Preventive Medicine Reports 2 (2015) 874–879

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: http://ees.elsevier.com/pmedr

Impacts of public transit improvements on ridership, and implications for physical activity, in a low-density Canadian city

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ARTICLE INFO

Available online 21 October 2015

Keywords:
Commute to work
Public transit
Physical activity
University employees
Kingston Ontario
Longitudinal study

ABSTRACT

Public transit ridership offers valuable opportunities for modest amounts of daily physical activity (PA). Transit is a more feasible option for most Canadian commuters who live too far from work to walk or cycle, yet public transit usage in midsized Canadian cities has historically remained low due to inefficient transit service.
The objectives of this longitudinal study were threefold: to assess whether the introduction of express transit service in the low-density city of Kingston, Ontario, has translated to greater transit use among a targeted employee group; to document the characteristics of those employees that have shifted to transit; and to examine the PA levels of employees using transit compared to other commute modes.
An online survey was administered in October 2013 and October 2014 to all non-student employees at Queen's University. 1356 employees completed the survey in 2013, and 1123 in 2014; 656 of these employees completed the survey both years, constituting our longitudinal sample.
Year-round transit ridership increased from 5.5% in 2013 to 8.5% in 2014 ($p < 0.001$). Employees who shifted to transit had fewer household-level opportunities to drive to work and more positive attitudes toward transit. Transit commuters accrued an average of 80 minutes/week of commute-related PA, and 50 minutes/week more total PA than those that commuted entirely passively.
Kingston Transit's express service has stimulated an increase in transit ridership among one of their target employers, Queen's University. The findings from this study suggest that shifting to transit from entirely passive commuting can generate higher overall PA levels.

Introduction

Commute mode and health

Within the field of public health, there is growing interest in promoting active commuting to increase daily physical activity levels among working-age populations (Butler et al., 2007; Shephard, 2008; Giles-Corti et al., 2010; PHAC, 2010; Bopp et al., 2011). This interest stems from mounting evidence that connects daily travel patterns to population health indicators, such as elevated obesity prevalence among those who commute passively (e.g., by private automobile) (Frank et al., 2004), and healthier body weights among active commuters (Gordon-Larsen et al., 2005). Active commuters also tend to be more satisfied with their daily commute (Páez and Whalen, 2010), making it a more attractive commute option for those who can choose it.

Health benefits of transit ridership

Despite established health benefits of active commuting, most Canadians do not live within close enough proximity to their place of work (i.e., within roughly 2 km for walking and 7 km for cycling (Larsen and El-Geneidy, 2010) to not rely on motorized transportation for at least part of the journey (Turcotte, 2011). In fact, over 70% of Canadians have been commuting by private automobile since 2006 (Statistics Canada, 2006, 2011a). However, there is growing recognition that riding public transit offers opportunities for active commuting, since the majority of transit trips involve walking at the beginning and end (Edwards, 2008; Lindström, 2008; Chaix et al., 2014). Indeed, cross-sectional studies have found that transit riders accrue more daily PA than those who commute by car (Besser and Dannenberg, 2005; Wener and Evans, 2007; Lachapelle and Frank, 2009). And, longitudinal research based in Salt Lake City, Utah, found that the introduction of light-rail transit (LRT) lead to increased total physical activity levels (Brown and Werner, 2007) and weight loss (Brown et al., 2015) among riders. Thus, promoting transit ridership may be a useful approach to increasing PA (as well as reducing traffic congestion and

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http://dx.doi.org/10.1016/j.pmedr.2015.10.001

pollution), especially among the majority of Canadians who live too far from work for it to be feasible to use active modes for the entire journey.

Barriers to, and opportunities for, increasing transit ridership

In midsized Canadian cities (i.e., populations 100,000–500,000), public transit systems often struggle with low ridership due to low population densities that are not supportive of efficient transit services (Turcotte, 2011). Low-density developments often lead to inefficient bus routing and inconvenient scheduling, and a recent study based in a midsized US city found that these factors present significant barriers to transit ridership (Lawson et al., 2012). The challenges faced by transit systems in midsized cities are compounded by the tendency for midsized cities to have ample parking supply in their central business districts, and limited traffic congestion on major corridors during peak hours (Shoup, 2011).

