IDENTIFYING THE LEADERS: APPLYING DIFFUSION OF INNOVATION THEORY TO USE OF A PUBLIC BIKE SHARE SYSTEM IN VANCOUVER, BC

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ABSTRACT

Public bike share programs are growing in popularity globally with increasing recognition of their potential and accrued benefits for mobility, health, and the environment. Any city planning to launch a program will be keenly interested in understanding who may use it in order to enable strategic marketing that will facilitate quick uptake and adoption. We applied the Diffusion of Innovation Theory to data from a population-based telephone survey to characterize who is most likely to use a new public bike share program based on self-reported likelihood. The telephone survey of 901 Vancouver residents was conducted prior to the launch of Vancouver's public bike share program. Results showed that a majority (n=614/901, 69.1%, 95% CI: 66.3%/72.7%) of respondents thought that public bike share was a good idea, however, only a quarter (n=217/901, 24.2%, 95% CI: 21.1%, 27.3%) said they would be either likely or very likely to use the program. Logistic regression identified characteristics associated with greater and lower likelihood of use. These characteristics were used to create an adoption curve that defines population segments anticipated to be the leaders in adopting the program. The theory was used to develop implementation recommendations to maximize program uptake including ensuring that the program has tangible advantages over driving or transit, is affordable and easy to try out, integrates with transit and car share opportunities, and appeals to social trends such as environmental responsibility. These results can assist planning and promotion in cities set to launch public bike share programs.

INTRODUCTION

Rapidly rising rates of chronic diseases attributable in part to sedentary lifestyles combined with pressure to reduce greenhouse gas emissions have contributed to a piqued interest in shifting from car-dominated to more sustainable and active modes of transportation (*1-3*). In urban areas, a majority of trips are under 10 km, and travelling these distances by bicycle instead of motorized modes provides opportunities for people to incorporate physical activity into daily activities to support their health while contributing to more environmentally sustainable transportation practices (*4-8*).

Public bike share programs are one initiative that can support opportunities to incorporate cycling trips into everyday activities. Public bike share programs provide a network of standardized bicycles distributed throughout an urban area at self-service locked docking stations (*9*). They are designed to allow users to make short one-way and round-trips and are positioned and priced to best facilitate utilitarian travel (trips 1-5 km or less than 30 minutes) (*9; 10*). These bicycles support "first-and-last-mile" portions of a multi-modal trips common in urban centres—providing easier connections to public transit, faster alternatives to walking, and efficient alternatives to driving (*9*). These programs lessen the costs and responsibility associated with owning, storing, parking, and maintaining a personal bicycle (*11*) . This makes utilitarian cycling more attainable for people who may not typically bicycle (*11*) as well as those otherwise unable to afford or operate a car or personal bicycle (e.g., people with low incomes, young adults, and seniors) (*9; 12; 13*). Public bike share programs may also increase social acceptance of cycling as a form of transportation (*11*), encourage improved cycling infrastructure, ameliorate negative attitudes towards cyclists by motorists (*14*), and possibly increase cycling (*15; 16*). Evidence to date suggests that existing bike share users are more likely young, have higher education (and sometimes higher income) compared to the general population, and are more likely to reside in close to bike share locations (*6; 17; 18*). Some studies have found that men are more likely to use bike share (*6; 17; 18*), while others have reported similar usage between sex (*19; 20*). This evidence focuses on bike share use, but here has been virtually no evidence on the diffusion of a bike share program within a city.

In the past decade, increasing urbanization coupled with fast-improving technology and demand for alternative transportation have contributed to a rapid global growth of bike share programs, particularly in Europe, Asia, and recently North America (*5; 6*). As of 2013, there were an estimated 500 public bike share schemes in 51 countries (*21*).

In acknowledgement of the growing body of evidence supporting the benefits of public bike share programs (*9; 15; 16; 22*) and with the knowledge that bicycling is the fastest growing mode of transportation in the jurisdiction (*23*), the City of Vancouver (BC, Canada) is planning to launch a public bike share program in Spring 2014 (*23*), with 1,500 bicycles at 125 docking stations across the downtown and business core of the city. In addition, to align with BC's all-ages mandatory helmet law, the City plans to provide well maintained, clean, and affordable rental helmets from vending machines incorporated in the system (*23*). The long period of planning this program provides an opportunity to explore local readiness to adopt the program and overall assess the potential of the program to influence transportation and physical activity patterns of the local population.

