men per week in "free time" that can be used for work or leisure. [17] People make decisions about how to spend their leisure time. Pursuits that are typically sedentary and involve little energy expenditure, such as watching television and using computers, compete with alternatives involving more energy expenditure.[17] This phenomenon has also affected children. This has resulted in observed trends of increasing sedentary behaviour among children and adolescents.[18, 19] These trends have affected not just their own behaviour but those of others who these individuals interact with, such as family members and friends. Parents' reduced physical activity and increased sedentary behaviour have had influential consequences on their children.[20] This may explain in part the secular declines in physical activity among youth.

1.4 The need for increasing opportunities for physical activity

Due to declining physical activity levels among youth, public health researchers argue that increased opportunities for youth to be physically active are needed.[7, 21] An opportunity is defined as a combination of favorable circumstances or situations that arise and therefore present a possibility for one to be physically active.[22] For example, the recess break at school may provide time, space, and playground equipment so that children can be physically active. Commuting to and from school is another opportunity for physical activity. Active transportation (AT) involves being physically active, such that energy is expended, while commuting from one place to another. This contrasts with passive transportation where little or no energy is expended. AT, such as walking, bicycling, skateboarding, or transporting by other non-motorized vehicles to and from school, represents an ideal opportunity for children to be physically active[23, 24] because it is affordable, easy, and most children need to travel to and from school. AT to/from school can be incorporated into daily routines and can supplement other leisure time and school-based physical activity in order to meet the Health Canada's guideline for moderate to vigorous physical activity of 90 minutes per day.[25] In order to increase overall levels of physical activity in youth, investigation of the determinants associated with AT is warranted.

Literature Review

In order to position the contribution of this thesis to the current knowledge base, this section provides a rationale for the study of active transportation to/from school, an exhaustive review of all studies (up to March 2010) in the literature that examine AT to/from school as both an outcome and a predictor, and addresses methodological shortcomings in existing studies. This review includes seven subsections. The first section defines physical activity and active transportation as well as how physical activity is distinguished from other related terms such as exercise and physical fitness. In the second section, the prevalence and patterns of AT to/from school across different industrialized nations are described. The correlates and patterns of AT to/from school are used as a guide in the selection of covariates and control variables to include in the analyses for the first, second, and third articles. In the third section, empirical evidence on the relationship between AT to/from school and health outcomes is outlined. The predictors identified in the literature are used as a guide to select those for the analyses performed in the fourth article. In the fourth section, theoretical frameworks that have been developed to illustrate the relationship between predictors and AT to/from school are presented. In the fifth section, measurement issues regarding AT to/from school are discussed. In the sixth, the relationship between socioeconomic position and health are explored. In the seventh, the role of socioeconomic position in AT to/from school will be described. The review is followed by a summary and statement of the rationale for the thesis and then by statements of thesis goals and structure.

2.1 Definitions of physical activity and Active Transportation

Physical activity, and related terms such as *exercise* and *physical fitness* are often used interchangeably, even though they represent different concepts. *Physical activity* has been defined as "any bodily movement produced by skeletal muscles that results in energy expenditure".[26] Physical activity is also cast as a type of health behavior because outcomes of physical activity include increased energy expenditure and elevated cardio-respiratory function. *Exercise* is a specific type of physical activity that is planned, structured, and repetitive bodily movement done to maintain one or more components of physical fitness. It may be seen as purposeful and volitional.[26] Physical *fitness* is a set of characteristics including cardiorespiratory endurance, muscular strength, muscle definition, body composition, and flexibility or related skills such as balance, speed, power, and coordination, that relate to the ability to perform physical activities.[26] Improved *physical fitness* may result from chronic physical activity and/or exercise. Although physical activity and physical fitness are related, some researchers have suggested that fitness, and not physical activity may be genetically determined, and that physical activity may be a more important factor in decreasing the risk of Cardiovascular disease (CVD) than physical fitness.[27, 28] *Active Transportation* (AT) is a form of physical activity and is defined as non-motorized commuting wherein energy is being expended, typically described by walking or bicycling.

2.2 Prevalence and patterns of AT to/from school

Search Strategy

In order to determine prevalence, patterns and correlates of AT to/from school, the following databases were used to search for articles: HEALTHSTAR, MEDLINE, Geography, Engineering, and PsychInfo. A total of 54 studies, including 53 cross-sectional and one longitudinal, were identified with the following search criteria: 1) Article topics had to be about students *walking to and from school*. Derivatives of *walking to school*, such as *active transportation to school, bicycling to school,* were also included as search terms. 2) Studies had to include AT to school as an outcome variable.

Of the 53 cross-sectional studies that investigated correlates of AT to/from school, 11 included large, population-based and representative samples of the study populations and selected for review.[29-39] The 11 studies were published between 1999-2010, which comprised of sample sizes ranging from 662 to 29,836, and were conducted across different countries and jurisdictions. **Appendix-1** summarizes these 11 published studies, and focuses on estimates of the proportion of students who use AT to and from school. For each study, a description of the population, the methods, and the main findings, are presented. Seven studies were representative of a nation and the remaining 4 were representative of a state or province. Two studies limited the sample to students living less than a mile away from school.[30, 39]

All of these studies were conducted in the United States and Australia, with the exception of one study conducted in Canada and one in Russia. When restricting studies to developed

and high-income nations (thus eliminating studies from Russia), estimates of the proportion of students who use AT to and from school ranged from 4% to 40%.[29-33, 35-39] Furthermore, selected studies show that AT to and from school has been decreasing in recent years.[36, 37] In a repeat cross-sectional study in New South Wales, the proportion of students aged 5-9 years that walked to school declined from 58% in 1971 to 26% in 1999-2003.[37] Similarly in the United States, repeated population-based, cross-sectional surveys showed a decrease in the proportion of students who walked or biked to school from 41% in 1969 to 13% in 2001.[30] In another US repeated cross-sectional study conducted in 1969, 87.0% of students who lived less than 1.0 mile from school used AT to/from school whereas in 2001, 62.5% of students walked or bicycled to and from school.[39] Selected authors have suggested that reversing this trend may be an essential step in decreasing the prevalence of overweight and obesity among children and adolescents.[37, 40, 41]

Overall, the prevalence studies indicate that a large proportion of youth are not using AT to/from school and are therefore not benefiting from an accessible and easy way to be physically active. The proportion of students who use AT to/from school has been declining in the last 30 years. Researchers argue that increased car use is the main factor for the decline in AT to/from school because as AT to/from school declined, car use to/from school has increased.[37, 39] In Australia, the estimated percentage of children aged 5-9 who were driven to school by car was 22.8, 37.3, 53.9, and 66.6 in 1971, 1981, 1991, and 1999-2003, respectively.[37] Similarly, in the US, the percentage of students who traveled by automobile increased from 16.3% in 1969 to nearly half (46.2%) in 2001.[39] The increased distance to school from home may be a reason for this increased trend in car use to/from school and a decrease in AT to/from school.[42] One report indicated that it has

become difficult for school boards to find affordable land in established urban or rapidly growing suburban communities. Instead, the land is often located on the fringe of the community where land is more affordable but with very few students within walking distance.[43] A change in perception of neighbourhood safety may also be linked to the use of the car to/from school. Perceived negative neighbourhood safety has been associated with decreased odds in using AT to/from school.[44-46] It is possible that parental perception of neighbourhood safety could have changed from positive to negative in recent years. This change could have lead to a decrease in parents allowing their children to use AT to/from school leading to a subsequent increase in car use.

More research is needed in order to gain a better understanding of what modifiable factors influence the adoption and maintenance of AT. By doing so, interventions and policies can be developed and implemented in order to promote AT to/from school and increase overall levels of physical activity, ultimately reducing the future burden of disease.

The correlates of AT to/from school of each of the 53 studies were identified and described in **Appendix-2.** For each study, the location, a description of the study population, the methods, and the main findings are presented. Most of the investigations were conducted in Australia or the United States. Almost all studies comprise a cross-sectional study design, with the exception of one that was qualitative and one that was prospective. The area of research is still relatively new and most studies are exploratory in nature, focusing mostly on socio-demographic correlates of AT to/from school. Nevertheless, there is some knowledge about the correlates of active transportation to/from school. Findings regarding the basic socio-demographic characteristics such as age, sex, and SEP have been inconsistent. Some studies report that younger children are more likely to walk to and from

school,[29, 38, 47, 48] while others indicate that older children are more likely to walk to school.[32, 35, 49-51] Similarly, boys are generally more likely to walk to school than girls,[29, 47-49, 52-54] but not always.[32, 55] Several studies suggest that children from lower socio-economic backgrounds are more likely to walk to and from school[29, 30, 45, 48, 52, 56-64] while others show no significant differences.[31, 61, 65-67] These inconsistent findings may be due to differences in study location, measurement or inclusion of covariates, measurement of the outcome, and study populations.

Consistent findings have emerged concerning the relationship between various covariates and active transportation to and from school. Students who live close to school, for example living within 1 mile (1.6 km) of a school, are consistently more likely to use active transportation modes to and from school in comparison to those who live further away.[36, 45, 48-52, 54, 60, 63-65, 68-77] Similarly, students who live in urban areas are more likely to use active modes in comparison to those living in rural regions.[29, 30, 47, 52, 71, 74, 77] Family ownership of a car is consistently negatively associated with active modes of transportation to and from school.[48, 51, 53, 55, 60, 64, 68, 72, 75, 76] Children attending private or independent school are less likely to use AT to/from school.[49, 78] Neighborhood perception of safety is generally positively associated with AT to/from school.[25, 44, 45, 49, 65, 66, 76, 79]

Additional factors have been identified as being associated with AT to/from school but have not been studied as routinely as the covariates already mentioned. Being of poorer health status, operationalized as being overweight or obese, is negatively associated with AT to school.[61] Similarly, parents of children with asthma reported child's respiratory condition and concerns about pollution as important factors underlying the decision to reject AT to/from school.[80] Being without a companion to commute to/from school was also inversely associated with AT to school.[75, 81] Children of parents who had themselves

walked to school or who believed that physical activity was important were more likely to use AT to/from school.[73] Students whose routes to school had no lights at crossings and steep roads were not likely to use AT.[67] Youths who lived in neighborhoods with high street connectedness were more likely to use AT to/from school.[82] Other features of the built environment have also been shown to be significantly associated with AT to/from school, including the presence of sidewalks and trees, and a high density of roads. [46, 54, 63, 64] Findings from the only longitudinal study to date conducted in this field indicate that children whose parents reported that their child had many friends in their area were more than twice as likely to increase their active commuting over two years in comparison to other children. [83] Among adolescents, those whose parents reported that there were no traffic lights at crossings available were significantly less likely to increase their AT to/from school in comparison to others.[83] Finally, certain ethnic groups, such as being of Hispanic or African-American background, have been shown to be significantly more likely to use AT to/from school.[58, 63, 79, 84]

2.3 AT to/from School and Health Outcomes

The relationship between AT to/from school and a range of health outcomes have been investigated.[85] Body mass index (BMI), physical activity, and cardiovascular fitness are examples of health outcomes commonly reported in this literature with walking to and from school being implicated in the prevention of excess weight gain.[41, 85] A description of the studies and the findings can be found in **Appendix-3**.

Current research indicates that children and adolescents who walk or bicycle to school participate more in leisure physical activity and are more likely to meet physical activity recommendations in comparison to children and adolescents who do not walk of bicycle to

school.[86-90] These patterns remain when physical activity is measured by parent-report,[86] self-report[89, 90], and when estimated with accelerometers.[87, 88] Furthermore, this relationship is found among elementary school children[86-88] and secondary school adolescents.[86, 90] In another study, it was observed that children and adolescents who cycled to school were more likely to have higher cardiovascular fitness in comparison to children who walked or used motorized transport.[91]

A study among Filipino adolescents indicated that the difference in energy expended due to active transportation to and from school translated to an energy expenditure of 8840 kcal/year for males, and 6640 kcal/year for females. This resulted in a potential weight reduction benefit of 2 to 3 lbs/year in comparison to adolescents who did not use active modes of transportation.[92] Limited data exist to describe the relationship between AT to school and a measure of overweight and obesity, such as BMI. Of the few studies conducted, results are inconsistent. One cross-sectional study was conducted among a national sample of boys and girls in grades 4 through 12 to examine the characteristics of children who use AT to/from school; no significant association between AT to and from school and weight status was observed.[66] In another cross-sectional study of 14-year-old adolescents in Germany, there was no association between using AT to and from school and fat mass or BMI; however, among those using AT to and from school, fat mass decreases as distance from school increased.[90] There are only three longitudinal studies that investigated the relationship between AT to/from school and indicators of weight status. In a cohort of youths aged 9 to 11 years attending eight rural Nebraska schools, researchers, somewhat counter intuitively, observed a positive relationship between involvement in AT to and from school and BMI but no association between and AT and body fat (BF) estimated with skinfold measurements.[23] In contrast, another group of researchers did not

observe a significant relationship between AT and changes in adiposity (body fat) over time, despite the presence of a significant negative cross-sectional association AT to and from school and both BMI and skinfolds among boys.[41] Moreover, results from a three year longitudinal study indicated a non significant relationship between AT to/from school and weight status among Portuguese students aged 11-16 years.[93]

Few studies have investigated the effect of AT on weight status among youth. Longitudinal studies involving large population-based samples are needed to better understand this relationship. No studies have investigated AT and weight status among children in the early school years.

The literature mostly comprises studies that use an exploratory cross-sectional design to identify factors correlated with AT to/from school **(Appendix-2)**. Exploratory studies are ones that seek out novel or alternative associations but offer little conceptual modeling. The dominance of exploratory studies is most likely due to the emergent nature of this topic of research. Nonetheless there have been some studies that are cast within a conceptual framework, such as the social-ecological model. For example, some researchers tested the hypothesis that the neighbourhood environment was an important factor influencing AT to/from school. One study investigated perceived neighborhood safety as a main exposure on the influence on AT while controlling for maternal education.[44] Another study identified the importance of characteristics of the built environment, such as busy and steep roads and the presence of lights at crossings, while controlling for gender and maternal education.[67] To advance this field of research, studies with a stronger conceptual basis and more rigorous designs are needed.

2.4 Diversity and quality of measurement of AT to/from school

All of the studies in the literature use self-report or parent-reported assessment tools to measure which modes of transportation to and from school are used by youths. The questions used vary across studies. There are strengths and weaknesses of the questions that can affect the inferences drawn from these studies. These issues are addressed in the following paragraphs.

Diversity in measuring active transportation

Diversity in measuring transportation modes to and from school presents a challenge when comparing results and can affect the robustness of inferences drawn from these studies. The mode of transportation used to travel to and from school is sometimes reported jointly,[29, 37, 57, 67, 71, 81] or as distinct events.[36, 49, 72, 73] Researchers who use the latter argue that there are different factors that influence travel to and travel from school and that each outcome should be investigated separately. [36, 49, 72, 73]

Another source of heterogeneity of measurement is the time period referenced over which students are asked to recall their travel to and from school. Some studies ask participants to recall their mode of transportation to and from school during a specific period. For example, "During the past week, how many times did you walk to school?" Other studies asked a more general question such as, "How do you usually travel to and from school?" Some studies ask students to self-report their mode of transportation,[44, 59, 70, 94] while others used parent-reported measures of their child's mode of transportation to and from school.[36, 49, 81] The lack of consistency of measurement of the outcome is indicative of the lack of

tools to assess transportation modes to and from school whose validity and reliability have been empirically supported.

Reliability and Validity

There is a lack of precise, well-validated measures of physical activity behavior and activity related energy expenditure for youth, i.e. absence of "A gold standard," which is a serious impediment to research in this area.[95] This lack of validated and reliable assessment tools also applies to the measurement of active transportation to and from school, with most studies providing no psychometric data on their outcome. Without full knowledge of the reliability and validity of these assessment tools, the ability to appreciate the potential for information bias is limited.

Nevertheless, some studies do provide some information on the reliability of their measures. For example, Kerr et al.[96] indicated that the intraclass correlation (ICC) of their measure was between 0.7 and 0.8, suggesting that most of the variability was between persons rather than within persons (a large proportion of within person variance would suggest lack of reliability of assessments within persons). Carver et al.[44] indicated that the ICCs of their measure of walking and cycling to school were 0.86 and 0.71, respectively. Evenson et al.[97] examined test-retest reliability among 54 children aged 8 to 11 years on 2 consecutive school days. Test-retest reliability of the daily survey indicated almost perfect agreement (98.1%) and the kappa coefficient was 0.96 (95% CI=0.90, 1.00). There has been one study conducted that investigated the validity of the assessment tools. Evenson et al.[97] assessed criterion validity among 26 children by comparing the parental report with the child's report on AT to and from school resulting in a kappa of 0.80 (95% CI=0.71, 0.89) and a mean percent agreement of 88.4%. While the evidence to date is reassuring,

establishing the psychometric soundness of current measures would benefit this area of research greatly.

2.5 Socioeconomic position and health

Social determinants of health refer to both specific features of and pathways by which societal conditions affect health. Potentially, these conditions can be altered by concerted action. [98] They have also been defined as "the socially derived economic factors that influence what positions individuals or groups hold within the multiple-stratified structure of a society".[99] Major chronic diseases, such as cardiovascular disease and type II diabetes are determined by specific exposures to these features and factors, which are a result of social, economic, and political forces.[100-102] The term social determinants of health evolved from the quest to identify specific exposures by which members of different socioeconomic groups come to experience varying degrees of health and illness.

Socioeconomic position (SEP) is an aggregate concept that includes both resource-based and prestige-based measures, as linked to both childhood and adulthood social class position.[98] Resource-based measures refer to material and social resources and assets, including income, wealth, and education.[98] Prestige-based measures refer to individuals' rank or social position in a social hierarchy, usually evaluated with reference to people's access to and consumption of goods, services, and knowledge, as linked to their occupational income, and educational level.[98] There exists a ranked hierarchy whereby higher SEP individuals have better access to resources and opportunities in comparison to lower SEP individuals. There is a well-established relationship between SEP of individuals and populations and their health.[103] People from lower SEP backgrounds are more likely to

have adopted harmful health behaviors such as smoking, being physically inactive, and eating an unhealthy diet,[104] experience worse health conditions such as being overweight and obesity,[105, 106] and are at higher risk for cardiovascular disease and diabetes[101] in comparison to individuals of higher SEP. Some researchers argue that the higher in SEP an individual is, the more power or more resources that individual has, which leads to greater access to health services and health promotion resources.[98] People from higher SEP have more opportunities to be physically active.[107] They can purchase gym memberships, sports' equipment, and other resources that increase the likelihood of being physically active. SEP is an extremely important factor in explaining variability in levels of physical activity.

2.6 Investigating the role of SEP in AT to/from school

Although research has indicated that SEP is related to health, whereby individuals from higher SEP backgrounds are more likely to adopt health-enhancing behaviors and experience positive health outcomes, AT to and from school is a rare example where the reverse association is observed. The large majority of studies indicate that children from lower SEP backgrounds are more likely to use active modes of transportation to and from school. [29, 30, 45, 48, 52, 56-64] There are only a few other health outcomes, such as breast cancer and prostrate cancer, where people from lower SEP are statistically favoured.[108, 109] However, a greater understanding of the contextual factors involved would suggest that this apparent advantage is not entirely favorable. People from lower SEP backgrounds are more likely to live in neighborhoods that are unsafe; thus crime and vehicle-pedestrian collision rates are generally higher in neighborhoods where people from lower SEP backgrounds live.[110, 111] As a result, AT may not benefit all students equally and in fact might expose some children to greater risks (e.g., collisions with motor vehicles). This paradox requires further study in order to better understand how contextual characteristics such as

neighborhood safety influence the SEP-AT association, and to inform appropriate health promotion strategies for increasing AT to school.

2.7 Theoretical Frameworks describing the predictors of AT to and from school

Theoretical frameworks have been proposed in the literature to help conceptualize the predictors of AT to/from school. These include the social-ecological model, McMillan framework, and the Ecological and cognitive active commuting framework.

Social-ecological model: The social-ecological model has been used to conceptualize the relationship between the built environment and physical activity behaviour.[42, 112] This model proposes that behaviour is influenced by variables linked to several layers, ranging from the individual level psychosocial variables, such as attitudes and beliefs, through to community-level variables, such as characteristics of the built environment, and policy-level variables, such as school busing policies and school locations. However, this model does not allow for an intricate statement of hypotheses which might outline how variables at different levels of influence interact with one another to produce behaviours and health outcomes.[42]

McMillan framework: This framework was developed specifically for AT and assumes that younger children play a lesser part in the decision-making process because it is parents who decide whether or not their child uses AT to/from school thus restricting this model's applicability to children in elementary school. **(Appendix-4)**.[42, 113] However, it incorporates only the built environment as the main predictor influencing AT to/from school and ignores other layers of influence such as municipal or school policy. Children attending elementary

schools generally attend schools that are within reasonable walking distance to their homes and therefore are more likely to use AT to/from schools in comparison to older children attending junior high or secondary schools.[42, 113] According to this framework, the built environment has an indirect relationship with the parents' decision to allow their child to walk to/from school. Parents are thought to process the characteristics of the built environment within the context of their perceptions, beliefs, and attitudes. These are then linked directly to the parents' decisions to allow their children to use AT.[42, 113] Effect modifiers interact with intra-psychological mediating variables to produce the parents' final decision about allowing their child to walk or bicycle to school. McMillan lists socio-demographic variables such as age, gender, number of children as a possible effect modifiers.[42, 113]

Ecological and cognitive active commuting (ECAC) framework: Experts in urban planning, transportation, and physical activity fields developed a framework that incorporates aspects of the social-ecological model and the McMillan framework **(Appendix-5)**.[42, 114] Similar to the McMillan framework, this model applies to children attending elementary school because younger children attend schools that have smaller catchment areas and therefore the distance to school is more feasible for active transportation. The ECAC framework takes into account variables at different levels of influence including policy, neighbourhood, and parent/family level variables.[42] Socio-demographic factors such as age, gender, and socio-economic status would modify parents' decision about allowing children to use AT to and from school.[42, 114] Policy decisions at the school, local, state/provincial, or federal levels will have an indirect effect on AT to/from school through infrastructure projects to support increased pedestrian traffic (physical environment), additional funding for increased crime prevention measures (social context), or federal funds to support local

school initiatives to promote walking to school (physical and/or social environment). Similar to the McMillan framework, the ECAC framework specifies an indirect relationship of environmental factors with the parents' decision. Objective assessments of the physical and social environments are filtered through the parents' perceptions. In turn, parents combine these perceptions with attitudes and beliefs of social norms, and discerned support (psychological mediators) regarding their child walking to school. The child's input, i.e. whether or not s/he likes walking to school, the child's perceptions of the physical environment and social context, and potentially other sources of information also influence a parent's decision to allow their child to use AT to/from school. Resources available to the family (number of vehicles, work schedules, time) may interact with the parents' perception of their environment or change their attitudes or beliefs (psychosocial mediators).[42, 114] Theoretically, an increased frequency of AT to school can lead to a positive change in physical activity, an increase in energy expenditure, which may lead to a decrease in BMI and can have an influence on other health outcomes.[42]

2.8 Context of the thesis within the conceptual framework

For this thesis, the ECAC, previously described, was used as a foundation. It was used as a guide to select the relationships to be examined more closely and to illustrate where these relationships fit with respect to each other and in the larger framework.

According to the ECAC, socio-demographic factors such as age, gender, and socio-economic-status would modify parents' decision to allow their children to use AT to/from school. An attempt to authenticate this part of the framework was made by determining if there were significant associations between socio-demographic factors and AT to/from

school both cross-sectionally and longitudinally. Based on the ECAC, it is conceptualized that older children are less likely to use AT to/from school. It is hypothesized that as children age, the likelihood of using AT to/from school declines. This decline would most likely occur after elementary school because the catchments areas of junior high and secondary schools are larger and the use of AT to/from school becomes impracticable. Therefore, distinct patterns of AT to/from school are expected as children are followed throughout the school years.

Important features of the ECAC are the physical and social environmental factors that potentially influence AT to/from school.[42] Neighbourhood safety and distance to school are examples of such area characteristics that were identified as possible predictors of AT to.from school within this thesis. The ECAC framework also identifies AT to/from school as potentially providing health benefits for school-aged children; part of this thesis will focus on this theory, and more specifically, on the role of AT to/from school as a determinant of a healthy BMI.

Summary statement, rationale, and thesis goals

Existing reports show that uptake of AT to/from school is low and could be substantially increased. Cross-sectional studies identify numerous environmental and social factors associated with AT to and from school. However, only one longitudinal study investigating the determinants of AT and a few longitudinal studies identifying the health benefits of AT to and from school among students have been conducted. In particular, most studies that explore the relationship between AT to and from school with physical activity or BMI have been cross-sectional, limiting our ability to address the temporality of effects. Few studies are couched within conceptual models. This current thesis will add to the knowledge base

by replicating existing findings, by extending these findings through the exploitation of longitudinal data sets that are population-based and representative, and by conducting analyses that describes how time-varying and time-invariant individual and ecologic determinants influence AT among children living in an industrialized nation. This study will test aspects of the ECAC model by conducting analyses with variables at different levels of influence, such as the neighbourhood and the parent/family, and their influence on AT to/from school. Also, the possible effect modification of neighbourhood level characteristics on the relationship between socioeconomic status and AT to/from school will be tested.

For this thesis, the ECAC framework, previously described, was used to contextualize the statistical modeling and analyses of each article **(Appendix-5)**. Both papers 1 and 2 attempt to show that age is an important factor of AT to/from school. Using a cross-sectional sample, paper 1 will describe the proportion of children who use AT to/from school stratified by distinct age groups. The second paper uses longitudinal analysis in the same cohort of children to illustrate the patterns of likelihood of using AT as they age. Other socio-demographic factors such as sex, SES, and maternal immigrant status will also be tested as possible significant covariates of AT to/from school.

Analyses examining the different levels of influence reflected by the neighbourhood and parent/family levels, were addressed in article 3. Mother's perception of neighbourhood quality, social cohesion, and neighbourhood decay were used to assess how the mother felt about their residential neighbourhood. These environmental measures were used to determine if perceptions of the neighbourhood were significantly associated with AT to/from school above the socio-demographic measures. Although some indicators of the

residential neighbourhood were measured, other important factors identified in the ECAC were not available. Since postal codes of the students' residents and their school were obtained, other databases were used in order to obtain missing information. For example, since the ECAC elucidates that car ownership may directly affect AT to/from school behaviour; a proxy measure of accessibility to a vehicle was obtained based on the proportion of adults who drive to work within the student's area of residence, using information from the 2006 Canada Long-Format Census. Rate of vehicle-pedestrian collisions within a child's residential neighbourhood was also obtained from an external source and included in this analysis.

The last article addresses the section of the ECAC that has AT to/from school as a precursor of health outcomes. More specifically for this thesis, sustained use of AT to/from school over three years was tested as a predictor of favourable BMI.

The ECAC has been used as the foundation for my research. The four articles comprising this thesis will attempt to address specific parts of the ECAC **(Appendix-5)**. Although not all of the ECAC will be tested, an examination of the remaining gaps will be presented in the discussion.

The overarching goals of this doctoral thesis are to identify individual and ecologic determinants of AT among children living in an industrialized nation and to evaluate the possible health benefits of AT. In order to accomplish these goals, secondary analyses were undertaken in already existing large population-based datasets. Thesis findings will also provide insight on the paradoxical relationship between SEP and AT.

In order to meet these overarching goals, four separate investigations were conducted that address the following specific objectives:

1) To describe the proportion of children who walked, used public transit, were driven to school in a school bus or vehicle, or used multiple transportation modes to and from school in a population-based sample of children and adolescents living in Quebec, Canada. (article 1)
2) To identify correlates of AT to and from school among children and youth in a population-based sample of children and adolescents living in Quebec, Canada. (article 1)
3) To identify time-varying and time-invariant individual and ecologic determinants of AT to/from school across the school years in population-based samples of Quebec and Canadian children. (articles 2 & 3)
4) To examine the relationship between AT to and from school with change in BMI from kindergarten to grade 2 in a population-based sample of Quebec children. (article 3)

Structure of the thesis

The first manuscript entitled "Proportions of students who use various modes of transportation to and from school in a representative population-based sample of children and adolescents, 1999" has been published in the journal *Preventive Medicine* (Pabayo & Gauvin 2008). This study helped to determine if the variables identified as being significant correlates with AT to/from school within the literature are also predictors of AT within a

large population-based, representative sample of Quebec children, participating in the Quebec Child and Adolescent Health and Social Survey (QCAHS). This study set the foundation for two longitudinal analyses identifying predictors of AT to/from school. The second manuscript is entitled "Identifying determinants of active transportation to/from school among children participating in the Canadian National Longitudinal Study of Children and Youth" and has been submitted to the *Pediatrics*. The third manuscript is titled "Understanding the determinants of active transportation to school among children: evidence of environmental injustice from the Quebec Longitudinal Study of Child Development" and has been submitted to *Health and Place*. Longitudinal analysis was conducted using the Quebec Longitudinal Study of Childhood Development (QLSCD). In the last article, titled "Sustained Active Transportation is associated with a favorable body mass index trajectory across the early school years: Findings from the Quebec Longitudinal Study of Child Development birth cohort" and published in *Preventive Medicine* (Pabayo et al., 2010), the possible health benefits from using AT to/from school were explored by again using the QLSCD. A brief overview of main findings, a discussion that synthesizes all four articles, strengths and limitations of the studies, possible public health implications, future directions for research, and concluding remarks are presented after the four manuscripts.

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ARTICLE 1

Proportions of students who use various modes of transportation to and from school in a representative population-based sample of children and adolescents, 1999

Roman Pabayo [1, 2]
Lise Gauvin [1, 2]

[1] Département de médecine sociale et préventive, Université de Montréal, Canada

[2] Centre de rechereche Léa-Roback sur les inégalités sociales de santé de Montréal, Canada

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Title: Proportions of students who use various modes of transportation to and from school in a representative population-based sample of children and adolescents, 1999.

Authors
Roman Pabayo, M.Sc
Faculté de médecine
Groupe de recherche interdisciplinaire en santé and Médecine sociale et préventive,
Université de Montréal

Lise Gauvin, Ph.D
Faculté de médecine
Department of Social & Preventive Medicine, Groupe de recherche interdisciplinaire en santé, and Centre de recherche Léa-Roback sur les inégalités sociales de santé de Montréal,
Université de Montréal

Corresponding Author
Roman Pabayo, M,Sc
Département de médecine sociale et préventive
1420 boul. Mont-Royal
Montréal, Québec
H2V 4P3

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Abstract:

Objective: The purposes of this study were to describe the prevalence of modes of transportation to school and to identify socioeconomic correlates.

Methods: Proportions of students using different modes of transportation were estimated among a population-based sample of 3613 youth aged 9, 13, and 16 years who participated in the 1999 Quebec Child and Adolescent Health and Social Survey.

Results: Weighted analyses showed significant differences in the use of different modes of transportation to and from school across socioeconomic groups. For example, 40.3%, 15.2%, and 13.0% of 9, 13, and 16 year olds walked to school. In addition, 1.2%, 11.3%, and 13.8% of 9, 13, and 16 y olds used public transportation whereas 33.1%, 51.2%, and 55.6% of 9, 13, and 16 year olds took the school bus to school; 14.3%, 7.3%, and 5.0% of 9, 13, and 16 y olds were transported by car; finally, 10.7%, 14.1%, and 11.7% of 9, 13, and 16 year olds indicated they used multiple modes of transportation. Girls, higher income children, children of immigrants, and rural-dwelling children were less likely to walk to school. *Conclusion*: Findings indicate that there are differing modes of transportation to and from school across socioeconomic groups.

MeSH Key Words: Walking, physical fitness, child, adolescent, socioeconomic factors, community surveys.

Precis

This population based representative study among 3613 youth aged 9, 13, and 16 indicates that there are two differing profiles of socioeconomic factors that correlate with walking to school behavior.

Introduction

Physical activity is important for health growth and development and can track into adulthood thus resulting in chronic disease prevention (Story et al. 1999; Malina et al. 2004). There are secular trends of declining physical activity among youth (Centers for Disease Control and Prevention 1994; Centers for Disease Control and Prevention 1998a) highlighting the need for opportunities for youth to be more physically active (Barnett et al. 2006, Malina et al., 2004). Active transportation to and from school, such as walking, is one potential opportunity for children to be physically active (Sirard et al. 2005; Heelan et al. 2005) and may contribute to preventing excess weight gain (Rosenberg et al. 2006). Proportions of children walking to and from school range from 4.2% to 25.0% (Sirard et al. 2005; Carlin et al. 1997; Ham et al. 2005; Martin & Carlson 2005; Bricker et al. 2002; Salmon et al. 2005), but only two estimates are based on large population-based studies (Ham et al. 2005; Bricker et al. 2002). Findings have been inconsistent showing that boys are more likely to walk to school in comparison to girls (Merom et al. 2006), but not always (Carlin et al. 1997; Bricker et al. 2002), that younger children are more likely to walk to school (Martin & Carlson 2005), that older children are more likely to walk to school (Merom et al. 2006; Bricker et al. 2002; Ham et al. 2005), that Hispanic and/or Black children are more likely to walk to school (Bricker et al. 2002; McDonald et al. 2007). Unfortunately, little is known about the use of a variety of transportation modes. We therefore describe the proportion of children who walked, used public transit, were driven in a school bus or vehicle, or used multiple transportation modes to and from school. Estimates are stratified by age, sex, 1998 household income, urban versus rural settings, and parents' birthplace.

Methods

Data for this study were from the 1999 Quebec Child and Adolescent Health and Social Survey (QCAHS), which is a representative population-based community survey that sampled 3613 youths in the province of Quebec, Canada aged 9, 13, and 16 years old (Paradis et al., 2003).

Sampling

The QCAHS was a multistage, stratified, cluster sampling survey. The sampling frame consisted of the 1998 to 1999 Quebec Ministry of Education student roll, which contains name, date of birth, home address, and school attended of all students in Quebec. Independent samples were drawn for each age group. Response rates to the student questionnaire among the nine, 13, and 16 year olds were 83.4, 79.2, and 77.6%, and 70.1, 68.8, and 63.7% for the parent questionnaire (Paradis et al, 2003).

Ethics approval was obtained from the ethics committees of the *Direction Santé Québe*c of the *Institut de la statistique du Québec*, the *Ministère de l'éducation du Québec,* and Ste-Justine's Hospital. Signed informed consent was obtained from parents and youths **(Appendix-6).**

Variables

Socioeconomic data included sex, age, 1998 family income in Canadian dollars (CAD), and parents' birthplace. Schools were categorized as being located in an urban area if they were situated in one of Quebec's six Census Metropolitan areas designated by Statistics Canada (http://www.statcan.ca/) and in a rural area otherwise. Students were asked which mode of transportation to and from school they used most often. Response options were: school bus,

walking, public transit, or motor vehicle or multiple modes of transportation. Copies of the questionnaires and data collection forms are available on the website of the *Institut de la statistique du Québec* (http://www.stat.gouv.qc.ca/publications/sante/enfant-ado_pdf.htm#questionnaires).

Data analysis

Estimation of the proportions of participants using different modes of transportation were weighted for design effects (Paradis et al, 2003) and then stratified by age, gender, urban vs. rural setting, 1998 household income, and parents' birthplace. Chi-square tests were performed to test for differences across strata. Multivariate analysis was conducted as well but not included in the published version of the paper. This is presented in **Appendix-7**.

Results

Descriptive statistics for the 3613 students who responded to the survey appear in Table 1. Overall, the sample was evenly divided across age and sex categories. About 60% of respondents lived in urban areas, one quarter had family incomes below $30000 (CAD), and just over 10% were offspring of at least one parent who was born outside of Canada. Use of different modes of transportation to school were as follows: walking=23.3%, using public transit=8.5%, taking school bus=46.2%, driven by motor vehicle=9.0%, or multiple modes =12.1%. Results from the multivariate analysis can be found in **Appendix-7**.

Table 1. Socioeconomic characteristics of youths participating in the 1999 Quebec Child and Adolescent Health and Social Survey, Quebec, Canada.

	Unweighted proportion of study population (n= 3613)	**Weighted proportion of study population (n= 3613)**
Age		
9 years	35.1	35.1
13 years	32.8	32.8
16 years	32.1	32.1
Sex		
Male	49.2	50.7
Female	50.8	49.3
Type of Setting		
Urban	57.1	60.3
Rural	42.9	39.7
1998 Household Income		
<$30,000	25.3	24.5
$30,000 - $60,000	41.7	41.2
>$60,000	33.0	34.3
Birthplace of parents		
Both parents born in Canada	87.6	86.6
One parent born in Canada	5.3	5.7
Both parents born outside Canada	7.0	7.7

Modes of transportation to school were associated with socioeconomic and demographic factors (see Table 2). Higher percentages of nine year olds walked (χ^2=317.10, p=<0.01) or were driven by car (χ^2=70.14, p=0.03) to school in comparison to 13 and 16 year olds. Higher proportions of the two older age groups used public transportation (χ^2=141.38, p<0.01) and took the school bus (χ^2= 142.07, p<0.01) in comparison to 9 year olds. The proportion of thirteen year olds who used multiple modes of transportation was significantly higher (χ^2=7.20, p<0.05) than otherwise. Greater proportions of boys indicated that they walk to school in comparison to girls (χ^2=4.19, p<0.05). The proportions of urban students who walked (χ^2=7.67, p<0.01), take public transportation (χ^2=199.08, p<0.01), and who were driven (χ^2=42.19, p<0.01) were higher in comparison to rural students. Conversely, the proportion of rural students who take the school bus to school (χ^2=178.31, p<0.01) was larger in comparison to urban-dwelling students. The proportion of students who walked to school was significantly higher among those whose income was less than $30,000 ($\chi^2$=45.45, p<0.01). The percentage of students who used public transportation (χ^2=16.48, p<0.01) was significantly lower among the students who had a household income between $30,000 and $60,000 in comparison to the higher and lower groups. The proportion of students who were driven to school was significantly higher among students whose 1998 household income was greater than $60,000 in comparison to lower two income groups (χ^2=55.62, p<0.01). Proportions of students who walked (χ^2=8.02, p=0.03) and took the school bus (χ^2=62.88, p<0.01) were highest among children whose parents were born in Canada in comparison to children who had at least one parent born outside of Canada. Finally, proportions of students who take public transportation (χ^2=99.46, p<0.01), are driven by car (χ^2=26.16, p<0.01), and use multiple modes of transportation (χ^2=10.29,

p<0.01) to school were significantly higher among children whose parents were not born in Canada.

Table 2. Weighted proportions of students, who walked, used public transportation, were driven in a school bus or car, or used multiple modes of transportation to and from school in the 1999 Quebec Child and Adolescent Health and Social Survey, Quebec, Canada.

	Walking		**Public Transportation**		**School Bus**		**Car**		**Multiple modes of transport**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Age, years										
9	**510**	**40.3**	**15**	**1.2**	**419**	**33.1**	**181**	**14.3**	**135**	**10.7**
13	**180**	**15.2**	**134**	**11.3**	**607**	**51.2**	**86**	**7.3**	**168**	**14.1**
16	**151**	**13.0**	**160**	**13.8**	**645**	**55.6**	**58**	**5.0**	**135**	**11.7**
Sex										
Male	**452**	**24.7**	150	8.2	861	47.0	148	8.1	204	11.2
Female	**389**	**21.8**	159	8.9	811	45.5	177	9.9	234	13.1
Setting										
Urban	**542**	**25.0**	**302**	**13.9**	**812**	**37.3**	**251**	**11.5**	260	11.9
Rural	**299**	**20.9**	**7**	**0.5**	**859**	**59.9**	**74**	**5.2**	178	12.4
1998 Household Income (CAD)										
<$30,000	**216**	**30.9**	**63**	**9.1**	321	45.9	**31**	**4.4**	64	9.1
$30,000 to $60,000	**297**	**25.2**	**65**	**5.6**	572	48.6	**85**	**7.2**	146	12.4
>$60,000	**167**	**17.1**	**99**	**10.1**	445	45.4	**139**	**14.2**	124	12.6

Table 2 (Continued). Weighted proportions of students, who walked, used public transportation, were driven in a school bus or car, or used multiple modes of transportation to and from school in the 1999 Quebec Child and Adolescent Health and Social Survey, Quebec, Canada.