Despite barriers to transit ridership in midsized cities, research suggests that improvements to transit services and programs that promote transit hold promise for encouraging people to shift to public transit for their daily commute (Shannon et al., 2006; Brown and Werner, 2007). Additionally, midsized cities across Canada are increasing efficiencies within their transit systems to increase ridership, and to make their municipalities more sustainable (AMO, 2008).

Knowledge gaps and study objectives

Much of the literature on the commute modes of working-age adults have been cross-sectional in nature (Evans et al., 2002; Pendola and Gen, 2007; Handy and Xing, 2011; Hansson et al., 2011; Feng and Boyle, 2014), which presents challenges with understanding the relationship between changes in the commute landscape, such as improvements to transit, and mode choice, and similarly, between mode choice and health. Additionally, most previous research on this topic has been conducted in large metropolitan areas, especially in the USA, where transit improvements are often for higher-order infrastructure such as subways, light-rail transit, and bus rapid transit (Wener et al., 2003; Evans and Wener, 2006; Brown and Werner, 2007; Frank et al., 2007; Kam et al., 2011; Lachapelle and Noland, 2012).

In midsized Canadian cities, like Kingston Ontario, transit improvements are typically more modest, such as the introduction of express routes. Yet, little is known about whether these modest improvements have the capacity to stimulate increased ridership, and whether the positive health outcomes associated with transit ridership that have been observed in larger cities are also observable in smaller cities. Thus, the objectives of this longitudinal study were threefold: to assess whether the introduction of express transit service in Kingston, Ontario, has stimulated greater transit use among a targeted employee group; to document the characteristics of those employees that have shifted to transit; and to examine the physical activity levels of employees using transit compared to other commute modes.

Study site context

The city of Kingston is located roughly equidistant between three major urban centers in Canada (i.e., Toronto, Montreal, and Ottawa) and is home to several large public institution employers (e.g., Royal Military College, Corrections Canada, St. Lawrence College, and Queen's University). Like most cities of its size in North America, Kingston Ontario is an automobile-centric city; the vast majority of households in Kingston commute by car (82%), with active modes accounting for 12% of commute mode share (9.6% walking, 2.4% cycling), and transit accounting for only 4% (SPCK&A, 2009). A major contributor toward Kingston's automobile dependency is its low population density. The city has a population of 123,363 and a population density of 273.4 people/km^2 (Statistics Canada, 2011b). While Kingston is unsurprisingly less dense than Canada's large cities of Toronto (4150 people/ km^2), Montreal (4520 people/ km^2), and Vancouver (5250 people/km^2), it is notably less dense than other cities of similar size. For instance, Burlington, Ontario, has a population of 176 k and density of 947 people/ km^2, while Barrie Ontario has a population of 135 k and density of 1750 people/ km^2.

To help reduce Kingstonians' heavy reliance on private automobiles, the City introduced a Transit Redevelopment Plan for 2011–2015 (Kingston, 2011). The plan centers on making critical improvements to the transit system to increase ridership, including the introduction of three new express transit routes that traverse the most common commuter routes in the city. The first of the three new express routes was introduced in September 2013, and the remaining two were introduced in May 2015 (Fig. 1). Providing more frequent service to Queen's University, situated within Kingston's downtown core, is identified as a top priority in the Plan. In support if the City's effort to promote transit ridership among Queen's employees, the university also introduced an employer-subsidized monthly transit pass in March 2014. These changes to the commuting landscape for Queen's employees offer a prime opportunity to evaluate their impacts on the commuting habits of this targeted employee group.

Methods

Methodology

This study involved an online survey administered at two points in time to the same population of non-student employees working at Queen's University in Kingston, Ontario. The survey captured information about commute patterns in general, and use of public transit in particular, among employees at Queen's University. Ethics approval was granted by the Queen's University General Research Ethics Board in September 2013 and September 2014, in advance of each survey round.

Sampling approach

Since improving transit service to Queen's University was identified as a top priority in the *Kingston Transit Redevelopment Plan* (Kingston, 2011), this study chose to focus on the impacts of transit improvements on the commute patterns of its employees. Queen's is the second largest employer in Kingston (KEDCO, 2014), is located in the city's grid-like downtown core, and is directly served by several public transit routes, including the city's first express transit route. Eligible employees were those living within the geographic area served by Kingston Transit (Fig. 1). This corresponded to postal codes with forward sortation areas of K7K, K7L, K7M, K7N, and K7P.

