Exposure to Walkable Neighbourhoods in Urban Areas Increases Utilitarian Walking: Longitudinal Study of Canadians

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ABSTRACT

Background:
Purposeful or utilitarian walking may allow a time-efficient, low cost accumulation of physical activity. While constructing a built environment that supports utilitarian walking is conceptually appealing, longitudinal research investigating the enduring influences of the environment on walking behavior has been limited.

Purpose:
This research examines the relationship between utilitarian walking levels and neighbourhood walkability through longitudinal analyses of a population-based cohort.

Methods:
Data are from Canada's National Population Health Survey (n=2,976; biannual assessments 1994-2006). Socio-demographic and health data were linked to residential neighbourhoods via postal code. Walkability was measured by the Walk Score®. Levels of utilitarian walking were modeled as a function of Walk Score® and socio-demographic and behavioural covariates using mixed effects ordered logistic regression and fixed effects logistic regression.

Results:
Moderate utilitarian walking increased from 24% to 36% over the study period, with the highest increase (15%) for participants living in the most walkable neighbourhoods. In multivariate analyses, a one unit increase in the probability of spending more time in the 4th vs 1st Walk Score® quartile neighbourhoods increased moderate utilitarian walking by 4% (95% C.I. 2.9%, 5.1%). The influence of neighbourhood walkability persisted through adjustment for individual co-variates including leisure time physical activity. Moving to a higher walkable neighbourhood increased the odds of moderate and high utilitarian walking by 59% (95% C.I. 3%-140%) compared to other types of residential moves.

Conclusions:
Exposure to more walkable neighbourhoods and moving from less walkable to more walkable neighbourhoods was associated with increases in utilitarian walking, even for individuals who were otherwise inactive in their leisure time. Walkable neighbourhood environments have the potential to increase utilitarian walking and walking-friendly neighbourhood design should be considered amongst policy options for increasing population level physical activity.

Key words: Longitudinal analysis, Walkability, Utilitarian Walking, Built Environment, Physical Activity, Walk Score®

INTRODUCTION

Constructing a built environment that facilitates walking is conceptually appealing and there are studies that signal an association between built environmental influences and utilitarian walking (Cervero and Gorham 1995, Cervero and Radisch 1996, Handy 1996, Kitamura, Mokhtarian et al. 1997, Handy and Clifton 2001, Handy, Boarnet et al. 2002, Besser and Dannenberg 2005, Wasfi, Ross et al. 2013, Thielman, Rosella et al. 2015). For example, the energy expenditure calculated from the number of estimated weekly utilitarian walking trips reported by residents of highly walkable neighbourhoods in Canadian cities was consistently higher by approximately 1.7 kcal/kg/day than those reported by residents of low walkable neighbourhoods (Thielman, Rosella et al. 2015). Similar associations between neighbourhood walkability and utilitarian walking persisted in a number of studies in the United States and Canada (Saelens and Handy 2008, Ewing and Cervero 2010, Grasser, Van Dyck et al. 2013). There are, however, a number of inconsistencies in the body of research examining associations between built environmental influences and physical activity (Handy, Boarnet et al. 2002, Ewing 2005, Handy 2005, Forsyth, Oakes et al. 2007, Smith, Brown et al. 2008). Research in this area has struggled to establish causal relationships because of reliance on cross-sectional study designs and their concomitant problems of self-selection of residents, who may already be motivated walkers, into more walkable neighbourhoods.

A longitudinal analysis in the United States (the Multi-Ethnic Study of Atherosclerosis (MESA)), estimated the impact of neighbourhood walkability on utilitarian walking for a sample of older adults (45 to 84 years old at baseline) who changed their residential location (Hirsch, Diez Roux et al. 2014). Moving to a more walkable neighbourhood (a 10 point higher Walk Score®) was associated

with increasing the odds of meeting " Every Body Walk" campaign goals (≥ 150 minutes/week of walking) by 11% (95% C.I. 0.2% , 21%). Our study aims to add to this emerging longitudinal evidence base of the influence of the built environment on utilitarian walking with a large population sample that includes both movers (people who changed their residential neighbourhood during the 12 years of the survey follow up) and non-movers (people who stayed in the same neighbourhood for the entire 12 years of follow up). We model not only the likelihood of walking for utilitarian purposes, but also levels of utilitarian walking (a revealed limitation in the MESA study due to insufficient sample size (n=701)).

METHODS

Data sources and sample size

Our sample comes from the National Population Health Survey (NPHS), a longitudinal survey conducted biannually by Statistics Canada starting in 1994/95. The target population of the NPHS is household residents in the ten Canadian provinces excluding some special groups (e.g. persons living on Indian Reserves and Crown Lands) (Statistics Canada 2009). We used the first seven cycles of data collection. Access to the data was granted by the Social Sciences and Humanities Research Council of Canada (#09-SSH-MCG-2068). Analyses were performed at the McGill-Concordia Quebec Inter-University Center for Social Statistics (QICSS).