The purpose of this paper is to describe Vancouver residents' self-reported readiness to adopt a public bike share program through analysis of survey data collected prior to the public bike share program implementation. The goal of this analysis is to provide a description of Vancouver residents most and least interested in considering use of a bike share. We applied Diffusion of Innovation theory (*24*) to estimate a predicted adoption curve which defines population segments anticipated to be the leaders in adopting the program. Diffusion of Innovation theory addresses how new ideas, products, practices or

behaviours (i.e., innovations) are spread successfully within a group (*24*). Central to the theory is a focus on peer networks and understanding the dispositions and needs of different user segments. The theory has been used to inform social marketing approaches to diffuse socially beneficial technology or knowledge (i.e., the innovation) that have perceived costs (e.g., time, effort, discomfort, money) for some benefit (e.g., health, fitness, environmental protection). The theory suggests that populations adopt innovations along a bell-shaped curve over time - only a few at the beginning, a majority later, and some much later or never. The theory has recently been applied to look at the spread of public bike share programs across Europe and North America, with a focus on city and organizational characteristics (*25*). This paper is complementary, applying the theory to look at uptake within a city. Any city launching a new public bike share is keen to know which population segments are the most likely to use a program. The integration of Diffusion of Innovation theory can help to develop better understanding the mechanisms which will best facilitate uptake and integration of public bike share by individuals, populations, and society at large, and to formulate appropriate recommendations for marketing.

METHODOLOGY

Survey

The City of Vancouver has a population of 603,500 people and is the highest density municipality in Canada (Statistics Canada, 2011). The downtown and business centre where the public bike share program is to be rolled out is home to over 130,000 residents, and employs over 207,000 people, the vast majority of whom commute from elsewhere. We designed a population-based telephone survey of City of Vancouver residents (aged ≥16 years) which was conducted in September and October 2012 and implemented by a market research company. The sampling used random-digit dialing and incorporated both land-line and cell phone samples (n=810, 90.2% and n=88, 9.8% respectively), with age- and sex-based quotas. The survey included 41 questions covering information on transportation in the previous two days, physical activity patterns, cycling patterns, helmet use, knowledge and perceptions of the proposed public bike share, and individual and household demographics. The survey protocol was approved by the Research Ethics Board at Simon Fraser University (certificate: 2012s0286).

Variables

Dependent Variable

The likelihood of using public bike share was determined from the survey question: “On a scale of 1 to 5, where 1 is a very unlikely and 5 very likely, how likely would you be to use the Vancouver bike share program, given that cost and station locations are accessible to you?” The Likert scale was collapsed into two categories for logistics regression analyses: “likely to use” (responses: very likely, somewhat likely, and neither likely nor unlikely) and “not likely to use” (somewhat unlikely and very unlikely). The neutral category (neither likely nor unlikely) was included in the “likely” category as these neutral respondents were thought to not be opposed to using a public bike share, and thus a potential market for convincing to use the system. Furthermore, we found that when we ran post-hoc analyses on the where we included this neutral segment with the “unlikely”, we found virtually the same results, indicating that these results are robust to the categorization of neutral responses.

Independent Variables

Independent variables were: individual demographics (sex, age, education, and occupation); household demographics (household income for 2011, household size, having children at home, home location within public bike share program proposed zone as determined by reported postal code or nearest intersection); transportation access (having a driver's license, having access to a car, being a car share member, number of cars in household, number of bikes in household); reported travel behaviour (use of car, transit, walking, or cycling in prior two days); cyclist type; and knowledge and perceptions of public bike share programs. The reported travel behavior variables were based on the prompted recall travel diaries, where participants reported all trips in the two days prior to the interview. If participants made any trip by a given mode they were categorized as a user (1), otherwise a non-user (0). Each variable is independent, i.e., if a participant made trips by each of the 4 modes they would be classified as a user for each mode variable. Cyclist type was based on self-reported cycling, reported seasonally. "Cyclists" were defined as those who had cycled in the last 12 months; "potential cyclists" as those who indicated that although they had not cycled in the past 12 months, they would consider cycling in the future. All other participants were considered as "non-cyclists". Categories for variables appear in Table 1.

Statistical Analysis

Analyses were completed in SAS 9.3 (SAS Institute Inc. 2011, Cary, NC), weighted by age and sex to represent the Vancouver population 16 years or older. Logistic regression was used to estimate the associations between the outcome variable (likelihood to use the Vancouver public bike share program) and each independent variable. Variables associated with the dependent variable at a significance level of $p<0.1$ in bivariate analysis were offered in multiple logistic regression, and backward stepwise regression was used to identify a parsimonious model which included variables that remained significant ($p<0.05$) after adjustment for other variables, as well as demographic variables typically associated with cycling (sex, age, education, and occupation), even if not significant.

Application of Diffusion of Innovation Theory Based on Survey Findings

We applied the Diffusion of Innovation (*24*) theory to estimate a theoretical adoption curve for the planned public bike share program, describing three main segments of the survey population by their likelihood to use the program: 1) the leaders, 2) the majority and 3) the resisters. This process was guided by the empirical analysis, which was used to identify characteristics that were associated with greater and lower likelihood of using the program. Our primary emphasis was on the leaders (innovators and early adopters) as these are a key group for successful implementation, and a group that can be identified by high a likelihood of adoption in the logistic regression models. After early implementation it may be warranted to focus on identifying differences between the majority and the resistors in order to refine marketing for mainstream uptake. To conclude, we applied five concepts developed within Diffusion of Innovation theory (relative advantage, compatibility, simplicity, trialability, and observability) to synthesize recommendations for improving uptake of the program during early implementation.

