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Association of implementation of a public bicycle share program with intention and self-efficacy: The moderating role of socioeconomic status

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Abstract

This natural experiment examines the effect of a public bicycle share program on cognitions and investigates the moderating influence of socioeconomic status on this effect. Two cross-sectional population-based surveys were conducted. Intention and self-efficacy to use the public bicycle share program were assessed by questionnaire. A difference-in-differences approach was adopted using logistic regression analyses. A significant effect of the public bicycle share program was observed on intention (exposure × time; odds ratio = 3.41; 95% confidence interval: 1.50–7.73) and self-efficacy (exposure; odds ratio = 1.61; 95% confidence interval: 1.28–2.01). A positive effect on intention was observed among individuals with low income (exposure × time; odds ratio = 27.85; 95% confidence interval: 2.51–309.25). Implementing a public bicycle share program is associated with increases in intention and self-efficacy for public bicycle share use, although some social inequalities persist.

Keywords

active transportation, built environment, intention and self-efficacy, intervention studies, socioeconomic status

Introduction

Regular participation in physical activity (PA) is associated with health benefits (Bouchard et al., 2007). Unfortunately, only small proportions of the population are physically active enough worldwide (Guthold et al., 2008). In Canada, recent accelerometer data revealed that only 15.4 percent of adults are meeting minimal recommendations for PA (Colley et al., 2011). Given the significant burden of low levels of PA on health and health systems (Lee et al., 2012), promoting this behavior represents an important public health priority (Kohl et al., 2012).

The promotion of active transportation is a promising strategy to increase PA and can be

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achieved by creating supportive environments (Sallis et al., 2006). For instance, increases in the number of transport-related destinations nearby home (supermarkets and bus stops within 800 m of participants' home or train stations and shopping centers within 1600 m of participants' home) experienced following residential relocation were significantly associated with more walking for transportation (Giles-Corti et al., 2013). Similarly, significant increases in cycling and walking were observed after retrofitting a neighborhood with an urban trail (Fitzhugh et al., 2010). Previously, we observed that implementation of a public bicycle share program (PBSP) was associated with increases in the likelihood of cycling among adults living in close proximity to the bicycle docking stations (Fuller et al., 2013). Despite early evidence of positive impacts of built environment interventions on active transportation behaviors, virtually no study has examined the impact of such interventions on psychosocial variables (intention, attitudes, self-efficacy, etc.). Furthermore, little information is available regarding conditions under which and for whom environmental interventions may work best. Knowledge of the processes leading to intervention effects is essential to inform policies aimed at implementing built environment interventions for promoting PA (McCormack and Shiell, 2011).

From a psychosocial perspective, intention and self-efficacy are two proximal factors consistently associated with the adoption of health-related behaviors, including PA (Bauman et al., 2012; Hagger et al., 2002; McEachan et al., 2011). According to the theory of planned behavior (TPB), intention represents the level of motivation of an individual toward the adoption of a given behavior (Ajzen, 1991). Intention is determined by a set of factors (attitude, subjective norm, and perceived behavioral control) that are in turn shaped by different personal characteristics as well as environmental and social contexts. Self-efficacy, a key construct of social cognitive theory (SCT), represents the degree of confidence that an individual has in his/her capacity to perform a given behavior or to overcome barriers (Bandura, 1986). According to SCT, self-efficacy can be modified by different means including vicarious experiences (modeling) and positive personal experiences with the behavior (Fleig et al., 2013). The effect of self-efficacy on goal formation and behavior is in close relationship with socio-structural factors such as the built environment. Hence, given that environmental contexts contribute to shaping cognitions or may interact with these cognitions in influencing behavioral performance, the first aim of this study was to examine the impact of an environmental intervention (implementing a PBSP) on intention and self-efficacy for using a newly implemented PBSP.