	Walking		**Public Transportation**		**School Bus**		**Car**		**Multiple modes of transport**	
	n	**%**	**n**	**%**	**n**		**n**	**%**	**n**	**%**
Birthplace of parents										
Both parents born in Canada	**641**	**24.6**	**163**	**6.3**	**1289**	**49.5**	**205**	**7.9**	**286**	**11.0**
One parent born outside Canada	**30**	**17.8**	**26**	**15.4**	**60**	**35.5**	**27**	**15.7**	**26**	**15.5**
Both parents born outside Canada	**43**	**18.4**	**55**	**23.5**	**57**	**24.4**	**36**	**15.7**	**40**	**17.1**

Numbers in bold represent statistically significant differences across strata as reported in the results section.

Discussion

The purposes of this study were to establish the proportion of children who walked, used public transit, were driven in a school bus or vehicle, or used multiple transportation modes to school, and to identify socioeconomic correlates. We observed that 40.3%, 15.2%, and 13.0% of 9, 13, and 16 year olds walked to school. In comparison, a 2001 American nationwide study showed that 17% of 5-18 year olds walked to or from school at least once during a usual week (Martin & Carlson 2005). Another study using a representative population-based sample in Georgia established the proportion of 5-15 year olds engaging in active commuting to be less than 5% (Bricker et al. 2002). Furthermore, 48.9% and

43.3% of this same sample took the school bus or were driven to school. Although these estimates appear to vary widely, it should be noted that methodologies differed substantially and classification of who walks to school were different. Moreover, estimates from existing studies are pooled across settings differing in urbanization which is likely linked to influential determinants such as of neighborhood safety, availability of public transportation, topography, and climate (Martin & Carlson 2005; Merom et al. 2006).

This study's main strength is that it is a representative population sample, generalizable to Quebec, yielding valid proportion estimates of students using various modes of transportation to school. However, the current study does not account for the travel distance between home and school nor for weather variations across seasons, which are substantial in Quebec. Also, the response options did not include alternative modes of transportation such as cycling, skateboarding, or rollerblading.

The study findings indicate that more systematic observation of modes of transportation to school have relevance for local population surveillance and cross-setting comparisons. Researchers and public health practitioners can determine if target populations are using active modes of transportation to school and establish public health goals for active commuting among youth.

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ARTICLE 2

Identifying determinants of active transportation to/from school among children participating in the Canadian National Longitudinal Study of Children and Youth.

Roman Pabayo

Lise Gauvin

Tracie Barnett

Cet Article sera soumis au Pediatrics.

Title: Identifying determinants of active transportation to/from school among children participating in the Canadian National Longitudinal Study of Children and Youth.

Authors

Roman Pabayo, M.Sc.

Faculté de médecine

CRCHUM (Centre de recherche du Centre Hospitalier de l'Université de Montréal),

Department of Social & Preventive Medicine, and Centre de recherche Léa-Roback sur les inégalités sociales de santé de Montréal, Université de Montréal

Lise Gauvin, Ph.D.

Faculté de médecine

CRCHUM (Centre de recherche du Centre Hospitalier de l'Université de Montréal),

Department of Social & Preventive Medicine, and Centre de recherche Léa-Roback sur les inégalités sociales de santé de Montréal, Université de Montréal

Tracie A. Barnett

Centre de Recherche du CHU Sainte-Justine

Faculté de médecine

Department of Social & Preventive Medicine

Université de Montréal

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Abstract:

Background

Concern has been raised among public health researchers and practitioners regarding the increased prevalence of physical inactivity among children. Active Transportation (AT) such as walking and cycling to/from school is an opportunity for children to be physically active.

Objective

To identify time-varying and time-invariant socio-demographic predictors of AT to/from school among school-aged children participating in the NLSCY.

Methods

The sample included 7848 school-aged children attending public school who were drawn from Cycle 2 (1997/1998) of the Canadian National Longitudinal Study of Children and Youth (NLSCY). Data were collected through structured interviews in the home with the person most knowledgeable about the child's health (the mother for almost 92% of participants). Parents were asked how their child usually gets to school. Responses were dichotomized into active (walking/bicycling) or inactive (school bus, public transit, is driven, or multiple) modes. Using three waves of data from the NLSCY, random effects

models were used to determine the relationships between socio-demographic factors and likelihood of AT to/from school across time.

Results

Longitudinal analyses indicated that as children age, the likelihood of using AT to/from school increases, peaks at age 10 years and then decreases. Urban settings (OR=3.66; 95% CI=3.23,4.15), households with inadequate income (OR=1.21; 95% CI=1.06,1.38), living with one parent (OR=1.46; 95% CI=1.29,1.65), and having at least one older sibling (OR=1.14; 95% CI=1.04,1.25) were significant predictors of AT to/from school.

Conclusion

Studying predictors of AT to/from school provide insight for the development and implementation of interventions designed to increase active travel behaviors.

Key words: Active transportation to/from school, walking, longitudinal analysis, population-based cohort, children and adolescents.

Introduction

Physical activity is needed for healthy growth and development and can track into adulthood thus preventing chronic diseases.[1, 2] Secular trends of declining physical activity among youth[3, 4] highlight the need for opportunities for youth to be more physically active.[2, 5] Active transportation (AT) to/from school, such as walking and cycling, is one potential opportunity for children to be physically active[6-8] and may contribute to preventing excess weight gain.[9, 10]

However, in keeping with population estimates observed for physical activity, the proportions of children using AT to/from school[11-14] have also declined, while concurrent increases in proportions of children being driven in cars[12-14] have been observed. In population-based repeated cross-sectional surveys in Australia, the proportion of children aged 5 to 9 years and 10-14 years walking to school declined from 57.7% and 44.2% respectively in 1971 to 25.6% and 21.1% in 2003.[14] Similarly in the United States, among 5 to 18 year olds, the proportion of children who walked or biked to school declined from 42% in 1969 to 16.2% in 2001.[13] These trends in AT to/from school provide evidence of widespread declines, but little is known about the predictors of AT to/from school across the school years.

Findings from cross-sectional studies indicate that socio-demographic characteristics are correlated with AT to/from school.[15, 16] For example, in comparison to older children, younger children are more likely to use AT to/from school.[11, 17-19] Youth from urban regions[11, 18, 20-23] and children from low socio-economic backgrounds[11, 19-21, 24-26] are consistently more likely to use AT to/from school. Children without commuting companions are significantly less likely to use AT to/from school.[27, 28] This evidence is

derived almost exclusively from cross-sectional studies; longitudinal studies could incorporate repeated assessments of these variables, (i.e. 'time-varying exposures'), thus allowing for a far greater understanding of the nature of their relationship with AT to/from school. For example, by following a group of students throughout the school years, the effect of age in the same sample of children on the likelihood of using AT to/from school can be observed. Patterns can be identified, which can help public health practitioners to target high-risk groups and to implement interventions at more opportune times.

To date, a single longitudinal investigation of the predictors of AT to/from school has been published. In their study comprising 121 children aged 9 years and 188 adolescents aged 14 years at baseline Hume et al.[29] 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 two years in comparison to other children. Adolescents were significantly less likely to increase their AT to/from school at two years follow-up if there were no traffic lights or crossings available, compared to others living in neigbourhoods with these features. While Hume's is the first longitudinal investigation in this area, her findings are of limited generalizability and its applicability to North American children is unknown.

For this analysis, sociodemographic variables will be tested to determine which covariates are associated with AT to/from school. Household income, number of parents in the household, and living in an urban setting will be tested as time-varying covariates because they were measured at repeated time-points during follow-up. Mother's immigrant status and the sex of the child were measured once at baseline and will be tested as time-invariant covariates. Therefore, the main objective of this study is to gain a better understanding of how sociodemographic variables influence AT to/from school as children age throughout

the school years among students participating in a national representative population-based cohort study.

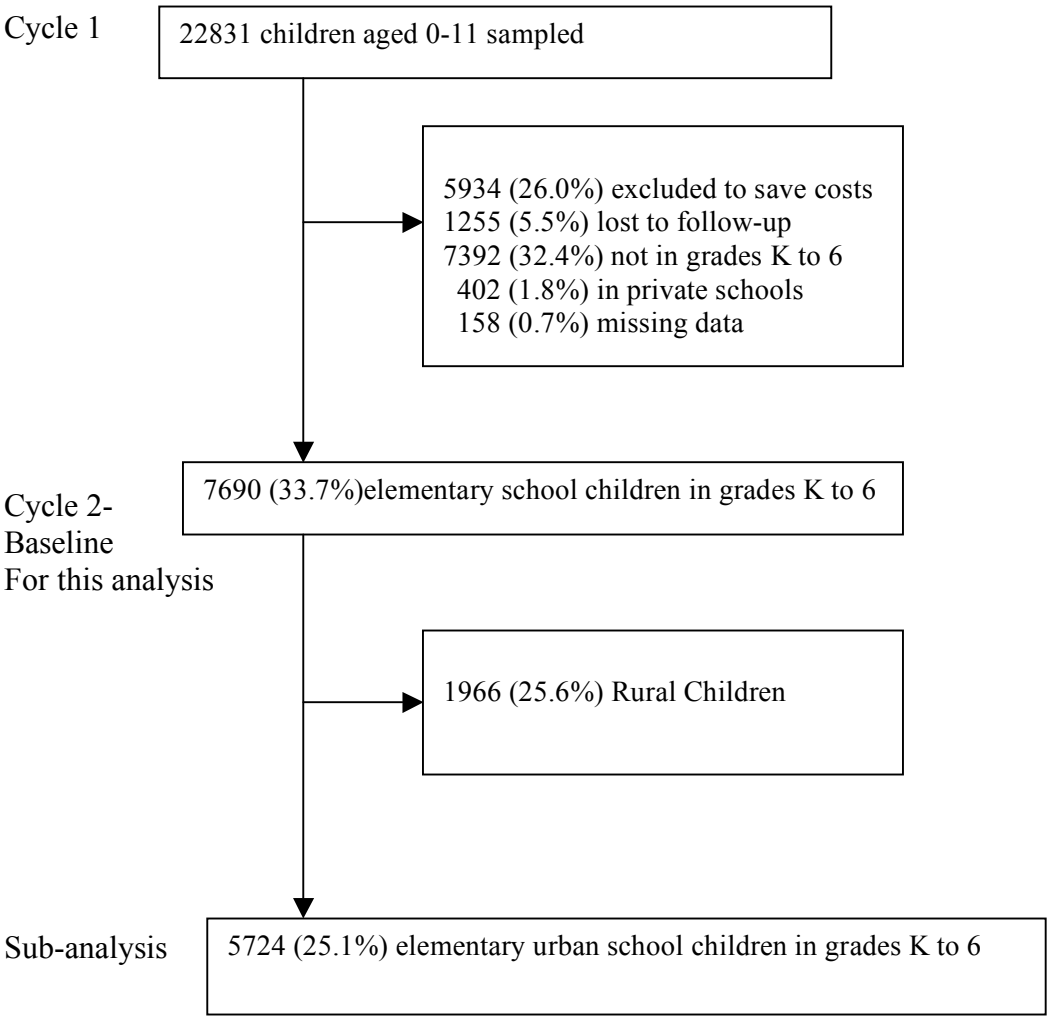
Methods

Data on AT to/from school for this study were from the Canadian (NLSCY). Inception of the Canadian NLSCY was conducted by Statistics Canada in 1994/1995 among 22831 children aged 0-11 years from the 10 provinces of Canada (figure 1). The details of the NLSCY have been published elsewhere in the micro-data's user's guide and are summarized briefly herein.[30] The goal of the NLSCY is to follow development and well-being of Canadian children every two years. The NLSCY is comprised of two cohorts, each of which includes several waves of data collection, called 'Cycles'. The first cohort of children were aged 0 to 11, were sampled in 1994/1995 and will be followed until they reach the age of 25 years. The second cohort consists of children aged 0 to 1 year at the time of their selection in 1996 and will remain in the survey until they reach the age of 5. These current analyses are based on the first cohort. The target population during Cycle 1 in 1994/1995 consisted of the population of Canadian children newborn through 11 years of age who lived in private households. Children living in institutions and children living on Indian reservations were not included in the sampling frame. For financial reasons, the sample for Cycle 2 of the NLSCY consisted of a subset of Cycle 1 respondents. In Cycle 1, there were 22,831 responding children from 13,439 households. In each of these households, a maximum of four children was surveyed. Of the households retained for Cycle 2, the number of children per household was limited to two. Following these cuts, 16,897 children from the original cohort were followed and surveyed in Cycle 2 (figure 1). The response rate for Cycle 3 and Cycle 4 were 88.6% and 84.5% respectively.[30]

Trained interviewers conducted face-to-face interviews with the household member or person most knowledgeable about the child (the mother for 91.3% of subjects). For the current analysis, data from Cycle 2 (1996/1997), Cycle 3 (1998/1999) and Cycle 4 (2000/2001) were used. Time-varying covariates, which are variables that are permitted to change, were measured at each Cycle. The sample was restricted to children attending school in grades Kindergarten through Grade 6 at Cycle 2, n=7848 (46.4% of the sample followed from Cycle 1). Therefore, the children were in grades 2 through 8 in Cycle 3 and grades 4 to 10 in Cycle 4. Children attending private schools (n=402/7848, 5.1%) were excluded from the sample since they were not as likely to attend a school within their neighborhood and AT to/from school may not be an option. Children attending private schools were significantly more likely to come from households with adequate household income, to have mothers who are non-European immigrants, and to have two parents living within the same household.

Students with missing data due to non-response of baseline characteristics, such as mother's immigrant status (n=158/7848, 2.0%) were excluded; complete data were available for 7690 (45.5%) students (figure 1). There were no significant differences between the children who were excluded and those who were retained on the following characteristics: gender of the child, household income, mother's immigrant status, number of older siblings at baseline and number of adults at baseline.

Figure 1. Flow Chart of Participants from the Canadian National Longitudinal Study of Children and Youth throughout the different sets of analyses in the current investigation.



Variables

Socio-demographic data included child's sex, age, birth rank, mother's immigrant status, and family income in Canadian dollars (CAD) at baseline. Copies of the questionnaires and data collection forms are available on the Internet at http://www.statcan.gc.ca/imdb-bmdi/instrument/4450_Q3_V1-eng.pdf.

Outcome

Parents were asked how their child usually gets to school. Response options were: school bus, public transit, walking/bicycling, is driven, or uses multiple modes. Usual mode of transportation to and from school was dichotomized as active (walking/bicycling) or inactive (school bus, public transit, is driven, or multiple modes).

Time-Varying Predictors

Age and age^2: Time was modeled as a function of age and its quadratic function (i.e., age^2). The quadratic term was added to determine if the likelihood of using AT to/from school accelerates or decelerates as children age.

Income inadequacy: Household income was dichotomized into inadequate and adequate. Inadequate income was defined as: Household income is less than $15,000 in a household with 1-2 persons; or household income is less than $20,000 for a household with 3-4 persons; or household income is less than $30,000 for a household with 5 people.

Mother's perception of the child's health: Mothers were asked at each time point to rate their child's health as: excellent, very good, good, fair, or poor. Responses were dichotomized as fair and poor or excellent, very good, and good. A previous validation study indicated that maternal perception was strongly associated with the different health indicators even after controlling for confounding variables.[31]

Number of older siblings: The number of older siblings (of the child) living in household, including full, half, step, adopted and foster siblings, was dichotomized to 0 and ≥ 1.

Parent status: The number of parents the child lives with was dichotomized to 1 parent or 2 parents.

Type of setting: The child's residence was categorized as being in an urban or rural setting. Statistics Canada defines an urban setting as area with a population of at least 1,000 and no fewer than 400 persons per square kilometre.[32]

Time-invariant predictors-These covariates were measured only once at baseline and cannot change over time.

Sex: The child's sex was evidently dichotomous.

Mother's immigrant status: Mother's immigrant status was categorized as: Canadian born/European Immigrant, or Non-European Immigrant.

Cohort: Students were categorized as a function of which grade they were in at baseline: Grade 1, Grade 2, Grade 3, Grade 4, Grade 5, and Grade 6, with Kindergarten as the reference.

Region: Region of residence at baseline was categorized into: the Atlantic Provinces, Ontario, the Prairie Provinces, Alberta, and British Columbia, with Quebec as the reference.

Data analysis

Mode of transportation to school was repeatedly measured for the same individuals; because of the hierarchical nature of the data (i.e. with time nested in individuals), we used a random effects model to examine the relationship between socio-demographic characteristics and likelihood of AT to/from school across time. Random effects 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.[33] Several authors[34, 35] 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 effects of socio-demographic factors on the likelihood of using AT to/from school, a step-up approach was adopted and different sequential analyses were performed. A first set of analyses included the null model so that the 95% plausible value

ranges were computed to estimate the degree of variability across individuals. Next, a set of analyses included parameters operationalizing time (age and the quadratic term of age), to explore whether or not the likelihood of using AT to/from school changed as children aged throughout the school years. In order to obtain a regression equation with an intercept that was more readily interpretable, the age variable was centered at 11 years. Thus, the intercept in the model can be interpreted as the likelihood of using AT to/from school at age 11 years. Analysis was then performed by adding the time-varying and time-invariant socio-demographic factors to determine which ones were significantly associated with AT to/from school as the children aged. The time-varying covariates included adequacy of household income, number of older siblings living in the household, number of parents in the household, and parental perception of the child's health. The time-invariant covariates added include sex of the child and mother's immigrant status. Since older children in elementary school are more likely to use AT to/from school, children in higher grades at baseline should be more likely to participate in this behaviour. This may result in differing patterns of likelihood of AT participation between the grades across the six years in which the students were followed. To determine if there was a cohort effect, a series of dummy variables representing the grade at baseline was also included as a time-invariant covariates. To determine if any of the predictors were associated with change in likelihood of AT across the school years, all variables were tested as moderators of the change in likelihood across time.

Subanalysis:

Since children in rural areas are unlikely to live within walking distance of their school, the random effects models described previously were repeated after removing students living in rural regions. Children living in rural regions (n=2024/7848 25.8% of the sample) were more likely to come from households with inadequate income, to have older siblings in the household, to have two parents living in the household, and less likely to have a mother who was a Non European immigrant.

Results

Characteristics at baseline for the 7690 students attending public schools in Canada in the NLSCY appear in table 1. Overall, the sample had slightly more boys (51.0%). About 75% lived in urban areas, 18.6% of students came from families with inadequate income, and 10.8% had mothers who were non-European immigrants. The average age was 8.0 years (SD=2.0).

Table 1. Sociodemographic characteristics of youths participating in Cycles 2, 3, and 4 of the Canadian National Longitudinal Study of Children and Youth Survey, 1996-2001 and who were attending public schools in 1996/1997.

	n	Proportion of study population, % (n=7690)
Sex		
Male	3922	51.0
Female	3768	49.0
1996-1997 Household Income		
Inadequate	1430	18.6
Adequate	6260	81.4
Mother's immigrant status		
Canadian/European born	7367	95.8
Non-European born	323	4.2
Grade at Cycle 2		
Kindergarten	1283	16.7
Grade 1	1237	16.1
Grade 2	1075	14.0
Grade 3	1030	13.4
Grade 4	1007	13.1
Grade 5	1037	13.5
Grade 6	1021	13.3
Region of Canada		
Quebec	1392	18.1
Atlantic Provinces	1838	23.9
Ontario	1891	24.6
Prairie Provinces	1223	15.9
Alberta	677	8.8
British Columbia	669	8.7
Mother's perception of Child's Health		
Excellent, very good, good	7582	98.6
Fair, poor	108	1.4
Number of older siblings		
None	3676	47.8
1 or more	4014	52.2
Number of Parents in Household		
2 parents	6452	83.9
1 parent	1238	16.1
Setting		
Urban	5814	75.6
Rural	1776	23.1

Random effects 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 at any time varied between 29.4**%** and 43.9**%** across children. Addition of the time variable not accounting for any other variables showed the likelihood of using AT to/from school decreased as children aged (OR=0.94; 95% CI=0.92, 0.96). Furthermore, a significant quadratic age term, age^2, indicated that this likelihood is not only declining but is also decelerating (OR=0.97; 95% CI=0.97, 0.98). This pattern is displayed in figure 2 and shows that the estimated proportion of students who use AT to/from school increases from age 6 years and peaks at age 10 years. The estimated proportion then declines, as children get older.

When adding the different predictors as moderators of the intercept in the model (thus likelihood of using AT at baseline), the following pattern emerged: the time-invariant variables: sex, mother's immigrant status, and living in Ontario or Alberta, and the time-varying variable: perception of child's health, were not significantly associated with AT to/from school (table 3). The time-invariant variable: children who were from the Prairie Provinces (OR=2.13; 95% CI=1.82, 2.49) or British Columbia (OR=1.43; 95% CI=1.19, 1.73) and the time-varying variables: being from income insufficient households (OR=1.21; 95% CI=1.06, 1.38), having older siblings in the household (OR=1.14; 95% CI=1.04, 1.25), being from a household with only 1 parent (OR=1.46; 95% CI=1.29, 1.65), and living in an urban setting (OR=3.66, 95% CI=3.23, 4.15), were more likely to use AT to/from school. Children from the Atlantic Provinces (OR=0.42; 95% CI=0.36, 0.49) were significantly less likely to use AT to/from school. Also, at baseline, all of the children in higher grades, with the exception of the grade 5 cohort, were significantly more likely to use AT to/from school

(table 3). This is an indication of a significant cohort effect (figure 3). None of the predictors were associated with change in likelihood of AT across the school years suggesting that the influence of variables associated with likelihood of AT to/from school at baseline were constant over time.

Figure 2. The association between age and AT to/from school among children attending public schools and participating in Cycles 2, 3, and 4 of the Canadian NLSCY, 1996-2001.

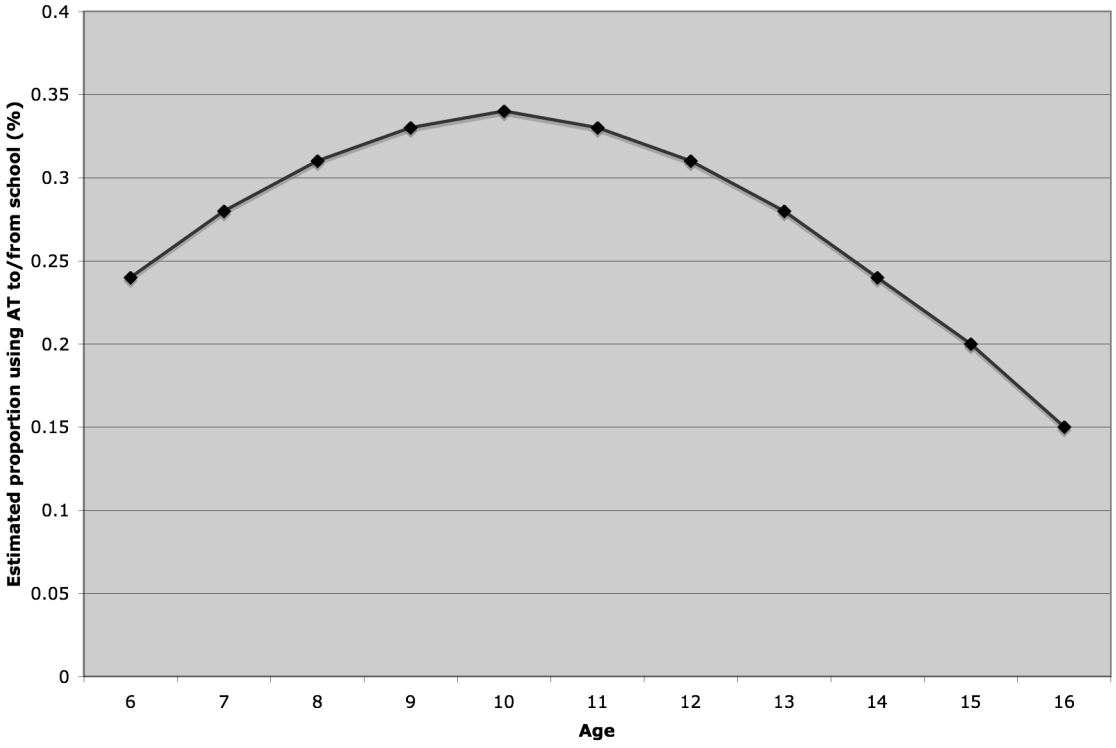


Table 2. Results of random effects analyses investigating association between sociodemographic factors and likelihood of using active transportation (AT) to/from school among children who attended public schools in urban regions and were participating in Cycles 2, 3, and 4 of the Canadian National Longitudinal Study of Children and Youth. 2004–2007 (n=7690).

Variance Components Between participants	**Parameter**	**Variance Estimates (μ)**	**Standard Deviation**	*df*	**p-value**
Baseline	μ_{0j}	1.83	1.35	***7676***	≤0.001
Within participant Fixed Effects	**Parameter**	**Coefficient**	**OR [95% CI]**	*(95% CI)*	**p-value**
Baseline	β_{00}	-2.10	0.12	(0.01, 0.15)	<0.001
Gender (ref: male)					
Female	β_{01}	-0.04	0.96	(0.80, 1.06)	0.41
Mother's immigrant status (ref: Canadian/European born)					
Non-European	β_{02}	0.14	1.15	(0.92, 1.45)	0.23
Region (ref: Quebec)					
Atl. Provinces	β_{03}	-0.86	0.42	(0.36,0.49)	<0.001
Ontario	β_{04}	0.09	1.09	(0.95,1.26)	0.22
Prairie Provinces	β_{05}	0.75	2.13	(1.82,2.49)	<0.001
Alberta	β_{06}	-0.02	0.98	(0.81, 1.18)	0.80
British Columbia	β_{07}	0.36	1.43	(1.19, 1.73)	<0.001
Grade at baseline (ref: K)					
Grade 1	β_{08}	0.17	1.19	(1.00,1.41)	0.05
Grade 2	β_{09}	0.26	1.29	(1.08,1.55)	<0.01
Grade 3	β_{10}	0.23	1.26	(1.04,1.53)	0.02
Grade 4	β_{11}	0.32	1.38	(1.13,1.68)	<0.01
Grade 5	β_{12}	0.11	1.12	(0.91,1.38)	0.29
Grade 6	β_{13}	0.41	1.51	(1.22,1.87)	<0.01
Follow-up-Age	β_{20}	–0.12	0.93	(0.91,0.95)	<0.001

Table 2 (continued). Results of random effects analyses investigating association between sociodemographic factors and likelihood of using active transportation (AT) to/from school among children who attended public schools in urban regions and were participating in Cycles 2, 3, and 4 of the Canadian National Longitudinal Study of Children and Youth. 2004–2007 (n=7690).

Within participant Fixed Effects	**Parameter**	**Coefficient**	**OR [95% CI]**	*(95% CI)*	**p-value**
Follow-up Age^2	β_{30}	-0.05	0.97	(0.97,0.98)	<0.001
Household Income (ref: sufficient)					
Insufficient	β_{40}	0.19	1.21	(1.06,1.38)	0.01
Number of older siblings (ref: 0)					
≥ 1 sibling	β_{50}	0.20	1.14	(1.04,1.25)	0.01
Perceived health Status (ref: excellent, very good, good)					
Fair, Poor	β_{60}	-0.10	0.90	(0.67,1.23)	0.53
Parents in Household (ref: 2 parents)					
1 parent	β_{70}	0.38	1.46	(1.29,1.65)	<0.001
Setting (ref: rural)					
Urban	β_{80}	1.30	3.66	(3.23,4.15)	<0.001

$\text{Prob}(Y=1|B) = p_{ij}$

Level-1 Model

$p_{ij} = \Pi_{0j} + \Pi_{2j}*(\text{Age}) + \Pi_{3j}*(\text{Age}^2) + \Pi_{4j}*(\text{Household Inc}) + \Pi_{5j}*(\text{Older sibling}) + \Pi_{6j}*(\text{Perceived health status}) + \Pi_{7j}*(\text{Number of Parents}) + \Pi_{8j}*(\text{Urban})$

Level-2 Model

$\Pi_{0j} = \beta_{00} + \beta_{01}*(\text{Female}) + \beta_{02}*(\text{Mother's Immigrant Status}) + \beta_{03}*(\text{ATL}) + \beta_{04}*(\text{ONT})$

$+ \beta_{05}*(\text{Prairies}) + \beta_{06}*(\text{AB}) + \beta_{07}*(\text{BC}) + \beta_{08}*(\text{Grade 1}) + \beta_{09}*(\text{Grade 2}) + \beta_{010}*(\text{Grade 3}) + \beta_{011}*(\text{Grade 4}) + \beta_{012}*(\text{Grade 5}) + \beta_{013}*(\text{Grade 6}) + \underline{\mu}_0$

$\Pi_{2j} = \beta_{20}$

$\Pi_{3j} = \beta_{30}$

$\Pi_{4j} = \beta_{40}$

$\Pi_{5j} = \beta_{50}$

$\Pi_{6j} = \beta_{60}$

$\Pi_{7j} = \beta_{70}$

$\Pi_{8j} = \beta_{80}$

Sub-analysis

The random effects modeling was performed among students living in urban areas attending public schools (table 3). Similarly, the likelihood of using AT to/from school increases until age 10 years and decreases as children age since the age and age^2 variables are statistically significant. Also, the statistically significant predictors associated with AT to/from school at baseline include insufficient household income (OR=1.15; 95% CI: 1.00, 1.32), having 1 parent in the household (OR=1.37; 95% CI: 1.21, 1.55), living in the Prairie Provinces (OR=1.90; 95% CI: 1.60, 2.25), and living in British Columbia (OR=1.40; 95% CI: 1.16, 1.70). Moreover, the effects of these predictors are associated with AT to/from school at baseline. This influence is held constant as the children age during the follow-up period. Similar to the model with children from both urban and rural areas, the model using a restricted sample showed a significant cohort effect since the following grades at baseline: students in grade 2, grade 4, and grade 6 were significantly more likely to use AT to/from school at baseline in comparison to students in kindergarten.

Figure 3. Cohort effects across time on AT to/from school among children participating in Cycles 2, 3, and 4 of the NLSCY, 1996-2001.

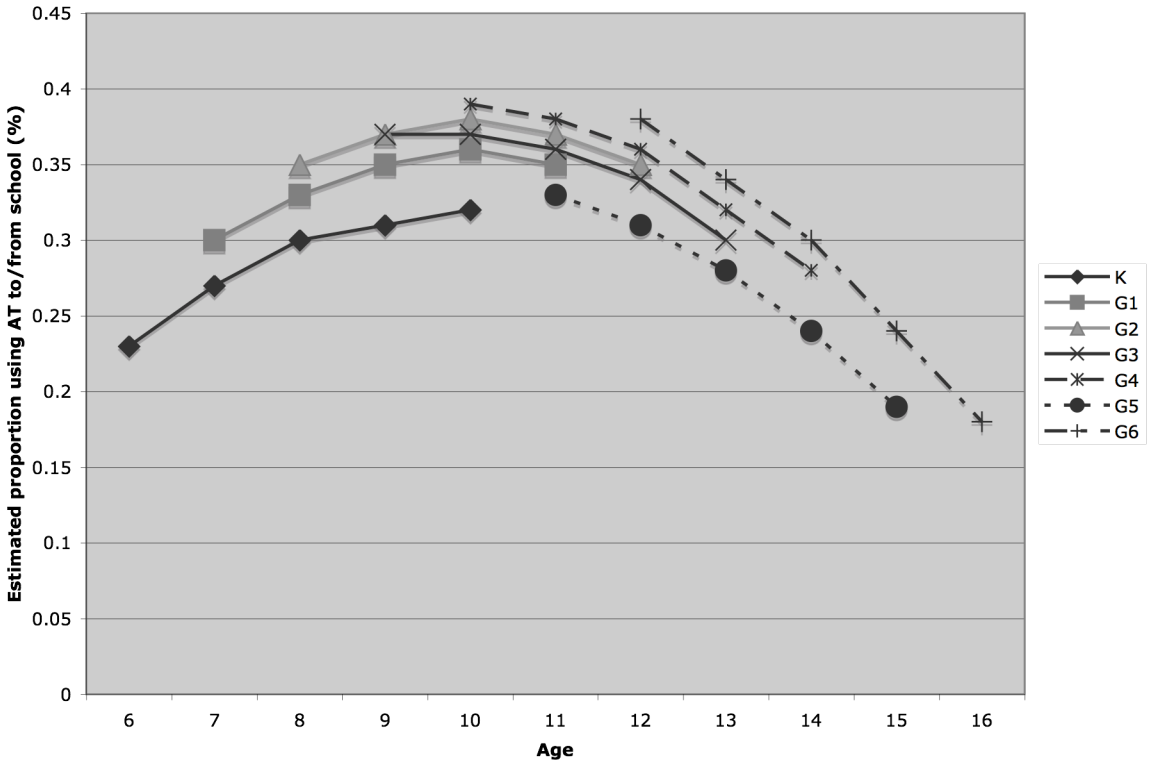


Table 3. Results of random effects analyses investigating the association between sociodemographic factors and likelihood of using active transportation (AT) to/from school among children who attend public schools in urban regions, and were participating in Cycles 2, 3, and 4 of the Canadian National Longitudinal Study of Children and Youth. 1996-2001 (n=5724).

Variance Components Between participants	**Parameter**	**Variance Estimates (μ)**	**Standard Deviation**	*df*	**p-value**
Baseline	μ_{0j}	1.74	1.32	**5710**	$\leq$0.001
Within participant Fixed Effects	**Parameter**	**Coefficient**	**OR [95% CI]**	(95% CI)	**p-value**
Baseline	β_{00}	-0.67	0.51	(0.42, 0.63)	<0.001
Gender (ref: male)					
Female	β_{01}	-0.06	0.94	(0.86, 1.04)	0.25
Mother's immigrant status (ref: Canadian/European born)					
Non-European	β_{02}	0.14	1.15	(0.92, 1.43)	0.21
Region (ref: Quebec)					
Atlantic Provinces	β_{03}	-0.75	0.47	(0.40,0.55)	<0.001
Ontario	β_{04}	0.10	1.11	(0.96,1.28)	0.16
Prairie Provinces	β_{05}	0.64	1.90	(1.60,2.25)	<0.001
Alberta	β_{06}	-0.08	0.92	(0.75, 1.12)	0.41
British Columbia	β_{07}	0.34	1.40	(1.16, 1.70)	<0.01
Grade at baseline (ref: K)	β_{08}	0.14	1.16	(0.97,1.34)	0.11
Grade 1	β_{09}	0.22	1.25	(1.03,1.51)	0.02
Grade 2	β_{10}	0.19	1.21	(0.99,1.47)	0.06
Grade 3	β_{11}	0.29	1.34	(1.09,1.64)	<0.01
Grade 4	β_{12}	0.15	1.16	(0.94,1.43)	0.17
Grade 5	β_{13}	0.32	1.37	(1.10,1.71)	<0.01
Grade 6					
Follow-up-Age	β_{20}	–0.06	0.94	(0.92,0.97)	<0.001
Follow-up Age^2	β_{30}	-0.03	0.97	(0.97,0.98)	<0.001

Table 3 (Continued). Results of random effects analyses investigating the association between sociodemographic factors and likelihood of using active transportation (AT) to/from school among children who attend public schools in urban regions, and were participating in Cycles 2, 3, and 4 of the Canadian National Longitudinal Study of Children and Youth. 1996-2001 (n=5724).

Within participant Fixed Effects	**Parameter**	**Coefficient**	**OR [95% CI]**	(95% CI)	**p-value**
Household Income (ref: sufficient)					
Insufficient	β_{40}	0.14	1.15	(1.00,1.32)	0.047
Number of older siblings (0: ref)					
≥ 1 sibling	β_{50}	0.12	1.13	(1.03,1.25)	0.01
Perceived health Status (ref: excellent, very good, good)					
Fair, Poor	β_{60}	-0.15	0.86	(0.63,1.18)	0.35
Parents in Household (ref: 2 parents)					
1 parent	β_{70}	0.31	1.37	(1.21,1.55)	<0.01

$\text{Prob}(Y=1|B) = p_{ij}$

Level-1 Model

$p_{ij} = \Pi_{0j} + \Pi_{2j}*(\text{Age}) + \Pi_{3j}*(\text{Age}^2) + \Pi_{4j}*(\text{Household Inc}) + \Pi_{5j}*(\text{Older sibling}) + \Pi_{6j}*(\text{Perceived health status}) + \Pi_{7j}*(\text{Number of Parents})$

Level-2 Model

$\Pi_{0j} = \beta_{00} + \beta_{01}*(\text{Female}) + \beta_{02}*(\text{Mother's Immigrant Status}) + \beta_{03}*(\text{ATL}) + \beta_{04}*(\text{ONT})$

$+ \beta_{05}*(\text{Prairies}) + \beta_{06}*(\text{AB}) + \beta_{07}*(\text{BC}) + \beta_{08}*(\text{Grade 1}) + \beta_{09}*(\text{Grade 2}) + \beta_{010}*(\text{Grade 3}) + \beta_{011}*(\text{Grade 4}) + \beta_{012}*(\text{Grade 5}) + \beta_{013}*(\text{Grade 6}) + \underline{\mu}_0$

$\Pi_{2j} = \beta_{20}$

$\Pi_{3j} = \beta_{30}$

$\Pi_{4j} = \beta_{40}$

$\Pi_{5j} = \beta_{50}$

$\Pi_{6j} = \beta_{60}$

$\Pi_{7j} = \beta_{70}$

Discussion

The purpose of this analysis was to investigate a range of time-varying and time-invariant determinants of AT to/from school among school-aged children and youth participating in the Canadian NLSCY. This is the first analysis to illustrate that as children age, the likelihood of using AT to/from school increases, peaks at age 10 years, and then decreases. As children get older in elementary school, parents may be more willing to allow their children to walk or cycle to school. However, once children transition into junior high and secondary school, students are less likely to attend schools close to home and therefore AT to/from school is not necessarily an option.

In comparison to rural areas, children living in urban areas were more likely to use AT to/from school. Random effects analyses indicated that children from households with inadequate income, with one parent, and children who have at least one older sibling are more likely to use AT to/from school over time. These findings indicate that there are numerous socio-demographic predictors associated with the likelihood of using AT to/from school. This is very useful information for public health practitioners because it points to populations who are the least likely to use AT to/from school. Implementing programs to facilitate children to travel together may encourage those who do not have a travel companion, such as an older sibling to adopt this behaviour.

This is the first large, population-based nationally representative study to investigate factors that influence AT to/from school over time. Although socio-demographic variables were included in this investigation, other potential variables such as distance to school [15, 16, 36, 37], car ownership, [24, 37, 38] and neighbourhood perception of safety [39-42] were not included but

have been shown to be correlates of AT to/from school. Future analyses could include linking the NLSCY dataset to environmental indicators, as neighbourhood features have been shown to increase likelihood of using AT.[29] Accident or crime data could also be linked by postal code to the child's residence or school, in order to characterize the safety of the environments in which children live and attend school and explore its role.

