Who will ride the REM?

Investigating the individual characteristics that affect intention to adopt use of a new light-rail system

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Supervised research project for the Master of Urban Planning at McGill University

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Policy Brief

The Réseau Express Métropolitain (REM) is a new rapid light-rail system under construction in Montreal, with operations planned to begin later in 2021. It is important to identify individual, social, and environmental determinants of intended use of the REM to better understand whose travel needs will be served by this new project and to identify ways in which the project's socio-economic impacts can be made more equitable. To identify these determinants, we conducted several statistical analyses of the results of a survey distributed in the Fall of 2019 about the REM and its impacts on travel behaviour and well-being.

Factors impacting intention to use the REM:

- **Attitudes**: A stated desire to ride public transport more often increased odds of intending to use the REM by 2.17 times, all else being equal. Meanwhile, a perception that the REM would be bad for Montreal reduced the odds of intending to use the REM by 57%. Similarly, a perception that the REM would be bad for one's neighbourhood reduced odds by 65%.
- **Physical activity**: Every additional hour of active transport physical activity in the previous week increases odds of intending to use the REM by 7%. Physical activity discourages intention to only drive to access the REM.
- **Walkable environment**: Higher walkscores around the home environment encourages choosing to walk to the REM.
- **Income**: Respondents living in households with incomes below $90,000 per year had between 33% and 37% lower odds of intending to use the REM compared to individuals living in households earning more than $120,000 per year
- **Gender**: Women have 38% lower odds of intending to use the REM than males, all other variables held constant at their mean. Women have 44% lower odds of intending to bicycle to the REM than men. Women are about as likely to use the REM to access work, but less likely to use it for non-work travel than men. The greatest gender gap in intended use is for non-immigrants and younger people.

Policy recommendations:

- Focus on cultivating positive perceptions and attitudes towards the REM to encourage ridership.
- Strategically support efforts to promote physical activity in order to promote LRT ridership.
- Encourage increased walkability in areas around stations to encourage walking to the REM.
- Design the REM and future project with gender in mind, particularly ensuring non-work travel needs and that the needs and comfort of younger women are considered.

Acknowledgements

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Table of Contents

Introduction

The 21st century will be defined by major infrastructure projects in cities around the world that move transport and land use systems in a definitive direction: away from systems dependent on the private vehicle produced in the 20th century, and towards systems based on shared and active modes that support planetary and human health.

The *Réseau Express Métropolitain* (REM), a major light-rail transit (LRT) project currently under construction in Montreal, is part of this global shift. The $6.5 billion project represents one of the most significant investments in rapid transit infrastructure in Canada. Adding 67km of system length to the existing 69km of metro network in Montreal, it will undoubtedly shift mobility and land use development patterns in the city.

In addition to leveraging the project's potential to reduce private vehicle modal share and reduce carbon emissions, it is also critical to realize its potential for expanding socio-economic opportunities, especially for groups in the metropolitan area that are underserved. It is not enough to design transport systems that have a positive environmental impact: they must also serve as vehicles for social inclusion and economic empowerment. To this end, it is crucial to identify what groups the REM will serve, and to examine the determinants of use of the REM such that design and policy decisions that seek to achieve social inclusion and equity can be effective. The purpose of this supervised research project is to contribute to this investigation and inform these efforts. To examine this, I posed the following research question: what individual, social and environmental factors influence people's stated intention to use the REM?

Percolating from the results of investigating the first research question, I also explored the following additional questions as part of this research effort: for individuals who intend to use the REM, what are the determinants of first-mile mode choice? In particular, what encourages or discourages specific sub-groups from choosing active modes to access the REM? Finally, what factors that influence intended use of the REM are specific to gender, given that women are significantly less likely to use the REM?

To investigate these questions, I used a survey dataset including thousands of respondents collected in 2019 by Transportation Research at McGill (TRAM) as part of a broader research effort to examine the REM's impacts on health and wellbeing in Montreal. I applied a logistic modelling approach to identify significant associations with intention to use the REM, and I interpreted the impact of these variables building on previous findings in the field of travel behaviour research. The findings of this research effort can directly inform policy and design decisions on the REM, on future LRT projects, and can advance discussions in the literature on travel behaviour, particularly research on adoption of LRT use.

This report is structured as two separate papers: the first investigates determinants of intention to use the REM in general and determinants of intended first-mile mode choice, while the second investigates gender interactions and their implication on equitable planning and design of the REM and other LRT projects. Both were co-authored by other members of the TRAM team, who contributed to all aspects of the project. A conclusion at the end of the report summarizes findings from both and makes specific calls to action to foster equitable and sustainable development of LRT systems.