Survey design and administration

The survey contained primarily closed-ended questions, and took an average of 12 minutes to complete. In both years, information on respondents' commute attributes (including seasonal variations), their household attributes, and their attitudes toward public transit was captured. In 2014, additional questions about health status, physical activity levels, and activity limitations were included. To the extent possible, we incorporated questions from existing Statistics Canada surveys, including the General Social Survey for general questions about commuting (Bechard, 2011), the Canadian Community Health Survey for questions about general health status (Statistics Canada, 2012a), and the Canadian Survey on Disability for questions about activity limitations (Statistics Canada, 2012b). However, the many of the survey questions were specific to the study context and had to be newly developed. For instance, questions about commute mode were context-specific, given the diversity of ways that Queen's employees get to work (e.g., many employees park off-campus and walk for the remainder of the journey), and existing surveys (Bechard, 2011) do not capture these nuances that have important implications for the relationship

Fig. 1. Map of express transit routes in Kingston, Ontario (Kingston, 2011).

between commute mode and health. Similarly, questions pertaining to the influence of the introduction of express transit in Kingston were context-specific. And, while survey instruments do exist that are designed to capture the amount and intensity of physical activity, such as the International Physical Activity (IPA) Questionnaire (Statistics Canada, 2012c), these survey modules tend to be quite lengthy and burdensome to respondents. Since we simply needed respondents to indicate the total amount of physical activity they engage in excluding time spent commuting, we decided to minimize respondent burden and capture this information through fewer questions that we designed using a similar format to those in the IPA. The researchers drew from well-established methodological sources to guide the development of new questions and the overall design of the survey (Salant and Dillman, 1994; Dillman et al., 2008).

The survey was administered online using the web-based platform *FluidSurveys*. To protect respondents' identities, the researchers partnered with Queen's University's Office of Institutional Research and Planning (OIRP), who took responsibility for identifying eligible employees, administering recruitment and follow-up emails, downloading the dataset once the survey was closed, and stripping the dataset of identifying information (e.g., names, email addresses). For the 2013 survey, initial recruitment emails were sent to the entire population of non-student employees at Queen's University (N = 3151), and 1356 completed the survey (response rate = 43.0%). For the 2014 survey, initial recruitment emails were sent to the same population of non-student employees (N = 3392), and 1123 completed the survey (response rate = 33.1%). Both surveys involved two reminder emails to non-respondents 2 weeks following the initial invitation. Of these samples, N = 656 completed the survey in both years, constituting our longitudinal sample, and the focus of this paper.

Statistical analysis

Cross-tabulations and chi-square statistics were generated for analyses of sample characteristics and changes in commute modes over time, and for tests of differences between employees that have versus have not shifted to public transit. Comparisons of physical activity levels by commute mode employed analysis of variance (ANOVA). A 95% level of confidence was the minimum threshold employed for all analyses.

Results

Respondent characteristics

Table 1 summarizes commute variable and socio-demographic characteristics of the longitudinal sample (N = 656). From 2013 to 2014, only one variable changed significantly; the number of respondents reporting having no children under 14 years of age increased from 70% in 2013 to 72% in 2014.

Change in commute mode over time

Commute modes were assigned to one of five general categories. *Exclusively passive* commuters were those employees that drove their own vehicle or carpooled and parked, or were dropped off, on Queen's

Table 1
Characteristics of longitudinal sample, N = 656.

		2013 Sample	2014 Sample
Commute variables	Works 5 days/week	82%	81%
	Flexible hours	44%	47%
	Access to vehicle for commute	88%	88%
	Permit to park at Queen's	38%	39%
	Lives within 5 km of Queen's	45%	45%
Socio-demographic variables	Female	66%	66%
	50 + years of age	49%	52%
	Household income <90 k	35%	33%
	No children < 14 years	70%	72%*

* Statistically significant at 99% confidence level.

Table 2
2014 commute modes, and percent change in mode since 2013, by season and year-round.

