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Does the social environment influence active travel? An investigation of walking in Hamilton, Canada

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ABSTRACT

This study adapts a conceptual framework from the physical activity literature to examine how walking as a mode of transport is related to individual, physical, and social environments. The data used in this study come from the Hamilton Active Living Study, which was conducted in Hamilton, Canada from May to September 2010. The analysis, based on 179 study participants, uses socio-demographic information, likert-scale questions about the social environment, and time spent walking for transport as recorded in a 7-day time-use diary. A series of linear regression models examine how components of the social environment (companionship, encouragement, role models, neighborhood social cohesion) influence time spent walking while controlling for individual and physical environments. The results find that only role models and neighborhood social cohesion influence walking time.

1. Introduction

Over the past decade, researchers have examined how the social environment influences physical activity participation (Ball, 2006; Cleland et al., 2010; Giles-Corti and Donovan, 2002; Harley et al., 2009; Hohepa et al., 2007; Mendes de Leon et al., 2009; Trost et al., 2002). In this context, the social environment is defined as the influence friends and family have on an individual's physical activity. Past research has consistently found that a supportive social environment increases physical activity (Ball, 2006; Trost et al., 2002). While the social environment is well-established as a factor increasing such activity, research is only now beginning to unravel how the social environment influences walking. Walking is an important type of physical activity as walking provides exercise to a wide range of people. Given that researchers have just started to examine how walking is related to the social environment (Cleland et al., 2010; Hohepa et al., 2007; McDonald, 2007; Mendes de Leon et al., 2009; Páez and Whalen, 2010), little is known about how the social environment influences walking.

A conceptual framework is used in this study to understand how the social environment fits into the existing knowledge surrounding walking as a mode of transport.[1] The framework, adapted from the physical activity literature (Cleland et al., 2010; Giles-Corti and Donovan, 2002), uses individual, physical, and social environments to better understand what factors influence walking. The individual environment refers to intrapersonal factors (e.g., personal preferences, self-efficacy) and socio-demographics of individuals, and the physical environment, otherwise known as the built environment, refers to the density, diversity, and design features of a city. Combining these different environments into a single analysis allows a better understanding as to the extent that each relates to walking.

This study makes two important contributions to the literature. First, a conceptual framework from the physical activity literature (Cleland et al., 2010; Giles-Corti and Donovan, 2002) is adapted in this study to include four components of the social environment: companionship, encouragement, role models, and social cohesion. These four components work together to create a comprehensive representation of the social environment. Second, the relationship between weekly walking time (as a mode of transport) and the social environment is examined while controlling for individual and physical environments in an effort to better understand the impact of the social environment on such walking. To our knowledge, this is the first such study on the subject.

This study uses a series of linear regression models to determine how each component of the social environment influences time spent walking while controlling for the individual and physical environments. The data analyzed in this study are from the Hamilton Active Living Study (HALStudy), which was conducted from May to September 2010 in Hamilton, Canada. Specifically, the data are drawn from two components of the data collection: the 7-day time-use diary and the personal questionnaire.

The next section of this paper presents the conceptual framework for the analysis. The data and methods section describes the data collection process, variables, and analysis approach used

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[1] This form of walking, sometimes referred to as "utilitarian" walking, falls under the umbrella of active travel.

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for the study. Results are discussed next. Finally, the conclusion summarizes the key findings and discusses their importance in the context of the literature.

2. Conceptual framework

The conceptual framework developed for this study is adapted from the physical activity literature and leads to a better understanding of how walking is influenced by three environments: individual, physical, and social (Cleland et al., 2010; Giles-Corti and Donovan, 2002). The literature finds that each environment is related to physical activity, but no known studies have examined the three environments in concert with walking. The individual environment refers to how intrapersonal factors and socio-demographics of individuals influence walking behavior. The intrapersonal factors examined in the physical activity literature are preference and self-efficacy. In this study, preference is defined as the desire and interest of an individual to walk, while self-efficacy is defined as the degree to which an individual believes he or she can walk (Bandura, 1977). These intrapersonal factors are found to significantly influence physical activity participation (Ball, 2006), but most researchers rarely use preference and self-efficacy as factors influencing walking. This may be a result of researchers who investigate walking not having data to evaluate how such factors are related to walking.