Chapter 1: Intention to use Light-Rail Transit and First-Mile Mode Choice

Abstract

Increasing the uptake of active and sustainable modes of transport has become a global imperative as cities and regions around the world invest heavily in new transit infrastructure in a bid to reduce rising transport-related greenhouse gas emissions. This study explores how spatial, sociodemographic, psycho-social, health, and mobility characteristics of individuals and households influence their stated intentions to use the Réseau Express Métropolitain (REM), a new light-rail transit (LRT) system in Montreal, Canada. We further examine how these factors may relate to intended mode choice for first-mile trips from home to the station. We investigate these questions by applying weighted multilevel binary logistic regression to a subset (n=2,767) of survey responses collected from residents before the LRT's operation as part of an ongoing study into the system's potential impacts. Consistent with previous research on this topic, we find that attitudes toward the LRT project and public transport in general strongly influenced individuals' intention to use the new LRT. Likewise, socio-demographic characteristics are also strongly associated with intention, in this identifying as a woman and having an annual household income less than 90K are negatively related with intention to use. Most notably, we find evidence that physical activity and markers of active lifestyles, such as bicycle ownership, had positive impacts on both the intention to use the LRT and to access it by active modes. Based on this finding, we conclude that policy objectives promoting active lifestyles would also benefit the objective of promoting the use of sustainable modes of transport, including LRT.

Introduction

Montreal, Canada's $6.5 billion Réseau Express Métropolitain (REM) light-rail transit (LRT) project is poised to nearly double the region's high-frequency rail transit network in just a matter of years, potentially reshaping land-use and transportation patterns across the region. The 67-kilometer, automated light-rail—slated to come online in phases starting in 2022—is being built as Montreal and other regions around the world face an urgent need to curtail spiraling transport-related greenhouse gas emissions (GHG) as part of their response to the growing impacts of climate change. To that end, governments have begun to articulate carbon-reduction goals accompanied, in some cases, by major investments in public-transport infrastructure aimed at bolstering sustainable mode share and reducing reliance on private automobiles. Montreal, Canada, for example, aims to boost public-transport mode for all trips to 35% by 2035, from 25% in 2012 (Montréal, 2012). Gauging how well the REM project, and others like it, will advance regional transport-related economic, social, and environmental goals, requires a keen understanding of the factors that shape the adoption and use of new LRT and metro systems. To that end, this study examines the sociodemographic, attitudinal, and built-environment and transport-network factors that influence people's intention to use and access the REM.

According to the theory of planned behaviour, there is a strong association between intended and realized behaviour (Ajzen, 2011). A greater understanding of the factors that determine potential transit users' intention to use public transit can help transit agencies make important decisions about their services. This information may be particularly helpful prior to the completion of the project, as agencies can still enact policies to improve public opinion about the project, converting unlikely users to potential users. At the same time, the intended mode taken to access the new LRT stations (first-mile travel behavior) provides information for the transit agencies in not only designing the appropriate infrastructure to support the desired travel behavior of potential users to access the stations, but also shape their behavior to use more environmentally sustainable active modes that have the added benefit of improved health conditions, in accordance with their planning goals.

As such, the present study aims to answer two questions: 1) what are the determinants that influence people's stated intention to use the REM and 2) for those potential users that intend to use the REM once it is operational, what are the factors that influence the modes, including active modes like walking and biking, that they intend to use to access the stations. To answer these questions, the present study makes use of a bilingual survey of several thousand Montreal-area residents conducted as part of an ongoing longitudinal study to document the impacts of the REM LRT project on travel behavior, health and well-being at various stages of the project lifecycle. We build upon the findings of recent research by N. Dent et al. (2021), which used the same dataset to apply a market-segmentation approach to identify clusters of potential as well as unlikely users of the REM, but instead focus more on the specific determinants of intention to use the REM and the transport mode that future riders plan to use to access the new LRT system. The modelling approach used in our study allows us to highlight specific policies and areas of intervention to improve eventual use of the LRT system itself as well as promote the use of sustainable modes to access the LRT system.

Literature review

Public transit mode choice

De Witte et al. (2013) found four primary categories of factors to affect transport mode choice: spatial, socio-demographic, journey characteristics, and socio-psychological. The idea that spatial, or built environment factors, have an impact on mode choice has been popularized through the concept of the 3Ds: density, diversity, and design (Cervero & Kockelman, 1997) and has been confirmed by various researchers (Boarnet & Crane, 2001; DeWeese & El-Geneidy, 2020; Ewing & Cervero, 2010; Handy et al., 2005). While proximity to transit, which is captured in the 3Ds, has a direct influence on public transit use, this influence has been shown to be moderated by other factors. For example, the design of the neighborhood can play a role to reduce the perceived distance to transit (Loutzenheiser, 1997). People are also more willing to travel further to access better quality transit (e.g. rail) (Cervero, 1995). Individual sociodemographic characteristics can impact mode choice in wide-ranging and complex ways. Women, for example, are more likely to use and depend on public transport (Ko et al., 2019; Limtanakool et al., 2006; Mensah, 1995; Mercado et al., 2012). Contrastingly, a study by Hsu et al. (2019) revealed how in Los Angeles, new rail line had a smaller effects on increasing transit use for women compared to men, which was largely explained by gender-associated concerns for personal safety. On the other hand, car availability, as one of the most often studied determinants of mode choice, has been found to be significant in the majority of the studies where it has been studied (De Witte et al., 2013). Journey characteristics related to quality of transit services, especially relative to alternatives such as private vehicles, have been found to inform transit mode choice. Notably, a study by Chakrabarti (2017) revealed how transit speed, frequency, and reliability relative to private vehicle were strong predictors of public transport mode choice in Los Angeles.