Another known, consistently identified predictor associated with AT to/from school is distance to school. [15, 16, 36, 37] Obviously, AT to/from school is not always feasible, depending on the distance between residence and school.[15, 16, 36, 37] Data on distance to school were not available; however, we restricted the sample to public school students, controlled for urban or rural setting of the child's residence, and by repeating analyses in a sub-sample excluding students living in rural settings, all of which produced similar results. By performing these analyses, students who do not have an option to use AT to/from school are controlled for in the analyses.

This study provides new information on the natural history of AT to/from school and allows public health researchers and practitioners an opportunity to develop and implement interventions aimed as these targets to increase the likelihood of using AT to/from school. Public health practitioners can work with urban planners and school board officials to ensure that schools are built within walking distance, within neighborhoods and not outside of neighborhoods.

Children from higher socioeconomic backgrounds are less likely to use AT to/from school. Researchers can further investigate the reasons for this trend and target these populations to promote increased adoption of AT to/from school. These findings also indicate that there

are noticeable differences regionally with respect to the estimated proportion of students who use AT to/from school. Further investigation can help determine why students from selected areas (i.e., Saskatchewan and Manitoba) are more likely to use AT to/from school. Identifying these factors and subsequently developing programs to help increase AT may be applied to students living in other areas (i.e., the Atlantic Provinces).

This study helps to illustrate how socio-demographic predictors are associated with health behavior over time. Future studies examining the role the environments over time in which children live and how decisions are made within families concerning travel to school are needed.

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ARTICLE 3

Understanding the determinants of active transportation to school among children: Evidence of environmental injustice from the Quebec Longitudinal Study of Child Development

Roman Pabayo

Lise Gauvin

Patrick Morency

Tracie Barnett

Béatrice Nikiéma

Louise Séguin

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Authors

Roman Pabayo, M.Sc.

Faculté de médecine

CRCHUM (Centre de recherche du Centre Hospitalier de l'Université de Montréal),

Department of Social & Preventive Medicine and Centre de recherche Léa-Roback sur les inégalités sociales de santé de Montréal, Université de Montréal, Montréal, Québec, Canada

Lise Gauvin, Ph.D.

Faculté de médecine

CRCHUM (Centre de recherche du Centre Hospitalier de l'Université de Montréal),

Department of Social & Preventive Medicine and Centre de recherche Léa-Roback sur les inégalités sociales de santé de Montréal, Université de Montréal, Montréal, Québec, Canada

Patrick Morency, MD

Direction de santé publique, Agence de la santé et des services sociaux de Montréal, Gouvernement du Québec, Montréal, Québec, Canada

Tracie A Barnett, Ph.D.

Centre de Recherche du CHU Sainte-Justine

Faculté de médecine

Department of Social & Preventive Medicine, Université de Montréal, Montréal, Québec, Canada

Béatrice Nikiéma, MD, M.Sc.

Faculté de médecine

Department of Social & Preventive Medicine, Institut de recherche en santé publique de l'Université de Montréal and Centre de recherche Léa-Roback sur les inégalités sociales de santé de Montréal, Université de Montréal, Montréal, Québec, Canada

Louise Séguin, MD, MPH

Faculté de médecine

Department of Social & Preventive Medicine, Institut de recherche en santé publique de l'Université de Montréal and Centre de recherche Léa-Roback sur les inégalités sociales de santé de Montréal, Université de Montréal, Montréal, Québec, Canada

Corresponding Author

Roman Pabayo, M.Sc.

Department of Social & Preventive Medicine

Université de Montréal

PO Box 6128, Downtown Station

Montréal, Québec, Canada

H3C 3J7

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Abstract:

Background

Concern has been raised among public health researchers and practitioners regarding the increased prevalence of physical inactivity among children. A concurrent public health concern pertains to unsafe neighborhoods characterized by neighborhood decay, low social cohesion, and high rate of collisions between pedestrians and motor vehicles. Active Transportation (AT) such as walking and cycling to and from school are opportunities for children to be physically active. Poverty has been shown to be a correlate of both greater likelihood of AT and of negative neighborhood characteristics with children from low SES backgrounds being more likely to live in areas fraught with lack of safety but also more likely to walk to school. Although poverty and living in unsafe neighborhoods clearly are determinants of AT to/from school, these associations have never been examined simultaneously.

Objective

To identify the determinants of AT and the extent to which AT to/from school is more likely to occur in safe or unsafe neighborhoods, we examined the combined influence of individual and neighborhood level variables of poverty and dangerousness related to rates of vehicle-pedestrian collisions of the neighborhood environment on the likelihood of AT to and from school among a population-based birth cohort of children followed throughout the early school years.

Methods

The sample included 1492 children that were part of the Quebec Longitudinal Study of Child Development (QLSCD), a birth cohort established in 1998 by the *Direction Santé Québec* of the *Institut de la statistique du Québec*. 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 one, and grade two. Parents were asked how their child usually gets to school. Responses were dichotomized into active (walking/bicycling) or inactive (school bus, public transit, is driven, or multiple) modes. Poverty was measured according to the Low Income Cut-Offs (LICO) from Statistics Canada. Household income levels below the LICO threshold were categorized as insufficient income and thus living in poverty. Four types of measures were used to assess neighborhood dangerousness. First, parents were asked if their neighborhood was excellent, good, average, bad, or very bad for raising their children. Second, a neighborhood social cohesion score was developed by asking parents questions about their neighbors and how they interacted with their neighbors. Third, a neighborhood decay score was calculated by asking parents questions about the crime and vandalism in their area of

residence. Fourth, in a subsample consisting of children living on the Island of Montreal, ambulance report data were used to compute the number of pedestrian-vehicle collisions (range=0 to 28). These estimates were linked to data from children in the QLSCD by matching of postal codes. A participant's area of residence was classified as being dangerous if the postal code had a pedestrian collision density greater than or equal to 1 pedestrian-vehicle collisions from 1999-2003 (the 65th percentile). Growth curve analyses were conducted to determine the combined effect of poverty and pedestrian-vehicle collision density on the likelihood of AT across time. All analyses controlled for sex, birth rank, mother's immigrant status, and mother's perception of the child's health, and mother's perception of neighborhood quality.

Results

Among children in urban regions of Quebec attending public school and who did not move, at age 6 years, insufficient household income (OR=1.80, 95% CI: 1.04, 3.11), birth rank greater than 1 (OR=1.75, 95% CI: 1.19, 2.57), living in a neighborhood that is average, bad, or very bad for raising children (OR=1.79, 95% CI: 1.10, 2.90), and living in an area with high neighborhood decay (OR=2.57, 95% CI=1.63, 4.05) were predictive of greater likelihood of using AT to school as children progressed from kindergarten through grade 2. However, restricting the sample to children living on the Island of Montreal and adding road danger indicators in this sub-sample of children, only high neighborhood decay (OR=3.68, 95% CI: 1.22, 11.12) and high rate of vehicle-pedestrian collisions (OR=3.43, 95% CI: 1.29, 9.12) were predictive of greater likelihood of using AT to and from school as children progressed through the early school years.

Conclusion

Since AT is most likely to be practiced among children living in poverty and because of evidence that AT is more likely to occur in unsafe environments among these children, many are experiencing a form of environmental injustice. Public health interventions aimed at providing safe routes to school are urgently required for children living in poverty and in unsafe neighborhoods, notably where there are more motor vehicle collisions.

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Introduction

Physical activity is needed for healthy growth and development and can track into adulthood thus preventing chronic diseases (1, 2). Secular trends of declining physical activity among youth (3, 4) highlight the need for opportunities for youth to be more physically active (2, 5). Active transportation to/from school, such as walking and cycling, is one potential opportunity for children to be physically active (6-8) and may contribute to preventing excess weight gain (9, 10). However, in keeping with population estimates observed for physical activity, the proportions of children using AT to/from school (11-13) have also declined, while concurrent increases in proportions of children being driven in cars (11-13) have been observed. In a population-based repeated cross-sectional survey in Australia, the proportions of children aged 5 to 9 year olds and 10-14 year olds walking to school declined from 62.6% and 44.2% respectively in 1971 to 29.4% and 32.7% (13). Similarly in the United States, among 5 to 18 year olds, the proportion of children who walked or biked to school declined from 42% in 1969 to 16.2% in 2001 (12). Although, these trends in AT to/from school provide evidence of widespread declines in AT to school, little is known about the predictors of AT to school across the early school years. Recent systematic reviews have identified several correlates of greater likelihood AT to/from school such as shorter distance to school, male gender, lower socio-economic status, no parental car ownership, unfavorable neighborhood characteristics, and non-white ethnicity (14, 15). These systematic reviews include only cross-sectional studies; 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 one longitudinal study that identifies the predictors of AT to/from school has been published. Hume et al. (16) conducted a longitudinal study among 121

children aged 9 years and 188 adolescents age 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 two 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 and from school. Although this is the first longitudinal investigation of the predictors of AT to/from school, this analysis was not a large population-based representative study. Furthermore, the researchers only used parental or self-reported data to assess environmental features. Measures from other sources (e.g., community surveys, crime data) to tap into neighborhood safety are required to avoid possible misclassification errors for neighborhood safety.

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 school (14, 15, 17-22). Furthermore, numerous cross-sectional studies have also identified features of the neighborhood such as perceived increased safety and the presence other children in the neighborhood as being significantly positively associated with AT to/from school (23-25). 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. This social inequality is a form of environmental injustice. Environmental justice refers to the attempt to address the disproportionate exposure to and

burden of harmful environmental conditions experienced by low-income populations (26). In this situation, students from low-income backgrounds living in unsafe areas are more likely to be exposed to danger when using AT to and from school. Although there are studies investigating the influence of socioeconomic position and neighborhood safety separately, none of the previously existing studies examines both factors simultaneously. Thus, we 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.

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 (27). Participants were drawn from the Québec live birth registry. The sampling design followed a three-step strategy. 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 Indian 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 (27). 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 figure 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 immigrant, 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%), children in rural areas (n=281, 18.8%), and children who did not remain in the same neighborhood from Kindergarten through Grade 2 (n=126, 8.4%) were excluded from the sample since they were not as likely to attend a school within 1.5 km (0.9 miles) of their home. Students attending private schools were less likely to have mothers who are non-European immigrants and less likely to have mothers perceive the health of their children to be good, average, and very bad. Children from rural areas were less likely to have mothers who were non-European immigrants and less likely to live in neighborhoods with high social cohesion. Children who moved out of the neighborhood were not included because the neighborhood variables were collected at age 6 years only. When comparing the students who moved and those that stayed in the same neighborhood, those that moved were more likely to be from insufficient income households, to have mothers reporting that the child's health is good, average, or bad, more likely to live in neighborhoods with low social cohesion, more likely to live in an area with high neighborhood decay, and more likely to live in a neighborhood that is perceived to be average, bad, or very bad.

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 Québe*c 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 (**Appendix-8)**.

Variables

Outcome: Parents were asked how their child usually gets to school. Response options were: school bus, public transit, walking/bicycling, is driven, or uses multiple modes. Usual mode to and from school was dichotomized as active (walking/bicycling) or inactive (school bus, public transit, is driven, or multiple modes).

Sociodemographic 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 & Roberts, 1999) and have been associated with child health in the QLSCD (Séguin et al., 2003; (28). 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 excellent/good or average/bad/very bad.

Mother's perception of the child's health: Mothers were asked to rate their child's health as: excellent, very good, good, fair, or poor. Responses were dichotomized as excellent or not excellent. A previous validation study indicated that maternal perception was strongly associated with the different health indicators even after controlling for confounding variables (29).

Child's birth rank: The child's birth rank was dichotomized as: 1st born or higher in birth rank. This variable was included because the literature has indicated that children who have other children to commute with, such an older sibling, are more likely to use AT to/from school.

Mother's immigrant status: Mother's immigrant status was categorized as: Canadian born/European Immigrant, or Non-European Immigrant.

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.

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: g*arbage, 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.

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 geographical 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 (**Appendix-9)**. Methods for data collection have been described elsewhere (30). 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, assumed to be the crash site, is instantly mapped in a GIS to dispatch and guide an ambulance. The mapping of all crash sites and the density calculations were performed in ArcGIS (31). Pedestrian victim density was computed with a pixel size of 10 m and search radius of 500 m (30). 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 pedestrian collisions.

Proportion of Adults on the Workforce Driving to Work: 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. The variable was categorized into less than 50% (i.e., the 10th percentile) of adults who drive to work and greater than 50%.

Data analysis

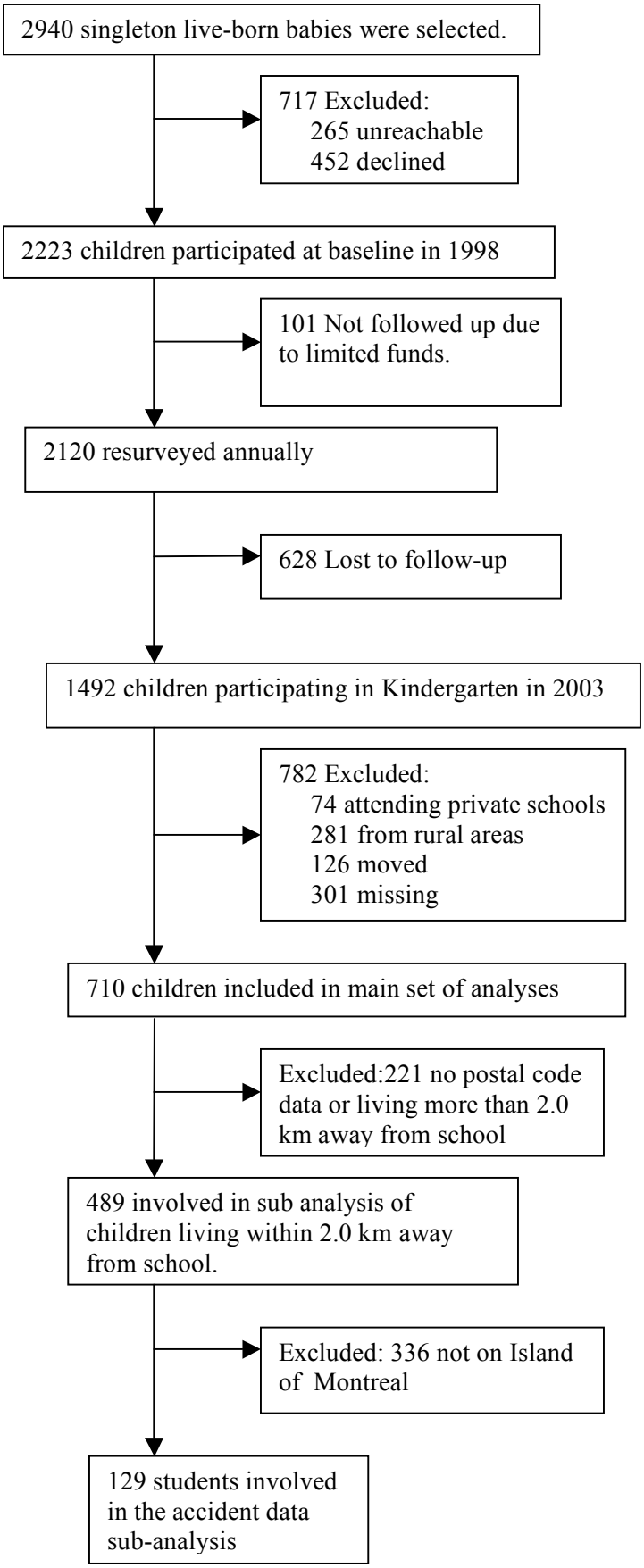
Bivariate analyses were conducted to determine if there were associations between household income and social cohesion, neighborhood decay, and perception of the neighborhood for raising children.

Because mode of transportation to 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 (33). Several authors (34, 35) 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 (35) 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 one and grade two (figure 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, birth rank,

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 neighborhood decay, all of which were included as variables moderating values 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 on the workforce who reported driving to work was added to the models.

Figure 1. Flow Participants from the Quebec Longitudinal Study of Child Development throughout the different set of analyses in the current investigation.



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 2.0 km away from school (n=425). 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 smaller radius, that is 1.5 km cut-off as well (n=377). 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 AT to/from school. However, data on pedestrian-vehicle collisions were only available for the Island of Montreal (n=129). A exploratory model including the pedestrian-vehicle collisions variable was tested in this subsample.

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%). About 54.8% of respondents were ranked second or higher in birth order, 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, and 17.6% of

the mothers perceived the quality of the neighborhood for raising children to be average, bad, or very bad.

Table 1. Descriptive information on the subsample of children born in 1997–1998 from the Québec Longitudinal Study of Child Development with complete data at age 6 years, when in kindergarten.

Variable	n=710	%
Male	343	48.3
Female	367	51.7
Birth Rank		
1st rank	321	45.2
> 1st	389	54.8
Mother's Immigrant Status		
Canadian born/European	679	95.6
Non European	31	4.4
Perceived health status of child		
Excellent	648	91.3
Good, average, very bad	62	8.7
Household income		
Sufficient	598	84.2
Insufficient	112	15.8
Social Cohesion		
High	534	75.2
Low	176	24.8
Neighbourhood decay		
Low	564	79.4
High	146	20.6
Quality of neighborhood		
Excellent	585	82.4
Good, bad, very bad	125	17.6

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 not accounting for any other variables showed the likelihood of using AT to/from school increased from Kindergarten to Grade 1 (OR=1.81; 95% CI=1.32,2.46) to Grade 2 (OR=2.19; 95% CI=1.61,2.98). When adding the predictors as moderators of the intercept in the model (thus likelihood of AT in kindergarten), the following pattern emerged: gender, mother's immigrant status, perception of child's health, and social cohesion were not significantly associated with AT to/from school nor at baseline or throughout the early school years whereas children who had a birth rank greater than 1 (OR=1.75; 95% CI: 1.19, 2.57), who were from households with insufficient incomes (OR=1.80; 95% CI: 1.04, 3.11), who were from a neighborhood that was perceived as either average, bad, or very bad 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 was associated with change in likelihood of AT across the early school years (i.e., moderators of the change in likelihood across time) suggesting that the influence of variables associated with likelihood of AT in kindergarten were constant across the early school years. When interaction terms of household income and each of the environmental variables were included, the main effects variables were no longer significant. However, the household income by neighborhood decay interaction term (OR=3.67; 95% CI: 1.24, 10.85) was significantly associated with AT to/from school at Kindergarten (results not shown). As seen in figure 2, Neighborhood decay modified the

relationship between household income and AT to/from school. In high decay neighborhoods, children from insufficient household incomes are more likely to use AT to/from school in neighborhoods in comparison to students from sufficient household income families. However, there is no difference in likelihood of using AT to/from school in neighborhoods with low decay. No other interaction terms were significantly associated with AT to/from school. When the analysis was stratified by low and high neighborhood decay (dichotomized at the 75th percentile), there were no significant differences in the likelihood of using AT to/from school children between children from sufficient income and insufficient income households (results not shown). However, among children who lived in high decay neighborhoods, children from insufficient income households were 4.43 (95% CI: 1.62, 12.09) times more likely to use AT to/from school as they age in comparison to children from sufficient income households. When the area-level variable, proportion of adults on the workforce who report driving to work was included in the model, being greater than first born rank (OR=2.06; 95% CI: 1.28, 3.30) and residing in a neighborhood that is perceived to be good, average, or poor (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 across the early school years. Although household income and neighborhood decay were no longer significantly associated to AT to/from school, children residing in an area where less than 50% of the adults drive to work were significantly more likely to use AT to and from school (OR=6.87; 95%CI: 2.96, 15.94).

Figure 2. Effect modification of neighbourhood decay on the relationship between insufficient household income and AT to/from school at baseline.

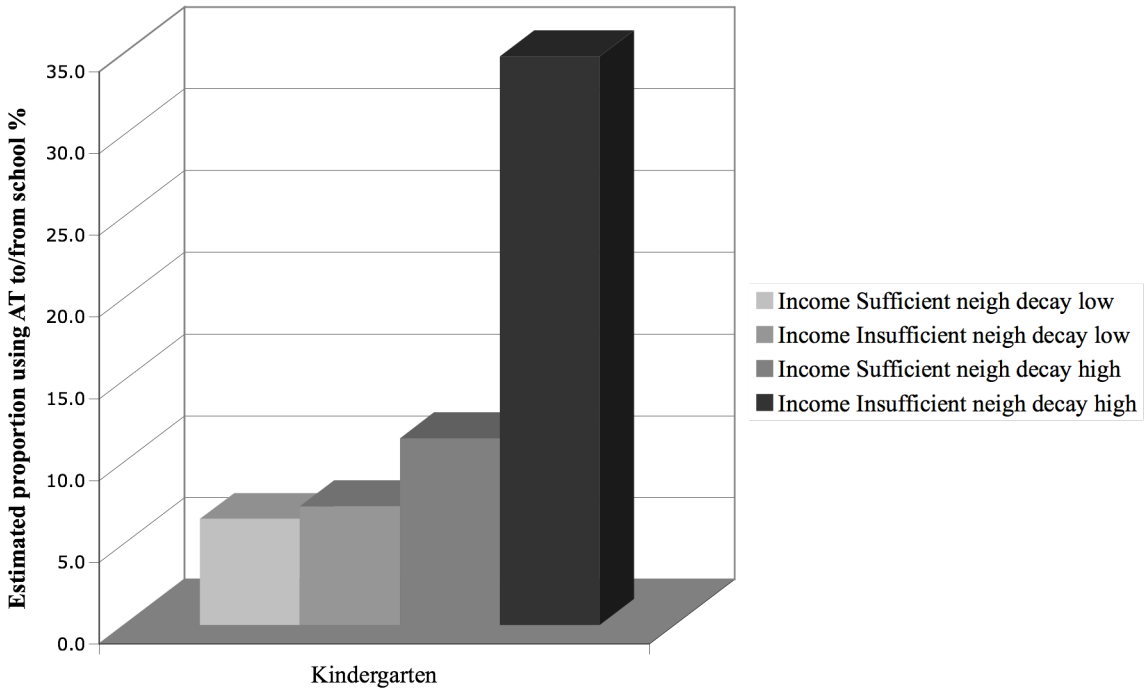


Table 2. Results of multilevel modeling analyses investigating the association between sociodemographic factors and likelihood of using active transportation (AT) to and from school among children attending public schools in urban areas and stayed in the same neighborhood from kindergarten to grade 2 participating in the Québec Longitudinal Study of Child Development, 2004–2007 (n=710).

Variance Components Between participants	**Parameter**	**Variance Estimates (μ)**	**Standard Deviation**	*df*	**p-value**
Baseline	μ_{0j}	1.78	3.17	701	<0.001
Within participant Fixed Effects		**Parameter**	**OR**	(95% CI)	**p-value**
Baseline - 6 yrs.		β_{00}	0.07	(0.04, 0.11)	0.00
Sex (Ref: male)					
Female		β_{01}	0.89	(0.52, 1.46)	0.64
Birth Rank (ref:1st)					
>1st rank		**β_{02}**	**1.75**	**(1.19, 2.57)**	**0.005**
Mother's immigrant status (Ref : non Immigrant/ European immigrant)					
Non-European Immigrant		β_{03}	1.27	(0.52,3.14)	0.59
Household Income					
(Ref: sufficient)					
insufficient		**β_{04}**	**1.80**	**(1.04, 3.11)**	**0.036**
Perception of Child's Health (ref: Excellent)					
Not Excellent		β_{05}	0.95	(0.51,1.75)	0.86
Perception of the neighborhood					
(Ref:Excellent/Very Good)					
Poor, Average, Good		β_{06}	**1.79**	**(1.10,2.90)**	**0.018**

Table 2 (Continued). Results of multilevel modeling analyses investigating the association between sociodemographic factors and likelihood of using active transportation (AT) to and from school among children attending public schools in urban areas and stayed in the same neighborhood from kindergarten to grade 2 participating in the Québec Longitudinal Study of Child Development, 2004–2007 (n=710).

Within participant Fixed Effects	**Parameter**	**OR**	***(95% CI)***	**p-value**
Social Cohesion(Ref: low)				
High	β_{07}	0.86	(0.54,1.36)	0.52
Neighborhood decay (Ref: low)				
High	**β_{08}**	**2.57**	**(1.63,4.05)**	**<0.001**
Follow-up 7 yrs	β_{10}	**1.83**	**(1.27,2.63)**	**0.001**
Sex (Ref: male)				
Female	β_{11}	0.96	(0.60,1.55)	0.88
Household Income (Ref: sufficient) insufficient	β_{12}	1.22	(0.75,1.96)	0.42
Follow-up 8 yrs	β_{20}	**2.43**	**(1.67, 3.52)**	**0.00**
Sex (Ref: Male) Female	β_{21}	0.89	(0.53,1.49)	0.66
Household Income (Ref: sufficient income) Insufficient	β_{22}	0.91	(0.50,1.68)	0.77

$Prob(Y=1|B) = p_{ij}$

Level-1 Model

$$p_{ij} = \pi_{0j} + \pi_{1j}*(7\ yrs) + \pi_{2j}*(8\ yrs) + E$$

Level-2 Model

$\pi_{0j} = \beta_{00} + \beta_{01}*(Female) + \beta_{02}*(Birth\ Rank) + \beta_{03}*(Mother\ is\ non\ European\ Immigrant) + \beta_{04}*(Income\ is\ insufficient\ at\ Kindergarten) + \beta_{05}*(Perception\ of\ Child's\ Health) + \beta_{06}*(Neighborhood\ Safety)$

$$+ \beta_{07}*(\text{Social Cohesion}) + \beta_{08}(\text{Neighborhood Decay}) + \underline{\mu}_0$$
$$\pi_{1j} = \beta_{10} + \beta_{11}*(\text{Female}) + \beta_{12}\ (\text{Income is insufficient at Grade 1})$$
$$\pi_{2j} = \beta_{20} + \beta_{21}*(\text{Female}) + \beta_{22}\ (\text{Income is insufficient at Grade 2})$$

Secondary analysis-approximate distance to school

The analysis restricted to students who live within 2.0 km away from school, yielded similar results (results not shown). The variables: birth rank greater than 1 (OR=2.06; 95% CI: 1.27,3.34), perception of the neighborhood being poor, average, or good (OR=1.89; 95% CI: 1.05,3.42), and neighborhood decay (OR=2.52; 95% CI: 1.45, 4.40) remained significantly associated with AT to/from school in kindergarten and this associated remained unchanged across the early school years. Similar results were obtained when the sample was restricted to students living within 1.5 km to school (data not shown). When the area level variable, proportion of adults on the workforce driving to work was added to the model, birth rank and perception of the neighborhood for raising children remained significantly associated with AT to/from school. Similar to the model with all children who did stay in the same neighborhood for all three years, household income and neighborhood decay were no longer significantly associated with AT to/from school but children from areas with less than 50% of the adults who drive to work were more likely to use AT to/from school as children age.

Table 3. Results of multilevel modeling analyses investigating the association between sociodemographic factors and likelihood of using active transportation (AT) to and from school among children who attend public schools in urban regions, stayed in the same neighborhood from kindergarten to grade 2 and lived within 2.0 km from school participating in the Québec Longitudinal Study of Child Development, 2004–2007 (n=425).

Variance Components Between participants	**Parameter**	**Variance Estimates (μ)**	**Standard Deviation**	*df*	**p-value**
Baseline	μ_{0j}	1.76	3.10	416	$\leq$0.001
Within participant Fixed Effects		**Parameter**	**OR**	*(95% CI)*	**p-value**
Baseline - 6 yrs.		β_{00}	0.07	(0.04, 0.13)	0.00
Sex (Ref: male)					
Female		β_{01}	0.93	(0.47, 1.84)	0.83
Birth Rank (Ref:1st)					
>1st rank		**β_{02}**	**2.06**	**(1.27, 3.34)**	**0.004**
Mother's immigrant status (Ref : non Immigrant/ European immigrant)					
Non-European Immigrant		β_{03}	0.70	(0.21,2.30)	0.55
Household Income					
(Ref: sufficient)					
insufficient		**β_{04}**	1.43	(0.67, 3.07)	0.36
Perception of Child's Health (ref: Excellent)					
Not Excellent		β_{05}	1.07	(0.44,2.64)	0.88
Perception of the neighborhood					
(Ref:Excellent/Very Good)					
Good)					
Poor, Average, Good		β_{06}	**1.89**	**(1.05,3.42)**	**0.034**

Table 3 (Continued). Results of multilevel modeling analyses investigating the association between sociodemographic factors and likelihood of using active transportation (AT) to and from school among children who attend public schools in urban regions, stayed in the same neighborhood from kindergarten to grade 2 and lived within 2.0 km from school participating in the Québec Longitudinal Study of Child Development, 2004–2007 (n=425).

Within participant Fixed Effects	**Parameter**	**OR**	*(95% CI)*	**p-value**
Social Cohesion (Ref: low)				
High	β_{07}	0.95	(0.54,1.68)	0.86
Neighborhood decay (Ref: low)				
High	**β_{08}**	**2.52**	**(1.45,4.40)**	**0.002**
Follow-up 7 yrs	β_{10}	**2.31**	**(1.33,4.03)**	**0.004**
Sex				
(Ref: male)				
Female	β_{11}	0.73	(0.34,1.59)	0.43
Household Income				
(Ref: sufficient) insufficient	β_{12}	1.35	(0.53,3.43)	0.53
Follow-up 8 yrs	β_{20}	**2.88**	**(1.66, 5.00)**	**0.00**
Sex(Ref: Male)				
Female	β_{21}	0.81	(0.37,1.74)	0.58
Household Income				
(Ref: sufficient income)				
Insufficient	β_{22}	0.84	(0.342.06)	0.70

$Prob(Y=1|B) = p_{ij}$

Level-1 Model

$$p_{ij} = \pi_{0j} + \pi_{1j}*(7\ yrs) + \pi_{2j}*(8\ yrs) + E$$

Level-2 Model

$\pi_{0j} = \beta_{00} + \beta_{01}*(Female) + \beta_{02}*(Birth\ Rank) + \beta_{03}*(Mother\ is\ non\ European\ Immigrant) + \beta_{04}*(Income\ is\ insufficient\ at\ Kindergarten) + \beta_{05}*(Perception\ of\ Child's\ Health) + \beta_{06}*(Neighborhood\ Safety) + \beta_{07}*(Social\ Cohesion) + \beta_{08}\,(Neighborhood\ Decay) + \underline{\mu}_0$

$\pi_{1j} = \beta_{10} + \beta_{11}*(Female) + \beta_{12}$ (Income is insufficient at Grade 1)

$\pi_{2j} = \beta_{20} + \beta_{21}*(Female) + \beta_{22}$ (Income is insufficient at Grade 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. 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.

Table 4. Results of multilevel modeling analyses investigating the association between sociodemographic factors and likelihood of using active transportation (AT) to and from school among children attending public school in urban regions, stayed in the same neighborhood from kindergarten to grade 2, lived 2.0 km away from school on the Island of Montreal participating in the Québec Longitudinal Study of Child Development, 2004–2007 (n=129).

Variance Components Between participants	**Parameter**	**Variance Estimates (μ)**	**Standard Deviation**	*df*	**p-value**
Baseline	μ_{0j}	1.94	3.76	119	≤0.001
Within participant Fixed Effects		**Parameter**	**OR**	(95% CI)	**p-value**
Baseline - 6 yrs.		β_{00}	0.19	(0.06, 0.59)	0.007
Sex (Ref: male)					
Female		β_{01}	0.61	(0.20, 1.84)	0.43
Birth Rank (ref:1st)					
>1st rank		β_{02}	1.92	(0.78, 4.71)	0.18
Mother's immigrant status (Ref : non Immigrant/ European immigrant)					
Non-European Immigrant		β_{03}	1.43	(0.39,5.26)	0.62
Household Income					
(Ref: sufficient)					
insufficient		$\boldsymbol{\beta_{04}}$	0.93	(0.25, 3.47)	0.92
Perception of Child's Health (ref: Excellent)					
Not Excellent		β_{05}	0.24	(0.06,0.97)	0.12
Perception of the neighborhood					
(Ref:Excellent/Very Good)					
Poor, Average, Good		β_{06}	0.98	(0.31,3.18)	0.98

Table 4 (Continued). Results of multilevel modeling analyses investigating the association between sociodemographic factors and likelihood of using active transportation (AT) to and from school among children attending public school in urban regions, stayed in the same neighborhood from kindergarten to grade 2, lived 2.0 km away from school on the Island of Montreal participating in the Québec Longitudinal Study of Child Development, 2004–2007 (n=129).

Within participant Fixed Effects	**Parameter**	**OR**	(95% CI)	**p-value**
Social Cohesion(Ref: low)				
High	β_{07}	0.89	(0.28,2.89)	0.85
Neighborhood decay (Ref: low)				
High	**β_{08}**	**3.68**	**(1.22,11.12)**	**0.027**
Vehicle-Pedestrian Collisions (Ref: lower)				
Higher	**β_{09}**	**3.43**	**(1.29,9.12)**	**0.021**
Follow-up 7 yrs	β_{10}	0.87	(0.38,1.98)	0.79
Sex (Ref: male)				
Female	β_{11}	0.98	(0.33,2.90)	0.98
Household Income (Ref: sufficient) insufficient	β_{12}	2.11	(0.90,4.94)	0.34
Follow-up 8 yrs	β_{20}	1.05	(0.43, 2.59)	0.00
Sex (Ref: Male)				
Female	β_{21}	0.59	(0.19,1.88)	0.47
Household Income (Ref: sufficient income)				
Insufficient	β_{22}	2.91	(0.83,10.17)	0.17

$Prob(Y=1|B) = p_{ij}$

Level-1 Model

$$p_{ij} = \pi_{0j} + \pi_{1j}*(7\ yrs) + \pi_{2j}*(8\ yrs) + E$$

Level-2 Model

$\pi_{0j} = \beta_{00} + \beta_{01}*(Female) + \beta_{02}*(Birth\ Rank) + \beta_{03}*(Mother\ is\ non\ European\ Immigrant) + \beta_{04}*(Income\ is\ insufficient\ at\ Kindergarten) + \beta_{05}*(Perception\ of\ Child's\ Health) + \beta_{06}*(Neighborhood\ Safety) + \beta_{07}*(Social\ Cohesion) + \beta_{08}(Neighborhood\ Decay) + + \beta_{08}(High\ pedestrian\text{-}vehicle\ colisions) + \underline{\mu}_0$

$\pi_{1j} = \beta_{10} + \beta_{11}*(Female) + \beta_{12}$ (Income is insufficient at Grade 1)

$\pi_{2j} = \beta_{20} + \beta_{21}*(Female) + \beta_{22}$ (Income is insufficient at Grade 2)

Association between the poverty and environment variables

We conducted bivariate analyses to determine if household income was associated with social cohesion, neighborhood decay, neighborhood perception for raising children, proportion of adults on the workforce who drive to work, and vehicle-pedestrian collisions. Results indicated that students who were from insufficient income households were more likely to live in areas with low social cohesion (OR=4.0; 95% CI: 2.6, 6.1), and high neighborhood decay (OR=3.4; 95% CI: 2.4, 4.7), but not significantly associated to living in neighborhoods perceived average, bad, or very bad for raising children (OR=1.5; 95% CI: 0.9, 2.5). The associations between the above variables are presented in table 5. The results indicate weak associations between these covariates.

Table 5. Phi-r correlation matrix between household income, social cohesion, neighborhood decay, and perception of the neighborhood for raising children.

	Household Income	Social Cohesion	Neighborhood Decay	Perception for the neighbourhood for raising children
Household Income	1.00	0.22	0.19	0.08
Social Cohesion		1.00	0.19	0.16
Neighborhood Decay			1.00	0.12
Perception for the neighbourhood for raising children				1.00

Discussion

The purpose of this analysis was to further explore the determinants of AT to/from school and the extent to which AT to/from school is performed in safe or unsafe neighborhoods. We were also interested in whether or not these associations changed across the early school years. We 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 throughout the early school years. Results indicate that children from disadvantaged backgrounds and areas, assessed using household income, neighborhood decay, and perception of the neighborhood for raising children were significantly more likely to use AT to/from school in kindergarten as well as when they progress throughout the early school years. These findings describe exposure to a form of environmental injustice and point to the need for making routes to school safer to protect children already using AT to/from school and to encourage others to adopt this behavior.

Two recently published literature reviews have identified correlates of AT to/from school (14, 15). However, this study adds to the literature because it is a longitudinal study with a large population-based sample. Researchers in Australia identified social and physical environmental predictors of AT to/from school among children and adolescents. Similar to our study, they identified parental perceptions of the environment as being a determinant of AT to/from school. However, these researchers identified a social cohesion variable, such that if the parents knew many people in their neighborhood as being positively associated with AT to/from school across time while the social cohesion variable was not observed to be significantly associated with AT to/from school as children aged in the QLSCD cohort. Hume et. al. (16) measured environmental factors using parent self-report surveys. We used environmental variables assessed through other sources such as rate of vehicle-pedestrian collisions as an indicator of safety in a participant's neighborhood, which are more objective and can eliminate measurement bias.

This study provides evidence that social inequalities persist among children who use AT to/from school. More specifically, children who are from lower socio-economic backgrounds are more likely to use AT to/from school and thus more exposed to dangers such as high vehicular traffic. Public health practitioners and researchers should work with urban planners and politicians to create safer neighborhoods more conducive for active transportation. Interventions such as decreasing traffic volume and lowering the speed limit and programs such as the Walking school bus may be implemented in order to decrease danger from vehicle-pedestrian collisions.

Our results also indicate that insufficient income is a predictor of AT to/from school among children who live in high neighborhood decay neighborhoods and that there is no difference in likelihood to use AT to/from school between sufficient and insufficient household income backgrounds when children live in low neighborhood decay areas. This may imply that children from insufficient income families do not have the luxury of being driven to school in high decay neighborhoods and must use AT modes to and from school because it is affordable resulting in the environmental injustice where children from poorer backgrounds are more likely to be exposed to danger and experience harm from vehicle-pedestrian collisions.

The strengths of the current study include the use of an objective measure of neighborhood safety, density of vehicle-collisions, as a determinant of AT to/from school. We had information from a small group of participants;, studies with larger sample sizes are needed in order to determine if these findings are replicated. In addition, this is the first longitudinal study that involves participants followed from kindergarten and the second cohort study that identifies predictors of AT to/from school. Limitations include parent-reported mode of transportation to school; no collection of objective measures of physical activity; and the large number of students who did not provide their postal code of residence at all kindergarten, grade 1 and grade 2 resulting in being omitted from some analyses. Another limitation is the lack of individual-level variables to account for car ownership, which the literature indicates is a possible strong determinant of AT to/from school. Although the proportion of adults on the workforce who drive to work was used as a proxy, this variable is an area-level variable and there is potential for ecological fallacy.

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ARTICLE 4

Sustained Active Transportation is associated with a favorable body mass index trajectory across the early school years: Findings from the Quebec Longitudinal Study of Child Development birth cohort

Roman Pabayo

Lise Gauvin

Tracie Barnett

Béatrice Nikiéma

Louise Séguin

Cet article a été publié en 2010 dans un supplément du périodique « Preventive Medicine » aux pages S59 à S64.

Abstract:

Objective. To determine the extent to which active transportation (AT) to and from school is associated with changes in body mass index (BMI) from kindergarten (6-year-olds) through grade 2 (8-year-olds).

Methods. The sample included 1170 children (50.4% of baseline participants) who were part of the Quebec Longitudinal Study of Child Development (QLSCD), a birth cohort established in 1998 in Quebec, Canada. Data were collected by trained interviewers using structured interviews and measuring height and weight in the home with the person most knowledgeable about the child's health. Relative weight was operationalized as age- and sex-adjusted BMI Z-scores.

Results. Growth curve analyses showed that using AT to and from school both when in kindergarten and in grade 1 was predictive of a lower BMI Z-score (coeff=-0.18, SE=0.09, p=0.05) in grade 1. Using AT to and from school in kindergarten, grade 1, and grade 2 was predictive of a lower BMI Z-score (coeff=-0.30, SE=0.098, p=0.003) in grade 2. No other covariates were predictive of relative weight across time, although having an overweight or obese mother was associated with a BMI Z-score of 0.39 (SE=0.07, $p<0.001$) across all time points.