	Fall		Winter		Spring		Summer		Year-round	
	% in 2014	% change since 2013	% in 2014	% change since 2013	% in 2014	% change since 2013	% in 2014	% change since 2013	% in 2014	% change since 2013
Exclusively passive	44.4	−0.8	46.9	−1	42.5	−1	41.6	−1.5	40.7	−0.6
Somewhat passive	10.3	−1.5	11.7	−0.9	9.2	−1.3	9.3	−0.9	8.5	−0.7
Transit	11.1	3.5*	14.0	3.9*	9.7	3.4*	9.0	3.1*	8.5	3.0*
Active	34.3	−1.1	27.4	−2	38.6	−1	40.2	−0.6	14.2	−0.7
Varies by season									28.2	−0.9
Total	100	0	100	0	100	0	100	0	100	0

* Statistically significant at 99% confidence level.

campus. *Somewhat passive* commuters were those that drove their own car, or carpooled with others, parked at a location off-campus, and walked to Queen's for the rest of the journey. *Transit* commuters took public transit for the journey to work, while *Active* commuters walked or bicycled for their commute. Finally, employees that did not employ the same commute mode year-round were classified as *Varies by Season* for the year-round commute category.

Table 2 summarizes the 2014 commute modes by season and year-round, along with the changes in commute modes since 2013. On a seasonal and year-round basis, the most common mode was exclusively passive. Transit was the only commute mode for which there was a statistically significant change since 2013, with a 3–4% increase in ridership across the seasons and on a year-round basis. Transit ridership was highest in the winter season, at 14% of mode share.

Characteristics of employees shifting to transit use

Employees that were *shifters* (i.e., those that did not commute by public transit in 2013 but shifted to riding transit in 2014; N = 23) were compared to *non-shifters* (i.e., non-transit riders in both 2013 and 2014; N = 591) on a range of variables (Table 3). Shifters were significantly more likely to be female and report a household income within the lower range for this sample. In terms of commute-related characteristics, shifters had significantly fewer opportunities to support driving to work (e.g., driver's license, car ownership, access to car for commute) and more opportunities to support taking transit (e.g., living near multiple bus stops, having a Kingston Transit pass). In terms of behaviors and attitudes toward transit, shifters responded more favorably to transit service improvements and the introduction of a subsidized bus pass through Queen's, and are more willing to spend at least 30 minutes on Kingston Transit to commute to work. Finally, in 2013, commute satisfaction was lower among shifters compared to non-shifters, whereas in 2014, there was no significant difference in commute satisfaction between shifters and non-shifters.

Table 3
Characteristics of Queen's employees that shifted to commuting by public transit in 2014 compared to those that did not make the shift.

Variable type	Variable	Shifters (N = 23)	Non-shifters (N = 591)	P-value
Socio-demographics	Female	91%	66%	0.036
	50 years of age or under	61%	51%	0.374
	Has one or more children under 14	22%	28%	0.525
	Household income <90 k	73%	30%	<0.001
Commute characteristics	Work hours are flexible	30%	47%	0.114
	Has driver's license	82%	98%	<0.001
	Has access to car for commute	65%	91%	0.001
	Has a Kingston transit pass	83%	4%	<0.001
	Has permit to park at Queen's, 2013	26%	41%	0.165
	Has permit to park at Queen's, 2014	4%	42%	<0.001
Behaviors and attitudes	KT express has increased KT use, 2013	21%	4%	0.001
	KT express has increased KT use, 2014	52%	7%	<0.001
	Bus pass has increased KT use	56%	4%	<0.001
	Willing to spend >30 mins on KT, 2013	35%	9%	<0.001
	Willing to spend >30 mins on KT, 2014	39%	3%	<0.001
	Satisfied with commute, 2013	65%	82%	0.036
	Satisfied with commute, 2014	78%	83%	0.573

Comparisons of physical activity levels by commute mode

The third objective of this study was to examine the physical activity (PA) levels of Queen's employees who use transit compared to other commute modes, captured through self-reported numbers of minutes engaged in both commute-related and non-commute-related PA (Table 4).

Daily commute PA minutes were captured as follows. Active commuter respondents reported the average number of minutes they spend per day walking or cycling one-way to work. For transit commuters, respondents reported on the number of minutes they spend walking to the bus stop from their home and from the bus stop to their place of work at Queen's. For somewhat passive commuters, respondents reported on the number of minutes they spend walking from the place they typically park their car off-campus to their place of work at Queen's. Entirely Passive commuters were not attributed any minutes of commute-related PA. For each case, the one-way daily commute PA minutes were multiplied by two to capture both journeys.

