1-1-2021

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Wellbeing, Space and Society 2 (2021) 100062

Contents lists available at ScienceDirect

Wellbeing, Space and Society

journal homepage: www.sciencedirect.com/journal/wellbeing-space-and-society

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ARTICLE INFO

Keywords:
Child
Active school travel
Physical activity
Gender
Environment
Transportation

ABSTRACT

Physical inactivity among children is a public health concern. Children's ability to travel independently is associated with increased physical activity and social connectedness. Consequently, it is concerning that children's independent mobility has decreased in recent years. Studies have highlighted that rates of independent mobility vary by gender; this study analyzed how correlates of independent mobility vary between boys (n = 476) and girls (n = 618) attending 32 elementary schools in Southwestern Ontario. Hierarchical logistic regression modeling methods were used. All analyzes were stratified by gender. For boys, age was negatively associated with travel with peers. Having one or more siblings of any age was associated with increased travel with peers and having one or more older/same siblings decreased the likelihood of travel alone. Parents' perceptions of the journey being too far/taking too much time was negatively associated with boys' traveling alone. In comparison, age was positively associated with traveling alone for girls. Having one or more younger or older/same siblings were associated with decreased traveling alone, while older/same age siblings were positively associated with traveling with peers. Distance was negatively associated with both traveling with peers and alone. For girls, parents' perceptions of the journey between home and school being easier to drive and having enough walking trails in the neighbourhood were negatively associated with travel alone and with peers, respectively. The findings of this study can aid in informing future interventions targeting children's school travel and help address inequities in independent mobility between boys and girls.

1. Background

Over half of Canadian children (5 to 17 years old) are not achieving their recommended amounts of moderate to vigorous physical activity (Statistics Canada, 2019). Low levels of physical activity are of concern as they have been associated with poor outcomes for body composition, physical fitness, and mental health (Janssen and LeBlanc, 2010; Poitras et al., 2016; Tremblay et al., 2011) Engaging in active school travel, which is any form of human-powered transport to and/or from school, provides an opportunity for children to increase their physical activity (ParticipACTION, 2020). In addition, active school travel is associated with environmental (Adams and Requia, 2017; Gilliland et al., 2019) and academic benefits (Martínez-Gómez et al., 2011). Despite these positive findings, rates of active school travel have decreased over the last 50 years (Gray et al., 2014; Buliung et al., 2009).

Parental permission to travel independently is an important aspect of children's participation in active school travel (Faulkner et al., 2010; Page et al., 2010; Ghekiere et al., 2016). Children's independent mobility is defined as children's freedom to travel around their community without adult supervision (Hillman et al., 1990). Independent mobility and active school travel have an interconnected relationship in which the trip to/from school represents one of the first milestones of

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https://doi.org/10.1016/j.wss.2021.100062
Received 14 April 2021; Received in revised form 21 September 2021; Accepted 21 October 2021
Available online 24 October 2021

independent travel for children and independent mobility is a key component of children's participation in active school travel (Faulkner et al., 2010; Crawford et al., 2017; Mitra, 2013). Beyond its foundation to active school travel, independent mobility is associated with increased physical activity (Schoeppe et al., 2013) and social connectedness (Prezza and Pacilli, 2007; Rissotto and Tonucci, 2002). Similar to trends of active school travel, independent mobility has decreased in recent years (Schoeppe et al., 2013; Fyhri et al., 2011; Loebach and Gilliland, 2019).

Studies examining correlates of independent mobility, including independent mobility for the school journey, often utilize the socio-ecological model to understand travel behaviors [for example, Crawford et al. 2017, Buliung et al. 2017, Carver et al. 2014, Foster et al. 2014, Ghekiere et al. 2017, Janssen et al. 2016, Riazi et al. 2019]. This model posits that independent mobility is influenced by determinants within the intrapersonal, interpersonal, physical environment, and policy levels (Sallis et al., 2006). The socio-ecological model is useful for understanding children's health behaviors as it systematically assesses mechanisms of change at multiple levels of behavioral influence (Sallis et al., 2006, 2008). Population-level interventions should target all these levels of influence to be most effective at changing behavior (Sallis et al., 2006). As current active school travel interventions are often conducted at the school-population level, using the socio-ecological model as a framework allows for exploration into behavioral influence and greater application of the results to active school travel interventions.

Within the intrapersonal level, both age and gender influence children's independent mobility. Research has found that older children are more likely to be granted independent mobility than younger children and boys are more likely to be granted independent mobility relative to girls (Buliung et al., 2017; Ghekiere et al., 2017; Riazi et al., 2019). Differences in correlates of independent mobility have also been noted for boys and girls. Neighbourhood design and access to a bike have been associated with girls' independent mobility, while car ownership and destination accessibility are associated with boys' independent mobility (Marzi et al., 2018). Children's family, parental education and encouragement positively influence independent mobility (Carver et al., 2014; Schoeppe et al., 2016). Other interpersonal factors that have been found to predict independent mobility include having siblings and peer support (Carver et al., 2014). The number of motor vehicles owned by the family is negatively associated with independent mobility (Nystrom et al., 2019).

Within the physical environment, characteristics such as land use mix and level of urbanicity are negatively associated with independent mobility (Buliung et al., 2017; Fyhri and Hjorthol, 2009; Lam and Loo, 2014). Walking facilities are positively associated with independent mobility (Veitch et al., 2017). Other barriers to independent mobility stem from parental perceptions of the environment. Perceptions that are negatively associated with independent mobility include excessive traffic, crime, and threats due to unknown adults in the community (Marzi et al., 2018).

Policy determinants largely consist of school busing policies that designate criteria for school bus service. In Southwestern Ontario, policies state that, excluding routes with pedestrian hazards or children with disabilities, children living within 1.6 km from the school are not eligible for bus transportation (Southwestern Ontario Student Transportation Services, Transportation Eligibility, 2020; Southwestern Ontario Student Transportation Services, Transportation Eligibility, 2017; Southwestern Ontario Student Transportation Services, Accessible Student Transportation, 2014). Instead, school board and busing officials promote active school travel, such as walking or bicycling, as modes of transportation for students residing within 1.6 km (Active and Safe Routes to School, 2020a). Since distance is a significant determinant of children's travel behavior (Marzi et al., 2018; Larsen et al., 2009; Wilson et al., 2018), such policies have large impacts on independent mobility.

The research focused on correlates of independent mobility on the journey to and from school is still emerging and continues to identify key factors within all levels of the socio-ecological model (for example: Buliung et al., 2017; Janssen et al. 2016; Riazi et al. 2019). Despite gender differences being noted over 20 years ago (Hart, 1979; Valentine, 1997), there is still little evidence on the different potential pathways to independent mobility among children of different genders (Marzi et al., 2018; Marzi and Reimers, 2018). When examining parental norms, girls are depicted as being more vulnerable and thus have less independent mobility compared to boys (Hart, 1979; Valentine, 1997). Studies of parenting practices have also suggested that mothers are more likely to determine the risk landscape and resulting mobility behavior and choices of their child(ren). These decisions are influenced by socially constructed discourses of risk and everyday experiences. Further influencing these decisions are perceptions of "good" versus "bad" mothering, in which "good" mothering is associated with acceptable levels of risk avoidance (Murray, 2009).

Examining gender differences in independent mobility is important to address equity within interventions. Equity refers to the absence of avoidable or systemic differences in children's engagement in active school travel (Braveman, 2006). It is important to consider equity in relation to children's independent mobility to ensure that all children can benefit from such interventions. Accordingly, this study offers a cross-sectional analysis of independent mobility and seeks to fill a gap in the gendered nature of independent mobility. The aims of this study were to: (1) analyze how the intrapersonal, interpersonal and physical environment factors that influence children's independent mobility differ by children's gender; and (2) controlling for those factors, investigate how parents' perceptions of barriers and facilitators to active school travel influence independent mobility by gender. Rather than classifying independent mobility as binary (i.e., independent or dependent travel), this study uses a novel method of independent mobility classification as dependent travel, travel with peers, or travel alone. As travel with peers may be the first step to travel alone (Crawford et al., 2017), understanding differences between the two enable greater insight into the factors that influence independent mobility for each category.