Conclusion: Sustained AT is associated with more healthful trajectories of BMI across the early school years.

MeSH Key Words: Active transportation, overweight and obesity, child, birth cohort, longitudinal analysis.

Introduction

Physical activity is important for healthy growth and development and can prevent childhood overweight and obesity (Dehghan et al., 2005; Epstein and Goldfield, 1999; Nemet et al., 2005; Steinbeck, 2001). Secular trends of declining physical activity among youth (Centers for Disease Control and Prevention [CDC], 1995; CDC, 1998) highlight the need for opportunities for youth to be more physically active (Barnett et al., 2006; Malina, 2004). Active transportation (AT), such as walking and cycling to and from school, is an important opportunity for children to be physically active (Sirard et al., 2005; Heelan et al., 2005), is associated with increased physical activity (Butcher et al., 2007; Davison et al., 2008; Faulkner et al., 2009), and may contribute to preventing excess weight gain (Rosenberg et al., 2006). A study among Filipino adolescents indicated that the difference in energy expended through active transportation to and from school translated to 8840 kcal/year for males and 6640 kcal/year for females, resulting in a weight reduction benefit of 2 to 3 lbs/year (0.91 to 1.36 kg/year) compared to adolescents who did not use active transportation modes (Tudor-Locke et al., 2003).

However, only limited data exist to describe the relationship between AT and measure of overweight and obesity. Of the few studies conducted, results are inconsistent. Fulton et al. (2005) conducted a cross-sectional study among a national sample of boys and girls in grades 4 through 12 to examine the characteristics of children who use AT to and from school; no significant association between AT and weight status was observed. In Landsberg et al.'s (2008) cross-sectional study of 14-year-old adolescents in Germany, there was no association between using AT to school and fat mass or body mass index (BMI); however, among those using AT, fat mass decreased as distance from school increased.

We know of only two longitudinal studies that investigated the relationship between AT and indicators of BMI. In a cohort of youths aged 9 to 11 years, attending eight rural Nebraska schools, Heelan et al. (2005) observed, somewhat counter intuitively, a positive association between involvement in AT and BMI but no association between AT and body fat (BF) as measured by skinfolds. In contrast, Rosenberg et al. (2006) did not observe a significant relationship between AT and changes in adiposity (body fat) over time, despite the presence of a significant negative cross-sectional association between AT and both BMI and skinfolds among boys. Currently, only a few studies investigate the effect of AT on indicators of BMI among youth. More longitudinal studies with large population-based samples are needed to understand this relationship better. In addition, no studies have investigated AT and indicators of BMI among children in the early school years.

If AT is a significant predictor of indicators of BMI among children, a puzzling paradox may emerge. Numerous studies have indicated that children from lower socioeconomic backgrounds are more likely to use AT modes to and from school (e.g., Pabayo and Gauvin, 2008). However, children from lower socioeconomic status (SES) families are also more likely to be overweight or obese (Danielzik et al., 2004; Guo et al., 2007; Kleiser et al.; 2009, McMurray et al., 2000). Poverty and low SES have been shown to be associated with health inequalities and specifically with many negative health and well-being outcomes among children (van Lenthe et al., 2004). A better understanding of the complex relationship between AT and overweight and obesity must take into account the socioeconomic context, including family financial circumstances.

The purpose of this study is to determine the extent to which AT to and from school is associated with changes in BMI from kindergarten through grade 2, using a population-based birth cohort of children.

Methods

Data 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). The sample was drawn from the Québec live birth registry. The sampling design followed a three-step sampling strategy. The resulting sample was representative of singleton live births registered in the Québec live birth registry in 1997–1998 with the exception on the Cri and Inuit territories, on Indian 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. By kindergarten, 1492 children 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 private schools (n=74) were excluded from the sample since they were not likely to attend a school within 1.5 km (0.9 miles) away from home, whereas children attending public schools usually

enroll in a neighborhood school. In the absence of data on distance to school, this procedure allowed us to control for potential outliers for distance to school. Students with missing data due to non-response (n=322/1492, 21.6%) were excluded; complete data were available for 1170 students.

Ethics approval was obtained from the ethics committees of the *Direction Santé Québe*c of the *Institut de la statistique du Québec*, the Faculty of Medicine of the *Université de Montréal,* and Ste-Justine's Hospital. Signed informed consent was obtained.

Variables

Sociodemographic data included child's sex, age, 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 http://www.jesuisjeserai.stat.gouv.qc.ca/outils_collecte_an.htm (E7, E8, E9).

Main exposure

Parents were asked how their child usually gets to school. Response options were: school bus, public transit, walking/bicycling, is driven, or uses multiple modes. Usual mode to and from school was dichotomized as active (walking/bicycling) or inactive (school bus, public transit, is driven, or multiple modes). In kindergarten, every participant was categorized as using AT to school or not. In each of grades 1 and 2, children were categorized as using "sustained active transportation" if parents had endorsed an active mode of transportation to school for the current as well as all previous grades. We also created a dummy variable to contrast children intermittently engaging in AT with children never engaging in AT across the three-year period.

Household income at 6 years of age: Insufficient income was operationalized according to the Low Income Cut-Offs (LICO) from *Statistics Canada* (http://www12.statcan.ca/english/census06/reference/dictionary/fam019.cfm), which takes into account the number of persons in the household and in 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 (Séguin et al., 2003; Séguin et al., 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 excellent/good or average/bad/very bad.

Mother's perception of child's health: Mothers were asked to rate their child's health as: excellent, very good, good, fair, or poor. Responses were dichotomized as excellent or not excellent.

Mother's overweight/obese status: Mothers' self-reported height and weight were obtained when the children were in kindergarten. BMI was calculated in (weight [kg]/height[m])^2. Mothers were then classified as overweight if their BMI was $\geq$25 kg/m^2 but <30 kg/m^2, or as obese if their BMI was $\geq$30 kg/m^2.

Outcomes

BMI Z-scores: Height and weight of participants were measured by trained interviewers during kindergarten, grade 1, and grade 2. BMI was computed as above. To standardize BMI values, we converted crude BMI values into age- and sex- specific BMI Z-scores according to CDC growth curves (2000). We also used three dichotomous indicators, based on BMI percentile cut-off values: at the 75^{th} and 85^{th} percentiles, participants were labeled at risk for overweight; at the 95^{th} percentile, they were labeled at risk for obesity.

Data analysis

Because BMI was repeatedly measured for the same individuals we used growth curve analyses to examine the relationship between sustained AT and BMI Z-score over time. BMI Z-score parameters were plotted at each grade. Growth curves of the children who sustained AT and those who did not were illustrated and compared. Growth curve models are a generalization of the linear model used in traditional regression analysis. Further information of 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) and HLM 5.04 (Hierarchical Linear Modeling, Scientific Software International, Chicago, IL).

To investigate the potential effect of active transportation on relative weight, we adopted a step-up approach (Raudenbush and Bryk, 2002). A first set of analyses included parameters operationalizing time, to explore whether or not BMI Z-scores changed as children progressed from kindergarten to grade 2. A second set of analyses was performed by adding the main exposure, AT to and from school, to determine if there was an effect on BMI Z-score. The contrast of interest was children who had sustained AT in comparison to all others. The children who never used AT and those who intermittently used AT were placed in the same group. Although there were no significant differences between these two groups in terms of mother's overweight/obese status, mother's perception of child's health, and child's sex, those students who used AT intermittently were more likely to be from urban areas, have sufficient household income in kindergarten, and to have a mother who perceived her neighborhood as excellent/good. A third set of analyses was performed to control for possible confounding variables, including living in a rural area, mother's weight status, sex, mother's perception of the child's health, and mother's perception neighborhood quality for raising children. Given the fact that children living in rural areas were less likely to live in close enough proximity to school to engage in AT and that the proportion of children engaging in AT differed substantially across rural and urban areas, we re-ran analyses on the subset of the sample that lived in urban areas. By replicating analyses on students attending public schools in urban areas (where students are more likely to live within 1.5 km [0.9 mi] of school), we were attempting to rule out cases where lengthy distance to school was an insurmountable barrier to AT.

All analyses were repeated with dichotomous weight status indicators (i.e., above the 75^{th}, 85^{th}, and 95^{th} percentiles) using logistic models to determine if there was a threshold at which sustained AT influenced weight status.

Results

Characteristics for the 1170 students attending public schools in Quebec who participated in the QLSCD appear in Table 1. Overall, the sample had slightly more girls (51.8%). About 77% of respondents lived in urban areas, 15.7% of students came from families with insufficient income, 29.7% of the participants had an overweight or obese mother, and 37.0% of the mothers perceived that the health of their child was less than excellent.

Table 1. Descriptive information on the subsample of children born in 1997–1998 from the Québec Longitudinal Study of Child Development with complete data at age 6 years, when in kindergarten.

Variable	**n=1170**	**%**
Male	567	48.2
Female	610	51.8
Urban	913	77.6
Rural	264	22.4
Weight status of child		
Normal	782	81.8
Overweight	106	11.1
Obese	68	7.1
Perceived health status of child		
Excellent	741	63.0
Not excellent	436	37.0
Mother's weight status		
Normal	829	70.5
Overweight	223	18.9
Obese	125	10.6
Household income		
Sufficient	992	84.3
Insufficient	185	15.7
Active transportation at age 6		
No	1008	85.6
Yes	169	14.4

At kindergarten, there were no significant differences in BMI Z-score values between students who used AT modes to and from school and those who did not. Figure 1 illustrates the unadjusted relationship between sustained AT and BMI Z-score. Results of the growth curve analyses are shown in Table 2. Children who did not sustain AT to school in kindergarten, grade 1, and grade 2 had no significant changes in BMI Z-scores at age 7 years (ß=-0.07, p=0.56) and age 8 years (ß=-0.07, p=0.97), which corresponds to BMI percentile scores of 50.8 in both grades. However, children who had sustained AT in grade 1 (i.e., used AT in both kindergarten and grade 1) appear to start on a healthier trajectory and had, on average, a BMI Z-score that was 0.18 (p=0.05) lower than the students who did not sustain AT through grade 1, corresponding to a BMI percentile score of 43.6. Furthermore, children who had sustained AT to school in grade 2 (i.e., used AT in kindergarten, grade 1, and grade 2) had on average a BMI Z-score that was 0.30 (p=0.003) standard deviations lower than all other children, corresponding to a BMI percentile score of 38.2. The only other variable that remained significant in the multivariate model was mother's overweight/obesity status when the child was 6 years old. Children whose mother was overweight or obese maintained on average a BMI Z-score difference of 0.39 ($p<0.001$; corresponding to a BMI percentile value of 65.2) across all grades compared with children whose mothers were not overweight or obese at baseline. SES was not a significant predictor of BMI Z-score within the multivariate model, although bivariately it was associated with likelihood of being overweight (OR=1.46; 95% CI: 1.00, 2.14) at kindergarten. Other researchers have argued that birth weight should be included as a potential confounder of the relationship between AT and BMI (McMillen et al., 2006; Gillman, 2004). However, when controlling for low birth weight (≤2500 g [5.5 lbs]), multivariate results did not change and the significant relationship between AT and BMI Z-score was unattenuated.

Table 2. Results of multi-level modeling analyses investigating the association between sustained active transportation (AT) to and from school and BMI Z-score among children participating in the Québec Longitudinal Study of Child Development, 2004–2007.

Variance Components Between participant	**Parameter**	**Variance Estimates (μ)**	**Standard Deviation**	**df**	**p-value**
Baseline	μ_{0j}	630.43	25.11	1150	<0.001
	E	265.50	16.29	--	--
Within participant Fixed Effects		**Parameter**	**Coefficient**	*SE*	**p-value**
Baseline-6 yrs		β_{00}	-0.08	0.06	0.19
Active transportation at age 6		β_{01}	0.07	0.10	0.50
Female		β_{02}	-0.03	0.06	0.67
Rural		β_{03}	-0.14	0.07	0.06
Income is insufficient		β_{04}	-0.01	0.09	0.89
Mother is overweight or obese		**β_{05}**	**0.39**	**0.07**	**<0.001**
Perception of the neighborhood		β_{06}	0.03	0.08	0.66
Perception of child's health		β_{07}	0.07	0.06	0.30
Follow-up-7 yrs		β_{10}	0.02	0.03	0.56
Active transportation at ages 6 and 7 yrs		β_{11}	-0.18	0.09	0.05
Follow-up 8 yrs		β_{20}	-0.001	0.03	0.97
Active transportation at ages 6, 7, and 8 yrs		**β_{21}**	**-0.30**	**0.10**	**0.003**

Level-1 Model

$$y_{ij} = \pi_{0j} + \pi_{1j}*(D\_Grade1) + \pi_{2j}*(D\_Grade2) + E$$

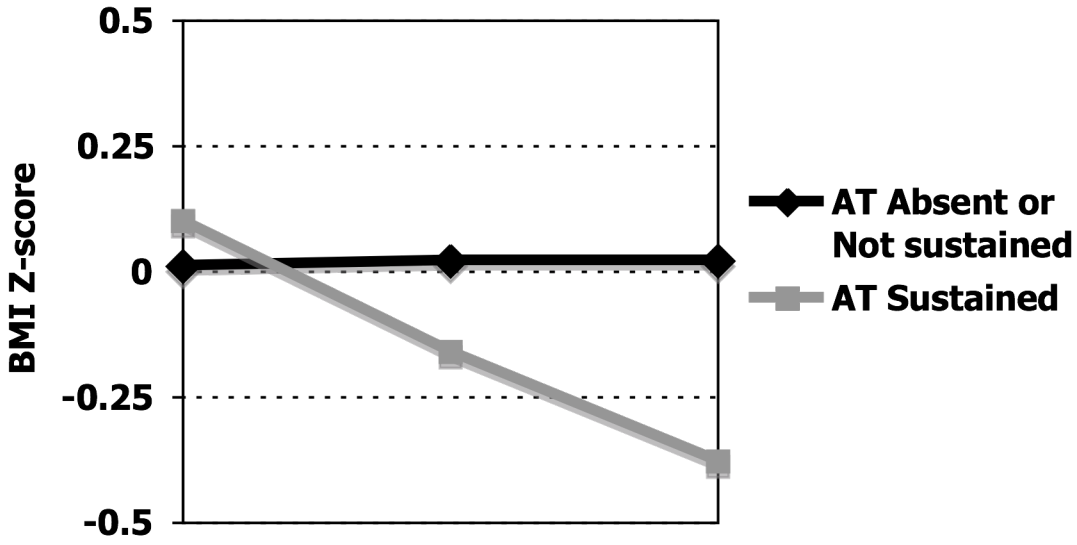
Level-2 Model

$$\pi_{0j} = \beta_{00} + \beta_{01}*(D\_ATKindergarten) + \beta_{02}*(D\_Female) + \beta_{03}*(Rural) + \beta_{04}*(D\_LowIncome) + \beta_{05}*(D\_MomOverweight/Obese) + \beta_{06}*(D\_SafeNeighborhood) + \beta_{07}*(D\_HealthNotExcellent) + \mu_{0j}$$

$$\pi_{1j} = \beta_{10} + \beta_{11}*(D\_SustainedATGrade1)$$

$$\pi_{2j} = \beta_{20} + \beta_{21}*(D\_SustainedATGrade2)$$

Figure 1. Average BMI Z-score across kindergarten, grade 1, and grade 2 as a function of Sustained active transport (AT) among children participating in the Quebec Longitudinal Study of Child Development, 2004-2007.



We found no significant associations between sustained AT and relative weight when the outcome was dichotomized at 75th, 85th, or 95th percentile cut-points. Results using the 85th percentile (threshold value for overweight or obesity) are shown in Table 3. There were no significant relationships between sustained AT and being overweight or obese in kindergarten (OR=1.19; 95% CI: 0.72, 1.98), in grade 1 (OR=0.66; 95% CI: 0.31,1.42), or in grade 2 (OR=0.95; 95% CI: 0.44, 2.05). However, maternal weight status was associated with being overweight or obese (OR=2.28; 95% CI: 1.68, 3.09) in all three grades.

Table 3. Results of multi-level modeling analyses investigating the association between sustained active transportation (AT) to and from school and likelihood of being overweight/obese among children participating in the Québec Longitudinal Study of Child Development, 2004–2007.

Variance Components Between participant	**Parameter**	**Variance Estimates (μ)**	**Standard Deviation**	*df*	**p-value**
Baseline	μ_{0j}	2.61	1.61	1162	<0.001
Within participant Fixed Effects		**Parameter**	**Coefficient OR (95% CI)**	*SE*	**p-value**
Baseline - 6 yrs.		β_{00}	-2.04 0.12 (0.09, 0.18)	0.17	0.00
Active transportation at age 6		β_{01}	0.18 1.19 (0.72, 1.98)	0.26	0.49
Female		**β_{02}**	**-0.30** **0.74 (0.55, 0.99)**	**0.15**	**0.046**
Rural		β_{03}	-0.20 0.81 (0.57, 1.17)	0.18	0.26
Income is insufficient		β_{04}	0.29 1.34 (0.01, 1.98)	0.20	0.14
Mother is overweight or obese		**β_{05}**	**0.82** **2.28 (1.68, 3.09)**	**0.16**	**<0.001**
Perception of the neighborhood		β_{06}	0.01 1.01 (0.70, 1.46)	0.19	0.97
Perception of child's health		β_{07}	0.21 1.24 (0.92, 1.68)	0.15	0.17
Follow-up7 yrs		β_{10}	-0.08 0.92 (0.70, 1.21)	0.14	0.56
Active transportation at ages 6 and 7 yrs		β_{11}	-0.41 0.66 (0.31, 1.42)	0.39	0.29

Table 3. Results of multi-level modeling analyses investigating the association between sustained active transportation (AT) to and from school and likelihood of being overweight/obese among children participating in the Québec Longitudinal Study of Child Development, 2004–2007.

Variance Components Between participant	**Parameter**	**Variance Estimates ($\underline{\mu}$)**	**Standard Deviation**	*df*	**p-value**
Follow-up 8 yrs		β_{20}	-0.038 0.96 (0.73, 1.26)	0.14	0.78
Active transportation at ages 6, 7, and 8 yrs		β_{21}	-0.048 0.95 (0.44, 2.05)	0.39	0.90

$Prob(Y=1|B) = p_{ij}$

Level-1 Model

$$p_{ij} = \pi_{0j} + \pi_{1j}*(D\_Grade1) + \pi_{2j}*(D\_Grade2) + E$$

Level-2 Model

$$\pi_{0j} = \beta_{00} + \beta_{01}*(D\_ATKindergarten) + \beta_{02}*(D\_Female) + \beta_{03}*(Rural) + \beta_{04}*(D\_LowIncome) + \beta_{05}*(D\_MomOverweight/Obese) + \beta_{06}*(D\_SafeNeighborhood) + \beta_{07}*(D\_HealthNotExcellent) + \underline{\mu}_0$$

$$\pi_{1j} = \beta_{10} + \beta_{11}*(D\_SustainedATGrade1)$$

$$\pi_{2j} = \beta_{20} + \beta_{21}*(D\_SustainedATGrade2)$$

In a final set of ancillary analyses (not shown), we explored whether or not the effects were attenuated when controlling for nutritional variables. Although measures of energy intake were not available from kindergarten to grade 2 as in previous measurement occasions (Dubois et al., 2008), we did have measures for the previous week of the number of times the child ate breakfast at home, the number of times the child drank soft drinks, and the number of fruits and vegetables consumed. When these variables were entered into the model predicting BMI Z-score, effects of AT remained unattenuated (coefficient for sustained AT in grade 2=-.30, $p<0.01$). When these variables are included in the model with overweight/obesity status as the outcome, the impact of sustained AT in grade 2 remained non-significant (OR=1.02; 95% CI: 0.47, 2.22).

Discussion

The purpose of this study was to determine the extent to which sustained AT to and from school is associated with changes in relative weight from kindergarten through grade 2, using a population-based birth cohort of children. Results indicated that students who sustained AT to and from school from kindergarten through grade 2 had, on average, a lower BMI Z-score in grades 1 and 2 than those who did not use AT modes or used AT intermittently, even after controlling for confounders.

Two literature reviews on the relationship between AT and indicators of overweight and obesity provide little support for an association (Davison et al., 2008; Faulkner et al., 2009). Our results are not consistent with findings from two recent longitudinal studies (Rosenberg et al., 2006; Heelan et al., 2005). Heelan et al. (2005) showed an unexpected positive

relationship between AT and BMI which the authors hypothesized was explained by weight gain of the overweight subsample. However, their follow-up period was less than one year, whereas students in the current investigation were followed for three years. The beneficial effects of AT may be delayed and may only appear when sustained over longer periods. Furthermore, it is possible that children in their study engaging in AT were from lower-income families, which increased the likelihood of overweight. Another longitudinal study examined the potential benefits of active commuting to school on overweight status (Rosenberg et al., 2006). They concluded that active commuting to school over 2 years was not associated with BMI change or overweight status. Although the Rosenberg et al. (2006) study also included sustained AT over time as a main exposure, children in their study were older (grades 4–5) than children in the current study. The impact of sustained AT to school may be more evident during the early years of childhood and when children typically have fewer alternatives for physical activity than do older children. Results from our study were significant only when the relative weight outcome was continuous, not when it was dichotomized. The continuous outcomes may be more sensitive to the influence of sustained AT to school than bluntly dichotomized outcomes. Nonetheless, these results indicate that sustained AT may be beneficial to children by setting children on a lower BMI trajectory, which might reduce chances of developing overweight or obesity.

We controlled for SES because of the well-known relationship between low SES and overweight and obesity (Danielzik et al., 2004; Guo et al., 2007; Kleiser et al., 2009; McMurray et al., 2000). Although significant in univariate analyses, SES was no longer significant in the multivariate model, perhaps due to the loss to follow-up of children from low-SES families. Future research should attempt to disentangle the separate and joint

effects of SES and sustained AT on BMI, with the former providing more long-term and powerful effects and the latter representing only one of many more proximal influences.

These results indicate that active transportation to school should be encouraged and adopted early on in childhood, for example during the first year of elementary school. Maintaining AT to school throughout the school years may favorably influence trajectories of BMI. The longer AT to school is sustained throughout the child's scholastic career, the more favorable the impact on relative weight.

Although there has been a call to develop and implement interventions to increase AT to and from school, it is important to stress that these programs need to be sustainable (Davison et al., 2008). Kingham and Ussher (2005) conducted an evaluation of the Walking School Bus program in Christchurch, New Zealand from its initiation in 2000 to its follow-up in 2003. They observed that few routes survived, beyond the first year and the average number of children on each route declined from 9 to 7.7. They identified several barriers to program sustainability including the lack of parent volunteers, inclement weather, poor road safety, and a lack of communication between schools and parent organizers. Although the program had positive process evaluation results, such as parent support of the program, the sustainability of the Walking School Bus could not be achieved.

The strengths of the current study include the use of a large population-based cohort from throughout Québec and a prospective cohort study design. In addition, this is the first longitudinal study that involves participants followed from kindergarten. Limitations include self-reported mode of transportation to school; no collection of objective measures of physical activity; only 14% of the sample using AT at age 6, which limited the

proportion of students that can be considered to maintain AT through the early school years; and the lack of data on exact distance between home and school. Further, although nutrition intake was assessed through 24-hour recalls when the children were 4 or 5 years old, the intake was not measured at ages 6, 7, or 8 years and could not be controlled for in the analyses. Nonetheless, this study is an indication that sustained AT is associated with a more favorable BMI trajectory over time.

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DISCUSSION

The overarching goals of this doctoral thesis are to identify individual and ecologic determinants of AT to/from school among children living in an industrialized nation and to evaluate the possible health benefits of AT. An overall statement regarding how the findings of the four investigations contribute to these overarching objectives, the strengths and limitations of the thesis, the next steps for future research, and implications for intervention in public health will be discussed in the following paragraphs.

Synthesis and Significance of Results

The prevalence of the differing modes of transportation to and from school, walking, school bus, public transit, motorized vehicle, and multiple modes were estimated using the data from the 1999 Quebec Child and Adolescent Health and Social Survey. Use of different modes of transportation to school were as follows: walking=23.3%, public transit=8.5%, school bus=46.2%, motor vehicle=9.0%, or multiple modes =12.1%. Bivariate results point to some interesting trends. For example, younger children, boys, children living in urban settings, students from lower income households, and children whose parents were born in Canada were more likely to walk to and from school.

In addition to Hume et. al.[83], this doctoral thesis includes the only other longitudinal studies investigating the predictors of AT to/from school. One of these used the Canadian National Longitudinal Study of Children and Youth, a nationally representative, population-based sample of school-aged children. As children aged, the likelihood of using AT to/from school increased and peaked at age 10 years and then decreased. The following time-varying predictors of using AT to/from school were identified: living in households with inadequate household income (OR=1.21; 95% CI=1.06,1.38), having an older sibling

(OR=1.14; 95% CI=1.04,1.25), having a single adult in the household (OR=1.46; 95% CI=1.65), and living in an urban region (OR=3.66; 95% CI=3.23,4.15). Each of these was predictive of using AT to/from school. Time-invariant predictors included: living in the Prairies (OR=2.13; 95% CI=1.82, 2.49), living in British Columbia (OR=1.43; 95% CI=1.19,1.73). Each of these was predictive of using AT to/from school. Children living in the Atlantic Provinces (OR=0.42; 95% CI=0.36,0.49) were significantly less likely to use AT to/from school. Also, a significant cohort effect was detected, where children from older cohorts were significantly more likely to use AT to/from school. None of these predictors were associated with change in likelihood of AT across the school years indicating that the influence of variables associated with likelihood of AT to/from school at baseline remained constant across the school years.

The second longitudinal study investigating the predictors of AT to/from school within the context of this doctoral thesis used the Quebec Longitudinal Study of Child Development, which comprises children followed yearly from Kindergarten to grade 2. Among children in urban regions of Quebec, insufficient household income (OR=1.80, 95% CI:1.04, 3.11), birth rank greater than 1 (OR=1.75, 95% CI:1.19, 2.57), living in a neighbourhood that is average, bad or very bad for raising children (OR=1.79,95% CI:1.10, 2.90), and living in an area with high neighbourhood decay (OR=2.57, 95% CI=1.63, 4.05) were predictive of greater likelihood of using AT to school as children aged from 6 to 8 years of age. However, restricting the sample to children living on the Island of Montreal and adding road danger indicators in this sub-sample of children, only high neighborhood decay (OR=3.68, 95% CI: 1.22, 11.12) and high rate of vehicle-pedestrian collisions (OR=3.43, 95% CI: 1.29, 9.12) were predictive of greater likelihood of using AT to and from school as children progressed through the early school years.

The health effects of AT to/from school were also examined using the QLSCD. The objective was to determine the extent to which AT to/from school is associated with changes in body mass index (BMI) from kindergarten to grade 2. Growth curve analyses showed that using AT to/from school both when in kindergarten and in grade 1 was predictive of a lower BMI Z-score (coeff=-0.18,SE=0.09, p=0.05) in grade 1. Using AT to/from school in kindergarten, grade 1, and grade 2 was predictive of a lower BMI Z-score (coeff=-0.30, SE=0.098, p=0.003) in grade 2. These results indicate that sustained AT is associated with more healthful trajectories of BMI across the early school years.

Overall then, the findings presented herein show that modeled as time-varying covariates, low household income, greater number of older siblings in the household, having a single adult in the household, and living in an urban region consistently predicted the likelihood of AT to/from school as children aged. Furthermore, modeled as time-invariant covariates, province of residence and being in an older cohort were also associated with greater likelihood of AT to/from school. These findings also demonstrate beneficial health effects of sustained AT to/from school, notably as illustrated by the favourable BMI trajectories.

Conceptual Framework

The ECAC has recently been developed to illustrate conceptually how factors influence AT to/from school **(Appendix-5)**.[42] In keeping with calls to guide future research using this framework, this doctoral thesis used the ECAC to test several hypotheses.

Although these studies reflect different parts of the ECAC framework, more research is needed in order to address other aspects. For example, there is a need for additional

research of how policy-level factors are related to AT to/from school.[42] Policy and policy changes may impact the physical environment, social context, which in turn can impact parental or student perceptions that may facilitate or discourage AT to/from school.[42] Policies involving traffic volume, street network design, the location of new schools may all have an effect on AT to/from school. For example, when laws are implemented to reduce traffic flow through residential neighbourhoods, parents and students may feel safer for their children to use AT to/from school. There is variability across jurisdictions concerning traffic and zoning laws. This may explain differences in the estimated proportion of children using AT to/from school across these jurisdictions. Results from this thesis indicate that there are regional differences in Canada regarding participating in AT to/from school. Students from the Prairie Provinces and British Columbia had the highest estimated proportions and the Maritime Provinces had the lowest estimated proportions of students using AT to/from school. Policy differences on how street networks are designed, where new schools are built and traffic laws may be reasons why there are provincial differences in the use of AT to/from school.

Another gap is the lack of studies that assess the child's personal influence. For example, whether the child wants to or likes to use AT has not been thoroughly studied. Also, self-efficacy, whether a child perceives that he or she has the ability to use AT to/from school may be a significant factor for this behaviour.[42] These personal characteristics of the child can have an influence on the parent's decision to allow the child to use AT to/from school. According to the ECAC, a parent's perception can be affected and therefore in turn influences the decision to allow the child to use AT to/from school. An increase in self-efficacy or a change in a child's desire to use AT to/from school may be reasons why the likelihood of using AT to/from school increases as a child ages. As a child gets older in

elementary school, he or she may become more independent and therefore have greater self-efficacy for using AT to/from school. Parents are therefore more likely to allow their child to use AT to/from school.

The effect of weather conditions on AT to/from school has not been thoroughly examined. Results from one study indicated that weather was not associated with AT to/from school.[126] Conceptually, weather is part of the physical environment within the ECAC. Extreme weather conditions can act on a parent's perception on whether their child should use AT to/from school. However, inaccessibility of resources, such as a car or money for a transit pass, may make weather conditions a negligible factor on AT to/from school.

Although the ECAC has been a valuable tool for investigators to guide their research, the framework leaves gaps in the explanation of the determinants and benefits of AT to/from school. The framework is incomplete when illustrating the relationship between AT to/from school and predictors and health outcomes. For example, the model does not account for work flexibility and whether the child goes to day care. These covariates can potentially influence a parent's decision to allow their children to use AT to/from school. Also, there is a bidirectional arrow between AT and BMI. The ECAC needs to incorporate other significant determinants of BMI such as dietary intake, physical activity, and sedentary behaviour. Future studies should attempt to include other factors that may confound the relationship between AT and health outcomes.

Time-Varying Covariates

It was an objective for this thesis to show the importance of time-varying covariates and their relationship with AT to/from school. A time-varying variable is one that is not constant over time. Since the data set has repeated measures within each participant, it was an excellent opportunity to observe possible associations between time-varying covariates and AT to/from school over time. The time-varying covariates that were tested within this thesis were income inadequacy, mother's perception of child's health, number of siblings, and type of setting (i.e. urban or rural). Although some of the variables such as income inadequacy were significant at baseline, there were no significant interactions between these variables and time. In other words, students from inadequate household income households were significantly more likely to use AT to/from school at baseline in comparison to students from adequate household income backgrounds but there were no significant changes in this likelihood as the children were followed across time. Perhaps the main reason for these findings was that there was not enough variability within students across time. For example, there were no large proportions of children moving from adequate to inadequate household incomes. Therefore, for this thesis, conceptualizing variables to be time varying was not useful. Nonetheless, studying the influence of time-varying covariates may provide insight if the situation was more appropriate. For example, conducting studies when high within variability is expected may be suitable. One example may be determining the effect of an economic recession on AT to/from school. It may be more likely to observe large numbers of families living in poverty during a recession and to come out of poverty after a recession. This change in income may have an effect on AT to/from school.

Environmental injustice

The investigation of patterns of mode of transportation to/from school provide further evidence that during elementary school years, children are more likely to use AT to/from school as they age. Children from lower SEP backgrounds are more likely to use AT to/from school. Although this behaviour is seen as the healthy mode of transportation, a form of environmental injustice is occurring since children who are from lower SEP backgrounds are more likely to live in neighbourhoods that are high risk. For example, children from lower SEP backgrounds are more likely to live in neighbourhoods that are perceived to be not optimal for raising a child, that have high decay, and that display low social cohesion. The effects of poverty whether described by income insufficiency, neighbourhood deprivation, or poor quality of the neighbourhood for raising children are compounded. Thus, children living in underprivileged and impoverished areas are more likely to use AT to/from school.

Density of pedestrian-vehicle collisions, an alternative assessment of neighbourhood safety was also identified as a predictor of AT to/from school albeit in a subsample of the dataset. Moreover, this effect was also compounded by neighbourhood deprivation. These results indicate that children from underprivileged backgrounds who use AT to/from school are disproportionately exposed to danger in comparison to children who are from privileged backgrounds. This evidence of environmental injustice underscores a need for regulations and interventions that provide equal access to safe living environments for all children.

As public health researchers and practitioners, AT to/from school should not only be encouraged but interventions and policies must be developed and implemented to create safer routes to school. These results should lead us to reflect on our car-dependent culture and its societal costs, including ever-increasing volumes of traffic, exposing children to air

pollutants and high rates of vehicle-pedestrian collisions. Decreasing speed limits, reducing traffic, and prosecuting motorists who drive recklessly are ways to make routes to school safer.[127] Also, finding safer alternatives to the automobile may be attractive solutions to the urban planner attempting to make city environments more livable.

Active transportation to/from school needs to be sustained

Although AT to/from school should be encouraged, this behaviour should also be sustained as children age. AT to/from school should be adopted early in a child's academic years and consistently incorporated into their daily routines. AT to/from school likely needs to be sustained throughout the school years in order for children to achieve health benefits. This has ramifications in terms of the development of interventions designed to encourage children to use AT to/from school. Interventions, such as the Walking School Bus have been shown to be difficult to sustain, with limited continuity after the first year of implementation.[128] More research is needed in order to help practitioners, school administrators, and parents develop and implement programs designed to sustain AT to/from school among students.

Strengths and Limitations

One of the main strengths of this doctoral thesis is that much of the data and analyses are longitudinal. This is novel and original in the emerging field of identifying correlates and predictors of Active Transportation to/from school. Only one other study thus far has examined the determinants of AT to/from school as children age.[83] The utilization of large population-based and representative cohorts is another strength of this thesis. Therefore the results are more likely to generalize to other urban populations in developed nations. The

usage of the Montreal ambulance service pedestrian-vehicle collision data is another strength. Most studies have utilized measures of perceptions to assess neighbourhood characteristics, such as safety and quality of the neighbourhood. By using alternative measures of the environment (i.e., data of collision between motor vehicles and pedestrians), respondent bias is eliminated.

Although this doctoral thesis has many strengths, there are also several limitations that need to be mentioned. In all four studies, the mode of transportation was measured by parent-report. Although the reliability of these measures has been tested, the validity has not. However, one of the only validation studies conducted has indicated that parent-proxy report is currently the best way to measure AT to/from school. Nonetheless, it has recently been suggested that travel patterns for students might be too complex to be accurately ascertained using a single question about usual mode of transportation to/from school.[39] Another limitation is the low sample size in the sub-analyses identifying the predictors of AT to/from school as children age in study 3. Due to missing data on postal codes, many students had to be excluded. Therefore, the analyses including pedestrian-vehicle collisions and approximate distance to school had small sample sizes. These results are thus exploratory and definite conclusions and inferences should not be drawn prior to replication. There were numerous variables that were not collected in the NLSCY and the QLSCD. Variables such as distance to school, environmental measures, having a traveling companion to and from school, weather conditions, and car ownership were not included in the model. In the third paper, an attempt to add these missing variables was attempted. For example, the proportion of adults who drive to work, a variable from Statistics Canada, within a postal code was used as a proxy of car ownership and then linked to the QLSCD data. However, since this proxy variable for car ownership is an aggregated variable,

ecological bias may have occurred. Although having a traveling companion to and from school was not included in the analyses, it was possible to include having an older sibling. Nonetheless, future research could include factors that describe the accessibility of traveling companions, the presence of children in the neighbourhood who also use AT to/from school, or even the availability of a AT to/from school program or initiative such as the walking school bus. Although the weather has been identified as a barrier to using AT to/from school among less than 25% of the American population,[33, 38] the effect it has on AT has not been thoroughly examined. Also, to account for distance to school, the approximate distance between the postal code of the child's residence and the postal code of the school was calculated for the students who did not move. Although household income was no longer significantly associated with AT to/from school, students who were living in the high decay neighbourhoods and students living in neighbourhoods that were perceived to be poor, or average were more likely to use AT to/from school. Household income may not have been significantly associated with AT to/from school because there was a loss in power due to missing data.

Possible Public Health Implications

Results from this thesis have implications for public health. Findings indicate that there is a need for continued and timely surveillance of AT to school among children. Surveillance data can help track this behavior and help detect trends in which there are distinctive changes in this behavior as children age. By doing so, interventions may be developed and at-risk groups, such as groups based on age, sex, and SEP can be targeted. These health promotion strategies can help maintain or increase proportions of students using AT to school. By identifying the children who do use AT to school, public health can help make routes to school safer. This health protection strategy can include policies such as

implementing traffic reduction and lowering the speed limit. More research and evaluation of programs intended to increase AT to/from school and protect those using AT can then be conducted on a continual basis in order to insure that programs and policies remain effective and sustainable.

Future Directions for Research

There remain gaps in the knowledge on determinants and outcomes of AT to/from school. Future studies are needed to determine the validity of the survey questions that assess the mode of transportation to/from school. Researchers can take advantage of novel technology, such as GPS devices and accelerometers and place them on children in order to test the validity of the questions. Since the sample size of the sub-analyses examining the relationship between pedestrian-vehicle collision density on AT to/from school was small, future studies with larger sample sizes are needed. For example, a large population-based sample of school aged children in the Montreal area could be generalizable to other urban populations from industrialized nations.

As previously stated, a major challenge was not having access to variables such as car ownership, neighbourhood characteristics, and distance between home and school. Researchers need to consistently collect these data in order to adjust for these variables in the model. A greater advantage would be to repeatedly measure these variables so it can be determined if these time-varying predictors are significant predictors of changes in use of AT to/from school. For example, by calculating the distance to school at each time point, researchers can examine use of AT to/from school among children who move to other residences or change schools and determine if distance to school is a time-varying predictor of AT to/from school. This would provide stronger evidence for causality. Access to a

vehicle should also be collected repeatedly. Research has consistently shown an increase in car dependency in recent years.[129] This can have ramifications not only on AT to/from school but also on other opportunities of physical activity. Hypothetically, repeated measures of access to a vehicle can help researchers illustrate how a loss or an increase of access can lead to greater or lesser likelihood of AT to/from school and increased or decreased physical activity levels. By collecting this type data, researchers can gain a more accurate picture of the predictors of AT to/from school. In the same manner, repeated measures of objective and subjective measures of perception of the neighbourhood also need to be collected. Changes in neighbourhood characteristics can lead to changes in AT to/from school.

Although there is a dearth of research in this field, future researchers may want to use experimental study designs to determine the effect of modifying neighbourhoods (e.g., school bus programs, traffic calming initiatives) on AT to/from school. This type of research can help in uncovering causal associations between neighbourhood features and AT to/from school. For example, a natural experiment can be taken advantage of if a new residential neighbourhood was to be developed. This neighbourhood could incorporate the environmental features that have been shown to be correlated with AT to/from school. Neighbourhoods would include schools within walking distance from residences, traffic calming features, and traffic lights and crosswalks. A pre-post measurement can be conducted to assess if the student used AT to/from school before moving and then after moving into the neighbourhood. A comparison group can also be identified by recruiting families who have moved into neighbourhoods without the neighbourhood features previously mentioned. By conducting such research, neighbourhood features as causal

factors of the use of Active Transportation to/from school and of other types physical activity can be illustrated.