Socio-demographic variables are primarily used in the literature to control for the underlying characteristics of the population and to see how socio-demographics influence walking. Four socio-demographic variables are consistently found to be related to walking: age (Harrison et al., 2007; Mendes de Leon et al., 2009), sex (Booth and Owen, 2000; Harrison et al., 2007; Owen et al., 2007), having a driver's license (Clark et al., in press; Copperman and Bhat, 2007), and educational attainment (Ball et al., 2001; Clark et al., in press). Aging is negatively related to walking due to health and mobility issues that arise as people age (Ferrucci et al., 2000; Harrison et al., 2007; Mendes de Leon et al., 2009). Males are found to walk significantly more than women (Booth and Owen, 2000; Harrison et al., 2007; Owen et al., 2007). Having a driver's license significantly decreases the propensity to walk (Clark et al., in press; Copperman and Bhat, 2007). In turn, those without a driver's license must use alternative modes of travel, such as public transit, walking, or bicycling, to access destinations. Past studies have shown that public transit users walk more than non-users (Besser and Dannenberg, 2005; Wener and Evans, 2007). Finally, a higher education level is related to a higher propensity for walking (Booth and Owen, 2000; Mendes de Leon et al., 2009). The increase in walking may be the result of more educated people having a better understanding of the benefits of walking than those with lower education levels.

The physical environment refers to the design of the urban landscape, and includes density (population density, residential density), diversity (land-use mix, accessibility), and design (street connectivity, parking availability, sidewalk availability). While past literature has tested many different components of the physical environment (Brownson et al., 2009), the general consensus is that the physical environment is significantly related to walking. This consensus has led to many researchers focusing on the relationship between walking and the physical environment, while possibly ignoring many other factors related to walking, such as the social environment and intrapersonal factors. While a few recent studies have examined how these other factors influence walking (e.g., Cleland et al., 2010; Hohepa et al., 2007), the physical environment seems to remain the primary focus for most researchers.

The review by Brownson et al. (2009) details the four most common measures of the physical environment that influence walking: population density (Boer et al., 2007; Braza et al., 2004; Clark et al., in press; Ewing et al., 2004; Kerr et al., 2006; Rodriguez and Joo, 2004; Rutt and Coleman, 2005), land-use mix (Boer et al., 2007; Cervero and Duncan, 2003; Ewing et al., 2004; Kerr et al., 2006; Rutt and Coleman, 2005), street connectivity (Boer et al., 2007; Braza et al., 2004; Cervero and Duncan, 2003; Ewing et al., 2004; Kerr et al., 2006; Rutt and Coleman, 2005), and sidewalk availability (Clark et al., in press; Ewing et al., 2004; Rodriguez and Joo, 2004; Rutt and Coleman, 2005). The review also discusses composite measures developed to summarize different physical environment variables using a single index (Ewing et al., 2003, 2006; Frank et al., 2005, 2006, 2010; Kligerman et al., 2007). These indices, referred to in the literature as walkability indices, combine multiple components of the physical environment into a single variable that is then used to evaluate how the physical environment impacts walking. One such index found to be significantly related to walking is that developed by Frank et al. (2010). Their index combines net residential density, intersection density, land-use mix, and retail floor area ratio. These studies conclude that the physical environment influences walking and needs to be considered when examining walking behavior.

The social environment refers to the influence that friends and family can have on an individual's walking. Researchers have only started to examine how the social environment influences walking (Cleland et al., 2010; Hohepa et al., 2007; McDonald, 2007; Mendes de Leon et al., 2009; Páez and Whalen, 2010), but there is a well-established relationship between the social environment and physical activity (Ball, 2006; Trost et al., 2002). From the physical activity literature, four components of the social environment emerge (Hohepa et al., 2007) and are adapted to walking: companionship, encouragement, neighborhood social cohesion, and role models.

The first component of the social environment is walking companionship, which refers to walking with other people rather than walking alone. The physical activity literature provides important findings as to the benefits of companionship. In one study, those who exercise with companions are less likely to stop exercising in the future (Harley et al., 2009). Companions also make exercise less isolated and hold individuals accountable to others who participate (Harley et al., 2009). No matter who the companion is, research has found companionship to significantly increase physical activity participation (Ball et al., 2001; Cleland et al., 2010; Cutt et al., 2007; Giles-Corti and Donovan, 2002; Harley et al., 2009).