We restricted our analysis to adults (18 to 55 years old at baseline) living in urban areas (> 50,000 population), who answered the following utilitarian walking question: "*In a typical week in the past 3 months, how many hours did you usually spend walking to work or to school or while doing errands? (None, less than one hour, 1 to 5 hours, 6 to 10 hours, 11 to 20 hours, more than 20 hours)*". We included participants who either did not change their residential location or who relocated to a new

neighbourhood once during the follow-up period, to allow for sufficient exposure time. Respondents with inconsistent answers (i.e., those who reported some utilitarian walking but also reported their inability to walk in another question) and those who stopped answering the survey after the first cycle were excluded from the analyses.

Description of variables

Outcome measure

The primary outcome of interest was utilitarian walking. We reclassified the six categories of utilitarian walking to four: (1) None, (2) Low (less than an hour per week), (3) Moderate (1 to 5 hours per week), and (4) High (6 hours or more per week). This is consistent with previous research in this field (Blair, Cheng et al. 2001, Bauman, Bull et al. 2009).

Neighbourhood walkability

The Walk Score® has demonstrated very strong explanatory capacity for utilitarian walking (Manaugh and El-Geneidy 2011) and it was our primary exposure of interest. The Walk Score® is based on distances to various weighted amenities (e.g. shopping, schools, parks and restaurants) and scores range from 0 to 100. We used the 2012 Walk Score® in the analyses. We divided the Walk Score® into four quartiles as follows: Low walkable neighbourhoods 0 to 39; Low-medium walkable neighbourhooods 40 to 55; Medium-high walkable neighbourhoods 56 to 69; and highly walkable neighbourhoods 70 to 100. We computed cumulative exposure to each Walk Score® quartile (WSQ) for all respondents based on the biannual reported residential locations and year of moving to a new residential neighbourhood, captured for every respondent as follows: *Proportion of cumulative exposure time (PCET) of respondent X to* Walk Score® *in quartile I after T survey years = (No. of total years in WSQI)/T.* In our analysis I ranged from 1 to 4, indicating the four Walk Score® quartiles and T ranged

from 2-12 (in multiples of 2), representing the time spent in each neighbourhood quartile level. Table 1 demonstrates an example of an individual (x) who moved from a low-medium walkable neighbourhoood (WSQ2) to a high walkable neighbourhood (WSQ4) 6 years from baseline. The table shows the cumulative exposure time (CET) spent in each neighbourhood type at each cycle of the survey (from 1994 to 2006), and the proportion of cumulative exposure time (PCET) to these neighbourhoods at each cycle.

Table 1: Demonstration of neighbourhood walkability cumulative exposure variable

Year	Time (T)	Individual ID (X)	WSQ (I)	*CET to WSQ1 in years	CET to WSQ2 in years	CET to WSQ3 in years	CET to WSQ4 in years	**PCET to WSQ1	PCET to WSQ2	PCET to WSQ3	PCET to WSQ4
1994	0	x	2	0	0	0	0	0	0	0	0
1996	2	x	2	0	2	0	0	0	2/2	0	0
1998	4	x	2	0	4	0	0	0	4/4	0	0
2000	6	x	4	0	6	0	0	0	6/6	0	0
2002	8	x	4	0	6	0	2	0	6/8	0	2/8
2004	10	x	4	0	6	0	4	0	6/10	0	4/10
2006	12	x	4	0	6	0	6	0	6/12	0	6/12

*CET: Cumulative exposure time   **PCET: Proportion of cumulative exposure time

NPHS respondents who moved over the follow-up period were particularly interesting as they provided a quasi-experiment of changes in utilitarian walking associated with changes in exposures to different levels of walkability. To determine the effect of moving between neighbourhoods with different walkability levels, we centered the Walk Score® quartile (*WSQ)* variable for each survey respondent around their baseline Walk Score® quartile. Centering variables around initial status is a common practice in longitudinal analysis to detect change (Singer and Willet 2003). From the centered Walk Score® quartile variable, we constructed two dummy variables that indicated whether the respondents "changed/ moved" two or more Walk Score® quartiles (in either direction) after relocation.

A positive change in Walk Score® quartile indicated an increase in walkability, and a negative change indicated a decrease in walkability.

Other potential determinants of utilitarian walking

The individual-level potential determinants of walking considered were age, sex, education, leisure time physical activity, and perceived health status. It has been suggested that a supportive built environment is insufficient on its own to guarantee that people will be physically active; motivation and good health are important drivers of utilitarian walking (Handy and Mokhtarian 2005). Accounting for these factors allows for more precise estimates of the incremental influence of the built environment on utilitarian walking. A physical activity index calculated from leisure time physical activity (Statistics Canada 2009) was classified as inactive (energy expenditure (EE) less than 1.5 kcal/kg/day), and moderately active (combined moderate (EE 1.5 to 2.9 kcal/kg/day) and active (EE greater than 3 kcal/kg/day), education level was classified as having a post-secondary education, yes/no) and perceived health was classified as unhealthy (poor or fair) versus healthy (good, very good, or excellent).