To estimate *weekly commute PA minutes*, the daily commute PA minutes for each respondent was multiplied by the number of days per week they reported typically working at Queen's. For *weekly non-commute PA minutes*, respondents were asked to estimate the total number of minutes per week they typically spend engaged in PA, excluding any PA they accrue through their commute.

Analysis of variance revealed significant differences by commute mode for all assessments of PA minutes. Transit commuters accrued nearly 80 minutes of PA as a result of their commute by transit, over half of the 150 minutes of weekly PA recommended by the Canadian Society for Exercise Physiologists (CSEP) (CSEP, 2012). While transit commuters did not accrue as much combined weekly PA as somewhat passive commuters, they did accrue 50 minutes more combined weekly PA than entirely passive commuters.

Discussion

Examining transit shifting and shifters

The findings from this study revealed that the introduction of express transit service stimulated increased ridership among a longitudinal sample of Queen's University employees; a 3% increase in year-round transit ridership was observed, with the highest shift in ridership occurring in the winter. The increase in transit ridership may be partly attributable to changing household-level characteristics of the sample; the number of respondents reporting not having children under 14

Table 4
Commute and non-commute physical activity levels by year-round commute mode.

Physical activity variable	Entirely passive	Somewhat passive	Transit	Active	*F*	P-value
Daily commute-related PA minutes	N/A	20.7 ± 2.3	16.7 ± 1.4	29.3 ± 1.1	327.19	<0.001
Weekly commute PA minutes	N/A	98.4 ± 11.4	79.2 ± 6.4	140.3 ± 5.8	276.38	<0.001
Weekly non-commute PA minutes	135.1 ± 7.8	141.4 ± 17.2	104.1 ± 13.4	157.2 ± 9.4	2.86	0.036
Weekly combined PA minutes	135.1 ± 7.8	237.4 ± 23.9	183.3 ± 15.5	296.3 ± 10.9	52.56	<0.001

increased significantly over time, suggesting fewer constraints on parents' commute habits, and thus greater opportunity to take public transit to work (Kim and Ulfarsson, 2008).

The comparison of shifters to non-shifters revealed some interesting patterns. Shifters to transit were much less likely to have a driver's license and access to a car to drive to work. This is an important and potentially promising finding, given emerging evidence on declining numbers of younger adults obtaining driver's licenses in Canada (Marzoughi, 2011). The findings also suggest that shifters made purposeful changes to their lives to support their use of transit to commute to work, by relinquishing their Queen's parking permits and by purchasing an employer-subsidized bus pass in 2014. These findings lend support to previous research that has found that workplace policies play important roles in promoting active commuting and employee health (Lachapelle and Frank, 2009; Brockman and Fox, 2011).

In both years, a significantly higher proportion of shifters reported being willing to spend more than 30 minutes on Kingston Transit to get to work, and that the introduction of express transit service increased their use of public transit. These findings suggest not only that shifters have a more positive attitude toward taking public transit, but also that they are amenable to changing their commute habits when services improve. What was particularly noteworthy, however, was that shifting to transit in 2014 led to an increase in commute satisfaction among shifters, suggesting that riding Kingston Transit does not produce dissatisfied commuters. This finding is promising, since research has shown that commute satisfaction is a key determinant of happiness and well-being (Olsson et al., 2013).

Physical activity implications of commute modes

Commute mode choice can dramatically impact the level of PA an individual accrues as part of the journey. Not surprisingly, active commuters in this study (i.e., those that walk or cycle for the entire journey) accrue the highest amount of daily (average 29 minutes) and weekly (average 140 minutes) commute PA minutes and approach the CSEP's recommended amount of PA through their commute habits alone (CSEP, 2012). Somewhat passive commuters (i.e., those that drive, park off-campus, and walk to Queen's campus for the remainder of the journey) also accrued a substantial amount of PA minutes through their commute, which is not surprising since these commuters likely adopt this behaviour in part to save money by not purchasing a Queen's parking permit, but also to incorporate exercise into their daily life. That transit commuters accrue 80 minutes of PA per week through their commute is particularly noteworthy, since it is likely that some of these commuters are opting for transit for reasons other than being physically active, and yet they are accruing more than half of the recommended 150 minutes per week of PA by riding transit.