2. Methods

This study uses baseline data collected as part of the Active and Safe Routes to School (ASRTS) program of Southwestern Ontario, Canada. The ASRTS program aims to increase active school travel among students attending elementary schools in the cities of London and St. Thomas, and the Counties of Elgin, Oxford, and Middlesex (Active and Safe Routes to School 2020b). Full details of the program are presented elsewhere (Buttazzoni et al., 2019). Schools self-selected their participation in the program through a needs assessment conducted with school administration and a public health nurse/school travel planning intervention facilitator. Next, the nurse/facilitator conducted presentations in grade 4 to 8 classrooms in participating schools. These presentations introduced the project to children and concluded by giving them a package to take home to their parents.[1] This package contained a letter of information providing parents with an overview of the research, a consent form to permit their child to complete the child survey, and a survey for the parent to complete and return to the school. Upon receiving parental consent, the nurse/facilitator gave children an assent form that they needed to fill-in before completing a youth survey.

Parent surveys were either completed online or via paper copy at home which were returned to school. Children independently completed surveys during the school day with help from the school health nurse/facilitator and research assistants. Both the family and child survey

[1] For this study, the term "parent" will be used to refer to the child's primary caretaker since the majority (96%) of adults completing the parent survey and consent form self-identified as a "parent".

asked dichotomous, multiple-choice, and Likert-scale questions. The parent survey asked questions regarding family demographics (e.g., family structure, socioeconomic status, postal code), travel behaviors, and perceptions of barriers and facilitators to active school travel and independent mobility. The child survey asked very similar questions related to child and family demographics, travel behaviors, and perceptions of barriers and facilitators to active school travel and independent mobility. These surveys use previously validated methods from the Healthy Neighbourhoods Survey and Neighbourhood Environment Walkability Scale (Cerin et al., 2006; Frank et al., 2010; Saelens et al., 2003). The University's Non-Medical Research Ethics Board (#105,635) and the two participating school boards approved this project.

2.1. Sample

The initial sample used in this study consisted of 1764 baseline parent surveys and 1952 child surveys from 32 schools, before four exclusion criteria were applied. First, observations were excluded if a paired child and parent survey were not completed, as responses from both were needed for the analyzes. Second, child and parent surveys were excluded if their home postal code was not reported, since the postal code was used to calculate built environment variables for the home neighbourhood. Third, children that were eligible for school bus service were excluded. Finally, observations were excluded if the child did not identify as a boy or girl. It is important to note that only nine students in the sample reported a gender other than a boy or a girl. Due to the very small sample size of this population, these observations were not included in the analysis. After applying these criteria, the final sample consisted of 476 paired parent and child surveys for boys and 618 for girls, or 1094 in total.

2.2. Measures

2.2.1. Dependent variable

The dependent variable was level of independent mobility on the journey to/from school. Independent mobility is defined as travel without adult supervision and was calculated using child-reported travel behaviors. Children reported how often in a typical week they used each of the following methods: walking, bicycle/scooter, skateboard/rollerblades, car/personal vehicle, school bus, and city bus. Children reported if they used each of the modes of travel never, almost never (1 to 2 days/month), sometimes (1 or 2 days/week), almost always (3 or 4 days/week), or always (5 days/week). Walking, bicycle/scooter, and rollerblades were classified as active travel modes that children could use independently. Car/personal vehicle was considered dependent mobility as elementary school-age children are unable to drive. The school bus and city bus were not used by children in our sample. Next, children reported who they normally travelled with, with the options of nobody, sibling(s), friend(s), parent(s), other adult(s), and/or other students(s).

Children were included in one of three categories based on the highest level of independence the child reported: dependent mobility (0), travel with peers (1), or travel alone (2). Dependent mobility encompassed children that were only driven or used active modes of travel with a parent or other adult throughout the week. Travel with peers included those that used active modes of travel (i.e., walk, bicycle, skateboard, scooter, rollerblade) with sibling(s), friends, or other children but never alone. Travel alone comprised of children who used active modes of travel alone to/from school anytime during the week.

2.2.2. Independent variables

Using the socio-ecological model as a framework, independent variables were broken down into three categories: intrapersonal, interpersonal, and physical environment. Policy level factors are accounted for by excluding children that live >1.6 km from the school.

Intrapersonal variables for the child were obtained from the child survey. These factors included age (a continuous measure in years [range = 8–14]), whether they owned a bicycle (yes [0] or no [1]), and if they had a dog (yes [0] or no [1]). Gender was reported as either boy (0) or girl (1).

Interpersonal variables were obtained using child and parent survey methods. Children reported whether they were permitted to walk (yes [0] or no [1]) and bike (yes [0] or no [1]) to or from school, and if their family had moved within the last two years (yes [0] or no [1]). Parents reported the number of motor vehicles in working order (discrete variable [range 0–4]) and their family type (lone parent [0] or two parents [1]). The highest level of education attained by parents within the household (high school or less [0], graduate school [1], or undergraduate college/university [2]) was derived using parent reports of their level of education. Based on parent reports of every child's age and gender in the household, sibling age was calculated for the child that completed the associated child survey. Sibling age was classified as to whether the child had one or more younger sibling(s) (0), older and/or same-age sibling(s) (1), younger and older siblings (2), or was an only child (3). Median family income from the 2016 Canadian census was applied for the census dissemination area in which the child's home postal code is located (Statistics Canada, 2020).

Variables within the physical environment were objectively measured based on the child's home postal code provided by the family survey. These include the distance between home and school, land-uses, population density, and intersection density. As this study focused on children that live within walking distance residing in urban areas and small towns, postal codes are appropriate proxies for home locations (Healy and Gilliland, 2012). Distance between home and school was measured in kilometers using the shortest network distance between a child's home postal code and school. The proportion of land use for commercial, institutional, recreation, and industrial purposes was also measured using data provided by the municipalities. Land use was measured within a 500-meter Euclidian buffer of the centroid of the home postal code, as this is considered an appropriate distance within the literature on children's mobility and environmental accessibility (Larsen et al., 2009; Tillmann et al., 2018; Gilliland et al., 2012). ArcGIS Pro 2.4 was used to calculate distances and proportions of each land use (ESRI, 2019). Population density and intersection density were also calculated in ArcGIS Pro 2.4 using a 500-meter Euclidean buffer, with population density measured as the number of people (in 100 s) per square kilometer and intersection density measures as the number of intersections per square kilometer.

Parents' perceptions of barriers and facilitators to active school travel were captured using a 4-point Likert scale ranging from strongly disagree to strongly agree. The questions were posed to reflect either barriers along the route to/from school or facilitators in their neighbourhood. These observations were analyzed as binary (agree and strongly agree [0] to strongly disagree and disagree (Statistics Canada, 2019)). Items were categorized into one of three groups: physical environment, social environment, or individual/family preferences (Supplementary Table A).

Approximately 5% of the data that met the inclusion criteria were missing. Missing data were found not to be missing completely at random as Little's MCAR test was significant ($p < .05$) (Li, 2013). To account for missing data, deductive imputation and multiple imputation methods were used to optimize sample size (Jakobsen et al., 2017; Stuart et al., 2009). For age, missing data were imputed based on age reported on the associated parent survey. For interpersonal and perception variables, multiple imputation in SPSS was conducted using fully conditional specification methods (van Buuren, 2007; Schafer, 1997). No data were missing for physical environment variables.

2.3. Statistical analyzes

To meet the first aim, this study used bivariate chi-square and bivariate and multinomial logistic regression to understand how

Table 1
Descriptive statistics about the sample (boys: $n = 476$, girls: $n = 618$).