The second social environment component is encouragement, which occurs when family, friends, or other acquaintances promote walking. Promotion occurs when people complement improved physical appearance that results from exercise (Booth and Owen, 2000) or when feedback is given regarding participation in walking (Booth and Owen, 2000; Cleland et al., 2010; Darlow and Xu, 2011; Hohepa et al., 2007). Past work has found that encouragement can significantly increase walking (Cleland et al., 2010; Hohepa et al., 2007). One study found that women living in socio-economically disadvantaged neighborhoods participated in more walking when encouraged by family and friends (Cleland et al., 2010). The second study found that juniors in high school walked to school more often when they had more support from their peers to walk (Hohepa et al., 2007).

The third component of the social environment is neighborhood social cohesion. The social cohesion of a neighborhood is determined by the extent to which a neighborhood is socially interconnected – that is, residents feel like they belong in the neighborhood. The cohesion of a neighborhood is measured through likert scale questions used to understand the friendliness and sociability of a neighborhood. Social cohesion is a popular topic in the transportation literature (McDonald, 2007; Mendes de Leon et al., 2009; Páez and Whalen, 2010; Whalen et al., 2012), including the influence it has on walking. McDonald (2007) found

children living in more cohesive neighborhoods have higher rates of walking to school. Work by Mendes de Leon et al. (2009) found older adults living in more cohesive neighborhoods are more likely to walk for exercise. Páez and Whalen (2010) found active travelers prefer living in an active neighborhood where there is a sense of community.

The final component of the social environment is role model. Role models, in regards to walking, are people who walk and whose own participation encourages others to become involved. Walking has yet to be related to role models, but physical activity research shows that there are many types of role models and they all play a part in increasing participation. Role models can be people close to the person such as friends, family, romantic partner, and co-workers; or they can be strangers, such as professional athletes, whose physical activity participation can increase activity levels. Past research has found role models increase participation in physical activity (Booth and Owen, 2000; Darlow and Xu, 2011; Giles-Corti and Donovan, 2002; Harley et al., 2009).

3. Data and methods

3.1. Data

The data used for this study come from the Hamilton Active Living Study (HALStudy). The purpose of the HALStudy was to learn about people's participation in physical activity and the barriers preventing people from participating in more physical activity. The sample was collected from May to September 2010 in Hamilton, Ontario, Canada. Hamilton is a city of about 540,000 people located southwest of Toronto on the shores of Lake Ontario. In order to ensure that people living in various types of neighborhoods were sampled in this study, 30 neighborhoods in urban Hamilton were targeted based on their walkability using a stratified random sampling design. Walkability is defined as the "extent to which characteristics of the built environment and land-use may or may not be conducive to residents in the area walking for either leisure, exercise or recreation, to access services, or to travel to work" (Leslie et al., 2007).

After acquiring phone lists for each neighborhood, the phone numbers were randomized and cold calls were made to acquire ten subjects from each neighborhood. Although the neighborhood-based approach was the focus, participants were not restricted based on the location of their residence. All subjects willing to participate were invited to do so. As a result, the final dataset had 201 subjects living in 40 neighborhoods.

There were three components to the HALStudy: an upfront interview, a 7-day time-use diary with passive global positioning system (GPS) tracking, and a personal questionnaire. The upfront interview required the participant to meet with a research assistant (RA). First, the RA asked the participant to draw their neighborhood on a tablet using mapping software called ArcPad®. Using this tool, participants drew a map of what they considered to be their neighborhood. Second, the researcher measured the participant's height using a SECA® stadiometer and weight using a digital scale. The height and weight measurements allowed a body mass index to be calculated. Finally, instructions were given on how to fill out the personal questionnaire, the time-use diary, and use the GPS data logger.

The time-use diary with passive GPS tracking collected detailed accounts of a participant's activities and trips during the 7-day study period. The GPS tracking was completely passive only requiring participants to charge the device nightly and to ensure they carried the device for the 7 days of the study. The device used was a QStarz® BT-Q1000X Travel Recorder™, and it recorded information every 5 s. The time-use diary asked subjects to record every activity and trip for the 7 days of the study. Details included start time, end time, activity type, mode, and involved persons. Subjects were only asked to include activities over 5 min of duration. However, all trips and legs of trips were recorded, regardless of their length. For instance, walking to a bus stop, waiting for a bus, riding the bus, and walking to work from the bus stop were all recorded in the diary. The combination of GPS data and time-use diary renders a complete picture of the activities and trips over the 7 days.

The personal questionnaire on active living was a detailed survey about all types of physical activity: exercise, organized and unorganized sport, walking, bicycling, and active video games. Each of the physical activity sections asked questions about participation level in the physical activity, perceptions of the activity, and barriers to the physical activity. Additional sections of the questionnaire asked about perceptions of physical activity, perceptions of neighborhood, travel behavior preferences, and socio-demographic information.