CONCLUSION

This study illustrates how environmental and individual variables interact to influence a health behaviour that can have an impact on public health. For example, safety of a neighbourhood measured in a variety of ways are associated with AT to/from school. Social and health inequalities are evident because those who are exposed to dangerous environments are youth from disadvantaged families. Also, this research shows a stark difference between living in urban and rural areas. Active transportation may only be a feasible opportunity for physical activity for urban populations. As a result, differing profiles of predictors for physical activity may be identified for urban and rural populations and therefore public health practitioners may need to develop and implement different interventions in differing settings in order to increase physical activity levels. By understanding the factors that influence AT to/from school, this behaviour can be adopted by youth and children and carried into AT to/from work in adulthood, which can have positive influences in later years of the life cycle.

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Appendices

APPENDIX-I

Table of population-based studies estimating proportions of students using active transportation to/from school

Appendix-1: Table of population-based studies estimating proportions of students using active transportation to/from school.

Author and Location	Study design & Population	How mode of transportation was measured?	Prevalence Results
Pabayo & Gauvin[29] 2008 Quebec, Canada	Data for this cross-sectional study were from the 1999 Quebec Child and Adolescent Health and Social Survey (QCAHS), which is a representative population-based community survey that sampled 3613 youths in the province of Quebec, Canada aged 9, 13, and 16 years old, n=3613	Students were asked which mode of transportation to and from school they used most often. Response options were: school bus, walking, public transit, motor vehicle, or multiple modes of transportation.	Significant results include: 40.3%, 15.2%, and 13.0% of 9, 13, and 16 year olds walked to school, respectively. Also, 24.7% of boys and 21.8% of girls indicated that they walk to and from school. When stratifying by SES, 30.9% (<$30,000), 25.2% ($30,000 to $60,000) and 17.1% (>$60,000) walked to and from school.
Booth et. al,[31] 2007 New South Wales, Australia	Data for this cross-sectional study were taken from the 2004 Schools Physical Activity and Nutrition Survey. A representative population survey of students attending kindergarten and grades 2, 4, 6, 8, and 10 in primary and secondary schools. Only grades 6, 8, and 10 were presented. n=1448 boys, 1302 girls.	Students were asked to report, separately, how they travelled to school and how they travelled home from school in a usual week. A checklist of eight modes of transport was provided (walking, train, bicycle, car, school bus, other bus, ferry or boat, and 'other') and students were asked which modes of transport they used, the number of weekdays on which they used each mode of transport and how long they spent on this mode each time they used it. Students could report more than one mode of transport for each trip.	Among grade 6 students, 30% walked to school. Amongst high school students, 15-20% walked to school. Other results include: Amongst Boys: 28.5%, 15.0%, and 17.3% walk to and from school grades 6, 8, and 10 respectively. Amongst Girls: 29.6%, 15.8%, and 17.1% walk to school, grades 6, 8, 10 respectively. Amongst grade 6 students when stratified by SES, 28.2% (Low), 31.2%(Medium), and 26.1% (high), walk to and from school. Amongst grade 8 students, 14.4% (Low), 18.7% (medium), and 11.1% (high) walked to and from school. Amongst grade 10 students, 19.2% (low), 19.7%(medium), and 12.6% (high) walked to and from school.

Author and Location	Study design & Population	How mode of transportation was measured?	Prevalence Results
MMWR report,[32] Georgia, USA 2000	Data on modes of transportation to school were collected as part of the Georgia Asthma Survey, a statewide, representative, random-digit-dialed telephone survey of Georgia households with children conducted during May-August 2000. Sample size of 1,656 children aged 5-15 years who attended school. Additional analyses were performed for a subset of children (n=315) who lived <1 mile from school.	Respondents were asked about the mode of transportation to school and the distance between home and school rounded to the nearest mile.	Of the children, 4.2% (95%CI: 2.9%-5.5%) walked to school the majority of days of the week. Of the 315 children who lived < 1 mile from school, 18.6% (95% CI: 12.8%-24.4%) walked to school the majority of days of the week. 19.3% (95% CI: 11.5-27.2%) and 17.9% (95% CI:10.2%-25.5%) of males and females respectively, living <1 mile from school.
Martin et. al,[30] 2007 USA	The study included a nationally representative sample of US children, aged 9 to 15 years, and one of their parents from 2004. The study population comprised two nationally representative cohorts that were each surveyed in the spring of 2004. Cohort 1 consisted of children aged 11 to 15 years and one of their parents. Cohort 2 consisted of children aged 9 to 13 years and one of their parents who underwent a baseline survey in 2004.	The number of miles each child lived from school was calculated based on parental response to an open-ended question: "How many miles does [he/she] live from school?" The proportion of children living <1 mile, was then calculated. Among those living <1 mile, usual number of days walking or bicycling to school was reported by the parent (0 to 5 days). Active travelers were defined in two ways: those reporting ≤1 day (n=1284), and those reporting 5 days (n=941).	Close to 35% of children live within a mile of school. Of these students, 47.9% were classified as active travelers. Just over 59% of students of parents with less than high school education were classified as active travelers compared to 33.7% of those with parents with an advanced degree. In terms of household income, ≤$25,000 (56.7%), $25,000-50,000 (51.1%), $50,000-$75,000 (45.1%), and >$75,000 (39.6%) were classified as active travelers to and from school. When stratified by gender, 48.1% of boys and 47.8% of girls were active commuters.

Author and Location	Study design & Population	How mode of transportation was measured?	Prevalence Results
MMWR report[33] 1999 USA	HealthStyles Survey, an annual mail survey of health-related attitudes and behaviors in the United States. In 1999, 3,550 households that had previously indicated a willingness to respond to survey questions. This sample was representative of the U.S. population on the basis of eight demographic variables: age, sex, marital status, race/ethnicity, income, region, household size, and population density. A total of 2,636 (74%) households responded. The 749 (28%) households with children aged 5-18 years were asked if their youngest child walked or biked to school at least once a week during the preceding month. Results were weighted to match population distribution in the US by using the eight demographic variables.	Parents of children aged 5-18 years were asked (1) if their youngest child walked or biked to school at least once a week during the preceding month.	Of the 611 respondents, 19% reported children walking and 6% reported children biking to or from school at least once a week during the preceding month.

Author and Location	Study design & Population	How mode of transportation was measured?	Prevalence Results
Tudor-Locke et al.[34], 2002, Russia	The Russian Longitudinal Monitoring Study (RLMS) is the first nationally representative household survey in the Russian Federation. Data were available for 1094 children aged 7-13 years. There were 572 boys and 522 girls.	Parents of participants were asked a series of questions about their children's physical activity behaviour, focusing on in-school physical education classes, out-of school physical activities an active commuting to school. Questions were asked to assess typical mode of commuting to school (car, walk or bicycle) and total duation of commute (minutes/day) both to and from school.	With regard to children's modes of commuting to school, 91.6% of parents reported children walking to school, 12.7% reported transportation by car to school, and 0.2% reporting bicycling to school.
Ham et al.,39 2005 USA	Cross-sectional analyses at two time points used data from the 1995 Nationwide Personal Transportation Survey and the subsequent 2001 National Household Travel Survey. The populations of interest were U.S. civilian noninstitutionalized adults (aged 18 years and older) and youth (aged 5 to 15 years). Trends were reported for walking trips of 1 mile or less to school (youth) using 3114 trips (1995) and 4073 trips (2001) made by youth.	NPTS: Diary questions asked for a trip distance (miles or blocks), destination, mode of travel, start time, duration, and identification of travel companions who lived in the household. Adult proxies were used for youth younger than 14 years. Walking trips were defined as those for which "walk" was the reported main travel mode, and trips to school were defined as all trips with a destination of "school." In the NHTS: Diary questions and prompts were modified in 2001 to improve underreporting of walking and bicycle trips. The operational definitions of walking trips, urbanization classifications, and exclusion criteria were the same as for the NPTS 1995.	For trips to school of 1 mile or less, youths also increased walking from 1995 (31.3%; CI, 27.9-34.4) to 2001 (35.9%; CI, 33.0-38.8).

Author and Location	Study design & Population	How mode of transportation was measured?	Prevalence Results
McDonald,[36] 2007 USA	Repeat Cross-sectional study. The National Personal Transportation Survey (NPTS) is a population-based survey conducted by the US Department of Transportation (DOT)in 1969, 1977, 1983, 1990, 1995, and 2001. The survey collects information on all trips undertaken by members of selected households on a randomly assigned survey day. Household members are asked to provide information on all trips including purpose, mode, and travel time.	"How did [child's name] usually get to school?" and "How did [child's name] usually get from school?" and "how many miles was it from home to [child name]'s school?"	Analysis of the NPTS data shows that walking and biking were the most common means of getting to school in 1969, accounting for 40.7% (95% CI=37.9-43.4) of all trips. By 2001, active commuting to school declined by 27.8% to 12.9% (95% CI=11.8-13.9) of school trips. Nearly the entire decline in ATS occurred between 1969 and 1983 with the sharpest change between 1969 and 1977. The decrease in walking and biking is mirrored by a rise in driving to school. Use of school buses and public transit declined during the study period but not as sharply as active modes.

Author and Location	Study design & Population	How mode of transportation was measured?	Prevalence Results
van der Ploeg et al.[37] 2008 Australia	Data on the mode of transport for journeys to and from school were extracted from the 1971, 1981, 1991, and the ongoing 1999-2003 Household Travel Surveys of the New South Wales Government Department of Planning. These surveys randomly selected households in the study area. In order to compare surveys, data was used from children aged 5-14. Ages 5-9	All usual household residents were asked to complete a 24h diary that recorded details were asked to complete a 24 h diary that recorded details on all trips made during the designated travel day. An interviewer visited the household before the travel day to explain the survey procedures and collect basic socio-demographic information. The interviewer returned after the travel day to obtain detailed trip information, and any other additional and missing information.	The proportion of children walking and taking the bus to and from school significantly decreased, while the proportion taking the car significantly increased between 1971 and 2003. The use of the train and other transport modes was relatively infrequent and did not show major changes over the study period. Cycling, the other major mode of active commuting besides walking was not very prevalent (1-2%). (1971)n=4284, (1981)n=4936, (1991)n=662, (1999-2003)n=816. Prevalence walking to school amongst ages 5-9: (1971)=57.7, (1981)=44.5, (1991)=35.3, (1999-2003)=25.6. Prevalence of walking from school amongst ages 5-9: (1971)=62.6, (1981)=48.2, (1991)=39.8, (1999-2003)=29.4. Prevalence walking to school amongst ages 10-14: (1971)=44.2, (1981)=39.4, (1991)=33.1, (1999-2003)=21.1. Prevalence of walking from school amongst ages 10-14: (1971)=49.5, (1981)=44.1, (1991)=37.9, (1999-2003)=32.7.

Author and Location	Study design & Population	How mode of transportation was measured?	Prevalence Results
Ham et al, [35] 2004, USA	For the ConsumerStyles survey, stratified random sampling (by region, household income, population density, age, and household size) was used to identify 10,000 potential respondents from a larger consumer-mail pantel of approximately 600,000 adults aged ≥ 18 years. A low/income/minority supplement were used to ensure adequate numbers of respondents from those groups.	Parents of children aged 5-18 years were asked how many times their youngest child walks to or from school during a usual week.	Approximately 17% reported that their child walked to or from school at least once per week during a usual week. Among students who walked to school, the average number of trips per week to or from school was 7.1 (range 1-10). The percentage of students who walked to or from school was higher among those aged 5-11 years than among those aged 12-18 years (18.7% versus 15.3%); this difference was not significant (p=0.08).

Author and Location	Study design & Population	How mode of transportation was measured?	Prevalence Results
Ham, SA, Martin, S. and Kohl, HK. 2008 USA.[39] This report describes changes in the percentage of US students (age to 18 years) who walked or bicycled to school and in the distance that they lived from or traveled to their school in 1969 and 2001 and travel patterns in 2001.	Data were from the 1969 National Personal Transportation Survey report on school travel and the 2001 National Household Transportation Survey. 1969-The NPTS was a cross-sectional survey of daily travel among civilian, noninstituionalized US residents living in 15,000 households representing all 50 states and the District of Columbia (N=49,883 students age 5 to 18 years). Household adults completed proxy interviews for youth age ≤ 16 years. How did [student's name] usually get to school?" Mode of transportation was classified as walk or bike, school bus, public transportation, automobile, and other. Distance that students lived from school was classified as <1.0 mile, 1.0 to 1.9 miles, 2.0 to 2.9 miles, or ≥3.0 miles. 2001, the National Household Travel Survey is a cross-sectional random-digit-dialed travel survey that was fifth in a series of follow-up surveys to the 1969 NPTS. Persons aged infant through 88 years (N=160,798 including 29,836 age 5 to 18 years). Adult proxies were used for youth less than 16 years of age. The NHTS asked participants to keep 24 hour travel diaries. Trips were defined from one address to another. Interviewers coded trip purposes into 36 categories including "go to school as a student" and modes of transportation into 17 categories including "walk" and "bicycle." Distance was classified as above.	NPTS: Diary questions asked for a trip distance (miles or blocks), destination, mode of travel, start time, duration, and identification of travel companions who lived in the household. Adult proxies were used for youth younger than 14 years. Walking trips were defined as those for which "walk" was the reported main travel mode, and trips to school were defined as all trips with a destination of "school." In the NHTS: Diary questions and prompts were modified in 2001 to improve underreporting of walking and bicycle trips. The operational definitions of walking trips, urbanization classifications, and exclusion criteria were the same as for the NPTS 1995.	In 1969, 34.7% of students lived <1.0 mile from school. In 2001, this percentage was 19.4% of students. The proportion of students who lived or traveled greater than 3 miles from school increased from 32.6% in 1969 to 52.0% in 2001. The percentage of US students who walked or biked to or from school declined from 42% in 1969 to 16.2% in 2001. In 1969, 87.0% of students who lived <1.0 mile from school walked or bicycled to school, whereas in 2001, 62.5% of students walked or bicycled to school. The percentage of students who traveled by automobile increased from 16.3% in 1969 to nearly half (46.2%) in 2001. Students who lived or traveled 1.0 to 1.9 miles to school were more likey to walk or bike in 1969 (49.3%) than in 2001 (17.6%). The percentage of students who walked or biked to school was lower in 2001 than in 1969 for all school distance categoriesl the percentage who rode a school bus increased among those who live <1.0 mile from school; and the percentage who traveled to or from school by automobile increased for all distance categories.

Appendix-II

Articles that identify correlates of active transportation to/from school

Appendix-2: Table of articles that identify correlates of active transportation to/from school

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Ahlport et. al, 2007[25] **Location:** Central North Carolina **Study Population:** Focus group participants were recruited from four elementary schools with a large number of 4th and 5th grade students who had no access to bus service. 37 parents and 37 children (11NAT and 26 AT of each) participated in 12 focus groups.	**Qualitative Study. Methods:** These qualitative data were collected through a series of focus group discussions with 4th and 5th grade students and their parents, which were designed to inform the development of an intervention to increase active travel to school for the Non-Motorized (NMT) Study. Separate semistructured focus group guides were developed consistent with recommended focus group methodology. The overall NMT study was guided by the social ecological and political economy of health frameworks. These frameworks also generally informed the questions included in the focus group guides.	**SES:** Investigators explored the effect of economics by asking parents how money factors into their decisions about school transportation. **Other Covariates:** Questions were posed that assessed walking and biking motivations (intrapersonal level), discussions/negotiations between parents and children (interpersonal), supports available at school (organizational), and supports available within the community such as sidewalks, crossing guards, and so on (community). Focus group guides also included questions about other social determinants of walking and bicycling to school. Personal safety barriers: fear of child walking alone, lack of parental peace of mind, fear of child being in an accident, immature judgement on the part of the child, bullies.	***Outcome:*** parents were asked whether or not their child walked or bicycled to school. Children who regularly or occasionally walked or bicycled to or from school were defined as active travelers (AT), and all other eligible students were defined as non-active travelers. ***Psychometric Properties****: None Provided*	Personal safety fears were identified by all groups as the most significant barrier to active travel. Two safety facilitators were mentioned repeatedly: having someone accompany the child, an early notification system was identified, ie having the school call if child does not arrive at school. Younger Siblings were identified as a barrier, if siblings attend different schools, or siblings who require naps. Older siblings can facilitate active travel because they provide someone to accompany the younger child when walking to school. **SES:** cannot be seen here because the participants were mostly white and rich.

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Author: Babey et al., 2009[47] Location: California Population: The present study examined sociodemographic, family, and environmental characteristics associated with active commuting to school among adolescents, using a population-based data set that includes a number of factors not examined in previous studies.	***Cross-sectional Study*** ***Methods:*** Data are from the 2005 California Health Interview Survey, a random-digit-dial telephone survey of more than 43,000 households designed to be representative of California's non-institutionalized population. One randomly selected adult was interviewed in each household. In households with adolescents (ages 12-17), one adolescent was randomly selected and interviewed. The interview completion rate for adolescents was 48.5%. The current analyses included responses from 3,983 adolescents. ***Statistical Analysis:*** Logistic regressions were conducted to examine the association of individual, family, and environmental characteristics with active commuting to or from school on one or more days. Analyses were weighted to be representative of CA population.	**SES:** Household Income, was examined as percent of the federal poverty level (below 200% or 200% and above. The US federal poverty level is a monetary threshold based on total household income and number of people in the household, which is used to determine who is in poverty. In 2005, the threshold for 200% of the federal poverty level was $39,942 for a family of four. **Other Covariates:** Age, gender, race/ethnicity, parental walking for transportation, urbanicty levels based on population density greater than 4,150 persons per square mile, school location and type, straight line between home and school using GIS software (<800 m, 800-1599m, 1600-3199 m, and >3200m.	***Outcome:*** Responses to two questions were used to assess whether adolescents made any active trips to or from school in the previous week: (1) how many days in the past week did you walk, bicycle, or skateboard to school? And (2) how many days in the past week did you walk, bicycle, or skateboard home from school? Adolescents who were not in school in the past week, but attended school in the past year (11%), were asked about a typical school week. Adolescents who responded 1 day or more to either question were categorized as engaging in any active commuting to school. ***Psychometrics:*** *Evenson et al. reported acceptable test-retest reliability of similar measures as well as rates of any active transport to school.*	49.8% reported walking, biking or skateboarding to/ from school at least once in the past week or in a typical week. 25% reported AT both to/from school ≥ 3 days in a week. After adjusting for all factors, distance to school was most strongly associated with AT. After controlling for distance, age was inversely associated with AT. Females were less likely to use AT. Latino youth were more likely to AT than whites. Youth from lower-income families were more likely than those from higher-income, adolescents attending public school were more likely than those in private school. Adolescents who had an adult present after school were more likely to actively commute. Urban areas more than rural. Parental perceptions of the neighborhood and parental walking for transportation were not associated with AT.

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Author:Bere et. al., 2008[45] **Location:** Netherlands **Study Population:** The YMR and ENDORSE studies collected data in school year 2005/2006 among adolescents in the first(12-13 year olds) and third year of secondary school (14-15 year olds). The study sample includes 1361 participants (82%), from 71 classes from 71 classes and 16 schools.	**Cross-Sectional Survey Methods:** The aim of the present study was to report frequencies of adolescents' active commuting school in Rotterdam and to explore potential sociodemographic correlates of active commuting to school. **Statistical Analysis:** Multilevel logistic analysis, taking the clustering of pupils within schools into account, were performed with walking, cycling, or non-active commuting to school as dependent variables. All regression models included sex, parental employment status, ethnicity, weight status, age, distance from home to school and school level.	**SES:** Employment status of parents was assessed by two questions asking whether their mother and father had paid work or not. **Other Covariates:** Sex, schoollevel, and date of birth, ethnicity, BMI-normal, overweight and obese. Distance from school.	**Outcome:** Commuting to school was measured by three questions: how many days a week do you travel to school: (1)walking, (2) cycling,(3) by public transport or car. Response categories were never, 1 day/week, 2days/week, 3days/week, 4days/week, 5days/week The three items were combined to one variable with four categories: Walkers, Cyclists, non-active commuters. **Psychometrics: None provided.**	The proportions of participants categorized as walkers, cyclists, non-active commuters and pupils not categorized into mode of commuting were 12%, 35%, 34%, and 19% respectively. Comparing walkers, cyclists and non-active commuters respectively to the remaining sample; adolescents from non-Western ethnic background (OR=2.0;95%CI=1.0-4.0) and older adolescents (OR=1.3; 95%CI=1.0-1.7) were more likely to be walkers, while adolescents living further away from school (OR=0.22; 95%CI=0.17-0.29) were less likely to be walkers. Mode of transport was associated with distance and ethnicity. Adolescents of non-Western background were more likely to be walkers and non active commuters.

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Author: Booth et. al,[31] 2007 ***Location*****:** New South Wales, Australia ***Study population: Stu***dents in grades 6, 8, and 10. Forty-five primary and 48 secondary schools were selected at random, so the number of schools selected in each education sector (Government, Catholic and Independent) was proportional to the number of students enrolled in that sector. The likelihood of a school being selected was proportional to the size of the student enrollment. Within each school, one class was chosen at random from each of grades being surveyed. n=2,750	***Cross-sectional Study. Methods:*** The SPANS 2004 was a representative population survey of students attending kindergarten, grs 2, 4, 6, 8, and 10 in primary and secondary schools in NSW, Australia. The data were collected from February to may 2004. The self-report questionnaire was only administered to students in Grades 6, 8, and 10. ***Statistical Analysis:*** Numbers and prevalence of modes of transport to and from school were tabulated separately by sex and school grade, and further by place of residence, SES and cultural background. Tests of differences in prevalence by sex, place of residence, SES and cultural background were conducted using GEE method. The GEE method extends the standard logistic regression model to allow for clustering by school and provides estimates of odds ratios and their confidence intervals.	**SES:** Postcode of residence was used as a proxy for SES, based on the Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage. The scores were used to rank students in tertiles of SES. **Other Covariates:** Correlates included: sex, urban vs. rural, Cultural background, (stratified by sex).	***Outcome***: Students were asked to report how they traveled to school and how they traveled home from school in a usual week. A checklist of eight modes of transport was provided (walking, train, bicycle, car, school bus, other bus, ferry or boat, and "other"). And students were asked which modes of transport they used, the number of weekdays on which they used each time they used it. Students should report more than one mode of transport for each trip. To be classified as walking to school, students had to walk ≥ 4 times/week for all or part of the journey, or traveled by car for part of the journey ≥4 times/week (ie. reported car travel ≥4 times/week and walking ≥4 times/week) or walked on some days and traveled by car on some days (ie. walking and car trips summed to five). ***Psychometric Properties*** None Provided	Approximately one-third of grade 6 students traveled to school by car every day and a slightly smaller proportion walked every day. About 20% used public transport. In contrast, approximately 50% of secondary school students used public transit while 15-20% walked and the same proportion traveled by car every day. **SES:** Socio-economic status was not significantly associated with walking to school.

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Author: Braza et. al,[54] 2004 **Location:** California, USA **Study Population:** Thirty four (23%) of 150 California public elementary schools holding October 1999 Walk to School Day events participated in the study. The unit of analysis was school and its surrounding neighborhoods.	**Cross-sectional Study, using aggregated data. Methods:** Data on walking and biking rates, neighborhood design, and demographic characteristics were aggregated into school-wide averages. **Statistical Analysis:** Descriptive statistics, pairwise correlations, and multiple regression models. Three multiple regression models with walking and biking rates as the dependent variable. The first model includes only the three urban design variables-population density, the number of intersections per street mile, and school size as independent variables. The second model, in addition to the three urban design variables, includes school demographic characteristics-percentage of students receiving welfare. Ethnicity-variables with correlations with walking and biking rates that are significant at the 0.10 level in pairwise correlations would be included. The third model is the same as the second except that it excludes all student ethnic composition control variables not significant at the .10 level in the second regression model	**SES:** The percentage of students receiving public welfare. **Other Covariates:** 1990 U.S. Census data measured population density and number of intersections per street mile. 1998-99 California Department of Education data measured school size, the percentage of students receiving public welfare, and the number of students of various ethnicities.	**Outcome:** Teachers asked fifth-grade students how arrived to school 1 week before Walk to school day. Hand counts of students were used to measure school walking and biking rates. Percentage of students walking or biking to school was the outcome. **Psychometric Properties:** None Provided.	Model 1: population density is significant associated with walking and biking rates (p=0.000). But number of intersections per street mile and school size are not significant, and there is multicollinearity between population density and intersections per street mile. Model 2: School size becomes significant. Model 3 is the best model: indicates that population density, **the percentage of students receiving welfare**, and the percentage of students who are Hispanic are all significantly associated with walk and bike rates in the expected direction and the number of intersections per street mile is not significant.

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Author: Bringolf-Isler,[61] et. al, 2007. ***Location:*** Switzerland ***Study Population*:** Bern, a German-speaking city with about 130000 people, Payenne a French-speaking rural town with about 8000 people and Biel/Bienne a town with about 50000 inhabitants speaking German or French. The study was conducted during the school year 2004/2005. N=528 girls and 503 boys. 35% were living in Bern, 25% in Biel/Bienne, (German-speaking) and 28% in Biel/Bienne (French-speaking), 12.3% in Payerne	***Cross-sectional study***. ***Methods*:** A completed written parental questionnaire was available for a total of 1345 (65%) invited children. ***Statistical Analysis:*** the reciprocal term of active mode of transport, non-active, was used so results could be easily comparable to these of regular car trips. The one-to-one association of personal, familial and environmental characteristics with non-active mode of transport to school and with regular car trips was evaluated using logistic regression analyses. Factors significantly associated with one of the outcome variables were included in the multivariate models. After graphical inspection of the data, it was observed that the relation of distance between home and school and non-active mode of transport was not linear, therefore, a quadratic term was tested.	**SES:** maternal education (low: less than two years of professional training, medium: 2 to 4 years of professional training, high: college or university education). **Other Covariates:** Sex, nationality, family structure (single versus dual parent family), regular day care attendance after school and the number of cars in the household. Parents indicated their child's height and weight. International age- and sex-specific cut-points were applied to body mass index to define overweight. Parents were asked whether they perceived the way to school as safe, whether the child was in general allowed to go out after dark, whether the child was allowed to travel by bus by himself and whether they accompanied the child to school. Environmental data: Distance to school, whether they crossed a motorway a main street or a side street. The altitude difference between home and school and the population density.	**Outcome:** Two approaches have been used to assess factors, which could determine the mode of traveling to school. First, parents reported how their child usually travels to and from school, during winter and summer. Response categories included walking, traveling by bicycle/kick scooter/inline skates, traveling by car, using bus/train/tram or others. Active commuting was defined as usually walking or cycling to and from school during winter and summer. Second, parents wre asked how often they were driving their child to school. Regular car trips were defined as such if parents drove their child to school at least once a week. **Psychometric Properties:** None Provided.	Among all families, 77.8% indicated that their child usually travels to school using only active modes of transportation. Sex, **maternal education**, nationality, family structure and parental restrictions **were not significantly associated with** outcome variables and thus excluded from the final model. Beside the child's age and the number of cars in the household, non-active commuting to school was mainly associated with distance of the way to school and crossings of main streets. Parents who were concerned about the safety on the way to school, those with two or more cars and those whose children were at day care were more likely to regularly drive their children to school.

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Author: Buliung et al., 2009[48] Location: Greater Toronto Area Population: This study describes temporal and spatial trends in active transportation for school trips in the Greater Toronto Area.	***Repeat Cross-sectional Study Methods:*** Data were taken from the Transportation Tomorrow Survey (TTS). The TTS is a series of population-based cross-sectional travel surveys conducted in the GTA once every five years, starting in 1986. A one-day retrospective, telephone interview was used to collect travel behaviour for a single weekday in the fall of the year. Travel behavior for randomly selected households (including children 11 years and older) was proxy reported by an adult household member. ***Statistical Analysis:***.School trip data from the 1986, 1996, 2001, and 2006 versions of the TTS were organized into two discrete time intervals to describe differences in school mode trips from home to school (am) and from school to home (pm).	**SES NO Other Covariates:** Stratified analysis by suburb, age and time.	***Outcome:*** Questions were asked regarding walking for work and school travel. ***Psychometrics:*** The proxy reporting of school transportation is expected to be reliable for a.m. trips because the activity originates from home and occurs regularly (McDonald, 2007).	Between 1986 and 2006 there has been a decline in active school travel across the GTA. The decline is evidcnt for both age groups, although the shift toward automobility appears to be greater for 14-15 year olds. Declines are also evident when looking at am and pm. Declines are steeper in the suburban regions compared to the urban regions.

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Author: Bungum TJ et al., 2008[79] Location: Northern Utah Population: The purpose of this study is therefore to assess the relationship of selected environmental and psychosocial variables with ATS among a sample of middle and high school students. Data were collected from students who attended one of two junior highs, or one of two high schools in a northern Utah community.	***Cross-sectional Study*** ***Methods*** *A 30 item* survey was administered to all participants. ***Statistical Analysis:***.The logistic *regression models* used to identify predictors of using ATS included street connectedness, PA barriers, PA benefits and gender as predictor variables. Because of parametric statistical violations and the potential that logistic regression has for producing spurious results when group sizes greatly difer, random sample of those who did not use ATS (n=124) was matched by school grade to those who did not use ATS (n=124). Age was not included in this model because in selecting a comparison group, it was matched.	**SES NO Other Covariates:** Data on one characteristic of the environment, street connectedness, was assessed. Child's attitudes towards physical activity. Ethnicity, gender.	***Outcome:***"How do you usually get to and from school?" Response choices were "car, bus, walk, bicycle, or some other way." Those who indicated that they usually walked or biked to and from school were labeled as using ATS. ***Psychometrics:*** "A search for a validated ATS instrument was unsuccessful.	Less than 5% of students (n=124) reported using ATS. Street connectedness and gender were the only significant predictors. Those who attended the most connected school were 2.08 (CI=1.19-3.60) times more likely to use ATS than were those at the other schools. Males were 2.69 (CI=1.63-4.43) times more apt to use ATS than were females, while neither PA benefits, or PA barriers, predicted use of ATS.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Butler et. al,[55] 2007 **Location:** Canada **Study Population:** Canadian respondents aged 12 and over residing in households (n=127,610), in all provinces and territories. The 2003 Canadian Community Health Survey sample is representative of the Canadian household population.	**Cross-sectional Study** **Methods:** Canadian Community Health Survey (CCHS). The CCHS is a biannual cross-sectional computer assisted telephone interview survey of Canadian respondents aged 12 and over residing in households (n=127,610), in all provinces and territories.	**SES:** education, household income. **Other Covariates:** Sociodemographic predictors, age, marital status, labour force status, student status, education level, yearly household income, immigrant status; region; urban/rural status; smoking status; typical daily activity and leisure-time physical activity as measured by the Physical Activity Index (PA).	**Outcome**: All data were self-reported. Answers to questions asking respondent how many hours per week they spent cycling or walking to school, work or errands were recorded into the categories of cycling at all and walking 6 or more hours to school, work or errands. Because walking to school, work or errands at all was a common occurrence, a more conservative threshold of 6 or more hours per week was chosen to identify those who regularly walked as a mode of transportation. ***Psychometric Measures:*** None Provided	Cycling: Age appears to be important, with the youngest being significantly more likely to cycle than middle-aged adults and older adults being less likely. Single individuals are more likely to cycle, as are those who are currently enrolled in school. Education and income play a role for men only, with the most highly educated, and those with the lowest income most likely to cycle. For both genders, and all models, **lower incomes were more highly associated with walking.** Being a student is associated with walking for transport. For both genders, walking for transport appears much less likely in Quebec than in any other region.

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Author: Carlin et. al,[50] 1997 **Location:** Melbourne and Perth Australia. **Study Population:** 6-9 year olds and their parents in Melbourne and Perth Australia. Schools were selected with a probability proportional to the school's total enrolment in the age groups of interest (stratified according to whether they were public, Catholic, or independent) from all schools with an enrollment of at least 100 pupils in the Melbourne and Perth metropolitan areas. Outer suburban municipalities where the population density was less than 500 persons per square km were excluded. Within each school, it was intended that a complete class of age 6 and age 9 students would be selected at random from the available classes. The number of schools was chosen with the aim of obtaining 1500 children in each of the age groups to be studied	**Cross-sectional Study. Methods**: Parent and Child Questionnaires.	**SES:** Mother's education (Primary, Secondary, Tertiary), and Occupational Status (1st tertile, 2nd tertile, 3rd tertile). **Other Covariates:** Parents were also asked to estimate how much time the child spent as a pedestrian, whether on the road, foot path or nature strip. Socio-demographic variables and indicators of walking and traffic exposure.	**Outcome:** Pedestrian activity was measured with a questionnaire that the child and parent were asked to complete on the evening of distribution by systematically reviewing the child's walking activity for that day. The questionnaire divided the day into four parts (before school, going to school, coming home from school, and after school) and asked whether the child walked in each period, and if so, how many streets were crossed, and whether the child was alone or accompanied. **Psychometric Properties:** None Provided.	**All the comparisons using indicators of SES show clear trends towards less walking with higher SES.** After adjustment for school type, lack of car ownership, non-English speaking background and lower occupational status were predictive of walking. 35% (95% CI 31 -39%) of Melbourne children reported walking to school (including those who went by car for part of the way). In Perth, children reported slightly lower frequency of walking to school; 31%(95%CI 28-34%). In Melbourne, the proportion walking home from school was 5.5% (CI 4-7%) greater than that walking to school a smaller difference in the same direction was found for Perth (2.5%, CI 0.9-4.1%).

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Author: Carver et. al,[75] 2005. **Location:** Sydney, Australia. Study population. 12 and 13 year olds who participated in the longitudinal Nepean Study. The adolescents were part of a birth cohort born between August 1989 and April 1990 at Nepean Hospital, Penrith, in Western Sydney.	**Cross-sectional study.** A self-report and parental-report questionnaire were administered. This was part of the longitudinal Nepean Study. ***Statistical Analysis*:** Pearson's χ^2 tests of significance were performed to assess the need to stratify data for boys and girls in this sample. Pearson's χ^2 test of significance was performed to identify any significance was performed to identify any significant differences in perceptions of neighbourhood by sex of the adolescent. Bivariate linear regression models were performed to examine relationships between perceptions of neighbourhood with each outcome variable. For each outcome variable, all significant predictor variables at the bivariate level were entered into a multiple linear regression. All analyses were adjusted for level of maternal education.	**SES:** Maternal Education was collapsed into three categories: "low"-some secondary education or less; "medium"-completed secondary school, apprenticeship, or technical certificate;"high"-university/tertiary qualification. ***Other Covariates:*** None	**Outcome:** Adolescents completed a questionnaire regarding the duration and frequency of participation in walking to/from school. Participants recorded whether or not they performed the activity, and if so, the total time and frequency for this activity from Monday to Friday. ***Psychometric Properties:*** Test re-test reliability for these questions was established in an earlier study of 10 to 12 year old children and was found to be high, particularly for frequency of routine activities such as walking to school (Intra Class Correlation [ICC]=0.86 and cycling to school (ICC=0.71).	Adjusted Standardized Beta Coefficients for Time (minutes) Spent by Boys and Girls Walking and Cycling Boys: Worried about dogs roaming: -0.159 Lots of boys/girls same age to hang out with: 0.129 Wave/talk to neighbours most days: 0.108 Girls: Roads in neighbourhoods are safe: 0.183 Have many friends in the neighbourhood: 0.119 Wave/talk to neighbours most days: 0.103 Walking to school: Girls: Have many friends in neighbourhood: 0.230 There is so much traffic that it is difficult/unpleasant to go for a walk: -0.128 Lots of boys/girls same age to hang out with: 0.100

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Chillion[58] 2009 **Location: Spain** Population: A multicenter study was performed involving a representative sample of Spanish adolescents aged 13 to 18.5 years. Final sample size was 2183 adolescents.	***Cross-Sectional Survey Methods*:** The population was selected by multiple-step, simple random sampling-first taking into account location and then by random assignment of the school within each city. Sample size was stratified by age and sex. ***Statistical Analysis:*** Multivariate logistic regression with the following independent variabls: age, sex, SES variables. Interactions between SES and age and sex were tested.	**SES:** Parent Education Level: Both parents were asked to fill in a questionnaire about their education level. One of three possible answers from: primary school, secondary school/technical training, or university training. Parental professional leve**l:** Three categories of parental professional levels: managerial, skilled worker, unskilled worker/unemployed**.** **Other Covariates:** Type of school-public vs. private. Gender, age.	***Outcome:*** Mode of transportation was recorded by self-reported questionnaires. Resonse options included: car, walking, biking, bus/subway, motorcycle or other. The participants were classified to the Active commuting group if they traveled to school by walking or biking, otherwise classified as using nonactive commuting to school. ***Psychometrics: None provided.***	64.3% walked to school and 0.5% biked to school. In male adolescents, maternal primary education level showed an OR=1.55 (95%Ci=1.12-2.15) with respect to mothers with a university degree of using AT to school. In female adolescents, mothers with a primary education level showed an OR of 0.68(0.50-0.92) with respect to mothers with a university degree. Low maternal professional level showed an OR of 1.70 (1.29-2.24), with respect to high maternal professional levels. Students attending public schools showed an OR of 3.47(2.46-4.90), with respect to students from private schools. Socio-economic level seems to be inversely related to the AT to school in adolescents.

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Author: Cole et. al,[56] 2007. **Location:** South Queensland, Australia. **Study Population:** All parents (n-1,360) with children attending one of the four schools were invited to participate. The area largely consists of low-density residential housing (separate houses) and a higher than averafe proportion of young families. The response rate was 39% for the government school and 42% for the three nongovernment schools. Overall participation rate was 40%.	**Cross-Sectional survey. Methods:** Questionnaires were distributed to parents. Completed surveys were returned to classroom teachers. The survey was directed to the parent or carer who most often arranged school travel. Items were answered in relation to the oldest child. **Statistical Analysis:** Descriptive statistics were used to summarize the characteristics of the sample and responses on walking versus driving less than two km to school; perceived influential factors of walking to school. Two km or less was considered a viable distance to walk to school. Chi-squared tests were used to examine the associations between categorical variables. T-tests examined the statistical significance of the difference between the mean scores of parents who walked and those who drove less than two kilometers to school, on items relating to influential factors (measured as continuous variables using four-point Likert scales).	***SES:*** Parent Education Level: 10 years or less, 12 years or TAFE, University or degree. **Other Covariates:** *driving less than two km to school; duration of walking trips; parental accompaniment and distance to school; journey itinerary/stops; and perceived influential factors of walking to school. Two km or less was considered a viable distance to walk to school.*	**Outcome:** Two questions on mode of transport to school were used. 1) asked about habitual modes of school travel (e.g. "On a normal school day, what is the main form of transport your eldest primary school child uses to get to and from school?" The second addressed the frequency over the previous school week (In the last five school days, on how many days did your eldest primary school child walk or bike to or from school?). Parents were also asked to identify the school journey distance from response categories provided. The duration of parents' walking during the school journey was assessed by asking: "if you usually travel with your eldest, how much time do you spend walking during the trip?	Significantly greater proportions of parents reported walking for at least 10 min as a component of the journey to school if their child attended a government school (27% vs. 11% for non-government), had only one car in their household (30% vs. 14% for two or more cars; **had 10 years or less of education (32% vs. 15% for more than 10 years of education)**; and had school journeys <2 km (33% vs 11% for more than two km). Walking as the main form of school travel for journeys 10 minutes or longer were associated with child grade level (8% for years four to seven vs. 2% for pre-school to year three); and number of children attending the primary school (6% for one child vs. 3% for more than one child.