Another major public health issue is social inequalities in health (Lynch et al., 2000). A systematic review shows that individuals with the highest socioeconomic status (SES) were consistently more physically active when compared to individuals with the lowest SES (Gidlow et al., 2006). In order to reduce social inequalities in health, Lorenc et al. (2013) highlighted that "upstream" interventions such as changing the structural environment or implementing public policies for health are more likely to be successful. However, as mentioned by these authors, conclusions of their review were "tentative and provisional," and more research is required to investigate the effect of built environment interventions according to SES. Thus, the second aim of the study was to examine whether or not the environmental change of interest (PBSP implementation) influences the level of intention and self-efficacy among populations of different SES. In this analysis, education and income were used as individual-level indicators of SES (Galobardes et al., 2006).

Methods

Design and sample

This study is a secondary analysis of data from a larger natural experiment aimed at ascertaining the impact of implementing a PBSP (BIXI, for BIcyle-taXI) in Montréal, Canada, on

cycling behavior (Fuller et al., 2011; Fuller et al., 2013). The BIXI program was first implemented during the spring of 2009 in central and urbanized areas of the city. Given the Nordic climate of Montréal, this program runs from April to November and is discontinued during the winter months. For this analysis, data from two repeated independent cross-sectional random-digit dialing telephone surveys conducted in the falls of 2009 (T_1) and 2010 (T_2) were used. These two survey periods refer to the end of the first (fall 2009; 6 months post-implementation) and the second (fall 2010; 18 months post-implementation) seasons of the PBSP implementation. The response rates were 34.6 and 35.7 percent for T_1 and T_2, respectively. Full details of the study procedures are described elsewhere (Fuller et al., 2012; Fuller et al., 2011; Fuller et al., 2013). We elected to not include data from the baseline survey because insufficient proportions of the population were aware of the new amenity before its implementation and thus plausibly could not have formed clear intentions and self-efficacy in relation to it. The study population was adults living on the Island of Montréal and inclusion criteria were being aged 18 years or older and having a landline telephone. Because cycling is a rare phenomenon, individuals living in close proximity to PBSP docking stations were oversampled to ensure adequate statistical power.

To examine the effect of implementing the PBSP on intention and self-efficacy, respondents who already cycled for utilitarian purpose with their own bicycle or a bicycle from the PBSP at T_1 were excluded from these analyses ($n=156$). These active commuters were not included in the sub-sample because they were expected to show high levels of intention and self-efficacy toward active transportation and/or the use of the PBSP. Also, since older adults are more likely to be retirees and thus not expected to be active commuters to work, respondents aged 65 years and older ($n=877$) were also excluded from these analyses. The final sub-sample included 3978 respondents. The study was approved by the Ethics Committee of the Centre Hospitalier de l'Université de Montréal (CHUM), and all participants provided verbal consent prior to participation.

Measures

Although numerous variables were assessed with this study questionnaire, only measures of intention and self-efficacy were retained in this analysis because of the focus on cognitions. Intention was assessed with the following item: "To what extent do you have the intention to change your usual mode of transportation in favor of using BIXI bicycles in the next year?" Responses were obtained on a 4-point scale ranging from not at all (1) to definitively (4). Perceived self-efficacy was also assessed with one item "How confident are you in your capability of using BIXI if you chose to do so?" and was evaluated by a 4-point scale ranging from not at all confident (1) to completely confident (4). No neutral choice was provided to force participants to side one way or the other. Previous studies have shown adequate reliability for single items assessing similar cognitions in large telephone-based surveys (Godin et al., 1987, 1993; Valois et al., 1992).

Data analysis

To examine the impact of the PBSP on developing strong positive predispositions toward future use of this public amenity, the two dependent variables were dichotomized as being definitively motivated toward the use of the PBSP and completely self-confident (the highest score on the Likert-type scale (1) versus the other scores (0)). The independent variables were the survey periods (T_1 and T_2), residential exposure to the PBSP docking stations (living within a 500-m road network buffer from a bicycle docking station; see Fuller et al. (2013) for the full description of residential exposure), and the interaction between survey periods and residential exposure. Because the PBSP was implemented throughout the city by a private agency at strategic business points, no control group could be formed. Hence, to examine the effect of this type of programs conducted in a