For this study, the focus is on the social environment of walking. The data about social environment comes from five sections of the personal questionnaire: walking, motivations for physical activity, physical activity knowledge, neighborhood satisfaction, and social cohesion. The sample for this study consists of the 179 participants who answered the questionnaire and had diary entries available. The socio-demographic data collected as part of the personal questionnaire was also used in this study to account for the individual environment.

3.2. Concepts and measures

3.2.1. Dependent variable

The dependent variable for this study is the number of minutes spent walking as a mode of transport in a week. Such walking was selected as the dependent variable due to the paucity of research examining the relationship between walking as a means of transport and the social environment. Walking episodes were extracted from each subject's time-use diary. Walking episodes for transport were identified by comparing the surrounding activities. If the walking episode involved traveling from one location to another, it was coded as walking for transport. Otherwise, it was coded as walking for exercise.

3.2.2. Independent variables

Three types of independent variables are used in this study based on the conceptual framework: socio-demographics, physical environment, and social environment. Statistical summaries of the independent variables are provided in Tables 1 and 2. The socio-

Table 1
Summary statistics for variables describing individual and physical environments.

Variables	Statistics
Individual environment	
Age ($\times 10^{-1}$), mean (s.d.)	5.020 (1.713)
Body mass index ($\times 10^{-1}$), mean (s.d.)	2.738 (0.685)
Female (%)	68.8%
Marital status – single (%)	41.9%
Post-secondary degree attained (%)	68.1%
Parent (%)	29.4%
Driver's license (%)	83.8%
Bus pass (%)	18.1%
Physical environment, mean (s.d.)	
Population density: # of people/km^2 ($\times 10^{-3}$)	3.816 (2.195)
Street connectivity: 4-way/all-way intersections ($\times 10$)	4.220 (1.637)
Entropy index ($\times 10$)	6.092 (1.253)
Pedestrian infrastructure: sidewalk length/road length	1.534 (0.376)
Retail floor area ratio ($\times 10$)	3.533 (1.458)

Note: s.d. = standard deviation.

Table 2
Descriptive analysis of social environment factors: percentage of respondents, average minutes spent walking for transport in a week, and *p*-values for difference-of-means tests (ANOVAs and *t*-tests).

Social environment factors (3-point likert scale based on frequency)	Rarely (%)	Sometimes (%)	Always (%)	Rarely (min)	Sometimes (min)	Always (min)	*p*-Value[a]
Companionship							
How often do you walk alone?	17.9	50.3	31.8	79.8	126.7	209.3	0.121
How often do you walk with members of your household?	33.5	50.8	15.6	121.8	143.5	151.2	0.873
How often do you walk with members of your family who do not live with you?	72.6	24.0	3.4	141.4	102.2	560.0	0.192
How often do you walk with friends?	46.9	50.3	2.8	56.7	66.5	82.6	0.462
Social environment factors (3-point likert scale based on agreement)	Disagree (%)	Neither agree nor disagree (%)	Agree (%)	Disagree (min)	Neither agree nor disagree (min)	Agree (min)	*p*-Value[b]
It is difficult for me to walk more often because I have no one to walk with	70.9	15.6	13.4	143.5	124.6	118.3	0.690
There are people I can count on to be physically active with me	27.4	22.3	50.3	94.5	92.4	198.8	$p < 0.050$
Encouragement							
I participate in PA because the doctor requests that I do	44.7	30.7	24.6	154.7	135.8	109.9	0.397
My family encourages me to be active	22.3	30.2	47.5	95.9	109.2	186.9	0.108
My family forces me to be active	69.8	20.1	10.1	107.8	354.2	107.8	0.998
My friends encourage me to be active	31.3	40.2	28.5	105.7	144.2	168.7	0.292
People important to me encourage me to participate in PA on a regular basis	25.7	31.3	43.0	105.0	101.5	199.5	0.113
Neighborhood social cohesion							
I am satisfied with how many friends I have in my neighborhood	23.5	17.9	58.7	135.8	163.8	130.2	0.918
I have a sense of community in my neighborhood	25.7	17.3	57.0	105.7	107.1	165.9	0.236
I know my neighbors well	31.3	20.1	48.6	121.8	89.6	175.7	0.321
My neighborhood is close-knit	24.6	34.6	40.8	129.5	109.9	170.1	0.511
People in my neighborhood are willing to help their neighbors	12.8	16.8	70.4	185.5	198.8	118.3	0.361
People in my neighborhood can be trusted	20.1	26.8	53.1	84.0	197.4	136.5	0.251
People in my neighborhood do not share the same values	39.1	41.9	19.0	107.8	164.5	149.8	0.466
People in my neighborhood generally do not get along with one another	57.0	31.8	11.2	136.5	156.8	94.5	0.490
I am satisfied with the number of people I know in my neighborhood	16.2	16.2	67.6	152.6	182.7	124.6	0.653
Role model							
My family participates in PA on a regular basis	22.9	10.1	67.0	107.1	95.9	156.8	0.324
My friends participate in PA on a regular basis	17.9	30.2	52.0	114.1	149.1	138.6	0.664
Seeing my friends participate in PA makes me want to participate	21.8	29.6	48.6	46.2	175.0	191.1	$p < 0.010$
Seeing other family members participating in PA makes me want to participate	24.0	31.8	44.1	81.2	121.8	197.4	$p < 0.050$