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Author: DiGuiseppi, C,[64] et. al, 1998 **Location:** inner London boroughs of Camden and Islington, England. **Study Population:** All primary schools in the area. They weighted sampling probability by combining class sizes in year 2 (ages 6-7) and year 5 (ages 9-10).	**Cross-sectional survey. Methods:** Questionnaires, with a letter from the head teacher with a multilingual request from for translation, were distributed to pupils for completion at home. One week later, completed questionnaires were collected, gave new questionnaires to nonrespondents, and distributed requested translations. **Statistical Analysis:** Logistic regression, including a random effect (school) to account for cluster sampling, to estimate OR and 95% CI for determinants of car travel versus walking. Pupils who used public transport were excluded.	**SES:** Housing: Rented or housing association vs. owner occupied. **Other covariates:** distance to school, type of school (public, Anglican, Catholic), Car ownership, mother in paid work out of home, father in paid work out of home, attends play scheme after school, child allowed out without an adult, parents worried about abduction or molestation, parents worried about traffic danger, borough, ethnicity, year in school, bicycle ownership.	**Outcome:** mode of transportation to school. Not much detail provided. **Psychometrics:** None provided.	Most children walked (69%) or traveled by car (26%). Four cycled, and the rest traveled by bus, underground, or train. Proportions were similar for the journey home. The strongest predictors of car travel to school were car ownership, greater distance to school, attendance at an independent school, and parental worry about abduction. For the journey home, the strongest predictors were greater distance to school, car ownership, and attending an independent school.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Evenson et. al,[57] 2003. **Location:** North Carolina, USA. **Study Population:** Students in 6th through 8th grades (n=2151) and in 9th through 12th grades (n=2297) during the spring of 2001. All students are eligible to participate in the survey, if they are able to comprehend and respond to the multiple-choice items in a paper-and-pencil format.	**Cross-Sectional Study. Methods:** The YRBS was begun in 1990 to monitor adolescent health risk behaviors by the Centers for Disease Contol and Prevention. The survey gathers self-reported information from youth on behaviours associated with the leading causes of morbidity and mortality among young people and is administered at the state and national levels in odd-numbers calendar years. The present study used data from the 2001 state-level YRBS conducted in North Carolina and administered by the Dept. of Public Instruction. The questionnaire was designed at a seventh-grade reading level and given in English only. Administered the survey to 60 middle schools and 62 high school. **Statistical Analysis:** Unconditional logistic regression was used to calculate odds ratios and 95% CIs, predicting walking or bicycling or bicycling to school separately for middle school and high school youth.	**SES:** *:* Parental educational level. Categories included: <High school, High school, > high school. **Other Covariates:** , Sex, grade in school, race, BMI, days of physical education class per week, parental educational level, and how often an adult was home after school.	**Outcome:** Students were asked: "When the weather permits, on how many days per week do you usually walk to school?" and "When the weather permits, on how many days per week to you usually ride a bicycle to school?" (response options, 0-5 days) **Psychometrics:** The validity and reliability of this question are not known (the author write this).	Overall, 12.1% (95% CI, 8.9%-15.2%) of middle school youth and 6.4% (95% CI, 5.1%-7.8%) of high school youth reported 1 or more days bicycling or walking to school in a usual week. Multivariate analysis: among middle school, being male, being 6th and 7th grade in comparison to the 8th grade, and being African American were significantly associated to walking to biking to school. Being overweight is correlated with a less likelihood of walking or bicycling to school. Amongst high school students, being African-American, other, having physical education class 1-4 days per week, and having an adult never at home, were more likely to walk to school. **Parental education being more than high school is associated to a lesser likelihood of walking or bicycling to school.**

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Ewing et al.,[60] 2004 Location: Gainesville, Florida Population: Sample of K-12 students.	***Cross-sectional Study*** ***Methods:*** Two Travel diary surveys with the availability of many variables characterizing the built environment in Gainesville that could be used as independent variables in explaining mode choice. ***Statistical Analysis:***.All MNL and nested logit mode choice models were estimated with full information maximum likelihood and the LIMDEP?NLOGIT software. The universal choice set for the student population studied consisted of four travel modes: automobile, school bus, walking, and biking.	**SES:** Annual Household Income, Number of household motor vehicles. **Covariates:** School enrollment, school size, Built environment data such as overall density, job mix, proportion of street miles with street trees, proportion of street miles with bike lanes or paved shoulders, proportion of street miles with sidewalks, and average sidewalk width.	***Outcome:*** Data come from two diary surveys. The intention was to identify all K-12 school trips and only K-12 school trips. A total of 15, 980 trips were reported, from which school trips could be extracted and mode choices analyzed. ***Psychometrics: None provided***	Students with shorter walk and bike times to and from school are significantly more likely to walk and bike. The proportion of arterials and collectors with sidewalks along them proved to have the most significant influence of walking. The built environment did not have a significant effect on biking. Students from households with higher incomes and more vehicles per capita are less likely to walk to school than to take a car, school bus, or bicycle.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Authors: Fulton et. al,[62] 2005. **Location:** USA. **Study Population:** *:* 1,458 parent-child pairs residing in the U.S. n=1395	**Cross-Sectional Survey. Methods:** From September to October 1996, trained staff completed computer-assisted telephone interviews of 1,48 parent-child pairs residing in the U.S. The interviewers asked each parent and a randomly selected child from the same household about patterns of physical activity and characteristics thought to predict such activity. From the initial sample of randomly generated numbers, 14% of parent-child pairs were eligible (86% of numbers were not eligible or were not contacted). Seventy-two percent of eligible parent-child pairs completed the survey. ***Statistical Analysis****:* Significant characteristics ($p<0.05$) from univariate logistic regression analyses were included in multivariate logistic regression analyses.	**SES:** Education of parent: <high school, High school/some college, and College graduate + ***Other Covariates:*** measured include gender, grade, race/ethnicity, neighbourhood milieu, parent(s) living in the home, parents employed outside home, age group of parent, marital status of parent, gender of parent completing questionnaire, BMI of child,	**Outcome:** Each child was asked: How do you normally get to and from school? Possible responses include: walk, ride bike, or as motor vehicle (school bus, public transportation, drive yourself, or get a ride. ***Psychometric Properties:*** The validity of this question is not known, a similar question to assess daily travel to school was significantly associated with boys' daily physical activity.	Overall, 14% of children and adolescents reported ATS. ATS was more frequent among boys (16.6%) than girls (11.1%), and among children in lower than upper grades: 20.5% in grades 4-6% and 12.4% in grades 7-9 versus 8.0% in grades 10-12. Hispanic race/ethnicity, living with one parent, and perceiving a safe neighbourhood were associated ($p<0.05$) with ATS in the unadjusted but not the adjusted logistic model. After adjustment for parent education and significant variables in the unadjusted analysis, several characteristics remained independently ($p<0.05$) associated with ATS. **SES is not significantly associated.**

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Gilhooly, P & Low, DJ.,[65] 2005 **Location:** Midlothian, Scotland. **Study Population:** Primary school children, aged 5 to 12 and their parents. Midlothian, Scotland is located to the south of the city of Edinburgh and has a population density of 230 people per square km. n=1008 primary school children and 776 of their parents.	**Cross-sectional survey. Methods:** Two surveys were conducted, one in class with the students and the other with parents. All four schools were surveyed during the week of 3-7 December 2001. Using the same week for all four schools, and using schools that are close together, meant that factors such as weather were unlikely to cause differences between the schools. Survey of primary school parents: anonymous short questionnaires were distributed to parents. **Statistical Analysis:** The percentages of pupils using each mode, averaged over the five-day survey period.	**SES:** Not measured. **Other covariates:** Age: P1-3, primary school years 1, 2, and 3, corresponding to ages 5 to 8. P4-5: primary school years 4 and 5, corresponding to ages 8 to 10. P6-7: primary school years 6 and 7, corresponding to ages 10 to 12. Distance to school. The parents were asked why their children used their particular mode of travel, and how far they lived from school. A map was provided with the school catchment area with concentric circles indicating approximate distance from the school.	**Outcome:** Students were asked their mode of transportation to school and their mode of transportation from school. **Psychometrics:** None Provided.	There are clear differences between the two different directions of travel: travel to school and travel from school. Car use is reduced for the journey home from school. The second important feature, is that there is a clear effect of age on travel behavior. The youngest are most likely to be driven to school. There is a clear difference between schools. This may be due to differences in the size of each school's catchment area. Those closest to school are most likely to walk, with the proportion decreasing as distance from school increases. Reasons by parents driving their children to school were: a) too far to walk, b) local road are too dangerous, c)parents want to escort their children to school and it is easier to drive d) it is quicker and more convenient

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Gray & Kelly,[70] 2003 Location: Ireland. **Study Population: Adolscents aged 12-13,** 15-16, and 17-18 years old in one rural and one urban area in Ireland. Forty students in each class were surveyed, n=120 per school. The rural location: Drumsshambo is serviced by school buses around a 10 km catchment area. The area has the lowest population density in Ireland. The urban location was in Dublin, which is a population dense centre.	**Cross-sectional survey. Methods:** The survey was designed to be clear, short, and easy to answer was carried out in class with each question explained by the survey administrator**. Statistical Analysis:** Descriptive analysis only. Bar graphs are stratified by variables.	**SES: No Other covariates:** Distance to school, Number of cars per household.	**Outcome:** How do you usually travel to and from school? Separately. Response options were on foot, bicycle, school bus, public bus, by train, or by car. **Psychometrics:** None provided.	8.1% of rural students and 35.6% of the urban students travel to school on foot. In terms of walking from school, 13.7% of the rural students, and 34.7% of the urban students indicated they did so.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Ham et. al,[35] 2005. **Location:** USA. **Study Population:** The populations of interest were U.S. civilians noninstitutionalized adults (aged 18 years and older) andyouth (aged 5 to 15 years). Trends were reported for the percentage of walking trips of 1 mile or less to school (youth) using 3114 trips (1995) and 4073 trips (2001) made by youth.	**Repeat Cross-Sectional. Methods:** NPTS: 1995. Diary questions asked for a trip distance (miles or blocks), destination, mode of travel, start time, duration, and identification of travel companions who lived in the household. Adult proxies were used for youth younger than 14 years. Walking trips were defined as those for which "walk" was the reported main travel mode, and trips to school were defined as all trips with a destination of "school." In the NHTS: Diary questions and prompts were modified in 2001 to improve underreporting of walking and bicycle trips. The operational definitions of walking trips, urbanization classifications, and exclusion criteria were the same as for the NPTS 1995. **Statistical Analysis:** The prevalence of walking trips for transportation of 1 mile or less reported separately for youth and adults by sex, family income, urbanization classification, and geographical attainment.	**SES:** family Income **Other Covariates:** Sex, family income, urbanization classification, and geographic region, and for adults only by educational attainment. Data were weighted to adjust for survey nonresponse and selection bias and to represent all daily travel made by all individuals in 1995 and 2001.	**Outcome:** *NPTS:* Diary questions asked for a trip distance (miles or blocks), destination, mode of travel, start time, duration, and identification of travel companions who lived in the household. Adult proxies were used for youth younger than 14 years. Walking trips were defined as those for which "walk" was the reported main travel mode, and trips to school were defined as all trips with a destination of "school." In the NHTS: Diary questions and prompts were modified in 2001 to improve underreporting of walking and bicycle trips. The operational definitions of walking trips, urbanization classifications, and exclusion criteria were the same as for the NPTS 1995. **Psychometric Properties:** None Provided.	In 2001, of all trips to school made by children and adolescents aged 5 to 15, 36.2% were 1 mile or less in 2001, and 37.1 were 1 mile or less in 1995. Approximately 35.9% of these trips were made by walking in 2001, compared with 31.3% in 1995. In 2001, trips made to school by walking were about the same among girls (36.6% and boys (35.3%) and were more common for the age group 10 to 15 years than for the age group 5 to 9 years. The overall trend was no change from 1995 to 2001. Walking to school increased among girls aged 10 to 15 years (29.9% in 1995, 42.5% in 2001), those with family incomes less than $10,000 (35% in 1995, 54.5% in 2001), those with family incomes of $20,000-34.999 (28.2% in 1995, 45.3% in 2001), and urban residents (43.5% in 21995, 62.4% in 2001).

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Harten et. al,[52] 2004. **Location:** Australia. **Study Population:** 11 and 12 year olds from Adelaide, Australia. Eleven schools were randomly chosen from a list of all primary schools in South Australia and invited to participate in the study.	**Cross-Sectional Study. Methods:** The participants in this study were 136 children aged 11-12 years old from eight randomly chosen primary schools in Adelaide, South Australia. Each child recalled their trips on two school days and a non-school day. ***Statistical Analysis:*** Forward stepwise logistic regression, with the trip rather than the child as the unit of analysis (adjusted for clustering by child). In addition to ln(distance), gender, PAL category (high/low), SES tertile (high/medium/low, destination (school/shops/friends/play area), BMI status (normal/overweight), child dissatisfaction category (high/low) and parent dissatisfaction category (high/low) were used as independent variables. The dependent variable was trip mode (passive/active). Alpha was set at 0.05.	**SES:** was quantified on the basis of the child's home address using the Socio-Economic Index For areas (SEIFA). Based on the average SES characteristics of households within their Census district (a catchment of about 200 households). The nationwide average for the SEIFA is 1000, with a SD of 100. Children were categorized into three SES tertiles: low (575 to 1006), medium (1007 to 1052) or high (1053 to 1167). ***Other Covariates:*** Overweight/obesity status (BMI); parental and child amenity of neighbourhood, perceptions of safety, crime, traffic, scenery, pollution, and the accessibility of neighbourhood amenities-created a "neighbourhood dissatisfaction index." Distance to school.	**Outcome:** Information on transport patterns was solicited through one-on-one interviews using road maps of the areas they traveled. For each trip, children described the route they took, how they traveled (on foot, bicycle, other locomotion such as scooters, in private vehicles, or using public transport), who they traveled with, and their destinations: school, friends and relatives, shops, play areas.	One-third of all trips were active. AT was only a small contributor to daily EE. Children spent about 10 min a day walking or cycling, making up scarcely 1% of their daily EE. Distance, gender, activity levels, **SES** and destination type emerged as the most important predictors of AT. Boys were more likely than girls to use AT. High activity children were more likely to use AT. School as a destination was a determinant of AT in this study. The study's finding that parental dissatisfaction with their neighbourhood reduces the likelihood of AT highlights the growing concern of safety.Overweight/obesity was not associated with AT.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Hume et al.,[81]2009 **Location: Melbourne, Australia** Population:	***Longitudinal Study*** ***Methods:*** Study participants were initially recruited and assessed in 2001, and followed up 2004 and 2006. Participants and their families were recruited from 19 government primary schools I high (n=10) and low (n=9) socioeconomic areas. Final sample size was 121 children aged 9 and 188 adolescents aged 14.5. ***Statistical Analysis:*** Those who decreased their AT were excluded from longitudinal analyses because of their small numbers. Bivariate logistic regression analyses were performed, and ORs and CIs were calculated to examine associations between individual, social, and environmental factors and increases in active commuting to/from school between 2004 and 2006, adjusting for gender, SES, and clustering by child's school.	**SES:** Parents reported their highest level of education and that of their partner. Maternal education was categorized into: low=never attended school, attended primary school, or attended some high school; medium=completed high school or technical or trade school; high=college qualification. **Other Covariates:** Weight status, energy levels of children, likes to be outdoors, social cohesion variables, physical environmental predictors.	***Outcome:*** Outcome was assessed in 2004 and 2006. Parents completed a survey at home and students completed a survey at school. Parents of younger children reported whether their child ysyally walked or cycled to/from school in a typical week, and if so, the frequency of active transportation was computed in each time point. ***Psychometrics:*** Authors indcate that the measures are valid and reliable Telford et al., 2004.	Only one factor predicted increases in children's active commuting. Children of parents who reported that the child had many friends in their area were more than twice as likely to increase their active commuting compared with other children (OR=2.6; CI=1.2, 5.9; p=0,02). Adolescents whose parents reported that there were no traffic lights or crossings available were only half as likely (OR=0.4; CI=0.2, 0.8) to increase their active commuting those whose parents were satisfied with the number of pedestrian crossings in their neighborhood were twice as likely (OR=2.4; CIs=1.1, 5.4) to increase their active commuting.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Kerr et. al.[98] **Location:** Seattle, King County, Washington, USA. **Study Population:** Participants were recruited from Seattle, King County Washington who indicated in an initial survey there were children in their household were sent a second survey concerning their children's activity patterns, if their child was between the ages of 4 and 18 yr. Adults between the ages of 20 and 65 years living within study neighbourhoods were targeted for recruitment. Those participants whose child was between 4 and 18 yr of age were asked to complete a supplemental survey 6 months later. n=259	**Cross-sectional study. Methods:** The Neighbourhood Quality of Life Study (NQLS) is an observational epidemiologic study designed to allow comparisons between neighbourhoods stratified based on their "walkability" characteristics and median household income derived from Geographic Information System (GIS) and Census data. ***Statistical Analysis*:** Logistic regression analyses were conducted and controlled for child age (5-11 vs 12-18 yr), child gender, and responding parent's education (completed college or not) a proxy for SES. The outcome was actively commuting at least once a week or not. Odds ratios and 95% CI are provided for all analyses. In the first model; the objective and self-report environmental variables and parental concern scores were entered separately as independent variables.	**SES:** The median household income data for each block group were deciled and categorized into high and low income. Annual household income values less than $15,000 and greater than $150,000 were not included in the deciling process to avoid skewing the data with outliers. The second, third, and fourth deciles constituted the "low-income" category, and the seventh eighth, and ninth deciles made up the "high-income" category. Also, used parental education. **Other Covariates:** age, gender and parent education for the outcomes active commuting and parent concerns. The main predictor variables include objectively measured walkability measures and parental concerns.	**Outcome:** Parents reported how many days per week, their child walked or biked, rode in a car or school bus, or took public transportation to and from school. Outcome was AT at least once a week. **Psychometric Properties:** Similar measures have shown good (intraclass correlations: 0.7-0.8) test-retest reliability. Data were collected throughout an entire year, balanced by quandrant, to allow for variations in activity because of weather.	Three patterns of findings were documented. Parental concerns and aesthetics showed independent associations with the outcome with both remaining significant. Stores within a 20 min walk and perceived walk and bike facilities remained significant, but the relationship between walkability and commuting behaviour was no longer significant. When entered with walkability, perceived street connectivity and land use mix-access were no longer related to the outcome. Neighbourhood income was not associated with actively commuting to school. However interaction term neighbourhood walkability x income was significant. OR= 2.1 (1.12-3.97).

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Larsen et al.[49] 2009 Location: Canada **Study Population:** Students in grades 7 and 8 (aged 11-13 years) at a heterogenous sample of elementary schools varying by income and built environment throughout the city of London, ON. Of the 51 schools eligible for the study, 21 (41%) chose to participate. A total of 1666 students were recruited to participate; 810 students received parental consent and were present on the day of data collection. Response rat=49%.	**Cross-Sectional Survey Methods:** The survey asked students about their mode of travel both to and from school and neighbourhood characteristics as well as behavioral, demographic, and environmental questions. To obtain the demographic characteristics of individual households, parental questionnaires were distributed. Children who lived within 1mile of school (n=614) were included in the analysis. The researchers examine sociodemographic and environmental influences on a child's mode of travel between home and school. **Statistical Analysis:** The P values of the correlations between use of nonmotorized travel and sociodemographic and environmental variables were tested with univariate logistic regression and all significant factors (P<.05) were used in a stepwise logistic regression equation.	**SES:** Questions on household income, education, and single-parent families were asked in the parental questionnaires, but response rates were low. Data on neighbourhood levels of education attainment (proportion of adults 20 years and older with a high school diploma), single parenthood (proportion of families headed by single parents), median household income. **Other Covariates:** Data on sidewalks, road networks, street trees, pathways, and landuse type were obtained.	**Outcome:** A survey asked students about their mode of travel both to and from school. **Psychometrics: None provided.**	Nearly two thirds of students of 614 students who lived within 1 mile used an active mode of transport to school (95%walked). Analysis of the journey home from school revealed an increase of almost 10%. Logistic regression analysis for the journey to school indicated that the distance between home and school was the most important factor in determining whether a child used AT to school. Boys were 1.5 times more likely to use AT to school. Land use mix and presence of street trees were the only significant environment variables. Similar for travel home from school but the presence of street trees is no longer important, whereas AT decreased with both higher residential density and greater median household income in the school neighborhood.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Martin et. al,[30] 2007 **Location:** USA **Study Population:** The study population comprised two nationally representative cohorts of the YMCLS that were each surveyed in the spring of 2004.	**Methods:** The YMCLS is a random-digit-dialed survey. Cohort 1 consisted of children aged 11 to 15 years and one of their parents who underwent a follow-up survey in 2004. Cohort 2 consisted of children aged 9 to 13 years and one of their parents who underwent a baseline survey in 2004. Cohorts of parent/child pairs were weighted to the national population of same-age children, adjusting for different probabilities of selection, survey nonresponse, and under-coverage of age-eligible children both in nontelephone households and in other households. **Statistical Analysis:** Differences in active travel by geographic and demographic variables, and by variables related to attitudes, beliefs, barriers, and behaviours were investigated using unadjusted and adjusted logistic regression. Adjusted for child's age, gender, race/ethnicity, geographic region, urbanicity, parental education, household income, number of children in the household, and parent's marital status.	**SES:** parental level of education, household income **Other Covariates:** Demographic and geographic Variables: Residing in one of four geographic regions: Northeast, South, Midwest, or West. Households were categorized into five levels of urbanicity: urban, metro suburban, second city, town and rural. Demographic variables in these analyses included child's age, child's gender, race/ethnicity, parental level of education, household income, number of children aged <18 years in the household, and marital status. Child and Parental attitudinal variables, Child and Parental Behavioural Variables.	**Outcome:** The number of miles each child lived from school was calculated based on parental response to an open-ended question: "How many miles does [he/she] live from school?" The proportion of children living <1 mile, was then calculated. Among those living <1 mile, usual number of days walking or bicycling to school was reported by the parent (0 to 5 days). Active travelers were defined in two ways: those reporting ≤1 day (n=1284), and those reporting 5 days (n=941). **Psychometrics:** No mention	Of the 2649 respondents living ≤1 mile, 1365 reported no active travel; 92 reported 1 day; 69, 2 days; 106, 3 days; 76, 4 days; and 941, 5 days. The percent of active travelers (≥1 days/week) was 47.9%. Unadjusted correlates of active travel were age, race/ethnicity, region, urbanicity, parent level of education, household income, and marital status. After adjustment for demographic and geographic variables, the remaining correlates included age; urbanicity; education (children of parents with a college degree or higher were less likely to walk or bike than children of parents with less than a high school degree); and marital status. The same adjusted correlates were found when the definition of active travel was restricted to 5 days per week.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: McDonald, N,[36] 2007 **Location:** USA **Study Population:** The respondent is aged 5 to 18, the trip occurs on a weekday morning, and if the purpose is for school.	***Repeat Cross-Sectional Study*** **Methods:** The National Personal Travel Survey (NPTS) conducted by the U.S. Department Travel Survey (NPTS) is a population-based survey conducted by the US Department of transportation in 1969, 19777, 1983, 1990, 1995 and 2001. The survey collects information on all trips undertaken by members of selected households on a randomly assigned survey day. **Statistical Analysis:** Estimates of the prevalence of walking and biking for the 1977-2001 surveys were calculated for each sub-group by age and race. Weighting factors accounted for unequal selection probabilities, nonresponse. To understand the relative influence of individual, household, and trip characteristics across the study period, binary logit models predicting whether a child walked or biked to school were constructed using individual trip records from the 1977 through 2001 surveys.	**SES:** Household income: categorized: ie. <$30,000, $30,000-$60,000, and $60,000+(reference). **Other Covariates:** Trip distance, Age, Income, House Hold Vehicle Access	**Outcome:** "How did [child's name] usually get to school?" and "How did [child's name] usually get from school?" and "how many miles was it from home to [child name]'s school?" **Psychometrics:** None but the author mentions that it is likely that parents are accurate reporters because the trips originate from home and occur regularly.	Trip distance indicates that the closer to school, the more likely one is to walk to school. Trend is similar in 1977, 1983, 1990, 1995, and 2001. Age: 5-10 year olds are less likely to walk to school in every year except for 1995. Females are less likely to walk to school. Similar to amongst every year. Income: 30-60,000 is less likely to walk to school only in 1972. Less than 30,000 children are more likely to walk to school in 2001 only.

Author/Location/ Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: McDonald[59] 2008 Location: USA Population: This study presents rates of active travel by racial/ethic group and income and estimating models of active transportation by racial/ethnic group to ascertain whether there are significant behavioral differences across groups.	***Cross-sectional Study*** ***Methods*** The 2001 National Household Travel Survey is a population-based survey conducted by the US Department of Transportation that collects information on all trips undertaken by members of selected households on a randomly assigned survey day. . ***Statistical Analysis:***. Estimats of the prevalence of walking and biking were calculated for each racial/ethnic group and standardized to the overall distribution by age. Models controlled for trip distance. Models were constructed for whites, blacks, and Hispanics.	**SES Covariates:** *Household income.* Demographic characteristics (e.g., age, and gender), race and ethnicity.	***Outcome:*** Information was collected on all trips undertaken by members of selected households on a randomly assigned survey day. Household members, report information on all trips, including purpose, mode and travel time. Trips are considered to be for school if (1) the respondent is aged 5-18, (2) the trip occurs on a weekday, and (3) the purpose is "go to school as a student." ***Psychometrics:*** *None provided*	Hispanics had the highest rate of active transportation (27.7%), followed by non-Hispanics Blacks (15.5%), Asian and Pacific Islanders (13.4%), respondents reporting more than one race (12.2%), and whites (9.4%). Students from families earning < $30,000 walked 2 times more as students from households earning more than $60,000 ($p<0.001$). The model showed that living within a half-mile of school greatly increased the likelihood of walking/biking to school across all groups, even after controlling for individual and neighbourhood covariates. The data showed that low income and minority groups, use AT to school. Racial variation in travel patterns is removed by controlling for income, vehicle access, distance between home and school, and residential density.

Author/Location/ Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: McDonald et al.,[82] 2009 Location: neighborhoods near Oakland and Berkeley, California. **Population:** This study assesses how parent-report of the neighborhood social environment correlates with walking and biking to school after controlling for trip distance and demographic factors. Parents of 10- to 14-year olds living in highly walkable neighborhoods.	***Cross-sectional Study*** ***Methods:*** Data from a cross-sectional survey of parents of 10-to 14 year olds living in highly walkable neighborhoods. From ZIP codes with the appropriate environmental conditions, nine were selected as a stratified sample with low, medium, and high median household incomes and racial diversity as measured by the proportion of non-Hispanic whites in the ZIP code. ***Statistical Analysis:*** The analysis measured unadjusted and adjusted differences in rates of walking and biking to school between children whose parents believe levels of social control are high in the neighborhood and those who believe social control is low or neutral. Respondents were matched on child's age, race, sex, household vehicles per household adult, income, and distance to school.	**SES: Household income.** **Access to a car.** **Covariates:** Social environment, parents beliefs of whether neighbors will watch out for children, expectation that neighborhood residents can and will intervene on the behalf of the children etc. Ethnicity, household income.	***Outcome:*** Respondents were asked, "What is the primary way your child travels to school?" Parents indicating their child walked, biked, skated or scooted were counted as active travelers. ***Psychometrics:*** **Comparison of the parent-proxy and child report of school travel mode was assessed by randomly contacting the children of 32 respondents. Results indicated high levels of agreement between parent and child report (%agreement=0.91, K=0.83).**	Youth had higher rates of walking, biking, or scooting to school when parents believed it likely that neighbors would intervene to discipline behaviour among youth. Of children whose parents reported high levels of child-centered social control in their neighborhood, 37% walked to school, compared with 24% for students whose parents reported low or neutral evaluations of social control. After adjusting for covariates, the difference was 10 percentage points (p=0.04). The association was strongest for girls and non-Hispanic whites.

Author/ Location / Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Merom, et. al.,[44] 2006 **Location:** New South Wales Australia ***Study Population:*** Children aged 5-12 years of age.	***Methods:*** The survey was introduced as a study on child pedestrian safety on behalf of the Pedestrian Council of Australia and WSTSD related questions were asked at the end of the interview. The interview followed a standard computer-generated order starting with commuting behaviors questions focused on a single randomly selected child within the family. ***Statistical Analysis*:** Univariate and bivariate analyses were used to examine differences in means and proportions across age and sex and region and to identify correlates of "frequent" or "regular" active commuting. Two logistic regression models were applied to define the set of variables independently associated with frequent and regular active commuting. All estimates were weighted to the population age and sex distribution.	***SES:*** They mentioned that 30% of the participants had tertiary education but that is it. Appears that they did not include in multivariate analysis. ***Other Covariates*:** No main predictor, however, in multivariate analysis the following variables were included: distance (kms), child's age, gender, family status, car number, language spoken at home, school affiliation, child is dependent, child not keen to walk, unsafe roads to school, perceived walking to places as healthy, parent is active commuter to work.	***Outcome:*** Parents were asked: "in a usual week, how does your child get to school on Monday morning?" The response options were: walk, cycle, car or public transport. For each mode indicated, parents were asked "for how long (ie. time) does your child walk (cycle, travel by car or by public transport)?" Reported trips that included any walking or cycling were considered as active commuting. All active commuting trips to and from school were summed for each child to represent total weekly accumulated active commuting trips (frequency) and the walking/cycling minutes summed to represent total weekly active commuting minutes. Children who engaged in one or more active commuting trip in a usual week were considered "active commuters."	*Frequent active commuters (5 or more trips)* Distance from school (kms): ≤0.75 km is the referent 0.76-1.50: OR= 0.41(0.29-0.72) 1.51-2.50: OR= 0.23(0.14-0.39) > 2.50: OR= 0.15(0.09-0.24)***Child's age*** 5-10years: reference,11-12 years: OR=1.52(1.02-2.27),***School affiliation*** Public: reference Private: OR=0.67(0.46-0.99)***Child is dependent*** No: ref Yes: OR=0.58(0.41-0.82) ***Unsafe roads to school*** No: reference Yes: 0.68 (0.49-0.97) ***Perceived walking to places as healthy*** No: reference Yes: 2.32(1.40-3.70)

Author/Location/ Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Mota, J et. al,[53] 2007 **Location:** Aveiro District, Portugal **Study Population:** Eleven urban public secondary schools in Aveiro District, Portugal participated in this study. Schools were selected to encompass a wide range of social position. The potential sample included all the 841 girls from the 7th to 12th grades registered at the participating schools.	**Cross-sectional Study Methods:** The questionnaires were distributed and filled out during physical education classes. Physical activity was assessed by a questionnaire and previously used with good reliability (ICC: 0.92 to 0.96). **Statistical Analysis:** : For all analyses participants were classified as Active commuters or passive commuters. Differences in physical characteristics were tested by independent t-test. The chi-square test was used to determine the differences in SES, sedentary behaviors and perceived environmental variables between AT and PT groups. Bivariate associations between variables were investigated using Spearman correlation. Multivariate analysis with mode of transportation as the dependent variable was examined using logistic regression analysis.	**SES:** Socio-economic position was established using a questionnaire sent to the parents' home. The response rate was 82% from both parents. Two separate indices, occupation and education level, were used in the analysis. Parent's occupations were classified according to the International Classification of Professions-classified as Lower, middle, and upper social class. Parents' educational level was based on the Portuguese Educational System:1) 9 years' education or less; 2) 10-12 years' education, and 3) higher education **Other Covariates:** No main exposure, however, other predictors include: Television watching/computer use; Socio-economic position; Environment	**Outcome:** Participants were asked if they walked, bicycled, went by car, or went by bus to and from school. Based on their answers, the respondents were categorized as using active (walking, bicycling) or passive (bus, riding in a private vehicle) commuting. **Psychometrics:** None Provided	Description of the participants travel patterns showed that 52.6% of the girls reported active in their way to and from school (walking=27.3% and cycling=25.3%), while 47.4% were driven to school by car (24.2%) or took the bus (23.2%). Father's occupation: **Low (reference)** **Middle 0.51 (0.28-0.94)** **Upper 0.48 (0.15-1.52)** Father's education **Low (reference)** **Middle: 0.52 (0.29-0.95)** **High: 0.91 (0.20-4.01)** Connectivity of the street network: There are many four-way intersections in my neighbourhood: 1.63 (1.08-2.45)

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Nelson et. al,[66] 2008. **Location:** Ireland **Study Population:** 15-17 year old Irish adolescents. Subjects were eligible to participate if they were aged 15-17 yr, were not participating in state examinations, and obtained parental consent if under 16y, or provided their own consent if ≥ 16y. 4720 adolescents participated and 4013 completed all elements required for this study.	**Cross-sectional study Methods:** All data were collected as part of the TakePART study (Physical Activity Research in Teenagers). Take PART was a cross-sectional study of participation levels, aerobic fitness, physical health indices, psychosocial and environmental determinants of physical activity in 15-17 year old Irish adolescents. **Statistical Analysis:** Data are presented as means, standard deviations and proportions where appropriate. The Pearson Chi square statistic was used to determine the relation between mode of transport and gender, and mode of transport and population density. Mann-Whitney tests were used to compare distance from school between males and females, active and inactive commuters, and between inactive commuters who cited distance as a barrier and those who did not. Distance was entered into a bivariate logistic regression model that predicted active versus inactive commuting to school, and controlled for gender, population density, socio-economic status and clustering at the school level.	**SES:** Parental occupation was obtained **Other Covariates:** Other variables measured included: participants were asked if they had a disability that restricted their participation in physical activity. Area of residence was classified as i) large city, suburb or outskirts of a city, town, village.	**Outcome:** The usual mode of travel was assessed using a self-report questionnaire that was completed under supervision. Mode of travel responses were categorized as active commuting by foot or bicycle, or inactive commuting by car, bus, or train. Adolescents who used mixed mode trips responded based on the longest portion of their journey only. **Psychometrics:** Similar questions have been previously been used in this age group.	Approximately one third actively commute to school. Distance predicts active commuting to school ($\chi 2$ (df=1) = 2591.86, $p<0.001$), after controlling for gender, population density, socio-economic status and school clustering. A 1-mile increase in distance from school decreases the odds of active commuting by 71% (Table 6). The distance related shift from active to inactive mode is illustrated in Figure 2. Gender and density continue to influence the adjusted model. The odds of active commuting are 66% greater among males. Compared with village residents, the odds of active commuting are 2.1, 2.0 and 1.7 times higher for those who live in cities, suburbs and towns respectively.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Oreskovic **et al.**[77] **2009 Nelson et. al,63 2008. Location:** Boston, Massachussetts **Study Population**: 5 to 15 year old children with asthma, receiving care from 1 of 3 Boston area pulmonary-immunology clinics.	**Cross-sectional study Methods:** Families were recruited with implied consent from pediatric allergy. A questionnaire was developed to assess how children travel to school and specific factors that may be associated with active versus passive travel. Asked parents to indicate factors influencing their decisions regarding mode of travel to school. **Statistical Analysis:** Determined bivariate relationships of sociodemographic variables, individual, family, and neighbourhood characteristics, physical activity, and asthma-specific factors with child status (active vs. passive) using t tests for continuous variables and chi square and Fisher's exact test for nominal variables. **Multivariate analysis not shown.**	**SES:** Household income categorized by poverty level, highest education attainment. **Other Covariates:** Distance to school, was their a walking initiative in the neighbourhood, parent modes of transportation, physical activity, asthma specific factors, ie. daytime symptoms. Age, ethnicity, race, zip code. Parental perceptions, asthma-specific factors of parental perceptions.	**Outcome:** Parents were asked, "On most days, how does your child arrive at school?" Options were: walk, bike, school bus, family vehicle, carpool, transit, other. Active travel was defined as walking, biking, skateboarding, using a scooter, or inline skates. **Psychometrics:** None provided.	Only 16% actively traveled to school (all walked). Nearly two-thirds of parents felt that walking to school would not affect their child's asthma, with 18% believing it would worsen. When comparing active versus passive travelers, significant differences in I number of cars per household and distance to school were found to differ significantly. Parents most frequently reported distance among factors influencing decisions to allow child with asthma to actively commute to school. Parents reported few concerns about pollution and little physician counseling on active travel.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Pabayo & Gauvin,[29] 2008. **Location:** Quebec, Canada **Study Population:** 9, 13, and 16 year olds. Children that did not attend school were excluded from the sample. N=3613	**Cross-Sectional Study. Methods:** The tools used to measure the variables were included in the 1999 Quebec Child and Adolescent Health and Social Survey (QCAHS), which is a representative population based community survey. **Statistical Analysis:** Estimation of the proportions of participants using different modes of transportation was weighted for design effects and then stratified by age, gender, urban vs. rural setting, 1998 household income, and parents' birthplace. Chi-square tests were performed to test for differences across strata.	**SES:** 1998 Household Income in Canadian Dollars **Other Covariates:** sex, age, urban milieu, and parents' birthplace were included to determine if there were associations between each variable and each mode of transportation	**Outcome:** Students were asked which mode of transportation to and from school they used most often. Response options were: school bus, walking, public transit, motor vehicle, or multiple modes of transportation. **Psychometrics:** None provided	40.3%, 15.2%, and 13.0% of 9, 13, and 16 year olds walked to school. Nine year olds, being male, living in an urban setting, having a 1998 household income <$30,000, and having both parents born in Canada were significantly associated with walking to and from school.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Panter et al[72], 2010. **Location:** Norfolk County, south-east England **Study Population:** Children were sampled through schools in the county of Norfolk, England which were selected based on urban-rural status. 157 schools were approached, 92 agreed to take part and all children aged 9-10 years and their parents were invited to participate. The aim was to quantify the associations between personal, social and environmental characteristics of the local neighborhood and route to school and AT to school in a sample of children living in urban and rural areas.	**Cross-Sectional Study. Methods:** SPEEDY study, (Sport, Physical activity and Eating behaviour: Environmental Determinants in Young people). **Statistical Analysis:** In order to account for non-independence of observations, where similar active commuting patterns may be clustered among children attending the same schools, multilevel statistical modelling was used by employing a two-level structure of children nested within schools. Multinomial outcome models were specified with a three category outcome of walking, cycling or motorised travel. Variables were retained in the models based on the goodness of fit. Analysis was stratified by three cate- gories, based on distance to school; less than 1 km, 1–2 km and greater than 2 km. These cut-offs were chosen as they were hypothesized to be appropriate for detecting possible transitions between walking and cycling and to maximize numbers of children in each category.	**SES:** Access to or ownership of a car, highest education attained by parent. **Other Covariates:** ethnicity, attitudinal (it's more convenient to take my child to school by car) and social support factors (my parents encourage me to walk to school), neighbourhood and route environments, objective physical environment (using GIS), distance traveled to school.	**Outcome:** Children reported their usual travel mode to school using the four response categories provided ("By car", "by bus or train", "on foot", and "by bike". Responses were collapsed into three categories: motorized, by bicycle, and on foot. **Psychometrics:** None provided	40% of children reported usually walking to school, with 9% cycling to school and the remainder reporting use of motorized transport. Within each distance category, children who had a longer route to school were also less likely to walk or cycle (p,0.05), as were those whose parents reported having access to a car (p,0.001). As a result, these factors in were our multivariate analysis. Parental attitudes and safety concerns, the presence of social support from parents and friends and parent-reported neighbourhood walkability were all found to be predictors of active commuting, with children receiving peer and family support and living in supportive environments being more likely to walk or cycle. There was some evidence of a moderating effect of distance whereby attitudes were more important for short distances and safety concerns long.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Panter et al,[80] 2010b. **Location:** Norfolk County, south-east England **Study Population:** Children were sampled through schools in the county of Norfolk, England which were selected based on urban-rural status. 157 schools were approached, 92 agreed to take part and all children aged 9-10 years and their parents were invited to participate. To determine whether objectively measured characteristics of the neighbourhood, route, and school environments are associated with active commuting to school among children and to explore whether distance acts as a moderator in this association.	***Cross-Sectional Study.*** ***Methods:*** SPEEDY study, (Sport, Physical activity and Eating behaviour: Environmental Determinants in Young people). ***Statistical Analysis:*** To identify predictors of children's travel mode, multilevel statistical models were fitted. A two-level structure of children (level 1) nested within schools (level 2) was applied to account for clustering of children's characteristics, including behaviors, within schools. Multinomial outcomes were specified in the models with a three-category outcome of motorized travel, walking, or cycling, with motorized travel as the reference category. Analysis was stratified by two route-length categories: ≤ 1km (n=760 children) and > 1km (n=1252 children). To investigate any moderating effects of distance on associations, an interaction term (distance X predictor) was added to the models.	**SES:** Access to or ownership of a car, highest education attained by parent. **Other Covariates:** age, gender, child BMI, household car access, maternal travel mode to work.	***Outcome:*** Children reported their usual travel mode to school using the four response categories provided ("By car", "by bus or train", "on foot", and "by bike". Responses were collapsed into three categories: motorized, by bicycle, and on foot. ***Psychometrics:*** *None provided*	40% of children reported usually walking to school, with 9% cycling to school and the remainder reporting use of motorized transport. Fully adjusted models indicate that children who lived in a more deprived area were less likely to walk or cycle to school. Those who had a higher density of roads in their neighbourhood were more likely to walk. Further, children whose routes had a high density of streetlights were less likely to cycle to school. When the moderating effects of distance on the associations between environmental factors and active commuting were tested, none of the interaction terms were significant.