natural setting, difference-in-differences (DD) analysis was more suitable (Meyer, 1995). This analysis allows for the estimation of the impact of an intervention, taking into consideration the natural variations that might be observed among the overall population during the implementation of the intervention. This analysis allowed us to examine whether or not cognitions evolved 1 and 2 years following implementation of the PBSP and whether any changes observed among respondents differed as a function of residential proximity to the bicycle docking stations. Hence, separate DD analyses were performed for each outcome using hierarchical logistic regression to compare the proportions of respondents exposed or not to the PBSP who had strong intention and self-efficacy. The inclusion of survey periods served as a control for natural trends that might naturally occur in the population. Furthermore, analyses controlled for variables that might have changed over time (see the "Results" section).

Four-step hierarchical logistic regression analyses were conducted to test the impact of the PBSP on cognitions. In step 1, the effect of survey periods was entered. In step 2, the effect of exposure to the PBSP was tested. The interaction effect was entered in the third step, and finally, models were adjusted with covariates in step 4. Covariates included age, sex, education, annual household income, and the use of the PBSP. Since respondents with access to motorized vehicles may be more reluctant to shift from motorized to active commuting, the potential confounding effect of this variable was examined.

The impact of implementing the PBSP on intention and self-efficacy according to the SES status was examined in a second set of stratified analyses to compare the most deprived respondents with other respondents in terms of income and education. For income, those in the lowest household income category (<CDN$20,000) were compared to those having moderate-to-high household income (≥CDN$20,000). For education, those with the lowest level of education (high school or less) were compared to those with a moderate-to-high level of education (trade school, college, and university degrees). These stratified hierarchical logistic regression analyses were conducted following the procedure described above; step 1: survey periods, step 2: residential exposure to the PBSP docking stations, and step 3: the interaction term (survey periods × exposure). Finally, these analyses were controlled for age, sex, the use of the PBSP, and having access to motorized vehicle.

All analyses were performed among the largest sample sizes available (with no missing data); *t*-tests and chi-square analyses revealed that respondents with at least one missing value had significantly different socio-demographic characteristics when compared to those who provided complete data; those having missing values were more likely to be women ($p = .007$) and had lower household income ($p = .009$) and education ($p < .0001$). Also, these two samples differed significantly on their level of self-efficacy: a smaller proportion of the respondents with missing data were highly confident ($p < .0001$). When results of logistic analyses differed between samples with and without complete data, results for both samples were reported. Analyses were conducted using SAS 9.3 statistical software (SAS Institute Inc., Cary, NC, USA).

Results

Descriptive statistics

The socio-demographic characteristics of the sample appear in Table 1. The two survey cohorts did not differ significantly on income, but were significantly different for sex, education, and the use of the PBSP (see Table 1). This latter variable was assessed by the following item: "Have you ever used the PBSP?" and dichotomized as yes or no. Analyses were all controlled for these latter variables when applicable. Only a small proportion of respondents had a strong intention to change their usual modes of transportation in favor of using the PBSP (4.6% at T_1 and 4.5% at T_2). Lower prevalence of having strong intentions

Table 1. Socio-demographic characteristics of 3978 survey respondents in Montréal, Canada, in 2009 and 2010.

Variables	T_1 (n = 1929)	T_2 (n = 2049)	
	Mean (SD)		t-test (p value)
Age (years)	42.3 (12.7)	43.0 (12.8)	−1.7 (.09)
	N (%)		χ^2 (p value)
Use of the PBSP	116 (6.0)	227 (11.1)	32.4 (<.0001)
Sex (female)	1210 (62.8)	1189 (58.1)	9.2 (.002)
Education			
High school or less	461 (24.3)	391 (19.5)	14.0 (.003)
Trade school	113 (6.0)	115 (5.7)	
College degree	310 (16.3)	351 (17.5)	
University degree	1014 (53.4)	1153 (57.4)	
Household income (CDN$)			
<20,000	231 (15.3)	257 (15.7)	2.4 (.50)
⩾20,000 and <50,000	558 (36.9)	564 (34.5)	
⩾50,000 and <100,000	473 (31.3)	519 (31.7)	
⩾100,000	251 (16.6)	295 (18.0)	