Note: PA = physical activity.
[a] *p*-Values are calculated using ANOVAs to determine if there are statistically significant differences in time spent walking between rarely, sometimes, and always.
[b] *p*-Values are calculated using difference-of-means *t*-tests to determine if there are statistically significant differences in time spent walking between respondents who agree and those who disagree.

demographic variables are used to control for the individual environment. These variables include age, sex, marital status – single, educational attainment – post-secondary degree, parent, having a driver's license, having a bus pass, and body mass index. Age (Harrison et al., 2007; Mendes de Leon et al., 2009), sex (Booth and Owen, 2000; Harrison et al., 2007; Owen et al., 2007), having a driver's license (Clark et al., in press; Copperman and Bhat, 2007), and educational attainment (Ball et al., 2001; Clark et al., in press) are included as they have been found significant in past research. Having a bus pass is included since people taking a bus must walk to a bus stop, and past studies have demonstrated that bus users walk more than non-users (Besser and Dannenberg, 2005; Wener and Evans, 2007). Being a parent and marital status are included as they are directly related to intra-household influences. BMI is calculated by dividing weight by height squared with a higher value meaning an unhealthier individual (Centers for Disease Control and Prevention, 2011). It is included to control for body type.

The physical environment is measured using five measures that were consistently found significant in past literature (Brownson et al., 2009). The measures include population density, street connectivity, retail floor area ratio, pedestrian infrastructure, and land-use mix. The selected variables were developed in ArcGIS© 10 using the methods found in *Standards for Environmental Measurement Using GIS* (Forsyth et al., 2006) from data provided by the City of Hamilton. Each variable is calculated based on a 1000-m buffer around the home.

The definitions for each variable are as follows. Population density is the number of people living in the buffer per square kilometer. Entropy index, a measure of land-use mix, is the degree to which a zone has uniformly diverse land use. The index ranges from 0 for only one type of land use to 1 for equal distributions of land uses. In this study, land-use categories included residential, commercial, institutional, office, park and recreation, and industrial. Street connectivity is the ratio of the number of four-way intersections to all intersections. It ranges from 0 for a cul-de-sac street structure to 1 for a grid-like street structure. Retail floor area ratio measures the ratio of the area (m^2) of the building footprint to the area (m^2) of the parcel. The higher the ratio, the less store

frontage is present meaning there is less parking available for customers. Pedestrian infrastructure is the ratio of length of sidewalk (m) to length of road (m). The higher the ratio, the more sidewalks are available for pedestrians.

The social environment is measured using a series of likert-scale questions from the personal questionnaire. The questions are divided into four categories based on the conceptual framework: encouragement, role model, companionship, and neighborhood social cohesion. A list of the 24 questions and how they are organized into categories is found in Table 2, along with a summary. The reference category for the questions based on a frequency likert scale is 'rarely' and the reference category for the questions based on an agreement likert scale is 'disagree'. While agreement scales are usually centered on 'neither agree nor disagree', the decision was made to use 'disagree' as the reference category to allow a direct comparison of time spent walking between 'agree' and 'disagree' with respect to the social environment question.