Author/Location/ Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author:Robertson-Wilson et. al, [42].2008 Location: Canada **Study Population:** Students (grades 9-12) attending 76 high schools in Ontario as part of the SHAPES Ontario Study. 34,578 students were eligible. N=21,345.	**Cross-Sectional Survey Methods:** All surveys were completed in class time. The study uses a social ecological framework to explore the relationships between demographic, behavioral, social/psychological and environmental correlates of active commuting to school. **Statistical Analysis:** Dichotomous Hierarchical regression. Final model was a fully adjusted model accounting for the effects of all variables of interest on active commuting to school.	**SES:** No. **Other Covariates:** *Weight status, physical activity, sedentary behavior, smoking behavior. Behavioral: perceived athletic ability, perceived weight status, encouragement for physical activity. Environmental: type of school, school location, season.*	**Outcome:** Students responded to the single item:"In the last 7 days, how did you usually get to school" with response options of "actively" (ex. Walk or bike) ,inactively(ex car or bus),or"mixed". Students were classified as actively commuting to school if they responded "actively" or "mixed." **Psychometrics: None provided.**	Among the sample of high school students, 42.5% were classified as "active commuting." Of these students, 20.2% reported "active"only. Girls (OR=0.91, 95% CI:0.86, 0.97), grade 12 students (OR=0.80, 95%CI:0.74, 0.97), daily smokers (OR=0.88, 95% CI:0.795, 0.98), low active (OR=0.63, 95%CI:0.57,0.71), and moderately active (OR=0.83, 95%CI: 0.76,0.90). Students attending separate schools (OR=0.51, 95% CI:0.87,0.99) were less likely to actively commute to school. Students attending rural schools were less likely to actively commute.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Rodriguez & Vogt[46] Location: Michigan, USA Population: The purpose of this study was to better understand factors that influence was walking to school, including how attitudes are associated with walking to school. This was done by analyzing elementary school-aged children's attitudes about walking to school while controlling for demographic, environmental, and access factors.	***Cross-sectional Study Methods***. Cross-sectional data were collected from a convenience sample of elementary school-aged children (3^{rd}-5^{th} graders) t 11 elementary schools throughout Michigan during March, April, August, September, and October 2004. ***Statistical Analysis:***.*Logistic regression multivariate analysis. Only variables that significantly ($p<0.05$) correlated with walking to school were considered for inclusion in the model.*	**SES:? Access to a car. Covariates:** Attitudes and beliefs of school transportation choices. Environmental factors: safeness of route infrastructure, community type; rural vs. urban. Assess factors: such as access to different modes. Attitude factors	***Outcome:*** Students were asked three questions about their transportation behaviour" Today's method of getting to school" was used. ***Psychometrics:*** *None provided*	Most children went to school by car (41.0%) ot by school bus (41.3%); 11.1% walked, and 1.4% biked to school. The results indicate that the odds of walking to school increase the older children and more the students perceive that walking to school saves time. The odds of a student walking to school decrease the farther a student lives from their school, of his or her parents have a car, and if student has access to a school bus. Perceiving that walking as fun, school type, and safe route infrastructure did not significantly predict the odds of walking to school.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Salmon et. al,[78] 2007 **Location:** All capital cities in Australia **Study Population:** Families with children of primary or elementary school age from all capital cities in Australia. Parents (n=720) of school-aged children (4-13 years; 27% response rate; 49% parents of boys).	**Cross-sectional study. Methods:** This was an exploratory cross-sectional study and was based on data collected as part of the evaluation of the Pedestrian Council of Australia's National Walk Safety to School Day. **Statistical Analysis:** Logistic regression models examined which barriers were associated with active commuting to school for the whole sample, with "disagree" as the referent category for each barrier statement. Initially each barrier was entered into separate models that also adjusted for SES and the child's age and sex. Separate analysis were not conducted for the two age groups due to small numbers of older children or for boys and girls as the usual modes of transport were similar between sexes. All barriers that were significantly associated with active commuting to school were then entered into a multi-logistic regression model, which adjusted for child's age, sex, and SES. All logistic regression analyses were repeated for the subset of children who lived within a 15-minute walk to school.	**SES:** The responding parent's education, used as a proxy measure for family socioeconomic status (SES), was collapsed into three groups: (no school/some high school), medium (high school, technical or trade certificate, or apprenticeship), and high (university or tertiary qualification). **Other Covariates:** Age, sex, and barriers to walking to and from school	**Outcome:** Parents were asked to report their child' usual mode of transport (car, public transport, cycling, or walking), to or from school in a typical week during the current school term and how many times in a usual week the child used each mode (home to school=1 trip: maximum possible trips=10). Two variables were created: "usual" mode of transport to school, defined as the mode used for at least 50% of trips per week and "active commuting to school" defined as walking or cycling to school at least once per week. **Psychometrics:** None provided.	The proportion of the sample that indicated they walked or cycled to school at least once per week was 41%. In the multiple logistic regression model, two individual (the child prefers to be driven by car and child does not have enough time in the mornings), three social (there are no other children for the child to walk with, there are no adults for their child to walk to school with, and they are worried their child would take risks), and two environmental barriers (the school is too far for their child to walk to and there is not direct route to school) remained significantly inversely associated with AT. Similar results when the subset was reduced to children living in a 15 min walk to school.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Salmon & Timperio,[96] 2005 Location: Australia Study Population: Children aged 9-13 years in Australia in 1985 and 2001.	***Repeat Cross-sectional Study. Methods:*** In 1985, the Australian Council for Health, Physical Education and Recreation's (ACHPER) Australian Schools Health and Fitness Survey (ASHFS) collected extensive data on the health and fitness of a nationally representative sample of 8,484 children aged 7-15 years. In 2001, children aged 9-13 years in the Children's Leisure Activities Study Survey (CLASS) were recruited from fifth and sixth grade from 19 government primary schools in high (n=10) and low (n=9) socio-economic areas of Melbourne, Australia. **Statistical Analysis:** Descriptive statistics were employed to characterize and compare the two samples. Ordinal regression analyses were performed and, provided the proportional odds assumption was not violated, the combined relative risk was (95% CI) was then calculated.	**SES:** socio-economic status of the schools was quantified based on the Australian Bureau of Statistics Socio-economic Index of Relative Disadvantage for areas (SEIFA). Geographical SES. This index incorporates attributes such as income, educational attainment, unemployment, and jobs in relatively unskilled occupations. Schools were categorized as "high" SES if they were located in a Statistical Local Area with a SEIFA score above the national median (>1,000) and "low" SES if they were located in an area below the antional SEIFA median. **Other Covariates:** Other variables looked at were overweight and obesity using internationally accepted age- and sex-specific cut-points to define overweight and obesity	**Outcome:** 1985: Children were asked how many times they had traveled to school by bicycle, traveled to school by walking, participated in PE, an participated in school sport in the last week. In 2001: children completed the CLASS questionnaire about their usual frequency of walking and cycling to and from school and participation in school sport and physical education classes during the week. ("Which of the following physical activities do you usually do during a typical week?" "How many times Monday-Friday?" **Psychometrics:** These self-report measures have been shown to have acceptable reliability. Telford et al. 2004.	Within the 1985 sample, there was a significant difference in children's walking to school between the two SES areas (p=0.007). Children in high SES areas were 1.7 times more likely to walk to school (95% CI 1.2-2.5) compared with children in low SES areas. In 2001, children attending schools in low SES areas walked to and from school more frequently than children attending schools in high SES areas (p<0.01). Children walked to and from school less frequently in 2001 compared with 1985. The trend varied by SES, with approximately a 50% decline in walking 6-10 times/wk among children attending schools in high SES schools; however, for those attending schools in low SES areas the confidence intervals were overlapping in the comparison between survey years.

Author/Location/ Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Schlossberg et. al,[67] 2006**. Location:** Oregon, USA Study Population**:** *:* Four schools in Oregon. Two schools were located on the urban periphery, while the other two were located in more central neighbourhoods with gridded street patterns. Four middle schools of comparable size received surveys, two in Bend and two in Springfield Oregon. In each city, one school is newer and located on an urban edge that has few interconnected streets and the other is older and is located in an area with greater street connectivity.	**Cross-sectional Study Methods:** This study examined the relationship between urban form, distance, and active transportation to school. Surveys were distributed through each school to households of students requesting information on mode of transportation school and household address. ***Statistical Analysis:*** Multivariate logistic regression to isolate the individual relationships of the urban form measures and distance with the dependent variables while controlling for other independent variables. Income, grade level, ethnicity, nor number of cars owned by the household predicted mode of transportation, nor did they influence odds ratios for the dependent variables. They have not been included in the models.	**SES:** the family's approximate prior year income before taxes **Other Covariates:** basic demographic questions including the student's gender and grade, the number of cars in the household, the family's approximate prior year income before taxes, and race/ethnicity. Other independent variables in this study are distance from school on the street network and five measures of urban form: intersection density, dead-end density, route directness, major roads, and railroads. Route directness was measured as the ratio of the straight line distance from school to the network distance from home to school.	**Outcome:** The dependent variables in this study are the "primary" modes of travel (three or more days per week) for each student's trips to and from school. Also, measured whether the child ever traveled to or from school by walking or biking, the two active modes. **Psychometrics:** None provided	About 84% of the children surveyed primarily traveled to school by car or bus, while about 75% returned home. However, walking or biking was the primary mode for 15% of students on the way to school and about 25% on their way home. Twice as many students walk home from school as walk to school (20% vs. 10%). Those who live within one mile of school are by far the most likely to walk, followed by those living 1 to 1.5 miles. Those living beyond 1.5 miles were more likely to ride the bus. Observed no relationship between distance to school and travel by car. Adjusting for the measures of urban form, distance to school was still highly associated with walking to and from school. Students who live less than 1 mile from school were the most likely to walk, followed by those living up to 1.5 miles away.

Author/Location/Study Population	Study Design/Methods/ Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Shi et. al,[117] 2006 **Location: China Study** **Population:** Students from 16 classes (grade 7 and 8) in two prefectures in Jiangsu Province.	Cross-sectional Study **Methods:** A self-administered questionnaire containing information on sociodemographic and physical activity was filled in within a 40 min period in the classroom in the presence of health workers. **Statistical Analysis:** Chi-square tests were used to compare the frequencies. Ordinal logistic regression was performed to mode the association between physical activity level, and socio-demographic factors.	**SES:** *:* Household SES score was constructed based on sum up of ownership of 11 household possessions. It was further grouped into three categories: "Low": <=4; Medium: 5-8, and High 9-11. **Other Covariates:**	**Outcome:** Total physical activity score was based on three variables: active commuting to school, housework, and vigourous physical activity. Each item was given a score of 1 with some exception: active commuting scored 2 or 0 if distance between school and home was >3km or <0.5km, respectively, housework scored 2 or 0 if >2 h/day or <0.5h/day respectively; vigorous PA scored 2 if done >=3 times/week. The physical activity score was recoded to three categories: low(0-2); medium(3); high (>4). **Psychometrics: None provided**	64.8% bike to school and 22.9% walk. Active commuting to school is at 88%. Only a small proportion of the students commuted passively to school. More girls went to schools by bus than boys (15.4% vs. 9.4%). Boys from high SES families or with high education fathers had the lowest percentage of those walking to schools. There was a trend of negative association between SES and the physical activity in both genders but only statistically significant in boys. Household SES: low 22.3 passively commute, 63.4% bike, and 25.4% walk Household SES: Medium: 8.9% passively commute, 61.3% bike, and 29.8% walk Household SES: High: 9.4% passively commute, 75.8% bike, and 14.8% walk.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Sirard et. al,[24] 2005 Location: South Carolina, USA Study Population: Four schools from each level of urbanization (urban, suburban) were recruited from the 13 urban (9 low SES) and 18 suburban (8 low SES) public elementary schools.	**Cross-sectional study.** **Methods:** School was the unit of analysis in a cross-sectional study that was designed to observe the prevalence of active commuting of entire school populations. **Statistical Analysis:** *One-way Wilcoxon rank sum tests were calculated to determine group differences in transportation modes.*	**SES:** Schools with fewer than 67% of their students receiving free or reduced school lunch were considered moderate to high SES; other schools were categorized as low as SES. Other Covariates: school urbanization level, weather conditions, temperature.	**Outcome:** The prevalence of active commuting to school was assessed by direct observation of the number of children arriving at and leaving school via bus, special needs bus, child care center transportation for before – after school care, automobile, walking, or bicycling. 2 to 3 observers identified students' travel behaviours at each school for 60 minutes before and after school and recorded data on a 1-page form designed for the study. Each school was to be observed during the morning and afternoon on 5 consecutive school days during September to November 2002. Of 80 scheduled observations, 38 morning and 33 afternoon observations were conducted **Psychometrics:** None provided.	Only 5% of the observed students arrived at or departed from school via walking or bicycling, which was consistent within (morning vs. afternoon) and among days (Monday to Friday). The prevalence of walking and bicycling was not associated with school SES level, school urbanization level, weather conditions, or temperature.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Sisson et. al,[118] 2006. Location: Arizona, USA **Study Population:** Schools differing on the proportion of students bused were identified by using data maintained by Mesa Public Schools. The seven schools with the highest and lowest proportion of bused students were selected from the 56 public elementary schools in the district.	**Cross-sectional study Methods:** A nonexperimental analysis of the bikeability (including school biking policies) and biking prevalence of a select sample of elementary schools. **Statistical Analysis:** Nonparametric Mann-Whitney U-tests were conducted to determine the difference in bikeability scores and biking prevalence between high- and low-busing schools. Spearman correlation coefficients were computed to explore associations between bikeability score and biking prevalence.	**SES: None Other Covariates: Bikeability Assessment:** All street segments were subsequently assessed with a previously validated bikeability instrument according to seven factors: 1) average daily traffic, 2) number of through lanes, 3) speed limit, 4) outside lane width, 5) bike lane width, 6) pavement factors, 7) location factors. Individual street scores were then averaged to represent a composite bikeability score for each elementary school. Scores were interpreted as very good, good, fair, poor, very poor. **School biking Policies**	**Outcome:** Biking prevalence. Bikes in racks were counted during school hours for consecutive days. **Psychometrics:** A one-way repeated measures analysis of variance ($F=.2128$, $p=.14$) and intraclass correlation ($ICC=.9944$) was used to determine that random one-day sampling produced a reliable estimate of the number of bikes in racks and was used to compute biking prevalence.	Median biking prevalence was 3.1% in the low-busing schools and 1.3% in the high-busing schools ($p<0.05$).

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Spallek et. al,[51] 2006. **Location:** Brisbane, Australia **Study Population:** A sample of children aged 4-12 from the greater Brisbane area who were registered between 2001 and 2003 for a longitudinal cohort study of childhood injury. The sole exclusion criterion for selection of schools from this list was whether the school had a predominance of students whose family did not speak English.	***Cross-sectional Study Methods:*** Data on the children's transport to school were obtained from a cross-sectional survey administered at baseline to a sample of children aged 4-12 from the greater Brisbane area who were registered between 2001 and 2003 for a longitudinal cohort of childhood injury. **Statistical Analysis:** Descriptive statistics were used to present the variables of interest, distance to school and number of intersections crossed, and the analysis of variance (ANOVA) was used to assess the role of chance in differences in the distribution of demographic variables (children's age, education level of the primary carer, household income).	**SES:** Household income. $0-$31,999, $31,200-$51,999, $52,000-$72,799, $72,800 or more. School socio-economic rank: Low, Medium, High. Primary carer's education level: did not complete high school, completed high school, post-secondary education. **Other Covariates:** Age, gender, typle of school: private vs. public, distance to school, number of intersections crossed.	**Outcome:** The mode of transport as well as the amount of time (100% to school, 100% from school) traveling within each mode of transport for a typical week was obtained. **Psychometrics:** None provided	The majority of children in the study were driven by car both to (75%) and from school (72%) with the next highest proportion of children walking to school (15.6%) and from school (17.3%). Age, gender, primary carer's education level and school socio-economic rank were not associated with walking to and from school. However, Household Income, and type of school were associated with walking to and from school.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Timperio et. al[63] 2006. Location: Melbourne, Australia **Study Population:** Data were collected from families of 5 to 6 year old and 10 to 12 year old children, representing elementary school entry and exit ages.	**Cross-sectional study Methods:** *Questionnaires were completed by parents of both age groups at home, and by older children at school, between July and December 2001* ***Statistical Analysis:*** Frequency of walking or cycling to school was compared between age groups, and by gender within each age group, using Student's independent t-tests (continuous data) and Pearson's chi-square (categorical data). As there were few gender differences, boys and girls were combined for subsequent analyses. Each independent variable was entered into bivariate logistic regression analysis that predicted walking or cycling to school at least once per week. Variables with a statistically significant relationship in bivariate analysis were included in a multiple regression model, controlling for gender and maternal education. All regression analyses were performed separately for each age group and controlled for the clustering of participants according to school.	**SES:** Area-Level SES. Using the Australian Bureau of Statistics' Index of Relative Socio-Economic Advantage/Disadvantage, an area-based score for SES was assigned to each participant (based on residential postcode), and collapsed into tertiles for each age group. Higher scores indicate greater advantage. Highest level of maternal education was used as a proxy of SES, which was collapsed into three categories: low (some high school or less); medium (high school, technical cetificate, or apprenticeship); high (university/tertiary qualification). Other Covariates: personal, family, Parent and child - perceived social/physical neighborhood, School route <800m, busy road barrier along school route, school route along busy road.	**Outcome:** Parents reported whether their child usually traveled by walking to school during a typical week since the start of the school year and how frequently (to and from school equaled two times). These questions were repeated for cycling to school. Frequency of usual walking and cycling to/from school were collapsed into three categories: never; infrequent/occasional (one to four times per week); frequent (five or more times per week). **Psychometrics:** Percent agreement (reliability) was ≥ 73.0% for each item.	Amongst 5-6 years olds (adjusted only). No lights/crossings: OR: 0.4(0.1-0.9). Not many other children around: OR: 0.3 (0.1-0.8). School route <800m (referent≥800m): 5.2 (2.2-12.3). Busy road barrier along school route (ref=no): 0.1(0.0-0.5). Steep road barrier en route to school (ref=no):0.3(0.1-0.8) Amongst 10-12 years (adjusted only) No lights/crossings: OR: 0.6(0.3-0.9). Not many other children around: OR: 0.6 (0.4-0.99)**.** School route <800m (referent≥800m): 10.2 (5.9-17.6). Busy road barrier along school route (ref=no): 0.3(0.1-0.9). Direct route to school (referent=indirect): 0.7(0.5-0.98). Area-level SES was not significantly associated with walking to school (adjusted model).

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: van der Ploeg et. al,[37] 2008. Location: Australia Study Population: Randomly selected households in the study area. Obtained data obtained from children aged 5-14 on weekdays from August until November in Australia's County of Cumberland, which is a large urban area that includes the city of Sydney. Only the trips children made to school in the morning and from school at the end of the school day were examined.	**Repeat Cross-sectional Study. Methods:** Data on the mode of transport for journeys to and from school were extracted from the 1971, 1981, 1991, and the ongoing 1999-2003 Household Travel Surveys of the New South Wales Government Department of Planning. Children were interviewed personally or by adult proxy from the same household. **Statistical Analysis:** The prevalence of car, waking, bus, train and other modes as the main mode of transport to and from school were calculated for all four surveys. Odds ratios were estimated using logistic regression to compare the four surveys on the use of car, walking and bus as the main mode of transport to and from school (1971 was the ref). All analyses were performed separately for boys and girls and for children aged 5-9 and 10-14 and were corrected for clustering within households. The data were weighted for age, gender, area, day and week, such that the population represented the population.	**SES:** Not measured **Other Covariates:** measured by age group and sex only.	**Outcome:** All usual household residents were asked to complete a 24h diary that recorded details were asked to complete a 24 h diary that recorded details on all trips made during the designated travel day. An interviewer visited the household before the travel day to explain the survey procedures and collect basic socio-demographic information. The interviewer returned after the travel day to obtain detailed trip information, and any other additional and missing information. **Psychometrics:** None provided	The majority of children traveled to and from school by car or walking. Boys and girls showed mostly similar results. In both age groups the proportion of children walking and taking the bus to and from school significantly decreased, while the proportion taking the car significantly increased between 1971 and 2003. Cycling, the other major mode of active commuting besides walking was not very prevalent (1-2%). The duration of trips to and from school remained relatively stable. However, the data suggested a slight trend toward shorter walk and longer car trips. In all surveys a walk trip to or from school took around 10 min, car trips 5-10min and bus trips 25-30 min.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Voorhees et al, 2010[76] **Location: USA Study Population:** Healthy grade 6 girls age 11-12 years were recruited from 36 schools located in MD, MN, SC, AZ, CA and LA. A random sample of 60 girls was targeted for recruitment from each of the 36 schools.	**Multi-center cluster-randomized trial. Methods:** Data collectors participated in a centralized training to ensure standardization of survey administration procedures across all 36 study schools in the six field states. **Statistical Analysis:** The data in these analyses had a hierarchical structure, with girls nested within schools, and schools nested within sites. Mixed effects logistic models were used to analyze the relationships between individual perceptions and measures of neighbourhood characteristics and walking to school outcomes, while accounting for the correlations at each level of nesting by treating school and site as random effects. We combined perceived, objective, and sociodemographic variables into a single multivariate model to determine the contribution of each of the perceived and objective variables to any active commuting (walking to or from school) during the weekday for girls living within 1.5 miles of school.	**SES:** Neighbourhood socioeconomic status (SES) was defined with the Townsend Index using data from the 2000 US **Census. Other Covariates:** Perceived neighborhood questions were taken from a ten-item questionnaire about safety, aesthetics, access to facilities near home. Perception of facilities located near home. Objective neighbourhood variable descriptions, street connectivity, block size, population density, percent African American and Hispanic, Land Use Mix	**Outcome:** The mode of transportation to and from school was assessed by asking the following question: During the last 7 days not including today, how many days did you walk A) to school?, B) from school? Response options for both questions ranged from 0-5 days. These were reduced to a variable representing any weekday walking trips to or from school. **Psychometrics:** None provided	Of the 890 girls living within 1.5 miles of school, 500(56.2%) walked to/from school at some point during the past week. When combining both perceived, objective and sociodemographic variables in a nested mixed effects logistic model, several measures remained significant predictors of weekday walking to/from school. Girls who perceived that they had places to walk and perceived their neighbourhood was safe nearly twice as likely to walk to or from destinations available in their neighborhood were almost 1.4 times as likely to walk to or from school compared to girls who did not. Girls with more total destinations available in their neighborhood were 1.4 times as likely to walk to/from school. Girls from neighborhoods with larger block sizes were less likely to walk. Girls from neighbourhoods with a higher % of Hispanics were more likely to walk to/from school.

Author/Location /Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Wen et. al,[68] 2007 Location: Australia Study Population: Students and their parents from 24 schools in Australia. All public primary schools (n=61) located in the inner west of Sydney were invited to participate in the study, and 24 schools volunteered.	**Cross-sectional surveys Methods:** Surveys were conducted with students and their parents from 24 schools. The students and their parents completed a travel survey over 5 days and their parents completed a questionnaire. **Statistical Analysis:** Complex samples Descriptive analysis was conducted to produce the population estimates in describing the characteristics of the study population. Relationships between the study factors and the outcome factor were examined using bivariate analyses (Pearson chi-square tests) and multiple logistic regression. The logistic regression models were conducted by using Complex Sample Logistic Regression to take into account the cluster design. Variables that were found to be associated with car travelers (P=0.1) in bivariate analyses were entered into the multiple logistic regression model in order to determine the factors that are independently associated with the car travelers. Adjusted ORs with 95% CI were then calculated as a measure of the strength of associations.	**SES: Care-giver's education's level. Other Covariates:** Age, gender, employment status, educational level and language mainly spoken at home. The parents were also asked about their attitudes to the issues related to their child walking to school and their own modes of travel to work. Attitudes cover the following domains: encouragement of walking to school, of the child likes to walk, the child's road safety skills, if there is convenient public transport, perceived safety of the neighbourhood, and if there are dangerous roads near their school. Parents also recorded the estimated distance from their home to school and the distance from their home to their place of employment.	**Outcome:** Year 4 and 5 students recorded how they traveled to and from school in a travel survey for 5 consecutive school days. Students answered the questions, "how did you get to school yesterday?" and "how did you get home yesterday?" The study outcome variable was whether students were driven to school or not.. Students who reported being driven to or from school five times or more per week (out of 10 possible rips) were classified as "car travelers" and the rest were classified as "non-car travelers". **Psychometrics:** The reliability and validity of this travel survey had been tested in a pilot study, which found that the travel diary is reliable and valid.	Based on the students' travel survey, 41% of students were car travelers. Of these students, 89% were driven to or from school for 10 trips per week. Almost a third (32%) of students walked all the way to or from school for at least five trips per week. Only 1% of the students rode a bike, and 22% used more than one mode of travel to or from school. Among the car travelers, 29% lived less than 1 km from school and a further 18% lived between 1 and 1.5 km from school. After adjusting for other variables, factors that were found to be associated with being driven to school were the mode of parents' journey to work, parents' attitudes towards walking to school, number of cars available in the household and distance from home to school. As the distance from home to school increased, the adjusted odds of being driven to school also increased.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Yelavich et al.[43] 2008 **Location: Dunedin, New Zealand** Population: This study seeks to estimate the prevalence of walking to and from school among Dunedin primary school children and identify major predictors of this activity.	***Cross-sectional Study Methods***. Schools were identified from the Ministry of Education database. Children were asked to raise their hands if they had either walked or been driven to school, or got to school by any other means of transportation. Every child received a questionnaire to take home for their caregivers to complete and return to school. ***Statistical Analysis:***.A logistic regression model was used to predict walking on a given day/time with a random effect for schools (taking into account the cluster effects of schools) and accounting for the correlated nature of the possible walking periods for each child.	**SES:school level SES Access to a car. Covariates:** sex, age, ethnicity, number of adults in household, number of other children in household, distance from school, hours of physical activity per week, whether parent had walked to school and from school in a typical week.	***Outcome:*** Information about the number of days the child walked to/from school in a typical week. ***Psychometrics:*** *None provided*	34.5% of children had walked to school and 36.8% anticipated walking home on the study day. The proportion of children walking dropped off sharply as distance from school increased. Those living within 1 km of school were almost 30 times more likely to walk than children living more than 3km from school. Families without a car were 10 times as likely to walk as those with as many or more cars than adults in the household. Boys were one-third more likely to walk than girls. Children in years 4 to 6 were 72% more likely to walk than younger children. Those attending (socioeconomically disadvantaged) decile 2 to 4 schools were twice as likely to walk as those at higher.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author:Zhu & Lee[71] 2009 Location: Austin, Texas, USA Study Population: The Austin Independent School District has 74 elementary schools.55.4% of the students were Hispanics. The city selected a convenience sample of 9 lower SES schools. The final sample consisted of 19 elementary schools, which represented the school district in terms of students'sociodemographic characteristics and physical environmental conditions of attendance areas (distance to school, sidewalk completeness, traffic crash rate and crime rate.	**Cross-Sectional Survey Methods:** The study seeks to fill gaps in the literature by identifying the correlates of walking to or from school among elementary school children in diverse sociodemographic and physical environments, and by exploring the implications for policy interventions. **Statistical Analysis:** After data reduction, the odds of walking to/from school were predicted by estimating four multivariate logistic regression models in a sequential order. The final model also included 18 dummy variables. The bivariate associations between the student's SES and significant physical environmental correlates were examined to explore disparities in the physical environmental support for walking.	**SES:** Parents' highest education. **Other Covariates:** Gender, grade level, ethnicity, single-parent status, number of family members, household's car ownership, parents' personal barriers (no time to walk with my child, easier to drive, too much planning), child's personal barriers(my child has too much energy, my child gets too hot and sweaty), Parents' and children's positive attitudes and regular walking behaviors, and social factors such as school bus availability and positive peer influences, physical environment(ie. Distance ,perceived safety), presence of physical barriers, quality of overall walking environment.	**Outcome:** The use of walking as a typical mode of travel to/from school-parents/guardians were asked, "On a normal day, how does your child travel from home to school (from school to home)?"The 7 possible responses were: Walk alone, walk with friends, walk with a parent/adult, bike, school bus, public bus, private car, including car pool. The three walking options with friends, or with a parent)to or from school were coded as"Yes" for the outcome variable. **Psychometrics: None provided.**	The mode share of students who walked was 27.8% and 31.5% for the trips to and from school, respectively. In the final model, from the personal factors, parents' highest level of education and household car ownership were negative correlates Ors 0.821 and 0.712 respectively. The number of family members was a positive correlate (OR=1.134). A child was about four times more likely to walk if the parent perceived the distance to be close enough for the child. Disparities Analysis results: Parents with higher education were more likely to perceive the distance to school to be close enough for their children to walk (OR=1.078,P<0.001). The most educated group were more likely to perceive the distance to be walkable.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Ziviani et. al,[69] 2004 Location: Brisbane, Australia Study Population: Students in Grades 1-7 from a metropolitan state primary school in Brisbane, Australia. The school is situated in a middle to upper middle class residential area, this school had a number of features that could be considered facilitative of children walking based on ecological models.	**Cross-Sectional Study Methods:** Surveys were distributed to the parents of all children by inclusion in the weekly newsletter. Parents were requested to return the surveys to the school within two weeks, and reminders were issued in the newsletter. **Statistical Analysis:** Descriptive and inferential statistics were calculated. Chi square tests were used to determine statistical significance between the proposed barriers and whether or not children walked to school. Logistic regression was then employed to analyse further the dichotomous dependent variable, walking to school.	**SES: None Other Covariates:** Parents were asked to identify factors they felt facilitated or hindered their child walking to and from school. Demographic information about the child and family, such as the child's name, age, grade, address, number of siblings, approximate distance lived from the school and parent's hours of work. With respect to children walking to school, parents were asked to comment on a range of psychosocial and environmental concerns.	**Outcome:** Walking to school. The dependent variable had two levels; walking to school at least once per week, and never walking to school. There was no statistical difference on the basis of age or gender for either walking to school or home from school. For the purpose of further analyses, therefore, performance was collapsed across both. As walking to school was significantly associated with walking home from school, subsequent analyses adopted the former as the dependent variable. **Psychometrics: None provided.**	The mean number of days walked to school in a week by all the children was 1.00±1.62. With respect to walking home, the mean number of days was 1.16±1.69. Multivariate regression: Two psychosocial factors were found significantly to impact on walking to school: whether both parents had themselves walked to school and whether both parents considered physical activity important. Distance was found to have a substantial impact on walking to school.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: CDC Location[32]: Georgia Study Population: School children in Georgia under the driving age, aged 5-15 years of age. A parent or caregiver in households with at least one child aged <18 years reported on all children residing in the home.	***Cross-Sectional Survey Methods:*** Georgia Division of Public Health analyzed data from the Georgia Asthma Survey conducted during May--August 2000. ***Statistical Analysis:*** Weighted percentages were obtained using by SAS and SUDAAN. Additional analyses were performed for a subset of children (n=315) who lived <1 mile from school.	**SES: None Other Covariates:** Sex, age group, urban/rural, ethnicity of parent respondent.	***Outcome:*** Respondents were asked about the mode of transportation to school and the distance between home and school rounded to the nearest mile. **Psychometrics: None provided.**	Of 1,656 children aged 5-15 years included in the survey, 64 (4.2%) (95% confidence interval [CI]=2.9%--5.5%) walked to school the majority of days of the week. Of the 315 (19.0%) children who lived <1 mile from school, 56 (18.6%; 95% CI=12.8%--24.4%) walked to school the majority of days of the week. Older children were more likely to walk to school than younger children, and non-Hispanic black children were more likely to walk to school than children of other racial/ethnic groups. However, these comparisons and those between sexes and between urban and rural residents were not statistically significant.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: MMWR-CDC, 2002[33] Location: USA Study Population: In 1999, investigators solicited 3,550 households that had previously indicated a willingness to respond to survey questions. This sample was selected as representative of the U.S. population on the basis of eight demographic variables: age, sex, marital status, race/ethnicity, income, region,household size, and population density. A total of 2.636 (74%) households responded; the 749 (28%) households with children aged 5-18 years responded.	**Cross-Sectional Study. Methods:** HealthStyles Survey, an annual mail survey of health-related attitudes and behaviors in the United States. Population-based representative sample. **Statistical Analysis:** Results were weighted to match population distribution in the US by using eight demographic variables.	**SES:** None **Other Covariates:** whether any of six specified conditions made it difficult to do so: traffic danger, crime danger, long distances, weather, opposing school policy, or other reasons. Respondents also had the option of stating that their children had no barriers to waking or biking to school.	**Outcome:** *Parents of children aged 5-18 years were asked (1) if their youngest child walked or biked to school at least once a week during the preceding month.* **Psychometrics: None provided.**	Of the 611 respondents, 19% reported children walking and 6% reported biking to or from school at least once a week during the preceding month. Frequency of walking and biking trips ranged from zero to >10 times a week (mean frequency: six one-way trips a week). These trips represented 14% of all school trips (11% walking and 3% biking).Reported barriers to walking and biking included long distances (55%, 95% CI: +/- 4%), traffic danger (40%; 95%CI: +/- 4%), adverse weather conditions (24%; 95% CI=+/-3%), crime danger, opposing school policy, or other reasons. A reported 16% reported no barriers to their children walking or biking to school.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: MMWR-CDC,[119] 2004 Location: USA Study Population: Parents of children aged 5-18 years.	**Cross-Sectional Survey Methods:** For the ConsumerStyles survey, stratified random sampling (by region, household income, population density, age, and household size) was used to identify 10,000 potential respondents from a larger consumer-mail pantel of approximately 600,000 adults aged ≥ 18 years. A low/income/minority supplement were used to ensure adequate numbers of respondents from those groups. **Statistical Analysis:**	**SES: Other Covariates:** Whether one of six barriers: too dangerous because of traffic, too dangerous because of crime, live too far away, no protection from weather, the school does not allow it, and other reasons prevents that child from walking to school. Results were weighted to reflect the age, race/ethnicity, sex, income, and household size of the U.S. adult population as determined by the 2000 U.S. Census.	**Outcome:** Parents of children aged 5-18 years were asked how many times their youngest child walks to or from school during a usual week. **Psychometrics: None provided.**	Approximately 17% reported that their child walked to or from school at least once per week during a usual week. Among students who walked to school, the average number of trips per week to or from school was 7.1 (range 1-10). The percentage of students who walked to or from school was higher among those aged 5-11 years than among those aged 12-18 years (18.7% versus 15.3%); this difference was not significant (p=0.08). The most commonly reported barrier was distance to school (61.5%), followed by traffic-related danger (30.4%), then weather (18.6%). Fifteen percent of parents cited an "other" barrier; 15.9% (95%CI=14.1%-18.0%) of parents selected the response, "It is not difficult for my child to walk to school."

Appendix-III

Articles that identify relationships between AT to/from school (as a main exposure) and a health outcome

Appendix-3: Articles that identify relationships between AT to/from school (as a main exposure) and a health outcome such as weight status, physical activity, or cardiovascular fitness.

Author/Location/ Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Landsberg et al, 2008 **Location: Kiel, Northwest Germany Study Population:** 31 schools participated in the study. All eighth grade students were invited to attend the study.	**Cross-sectional Study. Methods:** Between April 2004 and September 2005 heads of all 35 secondary schools in Kiel were contacted twice and informed about the study. Parameters of adiposity of the adolescents were measured in school. Afterwards, adolescents completed a questionnaire about commuting mode and the lifestyle factors PA, media use, nutrition and risk behavior as described below. **Statistical Analyses:** BMI was log10-transformed before analyses because it was not normally distributed. All analyses were adjusted for gender, Tanner stage and the interaction term 'gender by Tanner stage'. Data were re-analyzed in a second model with additional adjustment for nationality and SES of the adolescents. In a third model, additional adjustment was made for parental overweight. Duration of structured and unstructured PAs, TV viewing and computer use were introduced into the model as continuous variables.	**Active Transportation Measure:** To assess AT to school, subjects were asked, "How do you typically get to and from school?" Response choices were (1) by walking, (2) by bicycle, (3) by bus, (4) by car (5) other. Answers were given for summer and winter times separately. The duration of a single trip was assessed. Adolescents were categorized into Active Commuting (both summer and winter) vs. Inactive (traveling to school by bus or car both in summer and in winter) commuting. only adolescents with a distance to school between X1.5 and p11.0 km **SES:** using mode of school at time of the measurement. **Other Covariates:** Distance, physical activity and media use, nutrition and risk behaviour (alcohol consumption), mother's and father's BMI-self-reported.	***Outcome*:** All anthopometric measurements were performed by trained nutritionists. Body mass index was recorded to the nearest 0.1 kg using a calibrated digital scale. BMI was calculated and international age- and gender- specific cutoffs were used to define overweight. Four skinfold-thickness measurements (triceps, biceps, suprailiacal and subscapular) were taken in triplicate to the nearest 1 mm on the right side of the body. Bioelectric impedance analysis was conducted with body impedance analyzer. Waist circumference	When compared with adolescents reporting an inactive commuting mode adolescents coming to school actively had significantly lower skinfolds and a lower FM. No significant group differences were detected for BMI and prevalence of overweight and overfatness. After adjustment for gender, Tanner stage and the interaction term 'gender by Tanner stage' (model 1), the interaction term 'active commuting by distance to school' and 'time spent in structured PA' were independent predictors of FM. Further adjustment for nationality and SES of the adolescents (model 2), and even for parental overweight (model 3), the interaction term 'active commuting by distance to school' and 'time spent in structured PA' remained as independent predictors of FM. Age at examination did not affect the results.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Bere et al, 2009 **Location:** Rotterdam, Holland and Kristiansand, Norway **Study population:** Collected data in the school year 2005/2006 among adolescents in the first (12-130year olds) and third year (14-15-year olds).	**Cross-sectional Study. Methods:** The investigation used data from the two studies ENDORSE and Youth in Balance studies. **Statistical Analysis:** The two datasets were analyzed separately. Descriptive analyses of weight status in relation to the independent variables were conducted using SPSS version 16. Multilevel logistic regression analyses, taking the clustering of pupils within schools into account, were performed with weight status as the dependent variable. We analyzed three models step- wise with fixed explanatory variables at level 1, in order to see how being overweight varies by means of individual characteristics. Model I included CYCLING and distance to school. as level 1 variables. Model II included sex and ethnicity1 model I, while model III included sport participation1model II. Sex, ethnicity and sport participation were included in the models in order to adjust for these potential moderators.	**Active Transportation Measure:** ENDORSE: three questions: adolescents indicated how many days of the week (never to 5) they traveled to school; walking, cycling, and by public transport or car. those cycling 3 days/week or more (Cyclists) are compared with Non-Cyclists (i.e. those not cycling 3 days/week). In Youth in Balance: How do you usually get to school? Bus, car, walking, cycling, rollerblades and scooter. Adolescents who reported cycling to school at all time points participating in the surveys were categorized as Cyclist, and were compared with NON-Cyclists **SES: Other Covariates:** Distance to school using postal codes. Ethnicity. Sport participation	***Outcome:*** Body mass index (BMI) was calculated from measurements of height and weight. Age- and sex-specific cut-off points were used to categorize adolescents by weight status [normal weight vs overweight (including obese)	A total of 25% and 18% were categorized as overweight, and 35% and 31% were categorized as cyclists, in Rotterdam and Kristiansand, respectively. Adjusted for school and distance to school, the OR for cyclists being over- weight compared with non-cyclists was 0.52 (95% CI 5 0.38–0.70) in Rotterdam and 0.54 (95% CI 5 0.36–0.81 in Kristiansand (Table 2, modelI). After including sex and ethnicity in the model, the OR was adjusted to 0.61 (95% CI 5 0.44–0.85) and 0.52 (95% CI 5 0.35–0.78), respectively, in Rotterdam and Kristiansand (model II). Further adjustments of sport participation resulted in ORs of 0.63 (95% CI 5 0.45–0.89) and 0.52 (95% CI 5 0.34–0.78) in the two analyses (model III).