Variable	Boys Travel with parents	Travel with peers	Travel alone	Girls Travel with parents	Travel with peers	Travel alone
Total, n (%)	259 (54.4)	117 (24.6)	100 (21.0)	357 (57.8)	176 (28.5)	85 (13.8)
Intrapersonal						
Age, Mean (SD)	10.8 (1.4)	10.4 (1.4)	11.2 (1.3)	10.7 (1.4)	10.5 (1.4)	11.5 (1.2)
Child owns a bike, n (%)						
Yes	226 (88.6)	97 (88.2)	81 (87.1)	303 (86.8)	148 (88.6)	73 (90.1)
No	29 (11.4)	13 (11.8)	12 (12.9)	46 (13.2)	19 (11.4)	8 (9.9)
Has a dog, n (%)						
Yes	115 (45.8)	51 (45.5)	37 (41.6)	129 (37.8)	77 (45.0)	39 (47.0)
No	136 (54.2)	61 (54.5)	52 (58.4)	212 (62.2)	94 (55.0)	44 (53.0)
Interpersonal						
Median family income (CAD, tens of thousands), Mean (SD)	9.7 (2.6)	9.2 (2.7)	9.4 (2.7)	9.4 (2.9)	9.7 (2.8)	9.3 (2.5)
Number of motor vehicles, Mean (SD)	1.8 (0.6)	1.6 (0.7)	1.7 (0.8)	1.7 (0.7)	1.7 (0.7)	1.7 (0.8)
Lone parent vs. two parents, n (%)						
1 parent	18 (7.3)	8 (6.9)	9 (9.3)	24 (7.0)	10 (6.0)	8 (9.6)
2 parents	228 (92.7)	108 (93.1)	88 (90.7)	320 (93.0)	158 (94.0)	75 (90.4)
Max. parent education level, n (%)						
High school or less	30 (12.3)	11 (9.5)	8 (8.2)	52 (15.3)	13 (7.8)	5 (6.0)
Graduate school	126 (51.9)	67 (57.8)	68 (70.1)	184 (54.1)	91 (54.5)	50 (60.2)
Undergraduate college / university	87 (35.8)	38 (32.8)	21 (21.6)	104 (30.6)	63 (37.7)	28 (33.7)
Relationship with siblings, n (%)						
Younger sibling(s)	73 (32.2)	43 (39.8)	19 (20.2)	108 (33.5)	59 (38.1)	19 (25.0)
Older/same age sibling(s)	41 (18.1)	27 (25.0)	5 (5.3)	52 (16.1)	44 (28.4)	4 (5.3)
Younger & older sibling(s)	10 (4.4)	16 (14.8)	3 (3.2)	26 (8.1)	12 (7.7)	1 (1.3)
Single child	103 (45.4)	22 (20.4)	67 (71.3)	136 (42.2)	40 (25.8)	52 (68.4)
Allowed to walk, n (%)						
Yes	205 (81.3)	108 (94.7)	94 (94.0)	298 (85.4)	165 (93.8)	84 (98.8)
No	47 (18.7)	6 (5.3)	6 (6.0)	51 (14.6)	11 (6.3)	1 (1.2)
Allowed to bike, n (%)						
Yes	151 (60.9)	66 (61.1)	72 (74.2)	199 (58.9)	97 (57.7)	63 (75.0)
No	97 (39.1)	42 (38.9)	25 (25.8)	139 (41.1)	71 (42.3)	21 (25.0)
Family moved within the last two years, n (%)						
Yes	48 (19.8)	27 (25.2)	20 (21.7)	70 (21.0)	26 (16.6)	17 (20.7)
No	194 (80.2)	80 (74.8)	72 (78.3)	263 (79.0)	131 (83.4)	65 (79.3)
Physical Environment*						
Distance to school (km), Mean (SD)	1.1 (0.5)	0.9 (0.6)	0.9 (0.4)	1 (0.5)	0.8 (0.5)	0.8 (0.5)
Commercial land use, Mean (SD)	2.1 (6.0)	2.4 (5.7)	3.0 (8.2)	3.3 (8.4)	2.1 (5.9)	2.6 (6.5)
Institutional land use, Mean (SD)	2.9 (4.6)	2.3 (3.6)	3.4 (4.7)	3.1 (4.8)	3.2 (4.9)	2.8 (4.1)
Recreation land use, Mean (SD)	19.7 (22.6)	19.4 (23.1)	16.2 (20.9)	17.4 (20.1)	18.6 (21.2)	17.1 (21.9)
Residential land use, Mean (SD)	72.1 (20.1)	72.6 (21.1)	74.2 (20.5)	73.0 (18.7)	74.1 (19.7)	74.3 (20.5)
Industrial land use, Mean (SD)	3.2 (7.7)	3.3 (6.3)	3.2 (7.0)	3.2 (7.0)	2.0 (5.2)	3.2 (7.4)
Population density, Mean (SD)	18.5 (10.0)	20.5 (10.9)	22.4 (10.6)	20.8 (10.2)	20.6 (10.4)	21.1 (9.7)
Intersection density, Mean (SD)	31.2 (9.7)	30.0 (10.8)	31.9 (12.3)	31.5 (10.9)	31.6 (12.7)	30.4 (11.3)
Parent Perceptions: Physical environment						
Too far/takes too much time, n (%)						
Agree	52 (21.8)	11 (10.2)	3 (3.3)	71 (21.4)	25 (15.8)	9 (11.3)
Disagree	187 (78.2)	97 (89.8)	89 (96.7)	261 (78.6)	133 (84.2)	71 (88.8)
Nowhere to leave a bike at school, n (%)						
Agree	65 (27.4)	21 (20.0)	18 (19.6)	62 (18.7)	35 (22.4)	16 (21.1)
Disagree	172 (72.6)	84 (80.0)	74 (80.4)	270 (81.3)	121 (77.6)	60 (78.9)
Route feels unsafe due to traffic, n (%)						
Agree	118 (49.2)	49 (47.1)	39 (42.4)	168 (50.5)	70 (44.6)	21 (27.3)
Disagree	122 (50.8)	55 (52.9)	53 (57.6)	165 (49.5)	87 (55.4)	56 (72.7)
Too many busy streets to cross, n (%)						
Agree	90 (37.7)	33 (31.1)	21 (22.6)	116 (34.8)	42 (26.8)	11 (14.5)
Disagree	149 (62.3)	73 (68.9)	72 (77.4)	217 (65.2)	115 (73.2)	65 (85.5)
Drivers speed on streets, n (%)						
Agree	161 (67.4)	71 (63.4)	63 (65.6)	224 (65.9)	108 (66.7)	60 (73.2)
Disagree	78 (32.6)	41 (36.6)	33 (34.4)	116 (34.1)	54 (33.3)	22 (26.8)
Enough sidewalks on the streets in the neighbourhood, n (%)						
Agree	172 (72.0)	83 (72.8)	67 (69.1)	276 (80.9)	127 (77.4)	60 (73.2)
Disagree	67 (28.0)	31 (27.2)	30 (30.9)	65 (19.1)	37 (22.6)	22 (26.8)
Walking trails in or near the neighbourhood, n (%)						
Agree	165 (69.0)	75 (66.4)	70 (74.5)	251 (74.7)	89 (55.3)	56 (69.1)
Disagree	74 (31.0)	38 (33.6)	24 (25.5)	85 (25.3)	72 (44.7)	25 (30.9)
Bicycle lanes or trails in or near the neighbourhood, n (%)						
Agree	90 (37.8)	52 (46.0)	36 (37.5)	129 (38.4)	56 (34.8)	40 (50.0)
Disagree	148 (62.2)	61 (54.0)	60 (32.5)	207 (61.6)	105 (65.2)	40 (50.0)
Lots of trees, n (%)						
Agree	181 (75.4)	81 (72.3)	75 (78.9)	263 (77.6)	120 (74.1)	60 (73.2)
Disagree	59 (24.6)	31 (27.7)	20 (21.1)	76 (22.4)	42 (25.9)	22 (26.8)
Parent Perceptions: Social environment						
Feels unsafe because of crime, n (%)						

(*continued on next page*)

Table 1 (*continued*)