Statistical analysis

At the outset, we conducted an attrition analysis to ensure that the remaining sample reflected similar characteristics to the original cohort. Attrition (i.e., the loss of participants over time) can be a methodological problem for longitudinal studies if participants do not drop out at random, (Little and Rubin 2002). We then used a mixed effects ordered logistic regression to model levels of utilitarian walking in order to take full account of the range of ordered responses to the utilitarian walking question. Our models did not violate the proportionality assumption of ordered logit. Marginal effects for each category of the dependent variable were computed. Marginal effects present the change in probability of a particular alternative as a function of a unit change in the independent variable (see (Eluru, Bhat et al. 2008) for a more detailed discussion). The mixed effects ordered logistic regression

was advantageous for accounting for multiple observations across the seven cycles of the NPHS. We also estimated a binary fixed effects logistic regression model for those who moved over the study period (i.e., respondents who "changed/ moved" 2 or 3 Walk Score® quartiles in either direction after relocation versus other movers) to estimate the effect of moving on utilitarian walking. The dependent variable was collapsed into two categories for ease of interpretation: none or low utilitarian walking (the reference category), versus moderate or high utilitarian walking.

Computing fixed effects estimates in the ordered and binary regression models allowed us to control for unobserved heterogeneity, which is a limitation of standard regression analyses (e.g. ordinary least squares or random effects models). The fixed effects approach accounts for any unmeasured confounding variables that are constant over time (e.g., time constant personal preferences), thereby reducing estimation biases (Frees 2004, Allison 2005). To explain the methods behind the fixed effects estimators, in a simplified manner, let us assume that there is only one source of unobserved group heterogeneity (for example, time constant personal preferences). In this case the fixed effects estimator would be equivalent to de-meaning the dependent and independent variables with respect to the group (i.e., the person in the case of multiple observations of the same person in longitudinal data) and then estimating the model using ordinary least squares. This is why in binary fixed effects regression models, estimates of time constant control variables (e.g., sex) are not computed. They depend on within-person changes. Fixed effects give us unbiased estimates for the main exposure of interest – in this case the change in Walk Score® quartiles as a result of moving from potential measured or unmeasured time constant confounders.

RESULTS

Sample description

From the 17,276 members of the original NPHS cohort in cycle 1, there were 10,367 adults living in

urban areas, and 6,545 of them were between the age of 18 and 55 years at baseline (i.e., by last follow-

up they were still mainly working age adults). From the 6,545 respondents, 3,483 did not change their

residential locations, or moved once during the survey follow-up period. After exclusions of respondents

with inconsistent answers, and people who were lost after the first cycle, we were left with a sample of

2,976 (Figure 1). Our attrition analysis showed no meaningful differences in health status or utilitarian

walking for people who were lost compared to those who remained in the sample (data available upon

request).
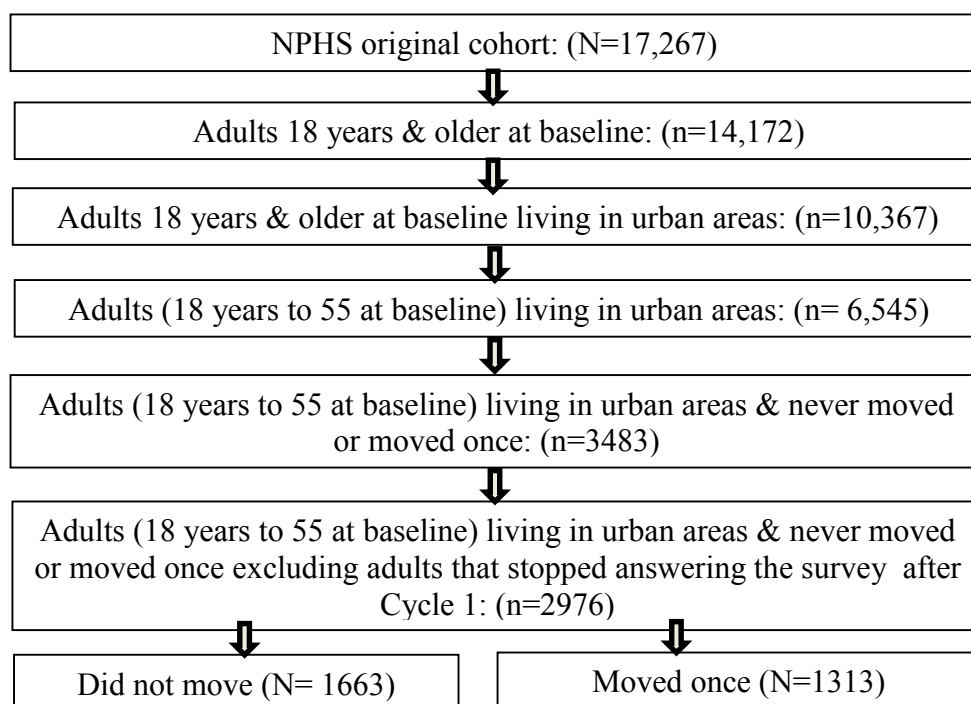
Figure 1: Construction of cohorts

Summary statistics

Men comprised 48% of the final sample, with mean age of 38 years old (SD=9) at baseline.