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Heelan et al, 2005 **Location:** Nebraska **Study population:** Six hundred 9-11 years old children in eight rural Nebraska schools.	**Cross-sectional study. Methods:** In September and April, research staff entered the public schools and measured body weight and height. In April, skinfold measurements of subcutaneous body fat were taken. **Statistical analysis:** Multiple regression analysis allowed to control for the influence of the relationship between the covariate (Septembber BMI) and the dependent variable (April BMI) from the effect of the exposure (SI).	**Active Transportation Measure:** The actual amount of physical activity accumulated from active commuting to and or from school was determined using an active commuting to and from school index (SI). The SI score was calculated by multiplying the number of times the child actively commuted to and/or from school during the assessment week (possible 10 times per week) by the distance they traveled to and/or from school. The distance between each child's home address and school address was estimated using Expedia.com**SES: Other Covariates:** parents completed a questionnaire to rank perceived barriers to daily active commuting to and from school such as no sidewalks, busy streets to cross, distance to school, parents work schedule.	***Outcome:*** BMI and skinfolds were measured in September and April.	On average, participants accumulated 3.6±4.3 km per week from active commuting to and from school (SI score). If participants were driven, their SI score was zero. After adjusting for the September BMI, there was a significant positive association between April BMI and SI (partial $r=0.03$, $p<0.05$). When completing the same multiple regression for normal weight and overweight children separately a significant positive association was found for the overweight children (partial $r=0.10$, $p<0.05$), but not the normal weight children. Gender was not a moderating effect.

Author/Location/Study Population	Study Design/Methods/ Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Aires et al**,** 2009 **Location:** Portugal **Study population:** Middle and high public school in a suburban setting comprising of all the students from the 7^{th} to the 12^{th} grade class.	**Longitudinal Study. Methods:** Over a period of 3 school years from 2005-2008, 345 students with ages from 11-16 at baseline were studied. All students were invited to perform fitness tests and to answer a questionnaire. **Statistical analysis:** Linear mixed effects modelling was performed to evaluate the relation between BMI and the fitness tests, ST, CS, PAI. In these analyses The mixed effect model that we applied consists of fixed effects, which describe 1) a population intercept and population slope; 2) random effects for individual variability in the outcome and changes over time. For fixed effects, main effects were used to model factors and covariates with included intercept.	**Active Transportation Measure:** Participants were asked if they went to school by car, bus, train, bike or walked to and from school and how much time it took. The respondents were categorized as using active (walking, biking) or passive (bus, train, car) commuting. For the purpose of this study we considered participants to be active commuters once they reported at least one school trip walking or bicycling. Time spent commuting to and from school was categorized as: (1) five minutes or less; (2) between 5 and 15 min; (3) between 15 and 30 min; (4) between 30 and 60 min; (5) more then 60 min, according to an established protocol **SES:** parents' education level **Other Covariates:** Physical fitness, physical activity index, screen time.	***Outcome:*** BMI used as a dependent variable was corrected for age and gender (BMIc). BMIc was calculated subtracting from the absolute BMI the value obtained from the age-and-sex-specific cut points for overweight, according to Cole et al. Thus, positive values indicate overweigh/obesity, and negative values indicate normal weight.	Table 3 shows results of the multivariable mixed effect model adjusted for all variables. After controlling for the remaining variables, participants UHZ in 20m-SR remained positively asso-ciated with BMIc (p__0.001), while CU performance was no longer significantly related to BMIc. AT was not associated with BMI.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Saksvig et al, 2007 **Location:** USA **Study population:** Sixth-grade girls enrolled in the Trial of Activity for Adolescent Girls. Sixty health sixth-grade girls were randomly selected from 6 schools at each of the 6 TAAG filed sites to undergo a series of measurements.	**Cross-sectional Study. Methods:** Age, ethnicity, socioeconomic status and neighbourhood factors were obtained from the participant by questionnaire. 2 weight readings were recorded to the nearest 0.1 kg on an electronic scale and 2 height measurements recorded to the nearest 0.1 cm using a portable stadiometer. The average was taken. **Statistical Analysis**: To properly account for the hierarchical nature of the data, with girls nested within schools and schools nested within field centers, we performed a series of linear mixed- model analyses. In these models, we treated travel by walk- ing (categorized as none, before school, after school, before and after school) as fixed and girl and school as random.	**Active Transportation Measure:** "Travel by walking" the code for walking for transportation as opposed to exercise, was the primary activity students reported before and after school on the 3DPAR**.** Participants were classified as walkers if they reported travel by walking on 1 or more weekdays before and after school. **SES: Other Covariates:**	***Outcome:*** Minutes of total physical activity and MVPA were accumulated before school, after school, and before and after school combined. A 3-day Physical Activity Recall (3DPAR) was used to augment the accelerometer data and provide contextual information regarding the physical activities that the participants performed.	Travel by walking was reported by 14% of participants before school and 18% after school. Girls who reported travel by walking before and after school (com-bined) had 13.7 more minutes (95% confidence interval, 1.2-26.3) of total physical activity and 4.7 more minutes (95% confidence interval, 2.2-7.2) of MVPA than girls who did not report this activity.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Alexander et al, 2005 **Location:** Edinburgh Scotland **Study population:** The researchers recruited four classes, each of about 30 pupils aged 13-14 years, from four schools in the Edinburgh area. How children travel to and from school may significantly influence their overall physical activity levels.2 The researchers measured moderate to vigorous physical activity (MVPA) among adolescents and explored their means of travel to and from school.	**Cross-sectional Study. Methods:** The researchers visited the classes three times: to introduce the study and distribute consent forms and information for pupils and parents or guardians; to allocate accelerometers; and to collect accelerometers and issue questionnaires. **Statistical Analysis**:	**Active Transportation Measure:** We collected data from the questionnaire responses about the children's main part of their journey to school (options were walking, car, bicycle, bus, train, or other). Responses to both questions reflected very good agreement after a 14 day retest (Kw = 0.874 and 0.836 respectively).**SES: Other Covariates:**	***Outcome:*** In spring 2004 objective measures of the children's activity with precalibrated accelerometers record activity accumulated each minute. Pupils were asked to wear the accelerometers on their hip from waking until bedtime. Except during water based activities. Age specific cut-off points to calculate minutes of MVPA per pupil for weekdays, during school, including morning and lunch breaks, time outside school. Cut-off points were ≥ 1399 and ≥ 1547per minute for ages 13 and 14 respectively.	Pupils who walked both ways accrued the most minutes of MVPA for every time period we examined, followed by those walking one way (table). Moderate to vigorous physical activity outside school hours was significantly higher among those pupils who walked both ways than among those using a car, bus, or train. In all, 87% (41/47) of the group using a car, bus, or train, accumulated an average of 60 or more minutes of MVPA on weekdays compared with 90% of those who walked one way and 100% of pupils who walked both ways.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Cooper, et al, 2003. **Location:** Bristol, UK. **Study population:** Primary-school children recruited from five urban primary schools.	**Cross-sectional Study. Methods:** Ten schools located in areas of the city where the catchment area would be predominantly from either upper/middle or lower social classes were identified and invited to participate. **Statistical Analysis**: ANOVA comparing was used to compare walkers and those who use the car to and from school stratified by sex.	**Active Transportation Measure:** Daily travel to school was measured using a brief questionnaire asking how the children usually traveled to and from school (car/cycle/bus/walk) and how long the journey took. **SES: Other Covariates:** Weight and Height	***Outcome:*** Physical activity was objectively measured for 7 days using an accelerometer except for during water activities. Physical activity volume (MTI/CSA counts per minute) and minutes of moderate or greater intensity physical activity (3 metabolic equivalents [METs]; moderate-to-vigorous physical activity [MVPA]) was calculated for each hour that the accelerometer was worn between 7 AM and 9 PM, since the MTI/CSA was worn infrequently outside of these times. MVPA was calculated using established age-dependent cut- points for children.	Children who walked to school on weekdays were significantly more physically active than those who traveled by car (p 0.05) and also recorded more MVPA (p 0.04). At the weekend, no significant differences were found between the two groups. A significant gender travel interaction for total physical activity during the week (p 0.03) revealed a large difference in activity levels between boys who walked or traveled by car that was not present in girls.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Cooper et al, 2005 **Location:** Odense, Denmark **Study population:** 9 year old Danish children from 25 schools.	**School-based cross-sectional study.** A multi-center international study. **Methods:** The study took place 1997/98. Schools were tested one at a time such that all children from an individual school were tested in the same period. The order of schools for testing was randomly assigned prior to commencement. All measurements except assessment of activity were carried out in the schools that the participants attended. **Data analysis:** The independent associations between travel mode on physical activity were tested using general linear models. Models were tested with and without adjustment.	**Active Transportation Measure:** "How do you usually travel to school? (response options: by car or motorcycle, by bus or train, by bicycle, on foot) with a similar question for travel home and "How long does it usually take you to travel to school from your home?" **SES:** none **Other Covariates:** gender, study location and season.	***Outcome:*** Physical activity was measured using an accelerometer programmed to record physical activity each minute. The accelerometer was worn on an elastic belt around the waist, positioned above the right hip, for at least 4 days (including 2 weekend days) in the week prior to physical assessment, except when swimming, bathing and sleeping.	There was a significant main effect of travel mode on physical activity counts per minute. Children who walked to school were significantly more active than those who traveled by car. There was a significant main effect for gender but no significant interaction between gender and travel mode. Children who cycled to school recorded counts between those who walked and those who traveled by car, but these differences were not significant.

Author/Location/Study Population	Study Design/Methods/Statistical Analysis	SES Indicator/Other Covariates	Outcome Variable; Psychometric Properties	Results
Author: Cooper et al, 2006 **Location: Study population:** Odense, Denmark. 1356 individuals from 28 schools. 919 provided both fitness and travel data.	**School-based cross-sectional study. Methods:**. The European Youth Heart Study (EYHS). **Data analysis:** Multivariate linear regression with robust standard errors was used to investigate the associations of mode of travel to school with fitness. Because of the association between obesity and fitness, body composition was controlled for using skinfold thickness. All modes were adjusted for the cluster sampling. Multinomial logistic regression was used to calculate the odds ration of belonging to the different quartiles of fitness according to travel mode, with the lowest quartile of fitness used as the comparison group.	**Active Transportation Measure:** "How do you usually travel to school? (response options: by car or motorcycle, by bus or train, by bicycle, on foot) with a similar question for travel home and "How long does it usually take you to travel to school from your home?" **SES:** none **Other Covariates:** BMI, skinfolds, gender, Puberty status,	***Outcome:*** Fitness assessment: cardiorespiratory fitness defined as maximal power output per kg was determined using a cycle ergometer test with progressively increasing workload until exhaustion on an electronically braked cycle ergometer. This test has been validated in both children and adolescents with a low test-retest coefficient and is highly correlated with directly measured VO2max.	There was a significant main effect of both gender and age group on the level of fitness, and there was a significant interaction between gender and age group. The fitness levels of participants using different travel modes. Unadjusted analyses showed that participants cycling to school were significantly more fir than those who used passive transport, with the exception of adolescent boys, and significantly more fit than those who walked to school, with the exception of young girls. Absolute fitness levels in those who cycled were consistently higher than those who used passive or walked to school.

Appendix-IV

McMillan-Framework

SAGE

Title: Urban Form and a Child's Trip to School: The Current Literature and a Framework for Future Research

Author: Tracy E. McMillan

Publication: Journal of Planning Literature

Publisher: Sage Publications

Date: 05/01/2005

Gratis

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BACK CLOSE WINDOW

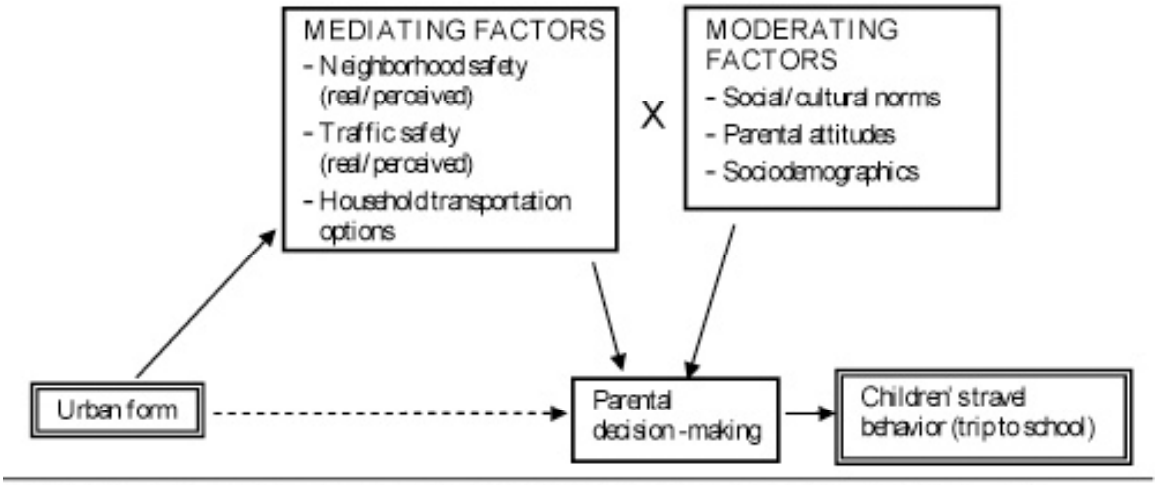

FIGURE 2. Diagram of the Conceptual Framework of an Elementary-Aged Child's Travel Behavior
NOTE: Solid arrows indicate hypothesized direct relationships, dotted arrows highlight hypothesized indirect relationships, and X indicates the interaction between mediating and moderating factors.

Appendix V

The Ecological and Cognitive Active Commuting (ECAC) Framework

Title: Walking and Bicycling to School: A Review
Author: John R. Sirard, Megan E. Slater
Publication: AMERICAN JOURNAL OF LIFESTYLE MEDICINE
Publisher: Sage Publications
Date: 09/01/2008

Gratis

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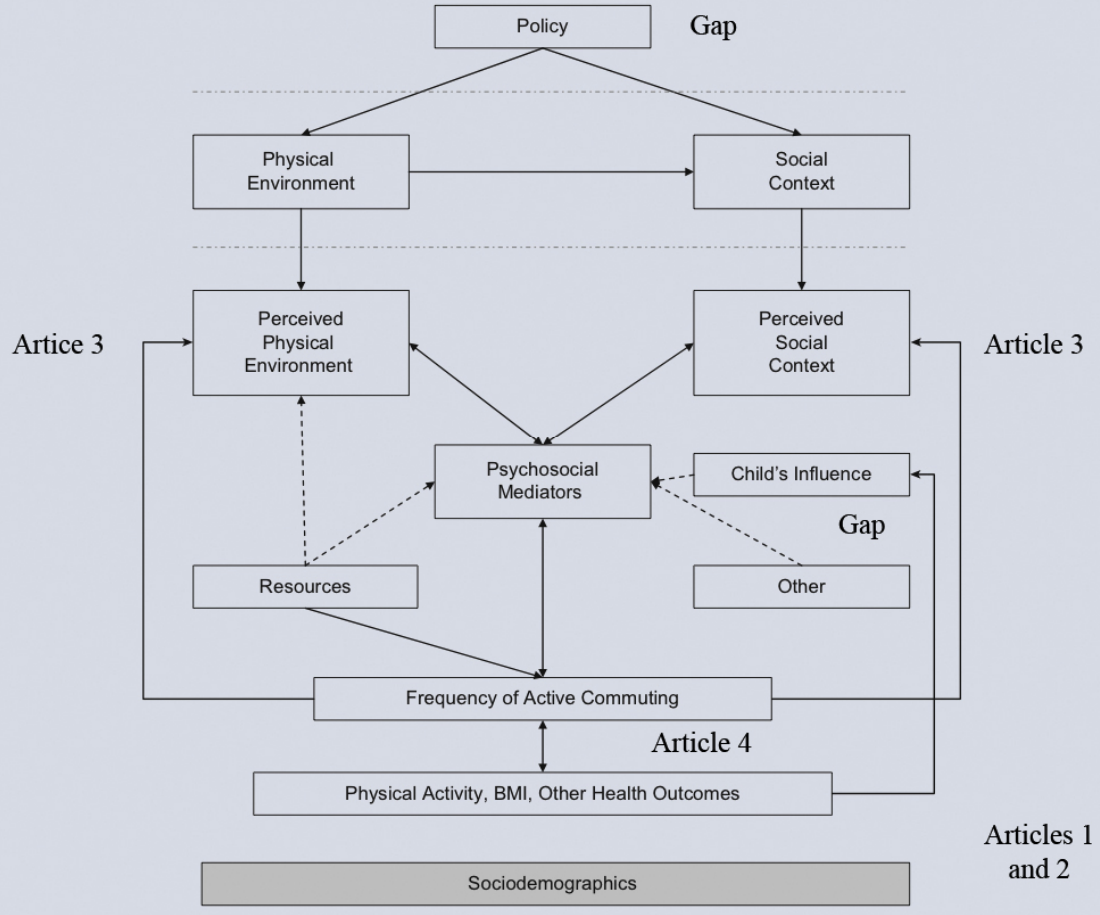
BACK CLOSE WINDOW

Figure 2.

The Ecological and Cognitive Active Commuting (ECAC) Framework



BMI, body mass index.

Appendix VI

Ethical Approval for Article 1

Appendix VII
Multivariate analysis from Article 1

Appendix-VII

Multivariate analysis from Article 1

Data Analysis

Multivariate logistic regression analyses were conducted to investigate the associations between sex, 1998 family income, birthplace of parents, and walking to school (yes or no). Analyses were stratified by age groups as well as urban versus rural setting. However, since there were few students attending rural schools whose parents were born outside of Canada, birth place of parents was not included in the rural setting models. Students who chose more than one method of transportation to and from school and 16 years olds who did not attend school were also excluded from the multivariate analysis. In order to control for sampling variance and obtain more precise estimates and confidence intervals, all logistic regression analyses were re-estimated with SUDAAN version 9.0.1 (Research Triangle Institute, Research Triangle Park, NC).

Results

The multivariate logistic regression analysis (table 3) amongst the students who attended a school located in an urban setting indicated that nine year olds whose parents indicated that they had a 1998 income of <$30,000 and between $30,000 and $60,000 were 3.22 (95% CI 1.85, 5.60) and 2.27 (95% CI 1.28, 4.04) times more likely to walk to school respectively, in comparison to the nine year olds whose parents reported that their 1998 household income was > $60,000. Also, amongst nine year olds, those whose biological parents were born outside of Canada were 0.29 (95% CI 0.13, 0.69) less likely to walk to school than those nine year olds whose parents were born in Canada. Amongst 13 year olds living in urban settings, those children whose household incomes were less than $30,000 were 4.15 (95% CI 1.75, 9.82) times more likely to walk to school. There were no significant relationships between household income, birth place of biological parents, or sex amongst 16 year olds living in urban areas and children aged nine, 13, and 16 within rural settings.

Table 3. Multiple logistic regression for correlates of walking to and from school amongst urban and rural settings.

Mode of transportation to and from school	**Urban**		**Rural**	
		OR (95%CI)		**OR (95%CI)**
9 year olds				
Sex, Girl (ref: Boy)	0.77	(0.55, 1.07)	0.77	(0.58, 1.02)
Income (ref: >$60,000)				
<$30,000	**3.22**	**(1.85, 5.60)**	1.38	(0.68, 2.79)
$30,000 to $60,000	**2.27**	**(1.28, 4.04)**	1.26	(0.75, 2.12)
Birthplace of Parents** (ref: Born in Canada)				
Both born outside Canada	**0.29**	**(0.13, 0.69)**		
One parent born outside Canada	0.52	(0.23, 1.19)		
13 year olds				
Sex, Girl (ref: Boy)	0.78	(0.43, 1.43)	1.21	(0.68, 2.18)
Income (ref: >$60,000)				
<$30,000	**4.15**	**(1.75, 9.82)**	1.60	(0.61, 4.18)
$30,000 to $60,000	1.92	(0.95, 3.87)	1.37	(0.66, 2.86)
Birthplace of Parents** (ref: Born in Canada)				
Both born outside Canada	0.50	(0.21, 1.20)		
One parent born outside Canada	0.84	(0.29, 2.44)		

Table 3 Continued. Multiple logistic regression for correlates of walking to and from school amongst urban and rural settings.

Mode of transportation to and from school	Urban		Rural	
		OR (95%CI)		OR (95%CI)
16 year olds				
Sex, Girl (ref: Boy)	0.82	(0.48, 1.41)	1.42	(0.80, 2.51)
Income (ref: >$60,000)				
<$30,000	1.88	(0.89, 3.93)	1.32	(0.75, 2.33)
$30,000 to $60,000	1.37	(0.81, 2.32)	1.31	(0.69, 2.48)
Birthplace of Parents** (Born in Canada)				
Both born outside Canada	1.18	(0.56, 2.52)		
One parent born outside Canada	0.90	(0.23, 3.55)		

** Since there were few children whose parent(s) were born outside of Canada in the rural regions, this variable was not included in the rural model.

Appendix VIII

Ethical Certificate for Articles 3 and 4

Sainte-Justine
100 ans
1907-2007
à faire grandir la vie.

LE COMITÉ D'ÉTHIQUE DE LA RECHERCHE

Un comité du CHU Sainte-Justine formé des membres suivants:

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant

Pour l'amour des enfants

Université de Montréal

Jean-Marie Therrien, éthicien et président
Anne-Claude Bernard-Bonnin, pédiatre
Geneviève Cardinal, juriste
Maja Krajinovic, scientifique
Denis Lebel, pharmacien
Albert Moghrabi, hémato-oncologue
Florina Moldovan, scientifique
Stéphanie Pellerin, infirmière de recherche
Jean-François Saucier, psychiatre
Chantal Van de Voorde, représentante du public

Les membres du comité d'éthique de la recherche ont étudié le projet de recherche clinique intitulé:

Longitudinal analysis of the Quebec birth cohort: Pathways between early childhood poverty, stress, child health, cardiovascular risk factors and associated secular trends, and resiliency.

No. de dossier: 2634

soumis par: *Marie Lambert M.D., Chercheur responsable au CHU Sainte-Justine et collaboratrice. Investigatrice principale: Louise Séguin, M.D., Université de Montréal. Co-investigateur: Gilles Paradis, Ph.D., McGill University. Collaborateurs: T. Barnett, M. Daniel, E.mDelvin, L. Gauvin, K. Gray-Donald, J. Hanley, E. Lévi, E. Loucks, S. Lupien, J. Lynch, J. McGrath, P. Newacheck, B. Nicalau, J. O'Loughlin, P. Poirier et M.-V. Zunzunegui*

et l'ont trouvé conforme aux normes établies par le comité d'éthique de la recherche du CHU Sainte-Justine. Le projet est donc accepté par le Comité.

Jean-Marie Therrien, Ph.D., éthicien
Président du Comité d'éthique de la recherche

Date d'approbation: 09 janvier 2008

3175, Côte-Sainte-Catherine
Montréal (Québec)
H3T 1C5
www.chu-sainte-justine.org

Sainte-Justine 100 ans 1907-2007
à faire grandir la vie.

Liste des documents approuvés par le CER

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant

Pour l'amour des enfants

Université de Montréal

Longitudinal analysis of the Quebec birth cohort: Pathways between early childhood poverty, stress, child health, cardiovascular risk factors and associated secular trends, and resiliency.

Protocole #2634

Marie Lambert, M.D., Chercheur responsable au CHU Sainte-Justine et collaboratrice. Investigatrice principale: Louise Séguin, M.D., Université de Montréal. Co-investigateur: Gilles Paradis, Ph.D., McGill University. Collaborateurs: T. Barnett, M. Daniel, E.mDelvin, L. Gauvin, K. Gray-Donald, J. Hanley, E. Lévi, E. Loucks, S. Lupien, J. Lynch, J. McGrath, P. Newacheck, B. Nicalau, J. O'Loughlin, P. Poirier et M.-V. Zunzunegui

- Protocole de recherche daté du 9 janvier 2008 (incluant l'annexe 1).
- Politique de gestion de la banque de matériel biologique conservée au centre de recherche du CHU Sainte-Justine.
- Politique de gestion de la banque de données de l'Institut de la statistique du Québec.
- Formulaire de consentement daté (2 janvier 2008) (versions française et anglaise).
- Lettre aux parents (versions française et anglaise).
- Lettre aux enfants (version française et anglaise).
- Questionnaire santé administré à l'enfant.
- Questionnaire santé autoadministré au parent.
- Guide de prélèvement de salive.
- Formulaire de visite à l'enfant.

3175, Côte-Sainte-Catherine
Montréal (Québec)
H3T 1C5
www.chu-sainte-justine.org

Appendix IX

Letter from the Urgences Santé
Approval for using Vehicle-Collision data

Urgences-santé
Québec
Direction des affaires médicales et de l'encadrement clinique

Le 15 mai 2009

Par courriel :

Monsieur Roman Pabayo
Étudiant
Programme de doctorat en santé publique
Université de Montréal

Objet : Accès à la base de données d'Urgences-santé

Monsieur Pabayo,

La présente fait suite à la lettre reçue le 29 avril dernier, et concernant votre demande d'accès à une base de données d'Urgences-santé. Cette base de données est déjà en possession de la Direction de la santé publique de Montréal-Centre.

Il nous fait plaisir d'acquiescer à votre demande d'accès. Les seules personnes autorisées à utiliser les données de cette base de données sont les Drs Morency, Barnett et Gauvin, et vous-même.

Les «conditions» d'utilisation sont celles mentionnées dans votre demande.

Espérant que ces données seront utiles pour votre thèse de doctorat.

Je vous prie de recevoir mes meilleures salutations.

Claude Desrosiers
Adjoint au directeur et
chef du programme d'amélioration
continue de la qualité

/dl

c.c. Dr Patrick Morency
Monsieur Éric Lareau, technicien en recherches, Urgences-santé

3232, rue Bélanger
Montréal (Québec) H1Y 3H5
Téléphone : (514) 723-5763
Télécopieur : (514) 723-5790
www.urgences-sante.qc.ca

CURRICULUM VITAE

NAME Roman A. Pabayo

CITIZENSHIP Canadian

LANGUAGES English, French

EDUCATION

2010-… Post-Doctoral Fellowship
Canadian Obesity Network
Physical Education
University of Alberta
Supervisor: Dr. John Spence
Topic: Relationship between eating behaviour and childhood obesity.

2006-2010 PhD. In Science
Epidemiology
School of Public Health
Université de Montréal
Supervisor: Dr. Lise Gauvin
Co-Supervisor: Dr. Tracie Barnett
Topic: Investigating Active Transportation to and from School:
Identification of Predictors and Health Benefits

2001-2003 Master of Science (M.Sc.)
Nutritional Epidemiology
Human Nutrition and Dietetics
McGill University, Montreal
Supervisor: Dr. K. Gray-Donald
Co. Supervisor: Dr. J. O'Loughlin
Topic: Effect of a ban on extracurricular sports activities by secondary school teachers on physical activity levels of adolescents: a multilevel analysis.

1998-2001 Bachelor of Applied Science (B.App.Sc.)
Dean's Honour List
Human Nutrition
Ryerson University, Toronto

1993-1997 Honours Bachelor of Science (B.Sc.)
Biochemistry
McMaster University, Hamilton

RESEARCH EXPERIENCE

2009 Research Assistant. Cochrane Review. Flexible working conditions and their effects on employee health and well-being. The main review objective is to evaluate the effects (benefits and harms) of flexible working interventions on the physical and mental health and wellbeing of employees and their families. Supervisor: Dr. Clare Bambra.

2008-2009 Internship. Department of Geography, Durham University, UK. Investigating area characteristics on physical activity among youth from age 11 to 15 among the National Institute Study of Early Child Care and Youth Development. Supervisors: Professor Sarah Curtis and Dr. Jay Belsky.

2003-2004	Principal Investigator Physical environmental determinants of youth smoking initiation. Direction de santé publique de Montreal-Centre Régie régionale de la santé et des services sociaux de Montréal-Centre
2003-2004	Critical Assessment of Studies Evaluating Smoking Cessation in Adolescents. A systemic review. Direction de santé publique de Montreal-Centre Régie régionale de la santé et des services sociaux de Montréal-Centre Supervisor : Dr. J. O'Loughlin
2001-2003	M.Sc. Thesis School of Dietetics and Human Nutrition MacDonald Campus, McGill University Project: Impact of the ban on extracurricular activities on students' levels of physical activity Supervisor : Dr. K. Gray-Donald Co-Supervisor : Dr. J. O'Loughlin
2000-2001	B.App.Sc. Senior Project School of Nutrition Ryerson University Project: The effects of stress and theoretical models of coping with stress Supervisor: Dr. J. Paisley

WORK AND TEACHING EXPERIENCE

2006-…	Epidemiology Online Skills Facilitator. Teaching an introductory epidemiology online course to public health professionals for Public Health Agency of Canada.
Nov 2004-2006	Program Evaluator. Policy and Planning, Healthy Living and Disease Prevention, Public Health, City of Toronto. Currently, I am evaluating several physical activity policies and campaigns that attempt to increase physical activity levels of Torontonians.
July 2004-Nov 2004	Research assistant. Applied Research and Evaluation, Public Health, City of Hamilton. Evaluated two social programs. Supervisor: Collen Van Berkel
2004	Research Consultant for the McGill University Aging and Frailty Project. Evaluated programs that attempted to prolong the onset of frailty amongst the elderly, part of a systematic review. The Jewish General Hospital, Montreal, Quebec. Supervisor: Dr. Tina Wolfson
2004	Consultant for Physicians for a Smoke-Free Canada. Characterising smoking policies on Canada's University and College campuses. Conducted literature reviews that describe the development of such programs and policies.
2002-2004	Research Assistant for McGill University Nicotine Dependence in Teens Study investigating social and physical determinants for adolescent behaviour, such as smoking and physical activity. Direction de la santé publique Régie régionale de la santé et des services sociaux de Montréal-Centre Supervisor: Dr. J. O'Loughlin

2001-2004	Interviewer for the McGill University Nicotine Dependence in Teens Study Helped administer youth nicotine dependence questionnaires and measured anthropometrics Direction de la santé publique Régie régionale de la santé et des services sociaux de Montréal-Centre Supervisors: Dr. J. O'Loughlin and E. MacMillan-Davey
2002	Teaching Assistant. Data Analysis in Nutrition Data School of Human Nutrition and Dietetics McGill University, MacDonald Campus Supervisor: Dr. G. Egeland
2002-2003	Teaching Assistant. Food Fundamentals School of Human Nutrition and Dietetics McGill University, MacDonald Campus Supervisor: Dr. L. Thibault
2002	Teaching Assistant. Nutrition and Behaviour School of Human Nutrition and Dietetics McGill University, MacDonald Campus Supervisor: Dr. L. Thibault
2001	Research Assistant for a study of the food choices of food bank recipients Ontario Association of Food Banks Toronto, ON
2000	Professional Practice Placement at Makati Public Hospital, the Philippines School of Nutrition Ryerson University Supervisor: J. Welsh, Director of the School of Nutrition

PUBLISHED PAPERS/MANUSCRIPTS

2010	Pabayo R., Spence J. Identifying Correlates of Regular Soft Drink Consumption Among Pre-school Children, Does the Accessibility of Grocery Stores, Convenience Stores and Fast Food Restaurants Matter? In Preparation.
2010	Pabayo R., Spence J., Barnett TA., and Gauvin L. The Relationship between television viewing and change in Body Mass Index across time among school-aged children participating in the Canadian national Longitudinal Study of Children and Youth. In Preparation.
2010	Pabayo R., Spence J. Food Intake by Preschool Children Living in Edmonton, Alberta: Do they meet the Canadian Food Guide For Healthy Eating Guidelines? In Preparation.

2010 Pabayo R., Gauvin L., and Barnett T. Sociodemographic Predictors of Using Active Transportation to School among children participating in the National Longitudinal Study of Children and Youth (NLSCY). Under Revision and Review- *Pediatrics.*

2010 Pabayo R., Gauvin L., Morency P., Barnett T., Nikiéma B., Seguin L. Understanding determinants of active transportation to school among children living in poverty:
Evidence of environmental injustice from the Quebec Longitudinal Study of Child Development. Under Review- *Health and Place*

2010 Pabayo R., Belsky J., Gauvin L., and Curtis S. Do Area Characteristics Predict Change in moderate-to-vigorous physical activity from ages 11 to 15? In Press- *Social Science and Medicine.*

2010 Pabayo R., O'Loughlin J., Gauvin L., and Barnett T. Does tolerance of smoking in and around schools contribute to initiation of cigarette use among adolescents? Under Review-Journal of Epidemiology and Community Health.

2010 Joyce K., Pabayo R., Critchley JA., Bambra C. Flexible working conditions and their effects on employee health and well being. *Cochrane Database Syst Rev.* 2010 Feb 17;2:CD008009.

2009 Pabayo R., Gauvin L., Barnett TA, Nikiéma B., Seguin L. Sustained Active Transportation is associated with a Favorable BMI Trajectory across the Early School Years: Findings from the Quebec Longitudinal Study of Child Development birth cohort. *Supp63* 2010 Jan;50 Suppl 1:S59-64. Epub 2009 Sep 19.

2008 Pabayo R. & Gauvin L. Proportions of students who use various modes of transportation to and from school in a representative population-based sample of children and adolescents, 1999. *Prev Med.* 2008 Jan;46(1):63-6. Epub 2007 Aug 3.

2006 Pabayo R., O'Loughlin J., Gauvin L., Paradis, G., Gray-Donald K
Impact of a ban on extracurricular activities on students' levels of physical activity.
Health Education & Behavior 2006.

PRESENTATIONS

2010 Oral Presentation. Pabayo R., Gauvin L., and Barnett T. Sociodemographic Predictors of Using Active Transportation to School among children participating in the National Longitudinal Study of Children and Youth (NLSCY). 3rd International Congress on Physical Activity and Public Health, in Toronto, Canada.

2010 Oral Presentation. Pabayo R., Gauvin L., Morency P., Barnett T., Nikiéma B., Seguin L.Understanding the determinants of active transportation to school among children living in poverty: Evidence of environmental injustice from the Quebec Longitudinal Study of Child Development, In San Diego, California.

2009	Oral Presentation. Pabayo R., Belsky J., Gauvin L., and Curtis S. Do Area Characteristics Predict Change in moderate-to-vigorous physical activity from ages 11 to 15? International Medical Geography Symposium, Hamilton, ON
2009	Oral Presentation. Pabayo R., O'Loughlin J., Gauvin L., and Barnett T. The role of the school environment in smoking initiation among adolescents in the Nicotine Dependence in Teens (NDIT) Study. Society of Behavioral Medicine in Montreal, Quebec.
2009	Plenary Oral Presentation. Pabayo R., Gauvin L., Barnett TA, Nikiéma B., Seguin L. The relationship between active transportation and body mass index from kindergarten through grade 2 among children participating in the Quebec Longitudinal Study of Child Development birth cohort. Active Living Conference in San Diego, California.
2008	Oral Presentation. Pabayo R., Gauvin L., Barnett TA, Nikiéma B., Seguin L. Predictors to active transportation to school among a cohort of 5 years olds in Quebec. International Conference on Public Health and Physical Activity. Amsterdam, The Netherlands.
2007	Poster presentation. Pabayo R. & Gauvin L. Proportions of students who use various modes of transportation to and from school in a representative population-based sample of children and adolescents, 1999. Society of Epidemiological Research. Boston, 2007.
2007	Poster presentation. Pabayo R. & Gauvin L. Active transportation to school and overweight and obesity amongst children. International Conference on Physical Activity and Obesity in Children. Toronto, 2007.
2006	Oral Presentation. Pabayo R. & Hansen B. Results of the Get Your Move On: Get Active Toronto Evaluation Study. Ontario Public Health Association Conference, Cornwall, ON.
2004	Media Launch and presentation. Dissemination of results from the Tobacco on Campus Study. This is occurring August 27, 2004. Ottawa, ON.
2003	Poster Presentation: Pabayo R., O'Loughlin J., Gauvin L., Paradis, G., Gray-Donald K. Impact of a ban on extracurricular activities on students' levels of physical activity Canadian Society of Epidemiology and Biostatistics (CSEB) Halifax, Nova Scotia
2003	Thesis Defence: Impact of a ban on extracurricular activities on students' levels of physical activity School of Human Nutrition and Dietetics McGill University, MacDonald Campus
2002	Thesis Proposal Defence: Impact of a ban on extracurricular activities on students' levels of physical activity School of Human Nutrition and Dietetics McGill University, MacDonald Campus

AWARDS AND DISTINCTIONS

2010	Post-Doctoral Fellowship award. Canadian Obesity Network. University of Alberta
2010	Travel Award for 3rd International Congress on Physical Activity and Public Health, in Toronto, Canada. Canadian Obesity Network.
2009	Groupe de recherche interdisciplinaire en santé (GRIS) travel award. Active Living Conference, San Diego
2009	Quebec Inter-University Centre for Social Statistics (QICSS) Matching Grant Award
2008	Groupe de recherche interdisciplinaire en santé (GRIS) travel award. International Conference Physical Activity and Public Health.
2008	Bursary for International Internship in Social Inequalities provided by the Centre de Lea-Roback. Internship at Durham University, UK.
2006	Canadian Institutes of Health Research-Institute of Population and Public Health. Doctoral Award.
2003	Predictors of Smoking Onset in Youth: How Important are Indicators of the Physical Environment? Canadian Tobacco Control Research Initiative. Student Research Allowance Grant $10,000
2001	Dean's Honour List Ryerson University Toronto, ON