RESULTS

Descriptive Findings

In total, 901 Vancouver residents completed the survey with a response rate of 10.4% (proportion of all numbers called, n=9018658) and cooperation rate of 18.7% (proportion of known eligible numbers called,

n=901/4816), based on market research standard definitions. Table 1 provides characteristics of survey respondents. The mean age was 44.3 years (range 16-88). Over the two days of the travel diary, 65.5% of respondents indicated having made at least one driving trip, 38.5% made at least one walking trip, 31.4% had used transit, and 10.5% made at least one cycling trip. Just over half (n=472, 52.4%) of the participants had used a bicycle in the last 12 months ("cyclists"). An additional 19.6% (n=177) indicated that although they had not cycled in the past 12 months, they would consider cycling in the future ("potential cyclists"). Of those that indicated cycling, most were regular cyclists (n=206/472, 43.6%), cycling on average at least once a week, and throughout most of the year regardless of season (n=175/472, 37.1% cycled three seasons and another n=182/472, 38.5% cycled year round).

TABLE 1 Characteristics of 901 Vancouver residents responding to a telephone survey in September and October 2012

Characteristic		n (weighted %)
Sex		
	Male	463 (51.5)
	Female	437 (48.5)
Age		
	16-24 years	116 (12.9)
	25-34 years	193 (21.4)
	35-44 years	164 (18.2)
	45-54 years	160 (17.7)
	55-64 years	128 (14.2)
	65+ years	140 (15.6)
Education		
	High school or less	147 (16.3)
	Post-secondary	477 (53.0)
	Graduate post-secondary	278 (30.9)
Occupational Status (n=900)		
	Works full time	426 (47.3)
	Works part time	131 (14.5)
	Student	115 (12.7)
	Does not work	126 (14.0)
	Retired	103 (11.4)
Income (n=706)		
	<$35,000	143 (15.9)
	$35,000-$74,999	213 (23.7)
	$75,000 +	339 (37.6)
	missing	206 (22.9)
# Household members		
	1 (lives alone)	201 (22.3)
	2	273 (30.3)
	3+	428 (47.5)
Has children living at home		
	Yes	291 (32.3)
	No	610 (67.7)
Home location in proposed bike share zone (N=897)		
	Yes	138 (15.7)
	No	739 (84.3)

Table continued on next page)

***TABLE 1 continued*… Characteristics of 901 Vancouver residents responding to a telephone survey in September and October 2012**

Characteristic		n (weighted %)
Has driver's license		
	Yes	784 (87.0)
	No	117 (13.0)
Has access to a car		
	Yes	714 (79.2)
	No	187 (20.8)
Car share member (n= 898)		
	Yes	88 (9.8)
	No	810 (90.2)
# Cars per household		
	0	167 (18.5)
	1	374 (41.5)
	2+	360 (40.0)
# Bicycles per household		
	0	217 (24.1)
	1	191 (21.2)
	2+	492 (54.6)
Has used a car in the last 2 days		
	Yes	590 (65.6)
	No	308 (34.4)
Has used transit in the last 2 days		
	Yes	281 (31.3)
	No	617 (68.7)
Has walked in the last 2 days		
	Yes	346 (38.5)
	No	552 (61.5)
Has cycled in the last 2 days		
	Yes	94 (10.5)
	No	804 (89.5)
Cyclist type		
	Non-cyclist	472 (52.3)
	Potential Cyclist	177 (19.7)
	Cyclist	252 (28.0)

Reported perceptions of cycling and public bike share are in Table 2. Most felt that cycling was somewhat or very safe in Vancouver (62.5%, 95% CI: 59.1, 66.0). Nearly two-thirds (n=567, 63.0%, 95% CI: 60.0, 66.9) had heard of a public bike share program before. The vast majority thought a public bike share was either a very good idea (44.5%, 95% CI: 41.0, 48.0) or a good idea (25.5%, 95% CI: 21.9, 28.1); however, far fewer said they would use the program if the cost and station locations were accessible to them (very likely to use: 12.6%, 95% CI: 10.1, 15.0; likely to use: 11.7%, 95% CI: 9.3, 14.0).

Table 2 Weighted perceptions related to cycling and public bikeshare from 901 Vancouver residents responding to a telephone survey in September and October 2012

Question		% responses	95% CI
Perceived safety of cycling in Vancouver (n=862)			
	Somewhat/ very safe	62.5	59.1, 66.0
	Neither safe nor unsafe	9.1	6.9, 11.2
	Somewhat/ very dangerous	28.4	25.2, 31.5
Heard of public bike share program (in any city) (n=895)			
	Yes	63.0	60.0, 66.9
	No	36.3	33.1, 40.0
Perception of public bike share in Vancouver (n=878)			
	Very good idea	44.5	41.0, 48.0
	Good idea	25.5	21.9, 28.1
	Neutral	15.8	13.3, 18.4
	Bad idea	7.0	5.3, 8.7
	Very bad idea	7.7	5.9, 9.4
Likelihood of using the program			
	Very likely	12.6	10.1, 15.0
	Somewhat likely	11.7	9.3, 14.0
	Neutral	14.9	12.3, 17.5
	Somewhat unlikely	15.0	12.5, 17.6
	Very unlikely	45.8	42.4, 49.3