There were 1,313 individuals (48% men) who changed their residential locations once and 1,663
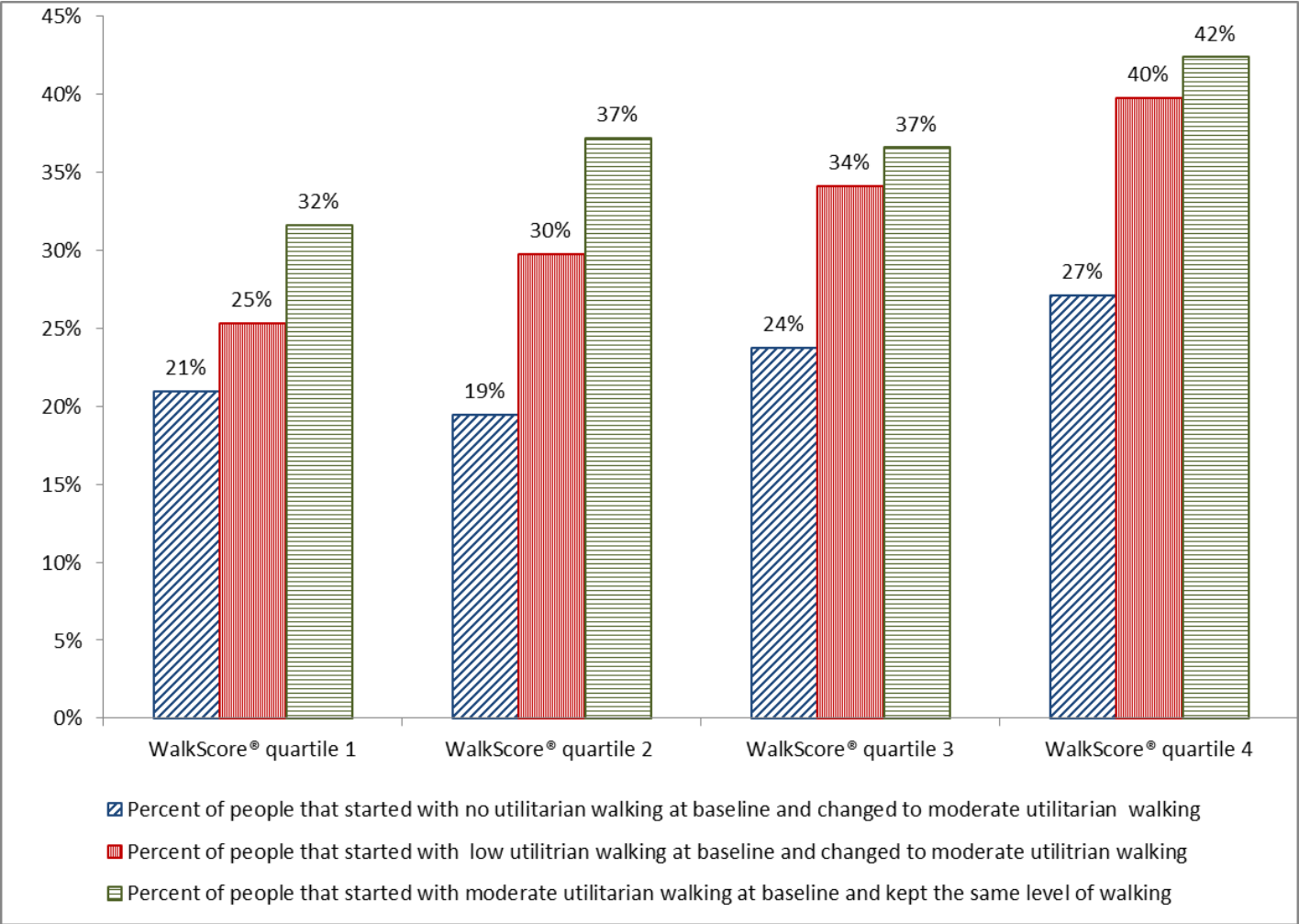
individuals who did not move (52% men). At baseline, approximately 59% of the sample completed

post-secondary education. More than half of the sample was inactive at baseline (60%); the vast majority

(93%) reported themselves to be healthy (Table 2). Approximately one third of inactive people changed

to being active over the follow-up period and 29% of active people became inactive, keeping the overall

percentage of inactive people similar across the follow-up period.

Table 2: Summary statistics at baseline (Cycle 1)

| Variables	%, or Mean (SD)				
	Overall sample at baseline	Living in WSQ1 at baseline	Living in WSQ2 at baseline	Living in WSQ3 at baseline	Living in WSQ4 at baseline
Age (SD)	38 (9)	39 (9)	39 (9)	38 (9.5)	37 (9.7)
Men	48%	53%	48%	46%	45%
Completed post-secondary education	59%	58%	57%	59%	57%
Good perceived health	93%	94%	94%	92 %	93%
Active in leisure time	40 %	42%	40%	35%	41%
No utilitarian walking	41%	46%	41%	40%	40%
Low utilitarian walking (less than an hour)	17%	14%	17%	18%	19%
Moderate utilitarian Walking (1 to 5 hours)	24%	21%	24%	24%	25%
High utilitarian walking (6 hours or more)	18%	19%	18%	18%	16%
Sample (n = 2976)	100%	37%	15%	29 %	19%