Variable	Boys Travel with parents	Travel with peers	Travel alone	Girls Travel with parents	Travel with peers	Travel alone
Agree	65 (27.1)	20 (18.7)	20 (22.0)	95 (28.6)	36 (22.8)	13 (16.9)
Disagree	175 (72.9)	87 (81.3)	71 (78.0)	237 (71.4)	122 (77.2)	64 (83.1)
Unsafe for child to walk alone, n (%)						
Agree	72 (30.3)	32 (28.6)	12 (12.6)	127 (37.6)	57 (35.2)	14 (17.1)
Disagree	166 (69.7)	80 (71.4)	83 (87.4)	211 (62.4)	105 (64.8)	68 (82.9)
Unsafe for child to walk with friends, n (%)						
Agree	38 (15.9)	17 (15.2)	7 (7.3)	58 (17.2)	36 (22.1)	7 (8.5)
Disagree	201 (84.1)	95 (84.8)	89 (92.7)	280 (82.8)	127 (77.9)	75 (91.5)
Worried about child being alone because of strangers, n (%)						
Agree	108 (45.2)	54 (48.2)	31 (32.3)	176 (52.1)	86 (53.1)	30 (36.6)
Disagree	131 (54.8)	58 (51.8)	65 (67.7)	162 (47.9)	76 (46.9)	52 (63.4)
Might get bullied/teased, n (%)						
Agree	49 (20.7)	19 (17.8)	19 (20.7)	77 (23.3)	21 (13.5)	10 (13.0)
Disagree	188 (79.3)	88 (82.2)	73 (79.3)	254 (76.7)	135 (86.5)	67 (87.0)
No one to walk with, n (%)						
Agree	51 (21.4)	14 (13.1)	17 (18.3)	84 (25.5)	26 (16.7)	16 (20.8)
Disagree	187 (78.6)	93 (86.9)	76 (81.7)	246 (74.5)	130 (83.3)	61 (79.2)
Know a lot of people, n (%)						
Agree	169 (70.1)	75 (66.4)	66 (68.8)	248 (73.4)	120 (73.6)	55 (67.1)
Disagree	72 (29.9)	38 (33.6)	30 (31.3)	90 (26.6)	43 (26.4)	27 (32.9)
Parent Perceptions: Individual/family preference						
Route is boring, n (%)						
Agree	19 (8.0)	8 (7.5)	12 (13.0)	29 (8.8)	5 (3.2)	5 (6.5)
Disagree	218 (92.0)	99 (92.5)	80 (87.0)	299 (91.2)	152 (96.8)	72 (93.5)
Get too hot/sweaty, n (%)						
Agree	25 (10.5)	10 (9.3)	10 (10.9)	45 (13.6)	16 (10.1)	6 (7.9)
Disagree	213 (89.5)	97 (90.7)	82 (89.1)	286 (86.4)	142 (89.9)	70 (92.1)
Not fun to walk, n (%)						
Agree	25 (10.5)	7 (6.5)	10 (10.9)	30 (9.1)	11 (7.1)	8 (10.5)
Disagree	214 (89.5)	100 (93.5)	82 (89.1)	300 (90.9)	143 (92.9)	68 (89.5)
Too much stuff to carry, n (%)						
Agree	59 (24.6)	22 (20.6)	27 (29.0)	103 (31.0)	40 (25.5)	16 (21.1)
Disagree	181 (75.4)	85 (79.4)	66 (71.0)	229 (69.0)	117 (74.5)	60 (78.9)
Easier to drive, n (%)						
Agree	94 (39.8)	32 (29.9)	20 (21.7)	131 (39.5)	52 (33.3)	10 (13.0)
Disagree	142 (60.2)	75 (70.1)	72 (78.3)	201 (60.5)	104 (66.7)	67 (87.0)
Too young to walk/bike, n (%)						
Agree	74 (31.2)	29 (27.1)	11 (12.0)	86 (26.0)	36 (23.1)	9 (11.7)
Disagree	163 (68.8)	78 (72.9)	81 (88.0)	245 (74.0)	120 (76.9)	68 (88.3)
No skills to bike, n (%)						
Agree	65 (27.1)	26 (24.5)	15 (16.5)	106 (31.8)	52 (33.1)	12 (15.8)
Disagree	175 (72.9)	80 (75.5)	76 (83.5)	227 (68.2)	105 (66.9)	64 (84.2)

Notes: "SD" refers to standard deviation; Numbers may not add to full sample size due to missing values; *Physical Environment measures were created based on the 651 unique home postal codes of participants (~1.7 participants per postal code).

intrapersonal, interpersonal, built environment factors, and parents' perceptions of barriers and facilitators to active school travel influence independent mobility. Bivariate analyzes were conducted for categorical independent variables using chi-square tests and for continuous variables using univariate logistic regression analyzes. These tests were conducted to determine which variables were significantly associated with independent mobility and should be controlled for in later analyzes. A critical value cut off of $p < .10$ was used to identify significant correlates.

Multinomial logistic regression, with odds ratios and 95% confidence intervals, was used to examine how parent perceptions influence independent mobility (Hosmer et al., 2013). A hierarchical process was used, following the stages of the socio-ecological model: (1) Intrapersonal; (2) Model 1 + Interpersonal; (3) Model 2 + Physical Environment; (4) Model 3 + univariate perceptions; (5) Model 3 + all significant univariate perceptions together. Dependent mobility was used as the reference category. Multicollinearity was assessed and found to not be a concern as variance inflation factors for all independent variables were below 3 (O'brien, 2007). To address the second objective of this study, all models were completed separately for boys and girls. To ensure comparability between children's genders, variables were included in the final models if they were significant for either boys or girls. A p-value < 0.05 was considered statistically significant. All analyzes were conducted using IBM SPSS Statistics 26 (IBM Canada Ltd., Markham, Ontario, Canada).

3. Results

3.1. Descriptive statistics

Descriptive statistics for the study sample by independent mobility can be found in Table 1. The sample consisted of 476 boys and 618 girls, ages 8–14 years (grades 4–8). Most children owned a bicycle (84.9% of boys, 84.8% of girls) and did not have a dog (52.3% of boys, 56.6% of girls). The average median family income per postal code (in CAD) for the sample was $95,000, which is higher than the City of London median family income $83,880 (Statistics Canada, 2017)). Families of both boys and girls also owned an average of 1.7 cars per household. Households with two parents were most common (89.1% of boys and 89.5% of girls). Most parents had completed some form of graduate school (54.8% of boys, 52.6% of girls). Most children had one or more siblings attending their school (boys: younger = 28.4%, older/same age = 15.3%, younger and older = 6.1%; girls: younger = 30.1%, older/same age = 16.2%, younger and older = 6.3%). Having permission to walk (85.5% of boys, 88.5% of girls) and bicycle (60.7% of boys and 58.1% of girls) was most commonly reported by children. Most children had not moved within

the last two years (72.7% of boys, 74.3% of girls) and approximately 75% of the sample came from suburban large city settlement areas.

3.2. Bivariate analyzes

To determine bivariate relationships between each independent variable and independent mobility, chi-square analyzes were conducted with categorical independent variables and univariate logistic regression was used with continuous independent variables (Supplementary Table B). Within the intrapersonal level, age was significantly different ($p < .001$) by mobility category for children of both genders, with children who travel alone being oldest on average (boys: $X^2 = 16.35$, $p < .001$; girls: $X^2 = 32.37$, $p < .001$). At the interpersonal level, sibling age (boys: $X^2 = 61.10$, $p < .001$; girls: $X^2 = 46.04$, $p < .001$), maximum parent education (boys: $X^2 = 9.72$, $p = .05$; girls: $X^2 = 10.31$, $p = .04$), and permission to walk (boys: $X^2 = 17.83$, $p < .001$; girls: $X^2 = 17.77$, $p < .001$) were significantly different between mobility categories for both boys and girls (see Supplementary Table B). Within the objective physical environment, distance between home and school showed a significant difference ($p < .001$) by mobility category for both genders, with mean distance being greatest on average for dependent mobility (boys: $X^2 = 14.53$, $p < .001$; girls: $X^2 = 30.41$, $p < .001$). Population density ($X^2 = 10.91$, $p < .01$) was also significantly different on average for boys by mobility category, with IM increasing as population density increases. No other variables were significant for girls (see Supplementary Table B).

3.3. Modeling intrapersonal, interpersonal, and physical environment variables

Hierarchical modeling is used to identify how intrapersonal, interpersonal, and physical environment variables influence independent mobility (Tables 2 and 3). This approach was used to build a model of control variables for use in the final model. Model C of Tables 2 and 3 show the effect that these three levels of the socio-ecological model have for boys' and girls' independent mobility, respectively.