Factors associated with likelihood of bike share use

Table 3 shows the results of the logistic regression models. In unadjusted models, demographic variables that were significantly ($p<0.05$) associated with greater likelihood of using the program included being a student (odds ratio (OR) = 2.68, 95% CI: 1.75, 4.01) and having a household income of $35,000-$74,999 (OR = 1.55, 95% CI: 1.04, 2.30). Significant transportation-related variables were having car share membership (OR = 1.94, 95% CI: 1.25,3.02), having walked in the previous two days(OR = 1.38, 95% CI: 1.05,1.82), having used transit in the previous two days (OR = 2.10, 95% CI: 1.58,2.80), being a potential cyclist (OR = 11.39, 95% CI: 6.98,18.60), or a current cyclist (OR = 6.66, 95% CI: 4.34,10.21). Also, thinking that cycling was safe (OR = 2.17, 95% CI: 1.57, 3.01) and thinking that the program was a neutral (OR = 6.73, 95% CI: 2.82,16.02) or good/very good idea (OR = 18.47, 95% CI: 8.31,41.04) was associated with a greater likelihood of using the program. Being older was associated with lower likelihood of using the public bike share program, with a consistent decline in OR in higher age brackets. Other variables associated with lower likelihood were being retired (OR = 0.29, 95% CI: 0.16, 0.51) and having access to a car (OR = 0.72, 95% CI: 0.52,0.99). In the adjusted models, age was the only significant demographic characteristic, and regular transit use, being a current or potential cyclist, and feeling cycling was safe were transportation-related factors retained in the final mode.

TABLE 3 Results of Logistic Regression Estimating Likelihood of Using the Public Bike Share Program among 901 Vancouver residents responding to a telephone survey in September and October 2012*

Variable	Unadjusted OR (95% CI)		*p-value*	Adjusted OR** (95% CI) (n=860)		*p-value*
Sex			*0.151*			*0.684*
Male	1.22	(0.93, 1.59)		1.07	(0.77, 1.48)	
Age						
16-24 years	1.00		*<0.0001*			*0.002*
25-34 years	1.11	(0.70, 1.77)		**2.46**	**(1.24, 4.90)**	
35-44 years	**0.54**	**(0.34, 0.88)**		1.41	(0.68, 2.95)	
45-54 years	**0.42**	**(0.26, 0.68)**		1.16	(0.55, 2.43)	
55-64 years	**0.24**	**(0.14, 0.42)**		0.91	(0.41, 2.03)	
65+ years	**0.17**	**(0.10, 0.30)**		0.90	(0.36, 2.25)	
Education*			*0.077*			*0.486*
High school or less	1.08	(0.74, 1.57)		0.82	(0.57, 1.18)	
Post-secondary	1.00	1				
Graduate post-secondary	**0.73**	**(0.53, 0.99)**		1.09	(0.65, 1.85)	
Occupational Status* (n=900)			*<0.0001*			*0.269*
Works full time	1.00					
Works part time	0.96	(0.64, 1.44)		1.31	(0.79, 2.17)	
Student	**2.68**	**(1.75, 4.01)**		0.74	(0.33, 1.66)	
Does not work	0.99	(0.66, 1.48)		1.62	(0.83, 3.14)	
Retired	**0.29**	**(0.16, 0.51)**		0.83	(0.51, 1.33)	
Income (n=706)			*0.065*			
<$35,000	0.99	(0.69, 1.41)				
$35,000-$74,999	**1.55**	**(1.04, 2.30)**				
$75,000 +	1.00					
# Household members			*0.058*			
1 (lives alone)	1.00					
2	1.21	(0.83, 1.78)				
3	**1.51**	**(1.06, 2.14)**				
Has children living at home	**1.45**	**(1.09, 1.93)**	*0.010*			
Home in proposed public bike share zone	0.79	(0.54, 1.18)	*0.068*			
Has drivers' license	0.70	(0.47, 1.03)	*0.068*			
Has access to a car	**0.72**	**(0.52, 0.99)**	*0.045*			
Has car share membership	**1.94**	**(1.25, 3.02)**	*0.003*			
# Cars per household			*0.135*			
None	1.00					
1	0.86	(0.59, 1.24)				
2+	0.70	(0.48, 1.01)				
# Bicycles per household			*0.014*			
None	1.00					
1	**1.55**	**(1.03, 2.34)**				
2+	**1.64**	**(1.17, 2.31)**				
Has used a car in the last 2 days			*0.060*			
Yes	0.77	(0.58, 1.01)				
No	ref					

(Table continued on next page)