PBSP: public bicycle share program.

was observed for respondents with the lowest level of education (3.0%) when compared to respondents with moderate-to-high education (5.0%: $\chi^2(N=3837)=5.7, p=.02$). Interestingly, higher prevalence of strong intentions was observed among respondents with the lowest household income (6.5%) when compared to those with moderate-to-high income (4.2%: $\chi^2(N=3094)=5.1, p=.02$). Over half of the respondents were completely self-confident in their capabilities to use the PBSP (51.8% at T_1 and 57.1% at T_2). Significant differences in the prevalence of high self-efficacy were observed between respondents showing the lowest household income (49.8%) and level of education (36.9%) when compared to those with moderate-to-high income (57.9%: $\chi^2(N=3066)=10.8$, $p=.001$) and education (59.7%: $\chi^2(N=3792)=133.8, p<.0001$).

Impact of implementing the PBSP on cognitions

The complete results of the DD analyses for intention and self-efficacy are presented in Table 2. In the fully adjusted models, a significant interaction effect for survey period by residential exposure was observed on intention (odds ratio (OR) = 2.8; 95% confidence interval (CI): 1.2–6.4), indicating that respondents exposed to the bicycle docking stations at T_2 were more likely to have higher intention when compared to respondents not exposed after the end of the first season. Regarding self-efficacy, significant main effects of residential exposure (OR = 1.5; 95% CI: 1.2–1.9) and survey periods (OR = 1.3; 95% CI: 1.0–1.6) were observed: the likelihood of having high self-efficacy regarding the use of the PBSP increased across survey periods among the overall sample, although those who were exposed to the PBSP docking stations in their residential neighborhood were more likely to have high self-efficacy when compared to those not exposed.

Effect modification of SES position on intention

Income. Among respondents with the lowest level of household income, a significant interaction effect (OR = 28.0; 95% CI: 2.4–330.9) was observed in the fully adjusted model

Table 2. The effects of survey period, exposure to PBSP, and their interaction on intention and self-efficacy among survey respondents in Montréal, Canada in 2009 and 2010.

Variables	Step 1	Step 2	Step 3	Step 4[a]
	OR (95% CI)			
Intention ($n = 3901$)[b]				
Time 1 (Ref)	1.0	1.0	1.0	1.0
Time 2	1.0 (0.7–1.3)	1.0 (0.7–1.3)	0.5 (0.3–0.9)*	0.4 (0.2–0.8)*
Not exposed (Ref)		1.0	1.0	1.0
Exposed		2.6 (1.8–3.6)***	1.6 (1.0–2.6)*	1.1 (0.7–2.0)
Time 1 × not exposed (Ref)			1.0	1.0
Time 2 × exposure			2.6 (1.3–5.2)**	2.8 (1.2–6.4)*
Self-efficacy ($n = 3854$)[b]				
Time 1 (Ref)	1.0	1.0	1.0	1.0
Time 2	1.2 (1.1–1.4)**	1.2 (1.1–1.4)**	1.2 (1.0–1.5)*	1.3 (1.0–1.6)*
Not exposed (Ref)		1.0	1.0	1.0
Exposed		1.7 (1.5–2.0)***	1.8 (1.5–2.1)***	1.5 (1.2–1.9)***
Time 1 × not exposed (Ref)			1.0	1.0
Time 2 × exposure			1.0 (0.7–1.3)	0.9 (0.7–1.2)

CI: confidence interval; OR: odds ratio; PBSP: public bicycle share program.
[a]Models were controlled with age, sex, household income, education, having access to motorized vehicles, and having used the PBSP at least once.
[b]Results were similar when performing the analyses among the sample with complete data on all variables ($n = 2899$).
*$p < .05$, **$p < .01$, ***$p < .001$.