For boys, having one or more siblings of any age had a positive relationship with travel with peers (younger sibling(s): OR = 2.58, $p < .01$, older/same age sibling(s): OR = 2.38, $p = .02$, or younger and older siblings: OR = 4.56, $p < .01$), while having one or more younger siblings and older/same age siblings was negatively correlated with travel alone (younger sibling(s): OR = 0.50, $p = .03$, older/same age sibling(s): OR = 0.25, $p = 0.01$). Distance between home and school was negatively associated with both travel with peers (OR = 0.60, $p = .04$) and alone (OR = 0.56, $p = .03$). Permission to walk was positively associated with travel with peers (OR = 5.25, $p < .001$), whereas age had a negative relationship (OR = 0.80, $p = .02$). Population density (OR = 1.03, $p = .03$) significantly influenced boys' travel alone.

For girls, model C of Table 3 shows that having one or more younger siblings or older/same age siblings was positively associated with travel with peers (younger sibling(s): OR = 1.71, $p = .03$, older/same age sibling(s): OR = 2.40, $p < .01$), while having one or more younger siblings was negatively associated with travel alone (OR = 0.38, $p < .01$). Like boys, distance was negatively associated with both travel with peers (OR = 0.46, $p < .001$) and alone (OR = 0.29, $p < .001$) and permission to walk was positively associated with travel with peers (OR = 2.24, $p = .04$). Age was positively associated with travel alone (OR = 1.38, $p < .01$), whereas parent education of high school or less was negatively associated (OR = 0.33, $p = .04$).

3.4. Modeling parent perceptions

While controlling for significant ($p < .10$) intrapersonal, interpersonal, and physical environment variables from bivariate analyzes, each of the parent perceptions was compared with independent mobility using logistic regression models to determine individual associations (Supplementary Tables C and D). No parent perceptions were significantly related ($p < .05$) to independent mobility with peers for boys. Perceptions of the journey being too far/taking too much time (OR = 0.30, $p = .03$) and the child is too young to walk/bike (OR = 0.45, $p = .04$) significantly decreased boys' travel alone compared to using dependent modes of travel.

For girls, parental perceptions of the neighbourhood having enough walking trails (OR = 0.37, $p < .001$) was negatively associated with travel with peers compared to dependent modes of travel. Perceptions of the journey being unsafe due to traffic (OR = 0.54, $p = .04$), easier to drive (OR = 0.41, $p = .03$), and knowing a lot of people in the neighbourhood (OR = 0.53, $p = .03$) significantly decreased girls' travel alone.

3.5. Final models

All perceptions that were found to be significant for either boys or girls (at significance level $p < .10$) in the univariate models were included in the final, multivariate models, displayed in Tables 4 and 5.

3.5.1. Boys

Within the intrapersonal level, age was statistically significant, indicating that as boys got older, they were less likely to travel with peers (OR = 0.78, $p = .02$). Sibling age and permission to walk were statistically significant interpersonal variables. Results showed that boys with one or more siblings of any age (younger sibling(s): OR = 2.83, $p < .01$, older/same age sibling(s): OR = 2.43, $p = .02$, or younger and older siblings: OR = 5.20, $p < .01$) attending the school were more likely to travel with peers compared to boys that did not have a sibling attending the school. Only those with one or more older/same age siblings were also less likely to walk alone (OR = 0.22, $p = .01$). Permission to walk was positively associated with travel with peers (OR = 4.96, $p < .01$). Within the physical environment, population density was positively associated with travel alone (OR = 1.03, $p = .04$).

Parents' perceptions of barriers and facilitators of active school travel were only significantly related to travel alone. Perceptions that the journey is too far/takes too much time (OR = 0.27, $p = .02$) was negatively associated with boys' travel alone. Parents' perceptions that the route is boring was positively associated with boys' travel alone (OR = 3.26, $p = .03$).

3.5.2. Girls

At the intrapersonal level, age was positively associated with travel alone for girls (OR = 1.33, $p = .01$). Significant interpersonal variables for girls were maximum parent education, sibling age, and permission to walk. Girls whose parents had a high school diploma or less were less likely to travel with peers compared to those that had an undergraduate university/college certification (OR = 0.40, $p = .04$). Girls that had one or more younger (OR = 0.39, $p < .01$) or older/same age (OR = 0.28, $p = .04$) siblings attending the school were significantly less likely to travel alone compared to girls who did not have a sibling attending the school. Only girls who had one or more older/same age siblings were significantly more likely to travel with peers (OR = 2.30, $p < .01$). Permission to walk was positively associated with travel with peers (OR = 3.13, $p = .01$). Within the objectively measured physical environment, distance and industrial land use were statistically significant correlates of girls' independent mobility. Distance was negatively associated with both travel with peers (OR = 0.48, $p < .01$) and alone (OR = 0.31, $p < .001$). Industrial land use was negatively associated with girls' travel with peers (OR = 0.96, $p = .05$).

Parents' perceptions of walking trails in the neighbourhood, safety with friends, and the route being boring were significantly associated to girls' travel with peers. Girls whose parents perceived there to be enough walking trails nearby (OR = 0.37, $p < .001$) and that the route was boring (OR = 0.31, $p = .03$) were less likely to travel with peers, while the belief that it was unsafe to walk with friends was positively

Table 2
Hierarchical logistic regression to develop predictive models of independent mobility based on socio-ecological framework variables for boys.

Variable	Travel with Peers				Travel Alone			
	Odds Ratio	Std. Error	*P*-Value	Confidence Interval	Odds Ratio	Std. Error	*P*-Value	Confidence Interval
A: Intrapersonal								
Age	0.81	0.08	**0.01**	0.69, 0.95	1.21	0.08	**0.03**	1.02, 1.42
Nagelkerke Pseudo R-Square = 0.04								
B: Intrapersonal and interpersonal								
Age	0.79	0.09	**0.01**	0.66, 0.95	1.07	0.10	0.50	0.88, 1.29
Number of motor vehicles	0.68	0.19	**0.05**	0.47, 0.99	0.77	0.19	0.17	0.54, 1.11
Max. parent education level (ref: Undergraduate college/ university)								
High school or less	0.82	0.44	0.66	0.35, 1.95	0.85	0.49	0.74	0.33, 2.21
Graduate school	1.50	0.27	0.12	0.89, 2.53	1.75	0.31	0.07	0.95, 3.20
Sibling age (ref: single child)								
Younger sibling(s)	2.54	0.32	**<0.01**	1.35, 4.79	0.48	0.31	**0.02**	0.26, 0.88
Older/same age sibling(s)	2.39	0.36	**0.02**	1.18, 4.81	0.26	0.53	**0.01**	0.09, 0.76
Younger & older siblings	4.44	0.49	**<0.01**	1.70, 11.62	0.49	0.69	0.31	0.13, 1.92
Permission to walk (ref: no)	6.13	0.50	**<0.001**	2.30, 16.36	3.10	0.50	**0.03**	1.16, 8.32
Permission to bike (ref: no)	0.80	0.28	0.41	0.46, 1.38	1.08	0.31	0.80	0.59, 1.99
Nagelkerke Pseudo R-Square = = 0.21–0.23								
C: Intrapersonal, interpersonal, and physical environment								
Age	0.80	0.09	**0.02**	0.67, 0.97	1.07	0.10	0.47	0.89, 1.30
Number of motor vehicles	0.71	0.19	0.08	0.48, 1.04	0.81	0.19	0.26	0.56, 1.17
Max. parent education level (ref: Undergraduate college/ university)								
High school or less	0.82	0.44	0.65	0.34, 1.95	0.81	0.50	0.66	0.30, 2.13
Graduate school	1.53	0.27	0.12	0.90, 2.58	1.82	0.31	0.06	0.98, 3.38
Sibling age (ref: single child)								
Younger sibling(s)	2.58	0.33	**<0.01**	1.36, 4.92	0.50	0.31	**0.03**	0.27, 0.92
Older/same age sibling(s)	2.38	0.36	**0.02**	1.18, 4.82	0.25	0.54	**0.01**	0.09, 0.74
Younger & older siblings	4.56	0.49	**<0.01**	1.72, 12.09	0.52	0.70	0.35	0.13, 2.05
Permission to walk (ref: no)	5.28	0.51	**<0.001**	1.95, 14.29	2.67	0.52	0.06	0.97, 7.34
Permission to bike (ref: no)	0.78	0.28	0.36	0.45, 1.34	1.03	0.32	0.93	0.55, 1.92
Distance to school (km)	0.60	0.25	**0.04**	0.37, 0.97	0.56	0.27	**0.03**	0.33, 0.95
Population density	1.01	0.01	0.22	0.99, 1.04	1.03	0.01	**0.03**	1.00, 1.05
Industrial land use	1.00	0.02	0.91	0.97, 1.04	1.02	0.02	0.39	0.98, 1.05
Nagelkerke Pseudo R-Square = 0.24–0.26								