When asked about non-commute weekly PA minutes, transit commuters reported the fewest number of minutes. Yet, when commute and non-commute PA minutes were combined, transit commuters accrued on average 50 minutes more per week than those that commute to Queen's by entirely passive modes. Thus, these findings corroborate the argument that incorporating physical activity into one's commute can be an effective approach to increasing overall PA levels (Shephard, 2008; Giles-Corti et al., 2010).

Policy implications and directions for future research

Given Kingston's low population density and the challenges that low density presents for creating efficient public transit service and encouraging ridership (Chen et al., 2008), the findings from this study are promising as they suggest that improvements in transit service even in low-density cities can generate the intended effects. Whether the increased ridership among Queen's employees, and among Kingstonians more generally, is actually meeting Kingston Transit's targets is unclear and warrants further investigation.

Given the potential physical activity benefits of shifting from passive commuting to commuting by transit, Kingston Transit could consider partnering with the local public health unit to launch education campaigns to promote transit use among the residents living within the outlying suburbs that are directly served by the express routes (e.g., comparing cost of monthly transit pass to parking permits, relating stop locations within neighbourhoods to number of potential minutes accrued in daily PA). Since several of Kingston's large employers are located at, or near, downtown, and along the express bus routes, such campaigns could result in mode shifts for employees of numerous organizations, and not simply for Queen's.

Non-shifters in this study are much more likely to have a permit to park at Queen's, suggesting this is a key barrier to shifting to transit. Since the cost of a permit to park on-campus is quite high ($90–120/month), once subscribed, it is difficult for the subscriber to justify making the switch to transit. The employer-subsidized bus pass program does appear to have helped stimulate transit use, since the vast majority of shifters did subscribe to this program. However, more work is needed by Queen's to ensure that its parking policies do not undermine the municipality's efforts to promote transit use.

Limitations

There are a few limitations of this study that are worth noting. First, individuals that were particularly interested in the topic of commuting, and in particular those that shifted to transit and wanted to report on their experiences, may have been more likely to complete the survey. If this happened, then the proportion of shifters in the longitudinal sample could be overestimated. This potential for bias was minimized by presenting the survey as one about commute modes and health. It is more likely that transit ridership statistics were underestimated, since the sample possessed a few characteristics that are associated with lower prevalence of transit use, namely living within close proximity to work, being older, and having higher household incomes.

Physical activity levels were determined based on self-reported estimates of number of minutes spent engaged in PA, for both commuting and non-commuting purposes. While the accuracy of these estimates is limited, there is no reason to believe that the level of inaccuracy varies by commute mode, and as such, would have little bearing on the PA analysis. We assumed that the mode of respondents' commutes back home would be the same as their commutes to work (e.g., taking transit to work and back home, walking to work and back home), and that within a given season, respondents would use the same commute mode for every day that they commute to Queen's. Given these assumptions, we multiplied the commute-related PA minutes by two (to capture commute-related PA for the journey home), as well as by the

number of days in a typical week that they go to work (to capture commute-related PA for the week). Since these assumptions may not be correct, our estimates of PA may be biased. Such limitations are typical when attempting to capture PA data from self-administered surveys and can only be overcome (often with much smaller samples) through more objective yet invasive and costly instruments, such as accelerometers. Finally, PA minutes were only captured in 2014, which precluded analyses of changes in PA over time. This same survey will be administered again in 2015, ensuring these analyses can be performed.

Conclusions

This study examined changes in commute patterns over time among employees at a large employer in a low-density Canadian city, following the introduction of express transit service. Differences in physical activity levels by commute mode were also examined, to assess the potential for health improvement if one shifted from exclusively passive commuting to commuting by transit. Most notably, there was statistically significant increase transit use from 2013 to 2014, in every season and year-round, suggesting that the City's improvements to transit service are having their intended effects on one of their priority populations. Compared to non-shifters, transit 'shifters' had fewer household-level opportunities to drive to work and were more amenable to transit-supportive programs and services. And, when compared by commute mode, transit riders accrue more weekly physical activity minutes than exclusively passive commuters. Taken together, these findings suggest that investments in public transit, even in low-density cities like Kingston Ontario, can reduce reliance on automobiles and promote health.

Conflict of Interest

The authors declare that there are no conflicts of interests.

Acknowledgments

This research received internal grant funding from Queen's University. The authors would also like to acknowledge staff at the Office of Institutional Research and Planning at Queen's for their assistance in administering the survey and preparing the data for analysis.

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