3.3. Method of analysis

The method of analysis used in this study is a series of linear regression models, which are used to quantify the impact of the social environment on the amount of time spent walking in a week for transport while controlling for the individual and physical environments. The models are specified as

$$\mathbf{T} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}$$

where $\mathbf{T}$ is a $n \times 1$ vector with elements t_i representing the natural logarithm of minutes spent walking for individual i ($i = 1, 2, 3, \ldots, n$). A natural logarithmic transformation was necessary to normalize the data for the linear regression model. $\mathbf{X}$ is a $n \times K$ matrix of $(K-1)$ independent variables that reflect the individual, physical, and social environments associated with walking as measured for each individual i. $\boldsymbol{\beta}$ is a $K \times 1$ vector of parameters to be estimated by the model. Since the dependent variable is based on a natural logarithmic transformation, each parameter is interpreted as a percentage change in weekly walking time associated with a unit change in the independent variable. $\boldsymbol{\varepsilon}$ is a $n \times 1$ vector with elements ε_i representing the unobserved error in i.

4. Results

4.1. Preliminary analysis

A preliminary analysis, presented in Table 2, examines how the social environment questions were answered and if there are any significant differences in time spent walking as a result. The results of the analysis find no real pattern as to the way questions were answered. Difference-of-means t-tests and analysis of variance (ANOVA) were used to determine if there is any difference in the average walking time between different likert scale answers. Difference-of-means t-tests identified three questions to have significantly different walking times with respect to the likert scale answers.

The question "There are people I can count be physically active with me" from the companionship category finds a statistically higher amount of walking for people who agree compared with those who disagree. Similarly, the question "Seeing my friends participate in PA makes me want to participate" from the role model category has a statistically higher walking time for those who agree compared with those who disagree. Finally, the question "Seeing other family members participating in PA makes me want to participate" is associated with a statistically higher walking time for those who agree compared with those who disagree.

4.2. Model specification

A series of linear regression models are estimated in this study while controlling for the individual and physical environments. A two-step modeling process is used to determine which questions from the social environment are included in the final model. Issues of sample size and potential multicollinearity among the social environment questions preclude a model that includes all of the variables at once. First, each preliminary model has one social environment question added to the control variables to establish if the question has explanatory power. Second, the questions that are significant in the first set of models are added to a final model examining how the four components of the social environment work together to influence weekly time spent walking while controlling for the individual and physical environments.[2]

An assumption underlying the modeling approach is that the variables characterizing the social environment are exogenous. However, it could be argued that some of the variables are endogenous in the sense that the behavior of others is influenced by the behavior of the participant. For instance, the reason that a participant trusts people in the neighborhood may be that those same people trust the participant. In other words, there is direct feedback between the participant's behavior and the group's behavior, resulting in a social multiplier (Manski, 1993, 1995). While this could be the case, a more sophisticated treatment of such social environment variables is beyond the scope of this study due to data limitations. At the same time, our approach of treating social environment variables as exogenous is not without precedent (e.g., Cleland et al., 2010).

The results from the preliminary set of models find that none of the six companionship questions, one of the five encouragement questions, one of the nine neighborhood social cohesion questions, and two of the four role model questions are significantly related to walking time.[3] The four variables found significant in the first set of models are entered into one final model along with the individual and physical environment control variables. Results of the final model are presented in Table 3.

4.3. Model results

4.3.1. Individual environment

The individual environment is defined as the role that socio-demographics, self-efficacy, and personal preferences play on the decision to walk. While all three have been found to impact the decision to participate in physical activity only socio-demographics have been studied extensively in the literature as factors related to walking. As a result, this study only controls for socio-demographics as measures of the individual environment. Understanding how preferences and self-efficacy influence walking as a mode of transport is beyond the scope of this study leaving future work to examine the impact.

The linear regression model finds three individual environment variables to be significantly related to the amount of time spent walking: age, having a driver's license, and having a bus pass. Age is one variable that is consistently found significant in the literature. In this study, like in past work, age is found to be significantly related to a decrease in walking time (Harrison et al., 2007; Mendes de Leon et al., 2009). As age increases by 1 year, the weekly walking time decreases by 1.9%. This decline may be

[2] The results of the preliminary models are available from the authors upon request.

[3] At this stage, to test for potential multicollinearity among the control variables and the social environment variables, weekly walking time was regressed against each of the social environment variables in the absence of the control variables. No evidence of multicollinearity was found.

Table 3
Regression model examining how the social environment influences time spent walking for transport in a week in Hamilton, Canada.