TABLE 3 continued*… Results of Logistic Regression Estimating Likelihood of Using the Public Bike Share Program among 901 Vancouver residents responding to a telephone survey in September and October 2012

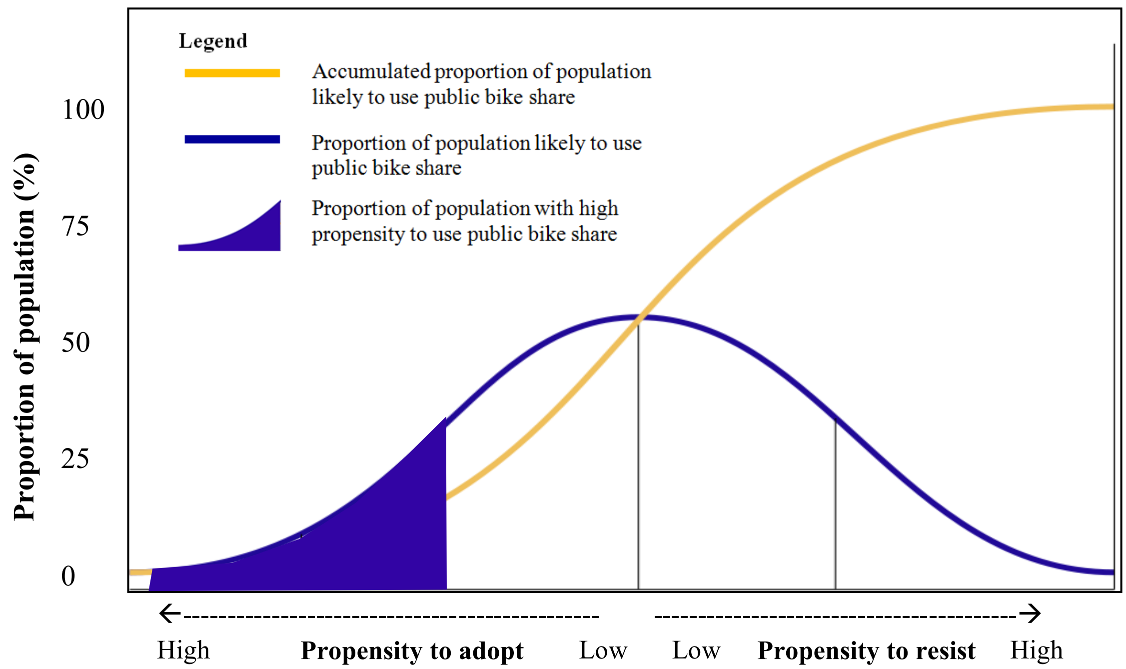
Variable	Unadjusted OR (95% CI)		*p-value*	Adjusted OR** (95% CI) (n=860)		*p-value*
Has used transit in the last 2 days			*<0.0001*			
Yes	**2.10**	**(1.58, 2.80)**		**2.12**	**(1.49, 3.00)**	*<.0001*
No	ref					
Has walked in the last 2 days						
Yes	**1.38**	**(1.05, 1.82)**	*0.020*			
No	ref					
Has cycled in the last 2 days						
Yes	1.37	(0.90, 2.11)	*0.147*			
No	ref					
Cyclist type			*<0.0001*			*<.0001*
Non-cyclist	1.00			1.00		
Potential Cyclist	**11.39**	**(6.98,18.60)**		**8.32**	**(4.78, 14.50)**	
Cyclist	**6.66**	**(4.34,10.21)**		**4.99**	**(3.05, 8.15)**	
Perceived safety of cycling in Vancouver (n=862)			*<0.0001*			*0.011*
Very safe/safe	**2.17**	**(1.57, 3.01)**		**1.61**	**(1.11, 2.33)**	
Neither safe nor unsafe	1.42	(0.83, 2.44)		0.88	(0.47, 1.65)	
Somewhat dangerous/ very dangerous	1.00					
Awareness of public bike share program (n=895)			*0.334*			
Yes	0.87	(0.66, 1.15)				
Perception of whether public bike share is a good idea for Vancouver						
Bad/very bad idea	1.00		*<0.0001*			
Neutral	**6.73**	**(2.82,16.02)**				
Good/very good idea	**18.47**	**(8.31,41.04)**				

* individual factors adjusted for in multivariate model despite p>0.05

** Note, dependent variable at a significance level of p<0.1 in bivariate analysis were offered in the multiple logistic regression, and the final parsimonious model included only variables with p<0.05 and key demographic variables significant associations in **bold**

Application of Diffusion of Innovation Theory

We used survey findings to develop a diffusion spectrum for Vancouver public bike share (see Figure 1). In this case, the use of the public bike share program can be understood as the behaviour or "innovation" in competition with "the leading brand", that being the current transportation mode (typically the car in North America). A standard diffusion adoption curve typically consists of five main adopter categories including: innovators, early adopters, early majority, late majority and laggards (*24*). We collapsed the five categories into three more parsimonious categories: the leaders (innovators and early adopters), the majority (early majority and late majority), and the resisters (the laggards-- likely never to adopt). The survey showed that a number of characteristics were not significantly associated with likelihood of use suggesting that these characteristics are distributed throughout the adoption continuum: male and females, and people with all education levels, occupational statuses, incomes, household types, household locations, and car/bike access. However, other characteristics were conceptually and operationally related to leaders, the majority, and resistors. These are outlined below.