There was an overall increase in the percentage of people who walked for utilitarian purposes in

all neighbourhoods over time. At baseline, 41% of the sample did not walk at all for utilitarian purposes;

this percentage decreased to 32% after 12 years. Similarly, the proportion of respondents reporting

moderate utilitarian walking increased from 24% to 36% over the study period. The increase in the

percentage of respondents that walked for utilitarian purposes was more pronounced in neighbourhoods

with higher Walk Score® values compared to lower ones. For those living in the least walkable

neighbourhoods (Walk Score® quartile1), the percentage of people reporting moderate utilitarian

walking increased by 10% (from 21% at baseline to 31% after 12 years) whereas it increased by 15% (from 25% to 40%) for those in high walkable neighbourhoods (Walk Score® quartile 4). Changes in utilitarian walking were detected for both non-movers and movers. Around 21% of non-movers, who did not walk for utilitarian purposes at baseline, and were living in the least walkable neighbourhoods, changed to moderate walking, compared to 27% of non-movers living in high walkable neighbourhoods. Similarly, 25% of non-movers with low utilitarian walking at baseline living in the least walkable neighbourhoods changed to moderate walking compared to 40% in high walkable neighbourhoods (Figure 2).

Legend:
- ▨ Percent of people that started with no utilitarian walking at baseline and changed to moderate utilitarian walking
- ▤ Percent of people that started with low utilitrian walking at baseline and changed to moderate utilitrian walking
- ▤ Percent of people that started with moderate utilitarian walking at baseline and kept the same level of walking

Figure 2: Changes in utilitarian walking levels for urban-dwelling "non-movers"; National Population Health Survey (1994/5-2006/7).

Nearly forty-four percent of people who moved from low to high walkable neighbourhoods increased their utilitarian walking, compared to 31% of those who moved from high to low walkable neighbourhoods. Around 41% of individuals who moved to lower walkable neighbourhoods decreased their utilitarian walking compared to 27% of those who moved to higher walkable neighbourhoods (Figure 3).
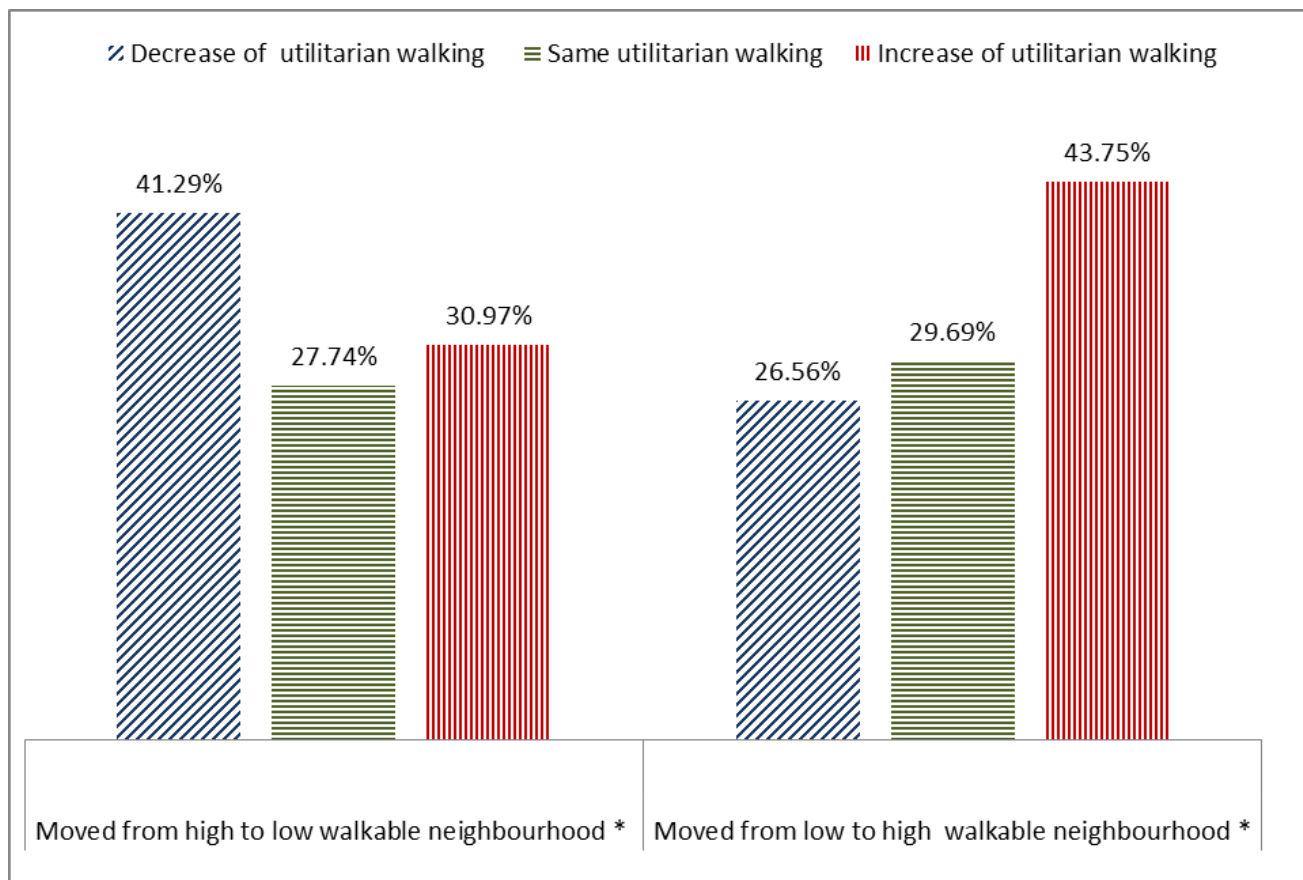
*Moved/changed 2 to 3 Walk Score® quartiles