Variables	Coef. (S.E.)	*p*-Value
Individual environment		
Age ($\times 10^{-1}$)	−0.185 (0.097)	$p < 0.100$
Body mass index ($\times 10^{-1}$)	−0.290 (0.232)	0.212
Female	−0.238 (0.365)	0.516
Marital status – single	−0.406 (0.354)	0.253
Post-secondary degree attained	−0.110 (0.366)	0.765
Parent	−0.251 (0.362)	0.489
Driver's license	−1.142 (0.491)	$p < 0.050$
Bus pass	0.692 (0.415)	$p < 0.100$
Physical environment		
Population density ($\times 10^{-3}$)	0.108 (0.106)	0.311
Street connectivity ($\times 10$)	−0.089 (0.206)	0.665
Entropy index ($\times 10$)	0.303 (0.154)	$p < 0.050$
Pedestrian infrastructure	−0.224 (0.576)	0.697
Retail floor area ratio ($\times 10$)	0.218 (0.209)	0.298
Social environment		
Encouragement (disagree is reference category)		
My family encourages me to be active		
Neither agree nor disagree	−0.262 (0.480)	0.585
Agree	0.160 (0.454)	0.724
Neighborhood social cohesion (disagree is reference category)		
People in my neighborhood can be trusted		
Neither agree nor disagree	0.937 (0.472)	$p < 0.050$
Agree	0.726 (0.430)	$p < 0.100$
Role model (disagree is reference category)		
My family participates in PA on a regular basis		
Neither agree nor disagree	−0.233 (0.618)	0.706
Agree	0.368 (0.411)	0.371
Seeing my friends participate in PA makes me want to participate		
Neither agree nor disagree	1.171 (0.461)	$p < 0.050$
Agree	1.073 (0.439)	$p < 0.050$
Intercept	1.997 (1.539)	0.196
n	179	
R^2	0.26	

Note: S.E. = standard error; PA = physical activity.

the result of increased illness, disease, and disability that occurs as people age. Also, older people may be more concerned about the safety of their neighborhood caused by poor walkability and crime (Grant et al., 2010).

The second individual environment variable found significant is having a driver's license. The results indicate that those who do not have a driver's license walk 114.2% more than those who do. This finding is supported by other studies, which also find that not owning a driver's license increases walking (Clark et al., in press; Copperman and Bhat, 2007). While not everyone who has a driver's license uses a car as the primary mode of travel, there is a much lower propensity to walk when having a driver's license. In contrast, those who do not have a driver's license walk more often because they need to use alternative modes of transport, such as public transit or walking, to move around a city.

The final individual environment variable found significant is having a bus pass. Those who have a bus pass walk 69.2% more than those who do not have one. Earlier studies by Besser and Dannenberg (2005) and Wener and Evans (2007) also document the important role played by public transit in increasing walking. Simply put, using a bus to travel means that a person must travel to and from a bus stop.

4.3.2. Physical environment

The physical environment, also called the built environment, refers to the design of the urban landscape. Objective measures of the physical environment used in this study include population density, street connectivity, retail floor area ratio, pedestrian infrastructure, and land-use mix. The model results find very little relationship between weekly time spent walking and the built environment supporting earlier work by Boarnet and Crane (2001) who suggested that a walking-friendly environment does not necessarily increase active travel. The only built environment variable found significant is the entropy index, which increases weekly walking time by 30.9% for every tenth of an increase in the index value. This shows that when individuals live in a neighborhood where they can easily access multiple land-use types, they are likely to walk more often.

4.3.3. Social environment

4.3.3.1. Companionship. While companionship has been found to increase the amount of walking for exercise (Ball et al., 2001; Cleland et al., 2010; Giles-Corti and Donovan, 2002) and to help make walking for exercise habitual (Harley et al., 2009), companionship has no influence on the weekly time spent walking for transport in this study. One reason why companionship does not influence such walking may be the result of intra-personal constraints (Hägerstrand, 1970; Kang and Scott, 2011; Scott and Kanaroglou, 2002). These constraints refer to the need for two or more people to arrange their schedules so they can meet at the same time and place. When walking for transport, these constraints can be quite restrictive as potential companions need to arrange their schedules to meet as well as traveling to and from the same general locations. These conditions may make the intra-personal constraints too difficult to overcome, potentially explaining why walking as a means of transport is not influenced by companionship.

4.3.3.2. Encouragement. The preliminary models find one encouragement question to be significantly related to time spent walking. Agreeing with the question "My family encourages me to be active" is found to increase walking by 70.2% compared with those who disagree. This finding is supported by past literature that has also found family support increases walking (Cleland et al., 2010). However, when included in the final model with the other components comprising the social environment, family encouragement becomes insignificant. This finding underpins the importance of examining all facets of the social environment collectively. Failure to do so may lead to wrong conclusions concerning aspects of the social environment that influence walking.