Adoption Categories	The Leaders	The Majority	The Resisters
Predicted population segment characteristics, based on survey results	Potential cyclists	Current cyclists	Non-cyclists
	Car share members	Those with access to car	Households w/ 2+ cars
	Transit users, walkers		
	Students	Work full-time, part-time, not working	Retired
	Young (<34 years)	Middle aged (35-64 years)	Older adults (65+ years)
	Think public bike share is a <u>very</u> good idea	Think public bike share is a good, neutral, or bad idea	Think public bike share is a <u>very</u> bad idea
		Think cycling is very safe, safe or neither safe nor unsafe	Think cycling is dangerous
Characteristics dispersed throughout adoption continuum	< - - - - - - - - - - - - - - - - - -- - - - - - -men & women - - - - - -- - - - - - - - - - - - - - - - - >		
	< - - - - - - - - - - - all levels of education, occupation and income - - - - - - - - - - - - ->		
	< - - - individuals from various household sizes with and without children - - - - -- - >		
	< - - - - - - - - -- - - - - lives within or outside of public bike share zone - - - - - - - - - - - ->		
	< - - - - - - - - - - - - has previous knowledge of what public bike share is - - - - - - - >		
	< - - - - - - - - - - - - - has access to a car and/or a bike - >		

Figure 1: Adoption Curve Characterising Population Segments Likely to Use the Pubic Bike Share Program, Based on Application of Diffusion of Innovation Theory (*24*) to Data Collected among 901 Vancouver residents responding to a telephone survey in September and October 2012

The Leaders

According to Diffusion of Innovation theory, innovators are characterized as being venturesome, creative, able to cope with high uncertainty, and eager to try new things even if it requires taking big risks (*24*). Innovators represent a small very proportion of the population (suggested as 2.5%) and in many cases include an elite segment of society that are visionaries and whom have the economic resources to take risks. They are thought to be rash; however this group is critical in piloting a new product, program or idea and are considered to be gatekeepers that approve or block an innovation from flowing into a social system or culture. Early adopters are typically less elite but like to be considered trendy social leaders. They are generally a step or two ahead of the majority in adopting a new idea, respected by peers and valued for their knowledge and opinion on these new ideas. Once these two groups have adopted the program, they can help contribute to momentum and broader uptake by providing a model, and social supports to encourage other segments less willing to test the program in early stages of implementation.

Factors associated with a high likelihood using public bike share in this survey can be used to determine who might be in this leader category. Given the survey data, this includes students, potential cyclists, car share members, regular transit users, and those younger people (<34 years).

An interesting finding of this study was connection between car share membership and interest in using a public bike share. Car sharing and bike sharing have commonalities: both require high density urban neighbourhoods with multiple destinations; allow users the freedom to use the mode without having to own the equipment; allow use on a "as needed basis"; and can connect users more seamlessly to public transit from their home and desired destinations (*26; 27*). They also serve complementary purposes, as bike shares provide a fast travel option when road congestion is heavy, and car shares provide options when carrying large loads or traveling with others (non-cyclists). As a combined package of options, car sharing and bike sharing can provide flexibility and an attractive alternative to the private car, an opportunity already being explored in some cities (*28*).

Students are identified as another group of the leaders. Students are typically younger, lower income, and less able to afford a car. Furthermore, students today are more interested and passionate about environmental issues and pushing the "green" agenda (*29; 30*). Students have been noted as early adopters in existing programs. The Montreal BIXI bike share program was found to attract the younger, university educated population (*31*), and bike share programs are in place at over 70 college and university campuses across North America (*9; 11*). Other studies of bikeshare programs in the United States have also found that compared to the general population, bikeshare users fit the student profile of being, on average, younger and highly educated (*18*).

Another population segment that is likely to be leaders are regular transit users. Public bike share is often seen to serve the "first-and-last-mile", facilitating links between transit stops and origins and destinations by replacing the walking portion of a transit trip [5]. Surveys of public bike share users in four US and Canadian cities suggest that the most common mode shifts are typically from walking and from transit, demonstrating the utility of the public bike share when travel speed, time, and cost are competitive (*6*).