Notes: The reference category is "Dependent mobility"; Significant ($p < .05$) correlates are bolded.

associated with travel with peers (OR = 2.12, $p = .02$). Perceptions of knowing people in the area (OR = 0.52, $p = .04$) and the journey being easier to drive (OR = 0.40, $p = .03$) were negatively associated with girls' travel alone. Drivers' speed on streets was positively associated with girl's travel alone (OR = 1.95, $p = .05$).

4. Discussion

The aims of this study were to: (1) analyze how the intrapersonal, interpersonal and physical environment factors that influence children's independent mobility differ by children's gender; and (2) controlling for those factors, investigate how parents' perceptions of barriers and facilitators to active school travel influence independent mobility by gender. Among all variables, only permission to walk showed similar influences on increasing travel with peers for both boys and girls. All other variables had differing effects on independent mobility between children's gender. Across almost all levels, more variables were statistically significant for girls' independent mobility than boys.

A novel contribution of this paper is its consideration of independent mobility both with peers and alone. Parents' perceptions of barriers and facilitators to active school travel were found to vary in their influence on travel with peers versus travel alone between boys and girls. Each perception either significantly influenced travel with peers or alone, but no perceptions influenced both modes. As active school travel interventions seek to influence parental perceptions to foster positive behavior change, insights into these differences provide a foundation for influencing children's independent mobility. Travelling with peers can facilitate a transfer of pedestrian and spatial skills among children and be a solution to parents' fears about their child travelling alone (Crawford et al., 2017). Understanding correlates of travel with peers, and how they differ from those of travel alone, can provide an opportunity to reduce barriers to travel with peers as a starting point for independent mobility. It is important to understand these factors as they differ between children's genders as there are differences in social activities and spaces between boys and girls. Although boys are granted independent mobility earlier, girls are thought to attain similar levels of independent mobility by travelling with peers (Brown et al., 2008). As such, the results of this study identify barriers to girls' travel with peers, providing a starting point for interventions addressing inequitable active school travel and independent mobility among children.

Gender differences in independent mobility among children are often reported as being a result of parental norms, which depict girls as being more vulnerable, and therefore in greater need of protection (Hart, 1979; Valentine, 1997). Examining the relationship between age and independent mobility provides support for the influence of gendered parental norms and spatial patterns influencing independent mobility. Parental norms are further illustrated in perceptions of having walking trails in the neighbourhood, the journey being easier to drive, and distance between home and school and their resulting implications for independent mobility between boys and girls.

Age was positively associated with girls' traveling alone; by contrast, it was negatively associated with boys traveling with peers. It is not surprising that age is associated with independent mobility, as children's maturity is related to parental expectations (Zebrowitz et al., 1991). Pertaining to independent mobility, children with greater cognitive capacity are seen by parents as being better able to navigate their environment or advocate for their safety in the presence of strangers (Mitra, 2013; Mammen et al., 2012). In terms of gender, parents grant boys independent mobility at an earlier age than girls, but differential rates of independent mobility decrease as children get older

Table 3
Hierarchical logistic regression to develop predictive models of independent mobility based on socio-ecological framework variables for girls.

Variable	Travel with Peers				Travel Alone			
	Odds Ratio	Std. Error	*P*-Value	Confidence Interval	Odds Ratio	Std. Error	*P*-Value	Confidence Interval
A: Intrapersonal								
Age	0.89	0.07	0.08	0.78, 1.01	1.53	0.09	**<0.001**	1.28, 1.84
Nagelkerke Pseudo R-Square = 0.06								
B: Intrapersonal and interpersonal								
Age	0.88	0.08	0.09	0.76, 1.02	1.36	0.11	**<0.01**	1.11, 1.67
Number of motor vehicles	0.89	0.16	0.46	0.64, 1.23	0.96	0.19	0.84	0.67, 1.39
Max. parent education level (ref: Undergraduate college/ university)								
High school or less	0.46	0.39	**0.05**	0.21, 1.00	0.36	0.54	0.06	0.13, 1.04
Graduate school	0.86	0.21	0.48	0.58, 1.30	0.89	0.28	0.68	0.51, 1.55
Sibling age (ref: single child)								
Younger sibling(s)	1.75	0.25	**0.03**	1.07, 2.86	0.43	0.30	**0.01**	0.24, 0.77
Older/same age sibling(s)	2.30	0.28	**<0.01**	1.34, 3.95	0.31	0.58	**0.05**	0.10, 1.00
Younger & older siblings	1.44	0.38	0.33	0.69, 3.01	0.17	1.14	0.13	0.02, 1.76
Permission to walk (ref: no)	2.75	0.37	**0.01**	1.32, 5.72	8.67	1.04	**0.04**	1.13, 66.66
Permission to bike (ref: no)	0.85	0.21	0.44	0.56, 1.28	1.21	0.31	0.54	0.66, 2.24
Nagelkerke Pseudo R-Square = 0.17–0.18								
C: Intrapersonal, interpersonal, and physical environment								
Age	0.87	0.08	0.08	0.75, 1.01	1.38	0.11	**<0.01**	1.11, 1.70
Number of motor vehicles	0.85	0.17	0.34	0.60, 1.20	0.95	0.20	0.78	0.65, 1.39
Max. parent education level (ref: Undergraduate college/ university)								
High school or less	0.46	0.40	0.06	0.21, 1.02	0.33	0.55	**0.04**	0.11, 0.97
Graduate school	0.85	0.21	0.43	0.56, 1.28	0.89	0.29	0.67	0.50, 1.55
Sibling age (ref: single child)								
Younger sibling(s)	1.71	0.25	**0.03**	1.04, 2.81	0.38	0.31	**<0.01**	0.21, 0.70
Older/same age sibling(s)	2.40	0.28	**<0.01**	1.38, 4.16	0.31	0.61	0.06	0.09, 1.04
Younger & older siblings	1.38	0.39	0.41	0.65, 2.93	0.14	1.17	0.10	0.01, 1.54
Permission to walk (ref: no)	2.24	0.39	**0.04**	1.05, 4.76	6.80	1.06	0.07	0.86, 53.83
Permission to bike (ref: no)	0.86	0.22	0.47	0.56, 1.31	1.26	0.32	0.47	0.67, 2.37
Distance to school (km)	0.46	0.22	**<0.001**	0.30, 0.71	0.29	0.32	**<0.001**	0.16, 0.55
Population density	1.00	0.01	1.00	0.98, 1.02	1.01	0.01	0.37	0.99, 1.04
Industrial land use	0.97	0.02	0.10	0.94, 1.01	1.02	0.02	0.41	0.98, 1.05
Nagelkerke Pseudo R-Square = 0.22–0.23								

Notes: The reference category is "Dependent mobility"; Significant ($p < .05$) correlates are bolded.