4.3.3.3. Neighborhood social cohesion. Both the preliminary model and the final model find the neighborhood social cohesion question "People in my neighborhood can be trusted" to be significantly related to time spent walking. Those who agree with the question walk 72.6% more than those who disagree. The results support past work examining the social cohesion of a neighborhood on walking (Mendes de Leon et al., 2009; Páez and Whalen, 2010). Trusting people in a neighborhood increases walking as residents may feel safer to walk and if there is a problem, they know they can ask for help.

4.3.3.4. Role model. Role model is a new component of the social environment to be investigated as it relates to walking. Past research has found that role models do influence physical activity (Booth and Owen, 2000; Darlow and Xu, 2011; Giles-Corti and Donovan, 2002; Harley et al., 2009), but little is known about how walking is influenced by role models. The preliminary models find two role model questions to be related to a significant increase in time spent walking: "My family participates in physical activity on a regular basis" (increase in time by 65.2%) and "Seeing my friends participate in physical activity makes me want to participate" (increase in time by 106.7%). After including both questions in the final model only the second was found to be significant.

The final results suggest that those who agree that seeing friends participating in physical activity makes them want to participate increases walking by 107.3% compared to those who disagree. This result shows that a role model can encourage walking. If an individual sees peers around them being active, it makes walking a possibility. In contrast, those who seldom see anyone active, are less likely to use walking as a mode of transport. Overall, having a role model changes what people consider to be a possibility and alters preconceptions when it comes to travel.

5. Discussion and conclusions

This study has investigated how walking as a mode of transport is related to the individual, physical, and social environments, overcoming a deficiency of past studies that have focused almost exclusively on the first two environments. Only recently have researchers started to examine walking as it relates to the social environment (Cleland et al., 2010; Hohepa et al., 2007; McDonald, 2007; Mendes de Leon et al., 2009; Páez and Whalen, 2010).

This study examined four unique components of the social environment – companionship, encouragement, neighborhood social cohesion, and role models – in an effort to understand how they influence time spent walking as a mode of transport. The results of the linear regression model suggest that only two of the social environment components are significant: social cohesion and role models. Companionship and encouragement were found to be insignificant in this study. Agreeing with the social cohesion question "People in my neighborhood can be trusted" and the role model question "Seeing my friends participate in PA makes me want to participate" is found to significantly increase the time spent walking for transport in this study.

An interesting finding of this study is that companionship does not influence time spent walking for transport despite consistently being found to significantly influence walking for exercise (Booth and Owen, 2000; Cleland et al., 2010; Cutt et al., 2007; Giles-Corti and Donovan, 2002; Harley et al., 2009). Understanding the reason for this finding can be traced to time geography. The foundation of time geography, as discussed by Hägerstrand (1970), concerns three constraints that bound everyone in time and space: capability, coupling, and authority constraints. Companionship is concerned with coupling constraints, which define where, when, and for how long an individual has to join other people to produce, consume, and travel. These coupling constraints are far more restrictive when walking for transport than when walking for exercise or participating in other forms of physical activity. For instance, if two people want to walk together, they need to communicate to set up a time and place to leave for their mutual destination. Individuals have their own personal activities that they need to schedule around, such as work, school, family commitments, and recreational activities. If these two people are unable to find a time that works for both of them, then they cannot walk together. In contrast, when walking alone, people are constrained only by their own schedule. Thus, if individuals decide to choose walking as a mode of transport, they can simply do so without being constrained by others.

In conclusion, this study has shown that the conceptual framework combining the individual, physical, and social environments can lead to a better understanding of what factors increase walking. If this study, like most others, ignored the social environment there would have been 29.6% less variance explained by the regression model. Instead, the four components of the social environment need to be considered along with the other environments to ensure a complete understanding of the factors influencing walking.

Future research on the topics of walking and, more generally, physical activity, could use the conceptual framework presented in this study as a standard approach for conceptualizing the social environment. While many past studies concerning physical activity have investigated the social environment, there is no consistency in the conceptualization methods used. Future research concerning walking could also investigate self-efficacy and preferences – two oft-neglected components of the individual environment. Finally, a future study concerning the relationship between walking and the social environment could be designed to investigate the issue of residential self-selection as it applies to the social environment. While the issue of residential self-section has been investigated as it relates to walking and the built environment (e.g., Cao et al., 2006), it would be interesting to see whether 'active' people locate in social environments conducive to active modes of travel.

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