Figure 3: Change in utilitarian walking for urban-dwelling "movers"; National Population Health Survey (1994/5-2006/7)

Multivariate analyses

Ordered logistic regression analysis for overall sample - interpreting the influence of walkability on utilitarian walking

Exposure to higher walkable neighborhoods (third and fourth Walk Score® quartiles,) had positive associations with utilitarian walking compared to exposure to low walkable neighbourhoods (first Walk Score® quartile) in multivariate analyses. The marginal effects of the ordered logistic regression can be interpreted as the change in probability of being in a particular alternative (in our case none, low, moderate and high utilitarian walking) as a function of a unit change in the independent variable (in our case the probability of spending more time in the second, third or fourth Walk Score® quartiles relative to spending time in the first Walk Score® quartiles). A unit increase in the probability of spending more time in the third Walk Score® quartile neighbourhoods increased the probability of moderate (1.4%, 95% C.I. 0.4%, 2.4%) and high utilitarian walking (2.7%, 95% C.I. 0.7%, 4.7%) compared to spending the same time in low walkable neighbourhoods (first Walk Score® quartile neighbourhoods). A unit increase in the probability of spending more time in the fourth Walk Score® quartile neighborhoods increased the probability of moderate (4%, 95% C.I. 2.9%, 5.1%) and high utilitarian walking (7.7%, 95% C.I. 5.8%, 9.7%) spending the same time in low walkable neighbourhoods (first Walk Score® quartile neighbourhoods) (Table 3).

Interpreting other covariates

Women were more likely to walk for utilitarian purposes at moderate (3%, 95% C.I. 2.4%, 3.6%) and high levels (5.8%, 95% C.I. 4.3%, 7.3%) than men (Table 3). Post-secondary education increased the probability of moderate (1.8%, 95% C.I. 1.3%, 2.3%) and high utilitarian walking (3.5%, 95% C.I.

2.3%, 4.6%). Being active in one's leisure time increased the probability of walking for utilitarian purposes at moderate (1.5%, 95% C.I. 0.5%, 2.6%) and high levels (3%, 95% C.I. 0.8%, 5%) compared to being inactive in leisure time, although importantly the influence of neighbourhood walkability persisted with this variable in the model. Individuals who perceived themselves as healthy were more likely to walk for utilitarian purposes at moderate (0.8%, 95% C.I. 0.1%, 1.6%) and high levels (1.6%, 95% C.I. 0.1%, 3.2%) than those who perceived themselves as unhealthy. A 0.01 increase in age decreased the probability of moderate (0.1%, 95% C.I. 0.1%, 0%) and high utilitarian walking (0.1%, 95% C.I. 0.2%, 0%).

There was an increase in utilitarian walking levels for the entire sample starting at cycle 4. This increase was more pronounced for high utilitarian walking (3.8%, 95% C.I. 1.8%, and 5.7%), with a steady increase (11.8%, 95% C.I. 8.5%, 14.3%) in utilitarian walking until cycle 7. Family structure and perceived neighbourhood safety were also tested to see whether they had an impact on the likelihood of changing utilitarian walking levels, but did not demonstrate any consistent associations.

Table 3: Marginal effects estimates of a mixed effects ordered logistic regression model of utilitarian walking

Dependent Variable (Amount of Utilitarian Walking per week)	None	Low	Moderate	High
	*Marginal Effects [95% Conf. Interval]	Marginal Effects [95% Conf. Interval]	Marginal Effects [95% Conf. Interval]	Marginal Effects [95% Conf. Interval]
Women *(ref. men)*	**-0.073*** [-0.081, -0.052]	**-0.015*** [-0.019, -0.010]	**0.030*** [0.024, 0.036]	**0.058*** [0.043, 0.073]
Age	**0.002*** [0.000, 0.002]	**0.000*** [0.000, 0.000]	**-0.001*** [-0.001, 0.000]	**-0.001*** [-0.002, 0.000]
Good perceived health (ref. unhealthy)	**-0.020** [-0.035, -0.001]	**-0.004** [-0.008, 0.000]	**0.008** [0.001, 0.016]	**0.016** [0.001, 0.032]
Active in leisure time *(ref. inactive)*	**-0.037*** [-0.057, -0.010]	**-0.008*** [-0.012, -0.002]	**0.015*** [0.005, 0.026]	**0.030*** [0.008, 0.050]
Post-secondary education (*ref. below post-secondary*)	**-0.044** [-0.051, -0.028]	**-0.009** [-0.012, -0.005]	**0.018** [0.013, 0.023]	**0.035** [0.023, 0.046]
Proportion of cumulative exposure time (PCET) to neighbourhoods Walk Score® quartiles (WSQ) *(ref. PCET WSQ1)*				
PCET to WSQ2	-0.006 [-0.028, 0.017]	-0.001 [-0.006, 0.004]	0.003 [-0.007, 0.013]	0.005 [-0.015, 0.025]
PCET to WSQ3	**-0.034** [-0.053, -0.008]	**-0.007** [-0.011,-0.001]	**0.014** [0.004, 0.024]	**0.027** [0.007, 0.047]
PCET to WSQ4	**-0.098*** [-0.112,-0.066]	**-0.020*** [-0.025, -0.014]	**0.040*** [0.029, 0.051]	**0.077*** [0.058, 0.097]
Time: (ref. Cycle 1: 1994)				
Cycle 2: 1996	0.002 [-0.020, 0.024]	0.000 [0.002, 0.003]	0.000 [0.011, 0.009]	0.000 [0.011, 0.009]
Cycle 3: 1998	0.008 [-0.012, 0.029]	0.009 [-0.014, 0.032]	-0.004 [-0.016, 0.007]	-0.006 [-0.020, 0.009]
Cycle 4: 2000	**-0.046*** [-0.066, -0.024]	**-0.010*** [-0.016, -0.004]	**0.018*** [0.011, 0.026]	**0.038*** [0.018, 0.057]
Cycle 5: 2002	**-0.071*** [-0.099, -0.053]	**-0.020*** [-0.028, -0.013]	**0.023*** [0.017, 0.029]	**0.069*** [0.046, 0.092]
Cycle 6: 2004	**-0.072*** [-0.094, -0.049]	**-0.021*** [-0.028, -0.013]	**0.023*** [0.017, 0.029]	**0.070*** [0.046, 0.094]
Cycle 7: 2006	**-0.097*** [-0.115, -0.078]	**-0.035*** [-0.044, -0.025]	**0.176*** [0.009 ,0.025]	**0.114*** [0.085, 0.143]