Finally, potential cyclists - those who have not cycled recently but showed interest in cycling in the future - can be considered in the leader segment. Intuitively, one might expect that it is the current cyclists who are most interested in using a public bike share program; however, our results found that potential cyclists actually show the highest likelihood. This supports the idea that public bike share can encourage new population segments to begin cycling, as has been reported elsewhere (*5; 32*). In fact, emerging data from bike share programs in Europe, the US and Canada shows that bike share programs

are increasingly attracting more members who prior to joining bike share did not own bikes, or who were not regular or experienced bike users (*16; 18; 33; 34*). Research on potential cyclists (categorized as "interested by concerned" by some (*32*) suggests that they have barriers and concerns such as not owning a bike, risk of theft, poor weather, feeling road facilities are unsafe, and a lack of knowledge, skill or comfort in cycling for transport (*32; 35*). The public bike share program can alleviate concerns related to owning and maintaining a bike, as well as weather, since trips can be made more spontaneously under good conditions. Given the desire potential cyclists express for safe cycling environments, this result calls for continued effort for improved cycling infrastructure, at least in areas with public bike share programs, if we are to shift behaviour in this segment.

The Majority

Once the leaders have begun to use a public bike share programs, the next challenge will be to work toward increasing uptake by the majority population. According to Diffusion of Innovation theory, early and late majority both compose about two-thirds of the population (*24*). These are those who need to see others do it before they are willing to give the program a try. They will likely need to be convinced of the benefits, be given time to consider, and to watch the innovators and early adopters. The early majority group have been described as deliberate in adopting an innovation, that they wait to see how leaders fare with it, but still wish to be ahead of the curve if the idea looks like a good one. If the early majority can be convinced to adopt, they play an integral role in bringing the diffusion process to a tipping point in which the new idea becomes broadly accepted and is adopted by the late majority (*24*). The late majority tends to be skeptical and will only adopt a new idea once they feel there is economic or social pressure to do so and almost all uncertainty about the idea is removed. Cautiousness to adopt a new innovation in this group typically comes from having limited resources, and little flexibility for taking risks (*24*).

The majority are a larger and more varied group, more difficult to define, and arguably less important to understand in early stages of implementation. It can be hypothesized that the population segments falling into this majority may potentially be swayed to try the program if it became the norm, and if social and environment circumstances aligned. Current cyclists who already ride regularly may need to be convinced of the unique benefits of a bike share. People with moderate safety concerns may be willing to try to system if the perception of cycling safety is shifted through improved infrastructure, marketing and programs.

The Resisters

The final category to describe are those at the tail end of the innovation curve—those who will be last to use it, or may never use it. This group are termed "the laggards" by Diffusion of Innovation theory, or sometimes referred to as resisters since they tend to be suspicious of new ideas. These individuals are traditionalists that are generally averse to change (*24*). The theory would suggest that the amount of effort and resources to convince the laggards to adopt a new idea is often so large it is usually not a worthwhile endeavour.

Looking to the study results it can be hypothesized that those factors that were associated with a low likelihood of using the public bike share program fit within this "resister" category. This includes those with adverse attitudes towards cycling, cycling safety, and the public bike share program. Logically, this also includes individuals who are physically unable to use the program. In the empirical analysis, older and retired people reported being less likely to use the program, however, given the universal design of the bikes, healthy and able individuals within this group may still use the system. Given that the profile

of city-dwelling older adults is changing, public bike share may become more appealing to this group in the coming years.

DISCUSSION

This population-based telephone survey showed that vast majority of the population thought that public bike share is a good idea for Vancouver, but that only a quarter reported being likely to use the program. This is in contrast to other Given this underlying support but cautious commitment, targeted marketing is important to promote widespread uptake of the program. We applied the Diffusion of Innovation Theory to characterize who is most likely to use a new public bike share program, providing guidance on the population segments that might be the leaders in the use of bike share. The Diffusion of Innovation theory has not been widely used in transportation, but can help better understand the mechanisms which will best facilitate public uptake and integration of transportation innovations, such as a public bike share program. We chose this theory based on its focus on population-level behaviour (as opposed to individual-level), its past success in understanding population-level health interventions, and its relevance to assessing a new innovation through considerations of social-systems and changes in behaviour over time (*24*). Although these findings are grounded in the Vancouver context, they may also be informative for other cities and jurisdictions considering a public bike share program.

Policy Implications & Recommendations

To develop recommendations for policy and practice to maximize public bike share program uptake, we apply Diffusion of Innovation theory's framework of five elements of successful innovations. These are: 1) relative advantage; 2) trialability; 3) compatibility; 4) simplicity; and 5) observability (*24*). Under each of these we have presented corresponding strategies that may be of use to cities implementing public bike share programs.

Relative advantage

Relative advantage is the extent to which an innovation (i.e., public bike share) is perceived as better than the competition (i.e., current travel mode), measured according to factors most important to the audience such as cost advantage, convenience, social prestige, or satisfaction (*24*). Making the system accessible 24 hours a day, 7 days a week (*14*) could provide advantage over transit service. Marketing messages could highlight that public bike share can save time, money and hassles associated with driving, parking, and even taking the bus. Linking public bike share and transit may also serve to increase the relative advantage of these combined modes, as public bike share can resolve much of the "first-and-last-mile" problem that challenges transit.