(Supplemental File 1). We note the large CIs due to low prevalence of strong intention and smaller sample size among the lower income group. Among respondents reporting moderate-to-high household income, no main effects of survey period (OR = 0.5; 95% CI: 0.2–1.0), residential exposure (OR = 1.3; 95% CI: 0.7–2.4), and interaction effect (OR = 1.7; 95% CI: 0.7–4.1) were observed.

Education. For respondents having the lowest level of education, no main effects of survey period (OR = 0.4; 95% CI: 0.1–1.7) and residential exposure (OR = 0.5; 95% CI: 0.1–2.2) nor interaction effect (OR = 5.9; 95% CI: 0.6–42.3) was observed on intention. A significant interaction effect was observed among respondents with a moderate-to-high level of education (OR = 2.4; 95% CI: 1.1–5.2), although this effect was attenuated when controlling for confounders (OR = 2.1; 95% CI: 0.9–4.6).

Effect modification of SES position on self-efficacy

Income. The results of the full hierarchical models for self-efficacy are presented in Supplemental File 2. For respondents having the lowest household income, no significant main effects of time (OR = 1.1; 95% CI: 0.6–1.9) and residential exposure (OR = 1.3; 95% CI: 0.7–2.3) were observed on self-efficacy in the fully adjusted models, as well as no significant interaction effect (OR = 1.2; 95% CI: 0.6–2.7). Among respondents reporting moderate-to-high household income, significant main effects of survey periods (OR = 1.3; 95% CI: 1.1–1.7) and exposure (OR = 1.7; 95% CI: 1.4–2.2) were observed but no interaction effect was found (OR = 0.8; 95% CI: 0.6–1.2).

Education. For respondents having the lowest level of education, no significant effects of survey periods (OR = 1.0; 95% CI: 0.7–1.5) and residential exposure (OR = 1.2; 95% CI: 0.8–1.8)

as well as no interaction effect (OR = 0.9; 95% CI: 0.5–1.8) were observed on self-efficacy. Significant main effects of time (OR = 1.2; 95% CI: 1.0–1.5) and residential exposure (OR = 1.7; 95% CI: 1.3–2.1) were observed among respondents with moderate-to-high level of education. The interaction term was not significant (OR = 0.9; 95% CI: 0.7–1.2).

Discussion

The findings of this study showed that strong intentions to use the PBSP as an alternative mode of transportation were not highly prevalent in the population. Nevertheless, strong intentions to use the newly implemented PBSP became more likely among people living in close proximity to the bicycle docking stations at the end of the second season. However, the proportion of respondents having strong intentions was by no means dominant, suggesting that the implementation of the PBSP was not necessarily accompanied by widespread changes in intention among the population. This result may support the need to implement motivational interventions alongside structural modifications to the built environment to increase intention to adopt this innovation. Bird et al. (2013) recently suggested the inclusion of behavior change techniques such as "intention formation" into interventions aimed at promoting walking and cycling. Although not addressing active transportation directly, some intervention studies in mobility management indicated substantial decreases in car use after implementing motivational interventions such as "travel feedback programs" or "personal travel planning" programs (Fujii and Taniguchi, 2006; Richter et al., 2011).

Regarding self-efficacy, a different pattern of effects emerged; about half of the population was completely self-confident in their capacity to use the PBSP. Moreover, the likelihood of having high self-efficacy increased among the overall population from the end of the first to the end of the second season of the PBSP implementation and was even more likely among people living in close proximity to the bicycle docking stations. Although additional barriers to cycling for transportation might have to be overcome (safety concerns, time, personal skills, end of trip facilities, etc.) (Bauman et al., 2009), this result suggests that exposure to a PBSP might represent one effective way of supporting the development of higher self-efficacy toward the use of this new amenity among populations (Krizek et al., 2009).