Binary fixed effects regression analysis for movers:

We also estimated a binary logistic regression model for those who changed residence during the study period (i.e., respondents who "changed/ moved" 2 or 3 Walk Score® quartiles in either direction after relocation compared to other movers). Moving from low to high walkable neighbourhoods increased the odds of moderate and high utilitarian walking by 59% (95% C.I 3%, 140%), compared to moving to a neighbourhood with a similar walkability level, (i.e., within one Walk Score® quartile change). In terms of covariates, the odds of moderate or high utilitarian walking were approximately 28% higher for active people compared to inactive people (Table 4). Recall that sex and post-secondary education are time constant variables and therefore do not have direct estimates in the fixed effects binary model. The estimation of effects in this model was based entirely on within-person changes; hence there is no potential bias from measured or unmeasured time-constant confounders.

Table 4: Odds ratio of a fixed effects binary logistic regression model of utilitarian walking

Dependent Variable (reference: none or low utilitarian walking)	(Moderate or high utilitarian walking per week)
	Odds Ratio [95% Conf. Interval]
Good perceived health	1.18
(ref. unhealthy)	[0.90, 1.53]
Active in leisure time	**1.28****
(ref. inactive)	[1.11, 1.47]
Moving between neighbourhoods *(ref. moving to a neighborhood with the same Walk Score® quartile,* *or change of one Walk Score® quartile)*	
Moving from low to high walkable Neighbourhood*	**1.59*****
	[1.03, 2.46]
Moving from high to low walkable Neighbourhood*	1.07
	[0.78, 1.48]
Time: (ref. Cycle 1: 1994)	
Cycle 2: 1996	1.07
	[0.89, 1.28]
Cycle 3: 1998	1.12
	[0.93, 1.35]
Cycle 4: 2000	1.10
	[0.91, 1.33]
Cycle 5: 2002	**1.45*****
	[1.19, 1.78]
Cycle 6: 2004	**1.48*****
	[1.22, 1.84]
Cycle 7: 2006	**1.90*****
	[1.53, 2.35]

*Moved/changed 2 to 3 Walk Score® quartiles

**statistically significant at 95% confidence level
****statistically significant at 99% confidence level

DISCUSSION

Cumulative exposure to highly walkable neighborhoods (3rd and 4th Walk Score® quartiles) was

associated with increased utilitarian walking. Long term exposure to high and medium walkable

neighbourhoods reduced the likelihood of no utilitarian walking incrementally more than exposure to

low walkable neighbourhoods. Moving to higher walkable neighbourhoods increased utilitarian walking while moving to lower walkable neighbourhoods did not show a significant decrease in utilitarian walking.

Our findings align with two longitudinal studies of utilitarian walking. The first is the Multi-Ethnic Study of Atherosclerosis (MESA) Study, (Hirsch, Diez Roux et al. 2014) which measured utilitarian walking before and after relocation to new neighbourhoods. Moving to a more walkable neighbourhood (a 10 point higher Walk Score®) was associated with an increase in the odds of meeting "Every Body Walk" campaign goals (≥ 150 minutes/week of walking) by 11% (95% C.I. 0.2% , 21%)) for middle-aged to older adults. In our study, we estimated that moving to neighbourhoods of 2 or 3 WalkScores® quartile higher (15 to 45 points higher Walk Score®) was associated with an increase in the odds of moderate or high utilitarian walking per week (>= 60 minutes/ week of utilitarian walking) of 59% (95% C.I. 0.33%, 145%) . The second is the RESIDE study in Perth, Australia, a quasi-experimental longitudinal study (n=1,813 at baseline) that tracked, over a 7 year period, the walking behaviour of subjects who relocated to new suburban housing developments. The RESIDE study found that the odds of walking for utilitarian purposes had a positive association with local accessibility to amenities (measured as the number of amenities within 1,600 meters buffer from respondents homes). Being in a neighbourhood with high local accessibility (8 to 15 amenities within a 1,600m buffer) was associated with an increase in the odds of walking by around 30% (p= 0.04) compared to being in a neighbourhood with low local accessibility (0 to 3 amenities within a 1,600m buffer).