(McDonald, 2012; Wolfe and McDonald, 2016). Since the sample consists of children under the age of 14, these findings coincide with the period of time in which differences in independent mobility are prominent (Wolfe and McDonald, 2016). The results of the descriptive statistics, show that the mean age of both boys and girls is lower among children who travel with peers, compared to children who travel alone. This provides some support for the notion that travel with peers is the first step towards travelling alone (Brown et al., 2008). As such, it is interesting that age is negatively associated with travel with peers for boys. These findings may suggest that, within the age group studied, a significant number of boys had already attained full independent mobility privileges and therefore did not need to travel with peers to be independent. In comparison, older girls were gaining independent mobility within this age group. Through the use of mapping exercises, research has noted that, compared to boys, girls' friends tend to be more scattered and spread out farther in their neighbourhood. As a result, girls must travel farther distances to see their friends (Brown et al., 2008). Applied to the journey to/from school, girls may be less likely to travel with friends, supporting the positive relationship between travel alone and age. Future research should consider using a wider age range consisting of younger children to further capture age-related and gendered trends in independent mobility.

Considering parental norms associated with children's gender and their resulting independent mobility, it is interesting to note that perceptions of the neighbourhood having enough walking trails nearby were significant for girls, but not for boys. Contrary to existing independent mobility literature (Evenson et al., 2006; Guliani et al., 2015), this study found that perceptions of the presence of walking trails were negatively associated with girls' travel with peers. Many of the trails in the region of study are more secluded when compared to sidewalks. Having passive surveillance in communities, or eyes on the street, contributes to parents' sense of safety and children's comfort when commuting independently (Holt et al., 2015; Jacobs, 1961; Jamme et al., 2018). When such trails are secluded, a reduced sense of safety exists (Holt et al., 2015). Combined with more protective parental norms for girls (Hart, 1979; Valentine, 1997), walking trails hinder independent mobility for girls. More research is needed examining children's independent mobility development to understand why this perception is only related to girls' travel with peers.

It is not surprising that perceiving driving as an easier mode of travel to/from school is negatively associated with independent mobility, as this mode of travel is often tied to convenience and parental availability (Faulkner et al., 2010). It is novel to note the gendered nature of this trend, as parental perceptions of the journey being easier to drive were only (negatively) associated with girls' travel alone. Two sets of norms are thought to contribute to these findings. First, are those surrounding safety. As parental norms dictate that girls are more vulnerable in public spaces (Hart, 1979; Valentine, 1997), driving presents an option for parents to protect their daughters. Second, social norms around physical activity are thought to impact parents' perceptions of travel modes. Research has found that physical activity is often deemed to be a masculine endeavor (Whitehead and Biddle, 2008), with girls receiving less social support for physical activity behaviors than boys (Reimers et al., 2019). Since independent mobility requires that girls partake in active modes of travel, noteworthy are the broader social norms influencing girls' independent mobility.

Distance is consistently found to be an important predictor of independent mobility (Marzi et al., 2018; Wilson et al., 2018; Sharmin and Kamruzzaman, 2017; Larsen et al., 2012). This study found that objectively measured distance had a significant negative relationship with

Table 4
Logistic regression analysis to understand the impact socio-ecological framework variables and perceived barriers and facilitators to active school travel have on boys' independent mobility.

Variable	Travel with peers Odds Ratio	Std. Error	*P*-Value	Confidence Interval	Travel alone Odds Ratio	Std. Error	*P*-Value	Confidence Interval
Intrapersonal								
Age	0.78	0.10	**0.02**	0.64, 0.96	0.99	0.11	0.93	0.81, 1.22
Interpersonal								
Number of motor vehicles	0.73	0.20	0.12	0.49, 1.08	0.82	0.21	0.36	0.54, 1.25
Max. parent education level (ref: Undergraduate college/ university)								
High school or less	0.74	0.47	0.52	0.29, 1.85	0.77	0.52	0.62	0.28, 2.15
Graduate school	1.48	0.28	0.16	0.86, 2.54	1.57	0.32	0.16	0.84, 2.96
Sibling age (ref: single child)								
Younger sibling(s)	2.83	0.35	**<0.01**	1.43, 5.60	0.57	0.32	0.08	0.31, 1.08
Older/same age sibling(s)	2.43	0.37	**0.02**	1.18, 5.03	0.22	0.54	**0.01**	0.08, 0.65
Younger & older siblings	5.20	0.52	**<0.01**	1.85, 14.63	0.56	0.72	0.43	0.14, 2.33
Permission to walk (ref: no)	4.96	0.53	**<0.01**	1.75, 14.05	1.65	0.54	0.36	0.57, 4.76
Permission to bike (ref: no)	0.83	0.29	0.53	0.47, 1.47	1.13	0.33	0.71	0.59, 2.18
Physical environment								
Distance to school (km)	0.62	0.26	0.07	0.37, 1.04	0.68	0.29	0.18	0.39, 1.20
Population density	1.01	0.01	0.25	0.99, 1.04	1.03	0.01	**0.04**	1.00, 1.06
Industrial land use	1.00	0.02	0.87	0.96, 1.03	1.01	0.02	0.53	0.98, 1.05
Parental perceptions (ref: disagree)								
Too far/takes too much time	0.66	0.46	0.37	0.27, 1.64	0.27	0.57	**0.02**	0.09, 0.83
Route feels unsafe due to traffic	1.32	0.38	0.46	0.63, 2.78	1.60	0.36	0.20	0.78, 3.26
Too many busy streets to cross	0.85	0.36	0.65	0.42, 1.73	0.52	0.39	0.10	0.25, 1.12
Drivers speed on streets	0.99	0.29	0.98	0.56, 1.75	1.16	0.30	0.62	0.64, 2.09
Walking trails in or near the neighbourhood	0.86	0.28	0.60	0.50, 1.50	1.10	0.35	0.79	0.55, 2.18
Unsafe for child to walk with friends	1.01	0.38	0.99	0.47, 2.13	0.70	0.51	0.49	0.25, 1.93
Know a lot of people	0.61	0.29	0.09	0.35, 1.08	0.90	0.33	0.76	0.47, 1.74
Route is boring	1.54	0.51	0.40	0.57, 4.22	3.26	0.54	**0.03**	1.11, 9.55
Easier to drive	0.80	0.31	0.47	0.43, 1.47	0.80	0.38	0.57	0.38, 1.72
Too young to walk/bike	0.91	0.33	0.78	0.48, 1.75	0.48	0.44	0.10	0.20, 1.15
Nagelkerke Pseudo R-Square = 0.29–0.31								

Notes: The reference category is "Dependent mobility"; Significant ($p < .05$) correlates are bolded.

Table 5
Logistic regression analysis to understand the impact socio-ecological framework variables and perceived barriers and facilitators to active school travel have on girls' independent mobility.

Variable	Travel with peers Odds Ratio	Std. Error	*P*-Value	Confidence Interval	Travel alone Odds Ratio	Std. Error	*P*-Value	Confidence Interval
Intrapersonal								
Age	0.86	0.09	0.08	0.73, 1.02	1.33	0.11	**0.01**	1.07, 1.66
Interpersonal								
Number of motor vehicles	0.84	0.18	0.33	0.59, 1.20	0.97	0.20	0.87	0.65, 1.44
Max. parent education level (ref: Undergraduate college/ university)								
High school or less	0.40	0.43	**0.04**	0.17, 0.94	0.38	0.56	0.08	0.13, 1.14
Graduate school	0.77	0.23	0.25	0.49, 1.20	0.95	0.30	0.87	0.52, 1.73
Sibling age (ref: single child)								
Younger sibling(s)	1.62	0.26	0.07	0.96, 2.72	0.39	0.33	**<0.01**	0.21, 0.74
Older/same age sibling(s)	2.30	0.29	**<0.01**	1.30, 4.06	0.28	0.61	**0.04**	0.08, 0.95
Younger & older siblings	1.25	0.41	0.59	0.56, 2.80	0.13	1.17	0.09	0.01, 1.42
Permission to walk (ref: no)	3.13	0.44	**0.01**	1.31, 7.47	8.11	1.10	0.06	0.95, 69.67
Permission to bike (ref: no)	0.83	0.23	0.40	0.53, 1.29	1.22	0.33	0.55	0.64, 2.33
Physical environment								
Distance to school (km)	0.48	0.24	**<0.01**	0.30, 0.77	0.31	0.35	**<0.001**	0.16, 0.62
Population density	1.00	0.01	0.73	0.98, 1.03	1.01	0.02	0.72	0.98, 1.04
Industrial land use	0.96	0.02	**0.05**	0.93, 1.00	1.02	0.02	0.31	0.98, 1.06
Parental perceptions (ref: disagree)								
Too far/takes too much time	1.36	0.34	0.37	0.70, 2.64	1.73	0.52	0.29	0.62, 4.85
Route feels unsafe due to traffic	0.80	0.29	0.44	0.45, 1.42	0.52	0.38	0.09	0.24, 1.11
Too many busy streets to cross	0.75	0.31	0.35	0.41, 1.37	0.63	0.46	0.31	0.25, 1.56
Drivers speed on streets	0.91	0.25	0.69	0.56, 1.47	1.92	0.33	**0.05**	1.01, 3.66
Walking trails in or near the neighbourhood	0.37	0.25	**<0.001**	0.23, 0.61	0.72	0.31	0.29	0.39, 1.33
Unsafe for child to walk with friends	2.12	0.33	**0.02**	1.11, 4.04	0.91	0.51	0.85	0.33, 2.47
Know a lot of people	0.93	0.25	0.78	0.57, 1.53	0.52	0.32	**0.04**	0.27, 0.98
Route is boring	0.31	0.54	**0.03**	0.11, 0.91	0.88	0.54	0.81	0.30, 2.54
Easier to drive	0.86	0.25	0.54	0.53, 1.39	0.40	0.42	**0.03**	0.18, 0.90
Too young to walk/bike	0.98	0.32	0.96	0.52, 1.84	1.38	0.45	0.48	0.57, 3.36
Nagelkerke Pseudo R-Square = 0.30–0.32								