Trialability

Trialability ensures that people are given low cost opportunities to try out a new idea in order to sway them that the benefits are larger than the drawbacks (*24*). Allowing the public to use the system for free or low cost for a limited time during early stages of implementation will allow both supporters and skeptics to test the program and experience its benefits while also having the potential to generate social and media buzz to boost the program's popularity (*36*). Providing discounts for early subscribers can provide a financial incentive to build member base quickly, as was done in the BIXI program (Montreal) which offered discount memberships for the first 500 members. Furthermore, providing low cost barriers to

trying and using bike-share will be important in making the program accessible to populations who may benefit from it the most such as those with low-income, youth and older adults.

Observability

Observability is the extent to which individuals can see how the innovation works and the benefits to be gained by embracing it (*24*) Observability will be especially important for the majority who wishes to see what participating in bike share program feels like and initiate discussion with peers before using the bicycles themselves. An Australian study showed that seeing people using the bike share program was a critical factor in others deciding to use it (*14*). The strategies of brightly coloured bikes (bright blue New York, red in Sevillee) are one method of increasing observability. Other strategies could include creating videos (i.e., YouTube) and promotional media tools demonstrating how simple and convenient it is to use the system. These can feature prominent people (e.g. Mayors, business leaders, and celebrities) as role models, as well as people of all ages and abilities.

Compatibility

Compatibility with existing values and practices is the extent to which an innovation is perceived as consistent with their past experiences, values and current needs (*24*). In consideration of the results showing high interest from student, transit users, and car share members, it is logical to ensure that stations are installed near to designated car share stations, along major student commuter routes and at entrances to training and educational institutions, and at bus exchanges and rail stations. Joint memberships between car shares and bike shares, or integrated transit-bike share passes would be strong initiatives toward compatibility.

Simplicity

Simplicity and ease of use is the extent to which an innovation is perceived as easy or difficult to use and understand (*24*). Cities launching public bike shares now have the advantage of not being at the front of the curve. The majority (63%) of the survey respondents had heard of public bike share systems, and many of them may have experienced a system in a different city. Marketing the public bike share system should be directed as something for "everyone" and for "everyday" trips—highlighting that the point of the system is actually to provide easy and convenient access for those who might not normally bike (as well as those who do).

In sum, we applied the Diffusion of Innovation theory to an empirical analysis of a population-based survey, which has provided an adoption curve of population segments most likely to use a public bike share. Using the theory's framework for successful innovations, along with our predicted adoption curve and emerging findings on public bike share elsewhere, we have developed marketing strategies that may optimize uptake and implementation. While this analysis can guide efforts to promote early adoption, cities planning for bike share launch should concurrently take consideration of equity issues and ensure the program is implemented in a manner the permeates social, gender, and cultural groups.

Study Strengths & Limitations

This study aimed to capture readiness for a public bike share program in Vancouver residents. Public bike share research is rapidly emerging and we are not aware of any other published population-based pre-implementation surveys. There are examples of city or consultant-led feasibility studies, however many of these do not provide sampling methodology or rely on convenience samples (*37; 38*). In our study, we

limited selection bias by using random digit dialing and supplementing with a cell phone list. The cooperation rate was 18.7%, a level which can allow for inferences from telephone surveys following weighting. We used sampling quotas to obtain a more representative sample, and weighting to generate population-based estimates. However, the sample had the usual skew towards higher income and more educated participants. For feasibility reasons, the survey could only be administered in English. While Vancouver is home to a large immigrant population, the 2006 Census data show that 90% of residents speak English so bias here is likely limited. The survey was introduced as being on travel behaviour so as not to deter people who may have negative views toward cycling. Not surprisingly the survey was of interest to the cycling population, with 22% of participants being reporting cycling at least weekly, but there was still strong representation from non-cyclists (28.0%) and potential cyclists (19.6%). In addition, although there is possibility for information bias in the self-report outcome of likelihood of use, and potential misclassification with the aggregation to a dichotomous outcome, when we re-ran analyses with neutral responses coupled with unlikely (instead of likely) we found virtually the same patterns for predictors of use. Additionally, there is no reason to suggest that over-reporting would vary across demographic groups. Finally, the diffusion spectrum of an adoption curve and population segments presented are projections based on survey results. As bike share launches in Vancouver in spring 2014, it will be interesting to evaluate this diffusion spectrum, and to see if the predicted population segments are indeed first to integrate public bike share into their everyday travel patterns.

CONCLUSIONS

Public bike share programs are important opportunities to shape active travel behaviour in North America, especially in light of their potential contributions to reducing congestion and promoting health in growing urban centres. Strategic marketing can contribute to success by enabling quick uptake and adoption of the program. This study showed that a majority of the Vancouver population thought a public bike share program was good for their city, but that certain population segments were more likely use the program. Important populations to promote early adoption include students, potential cyclists, and those who already use alternative forms of transportation such as transit, walking, and car share. These results and recommendations can assist planning and promotion in cities set to launch new public bike share programs. Future research could observe use of a public bike share upon implementation and determine how true usage matches or varies from the speculated adoption patterns discussed in this paper.

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