Our study differed from the MESA and RESIDE studies in several ways. First, our sample did not only consist of movers but non-movers as well. Second, our outcome variable was modeled across several levels to capture more information about utilitarian walking. Third, we accounted for confounding that may be introduced by health status and leisure time physical activity, providing

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increased precision in our estimates of the true influence of the environmental exposure (revealed as a limitation in the RESIDE study).

We detected an overall secular trend towards increased utilitarian walking over time, starting in 2000. This timeframe corresponds to the general trend of promoting active living that has been growing in North America in response to the high rates of inactivity (Federal-Provincial/Territorial Advisory Committee on Fitness and Recreation 1997, Lavizzo-Mourey and McGinnis 2002, Wharf-Higgins 2002, Transport Canada 2005). The trend towards increased utilitarian walking was more pronounced for high levels of utilitarian walking than for low ones. This secular trend could be explained by recall bias, generated as a result of repeated self-reported measures over time (Hassan 2005). If the increased trend were due to bias, however, we would have expected the same increase across all levels of utilitarian walking. New evidence in the US has found that people are driving less, and shifting towards more sustainable modes of transport (Tomer and Kane 2014). This increasing trend in utilitarian walking was not seen in the MESA study, possibly because of the advanced age of their sample (Hirsch, Diez Roux et al. 2014) nor in the RESIDE study (Knuiman, Christian et al. 2014), which showed a decline in the frequency of utilitarian walking (9% decline from baseline) after subjects relocated to new homes in suburban neighbourhoods around Perth, Australia.

In our study, the highest walkable neighbourhoods had Walk Score® values between 70 and 100 and represent neighbourhoods like one might find in the core of densely populated urban areas that have many amenities and where one could easily live without access to a private automobile. It was these types of neighbourhoods that had the largest influences on increases in high levels of utilitarian walking over time and corresponding declines in low levels of utilitarian walking. It suggests that land use planning needs to understand features of these very walkable places in order to have the largest possible impact on population level physical activity. Our study also suggests that any land use policies

implemented to increase neighbourhood walkability may not prompt an immediate change in utilitarian walking; exposure over time may be needed to detect an effect of environmental change.

The assumption that only active people will walk more in a supportive walkable environment did not hold true in our study. Longer cumulative exposure to highly walkable neighbourhoods was associated with increases in utilitarian walking for both people who were active in their leisure time and those who were not. That both leisure time active and inactive people increase their utilitarian walking in response to a walkable environment speaks to the population-wide potential for built environment interventions aimed at increasing physical activity.

Our study relies on self-reported information about utilitarian walking. Self-reported walking information is a clear limitation in cross-sectional studies. If, however, respondents over-report or under-report utilitarian walking levels, the direction of their misrepresentation is likely consistent over time. Reporting bias is arguably less of a problem in longitudinal analyses. Longitudinal studies have several advantages over cross sectional studies yet the problem of controlling for confounding variables to obtain precise coefficient estimates remains. Fixed effects regression (used in our analysis) offers a solution as it is a statistical technique that controls for all confounding variables even without measuring them (e.g., attitudes and preferences about walking), as long as they do not change over time (Singer and Willet 2003, Frees 2004, Allison 2005). Another possible limitation of our work is the lack of availability of historical Walk Score® data. That said, neighbourhoods do not usually change their physical characteristics quickly and we tested other measures correlated with Walk Score® (street connectivity and population density) that we computed from street network and Census data in 1996 and 2006 for all the NPHS respondents residential neighbourhoods. Measures computed at the two time periods were highly correlated (Pearson correlation coefficient = 0.94; p < .01).

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Individual and interpersonal factors, for example, personal attitudes and motivation, were measured in a number of studies, and found to be important for physical activity (Handy and Mokhtarian 2005). Thus Handy (2005) has argued that a supportive built environment is not sufficient alone to guarantee that people will be physically active. We found, however, that long term exposure to high walkable neighbourhoods was associated with higher reported levels of walking for utilitarian purposes in this 12-year follow-up of Canadians. This finding in a large sample across a wide age range suggests that features of neighbourhoods are, over the long term, influencing how much Canadians move, at least for utilitarian purposes. Sustained behaviour change to support better health is difficult to achieve. Our findings suggest that increasing neighbourhood walkability will lead to some increases in utilitarian walking, even for individuals who are otherwise inactive.

CONCLUSION

This study is the first national level longitudinal study to determine the impact of cumulative exposure to high walkable neighbourhoods on different levels of utilitarian walking. Previous studies do signal associations between the built environment and utilitarian walking; however, research in this area has been plagued by problems of causal attribution from an almost exclusive reliance on cross-sectional studies. Longer exposure to highly walkable neighbourhoods increases utilitarian walking levels, even for individuals who are otherwise inactive, and should be included amongst policy options for increasing population level physical activity.

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