Notes: The reference category is "Dependent mobility"; Significant ($p < .05$) correlates are boldedss.

girls travelling alone and with peers, but not for boys. This finding is in agreement with other studies that found that girls have a smaller range for independent mobility around the home than boys (Brown et al., 2008; Loebach and Gilliland, 2016). However, parents' perceptions of the journey between home and school being too far or taking too much time was significantly negatively associated with boys' travel alone. These findings are likely a reflection of more ambiguous independent mobility boundaries in place for boys compared to girls (Valentine, 1997). When considering distance, it is also important to note the processes that may contribute to distance between home and school. In Toronto, mean school travel distances did not change significantly between 1986 and 2006. However, distances that are perceived as walkable have shortened over the same time period (Mitra et al., 2016). Furthermore, living closer to a school is not available to all, and distance between home and school is strongly influenced by factors such as city planning, the politics of planning, market forces related to residential and commercial development, social housing policies, income levels that affect residential mobility, and school siting policies (Buliung et al., 2017).

Unexpectedly, this study found that parental perceptions that the route is boring and that drivers speed on streets were positively associated with travel alone for boys and girls. As research has shown that independent mobility is positively associated with children's spatial awareness (Rissotto and Tonucci, 2002), these findings are thought to be a result of a heightened environmental attentiveness from engaging in independent mobility. Spatial awareness associated with school travel has not shown to be significantly different between girls and boys (Ahmadi and Taniguchi, 2007). Therefore, it is interesting that the elements associated with awareness differ between boys and girls. As concerns regarding vulnerability and safety have been common themes underscoring girls' independent mobility (Hart, 1979; Valentine, 1997), it is thought that these concepts may be present in how girls and their parents perceive their environments. More research is needed to confirm this interpretation and understand how gendered norms may be present within children's and parents' spatial awareness.

There are complexities to parental perceptions of their child's gender and associated independent mobility. Namely, girls are generally more mature than boys the same age (among 8-to-11-year old's), boys are perceived to be more impulsive, and parents may ignore gender stereotypes and consider their child's individual personality when making independent mobility decisions (Valentine, 1997). Despite these views, this study provides evidence for more independent mobility barriers for girls than boys. With the positive benefits of independent mobility including greater physical activity and social connectedness (Schoeppe et al., 2013; Prezza and Pacilli, 2007; Rissotto and Tonucci, 2002), it is important to ensure that interventions targeting independent mobility are equitable to children of all genders.

4.1. Policy and practice

Findings from this study highlight gender differences in correlates of independent mobility for the school journey. Gender differences were noted in all categories: intrapersonal, interpersonal, physical environment levels, and parents' perceptions of barriers and facilitators to active school travel. This study supports previous research that identifies differences in independent mobility by gender (Buliung et al., 2017; Ghekiere et al., 2017; Riazi et al., 2019; Brown et al., 2008; Guliani et al., 2015). More parents' perception measures were significantly associated with girls' independent mobility than boys', reiterating the importance of understanding how parental, social, and gender norms influence independent mobility decisions for children.

Independent mobility and active school travel have an important reciprocal relationship in which independent mobility is a key component of participation in active school travel and active school travel is a foundational stepping stone for independent mobility (Faulkner et al., 2010; Crawford et al., 2017; Mitra, 2013). Interventions promoting active school travel have been shown to be effective at increasing overall rates of active modes of travel (Larouche et al., 2018); however, they have also been shown to have stronger effects for boys than girls (Hollein et al., 2017; Lambe et al., 2017). It is important to address gender disparities in children's ability to travel independently to ensure that children are able to participate in active school travel and address disparities in such interventions. Identifying modifiable correlates of independent mobility by gender (e.g., parents' perceptions) enables practitioners to better target their interventions to address independent mobility equity. Efforts should be put on changing parental perspectives to be more supportive of independent mobility and active school travel. Specifically, encouraging active school travel to decrease perceptions of the journey being easier to drive or boring may aid in increasing independent mobility and active school travel for girls (Sauvage-Mar et al., 2019).

4.2. Limitations and future directions

A limitation of this study is the use of self-reported measures of independent mobility and the inability to verify these measures. Using supplementary objective measures such as GPS logging would be beneficial to avoid bias or route discordance between network shortest path and a child's actual route distance (Buliung et al., 2013). Due to the correlational nature of this study, conclusions cannot be drawn about causation. However, many relevant confounding variables were included in this study to overcome biases associated with correlational relationships. Furthermore, due to the complexity associated with independent mobility decision-making, determining causational relationships is very challenging. Another limitation of the study is the inability to generalize to all populations, as the sample was of higher income than the average household in the region and lived in predominantly suburban neighbourhoods. Finally, our study does not account for the intersectionality of children's identities (e.g., gender, race, ethnicity, ability) (see Lambe et al., 2017; Sauvage-Mar et al., 2019). As risk landscapes are developed through socially constructed discourses and life experiences (Murray, 2009), they may be drastically different among parents and children of the same gender.

Future research should consider qualitative methods. This would allow further understanding into the trends identified from this study, as well as the norms and expectations associated with them. Children's perspectives are known to vary from those of their parents and have a role in parents' decision-making (Crawford et al., 2017; Wilson et al., 2018). Future quantitative research should seek to gendered trends in independent mobility and active school travel from children's perceptions of barriers and enablers. The "new" sociology of childhood paradigm (Tisdall and Punch, 2012) positions childhood as a social construct and asserts that children are active in the construction and determination of their own lives, the lives of those around them, and the societies in which they live (Tisdall and Punch, 2012). As such, this paradigm enables research to further capture children's agency, experiences, and perceptions of independent mobility and related self-efficacy.

5. Conclusion

This study makes multiple contributions to independent mobility literature. First, novel approaches are used to classify siblings and independent mobility. These methods enable greater exploration into the role that siblings and friends make in independent mobility. Second, this study finds significant differences in independent mobility between boys and girls. These differences occur among all levels of behavioral influence, both objective and perceived. Our findings suggest that interventions addressing independent mobility should focus on parental norms of safety, especially for girls.

Declaration of Competing Interest

None.

Acknowledgments

We gratefully thank all of the schools and community partners that participated in the Active and Safe Routes to School project. We would also like to share our appreciation for the undergraduate student research assistants and volunteers at the Human Environments Analysis Laboratory for their work on this project. Last, we would like to express our gratitude to the Children's Health Foundation for graduate student funding through the Children's Health Research Institute Quality of Life Initiative.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.wss.2021.100062.

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