Although a precise explanation of the overall effect of the PBSP on cognitions among respondents living in close proximity of the bicycle docking stations remains elusive, this result is in line with theoretical proposals regarding the influence of environmental features on cognitions. According to TPB, it could be hypothesized that implementing the PBSP in different neighborhoods favors the development of more positive attitudes or perceived behavioral control among individuals exposed to the bicycle docking stations and ultimately increases the level of intention. It can also be hypothesized, according to SCT, that the significant effect of the PBSP on self-efficacy be explained through the influence of modeling; individuals living in closer proximity of the PBSP had the opportunity to observe other residents using the service that in turn might result in increased self-efficacy. Obviously, these theoretical hypotheses would require additional planned testing in future studies. To our knowledge, only one study examined the association between built environment interventions, cognitions, and active transportation behaviors using an experimental design (Giles-Corti et al., 2013). Contrary to the theoretical proposals discussed above, these authors reported, however, a significant direct effect of the built environment on walking for transportation after residential relocation. However, these results were observed for walking and may not apply to cycling.

In this study, different patterns of change in cognitions across time and as a function of residential proximity emerged according to SES. One of the findings of this study is the positive and significant interaction effect of survey periods by exposure on intention among respondents with the lowest household income. This (exploratory) result should, however, be

interpreted cautiously given the low prevalence of strong intentions, the small sample size in the lowest category of income, and corresponding large CIs obtained (Supplementary File 1). Nevertheless, this specific observation is in line with the suggestion that environmental interventions might support the reduction of social inequalities in health, although the overall pattern of results suggests persistent inequalities (Lorenc et al., 2013). Indeed, respondents among the other highest SES categories were consistently more likely to be highly motivated and self-confident, highlighting the persistence of inequalities in health and the challenge to reach low-SES populations. Moreover, the intention–behavior relationship tends to be weaker among individuals having low SES, suggesting that increasing intention among more deprived populations might not be sufficient to favor the adoption of an active lifestyle (Conner et al., 2013). Although a number of studies showed that intention may represent a necessary condition for behavioral performance, increasing intention will not necessarily lead to the adoption of a given behavior or the development of strong habits (Sniehotta, 2009). Hence, the implementation of PBSPs to promote active transportation among low-SES populations might benefit from additional self-regulatory interventions that could support the enactment of intentions into action (implementation intentions or action plans) (Gollwitzer, 1999; Sniehotta et al., 2005).

Some limitations should be acknowledged. First, this study was a secondary analysis of a larger study not specifically designed to investigate the impact of an environmental intervention on cognitions. Hence, this study was exploratory in nature. However, the mechanisms by which environmental interventions operate in natural settings have been understudied, and this preliminary analysis allowed for the identification of some interesting avenues of investigation for future studies, particularly among low-SES populations. Other limitations of this study are related to the measurement of cognitions with single items and the particularity of the items used. The measure of intention was very specific; respondents were asked about their intention to *change* their usual mode of transportation in favor of using the PBSP. Consequently, it cannot be excluded that respondents highly motivated to use the PBSP as an occasional alternative to their usual mode of transportation were not motivated to change their overall mode of transportation in favor of using exclusively the PBSP. Also, it is noteworthy that the measure of self-efficacy expressed the perceived capability of respondents. Finally, self-selection and response bias remained important issues when examining the effect of environmental characteristics on behavior at the population level. However, results remained similar when controlling for the number of street intersections near the residence (density) and when performing the analyses among respondents with complete data (data not shown), suggesting no major threat to the generalizability of the present findings. This study also has additional strengths. Among others, this is, to our knowledge, the first study that investigated the effect of an environmental intervention on psychosocial mediators using a rigorous evaluation design for natural experiments. Moreover, this study provides useful information regarding the effect of implementing the PBSP on the levels of intention and self-efficacy among the population and the potential contribution of such programs to address the burden of physical inactivity among individuals showing different SES.

To conclude, this study showed that strong intentions to use the newly implemented PBSP were not highly prevalent among the population. The positive effects of this environmental intervention on intention were generally more likely to occur among individuals living in close proximity to the bicycle docking stations. In the same way, respondents living in a closer proximity of the PBSP were more likely to have higher self-efficacy when compared to respondents not exposed. More importantly, these findings highlighted the persistence of social inequalities in health, although some positive effects of the PBSP on intention were observed among individuals with low income and living in close proximity of the bicycle docking stations.

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