Socio-psychological factors such as experience with transit, attitudes towards transit, habits and lifestyle choices, while less often studied, have been shown to exert strong influences on mode choice (De Witte et al., 2013). Various studies have documented how positive attitudes towards public transport, including satisfaction with service, encourage public transport use (Bagley & Mokhtarian, 2002; Kitamura et al., 1997; Lai & Chen, 2011; Spears et al., 2013). Other studies have put forward evidence suggesting that attitudes have an even stronger impact on mode choice than built environment and demographic factors (De Vos et al., 2020; Sener et al., 2020; Şimşekoğlu et al., 2015). However, these effects are not necessarily mutually exclusive. A recent study by De Vos et al. (2021) suggests that built environment may influence attitudes, which, in turn, may influence mode choice. Similarly, attitudes may encourage a selection of residence that is compatible with preferred modes of travel (Cao et al.,

2009). In short, mode-choice models must account for a wide range of factors as identified in De Witte et al. (2013) (spatial, socio-demographic, journey characteristics, and socio-psychological factors).

Future intention to use public transit

The determinants of intent to use public transport have been explored in the existing literature. Lai and Chen (2011) and De Oña et al. (2016) found that perceptions of service quality were most strongly associated with intended use. De Vos et al. (2020) modelled future intention to use public transport among students in Quebec City. Their model showed that current satisfaction with public transport and positive attitudes towards it were strongly associated with intention to use in the future. Sener et al. (2020) examined the determinants of intention to ride a newly opened LRT in Houston. This study found that attitudes towards public transport were more strongly associated with intention to ride than environmental or socio-demographic variables, a result that is supported by Zailani et al. (2016) in Malaysia. A novelty in the study from Sener et al. (2020) is the inclusion of variables accounting for health status and awareness of the physical-activity benefits of public transport use. Investigation into the connections between health status, and particularly physical activity, with propensity to use public transport represents a gap in this body of literature that presents an opportunity for further investigation.

First-mile active mode choice to public transit

There are a variety of factors that influence the mode selected by public transport users to access public transit services. Most of these factors are examined in the context of walking to transit. Kim et al. (2007) investigated factors that encourage walking to LRT and found that socio-demographic factors, namely being a student and being a high-income rider, encouraged active access. Tilahun and Li (2015) found that higher crime rates reduce the likelihood of walking to public transport, as does vehicle ownership, while sidewalk availability increased the likelihood of walking. Lu et al. (2021) found that higher intersection density, higher accessibility to services and a more diverse land use mix near the home encouraged walking to public transport. van Soest et al. (2020) through a systematic review, found that factors that encourage walking over longer distances to public transit include being employed, having higher income (in North America and Australia but not in Asia or Europe), and higher walkability.
The decision to use a bicycle to access public transport is found to be encouraged by being male (de Souza et al., 2017; Ji et al., 2017), younger age (Ji et al., 2017), presence of bicycle paths along the route, bicycle parking at origins and destinations (de Souza et al., 2017), and trip purposes (Ji et al., 2017). Other research has found that using public transport to access rail services is encouraged by shorter distances between home and station (Goel & Tiwari, 2016) and by improvements in bus service as measured by travel time (Halldórsdóttir et al., 2017). Factors that have been identified to encourage driving to fulfill the first-mile trip are availability of parking (Kim et al., 2007), access to a private vehicle (Azimi et al., 2021; Kim et al., 2007), and possession of a driver's license (Azimi et al., 2021; Kim et al., 2007).

In terms of transit users' propensity to access the station via public transit or driving, Kim et al. (2007) found that riders with valid driver's license are more likely to drive to LRT stations in St. Louis, Missouri than those without a license. The same result is also true for vehicle availability. For users who take the bus to access LRT stations, direct bus service availability between the home and the station was found to be influential, after accounting for the effects of having a driver's license, having an available vehicle, presence of park and ride lots and other socio-demographics factors.

Study context

The REM is an automated LRT system under construction in Montreal, Canada, that is expected to begin operations progressively in phases between 2022 and 2023. When complete, the REM will connect Montreal's West Island, international airport, and southern suburbs to Downtown (shown in green in Figure 1) and is expected to have a daily ridership of 190,000 (Steer Davies Gleave, 2017).

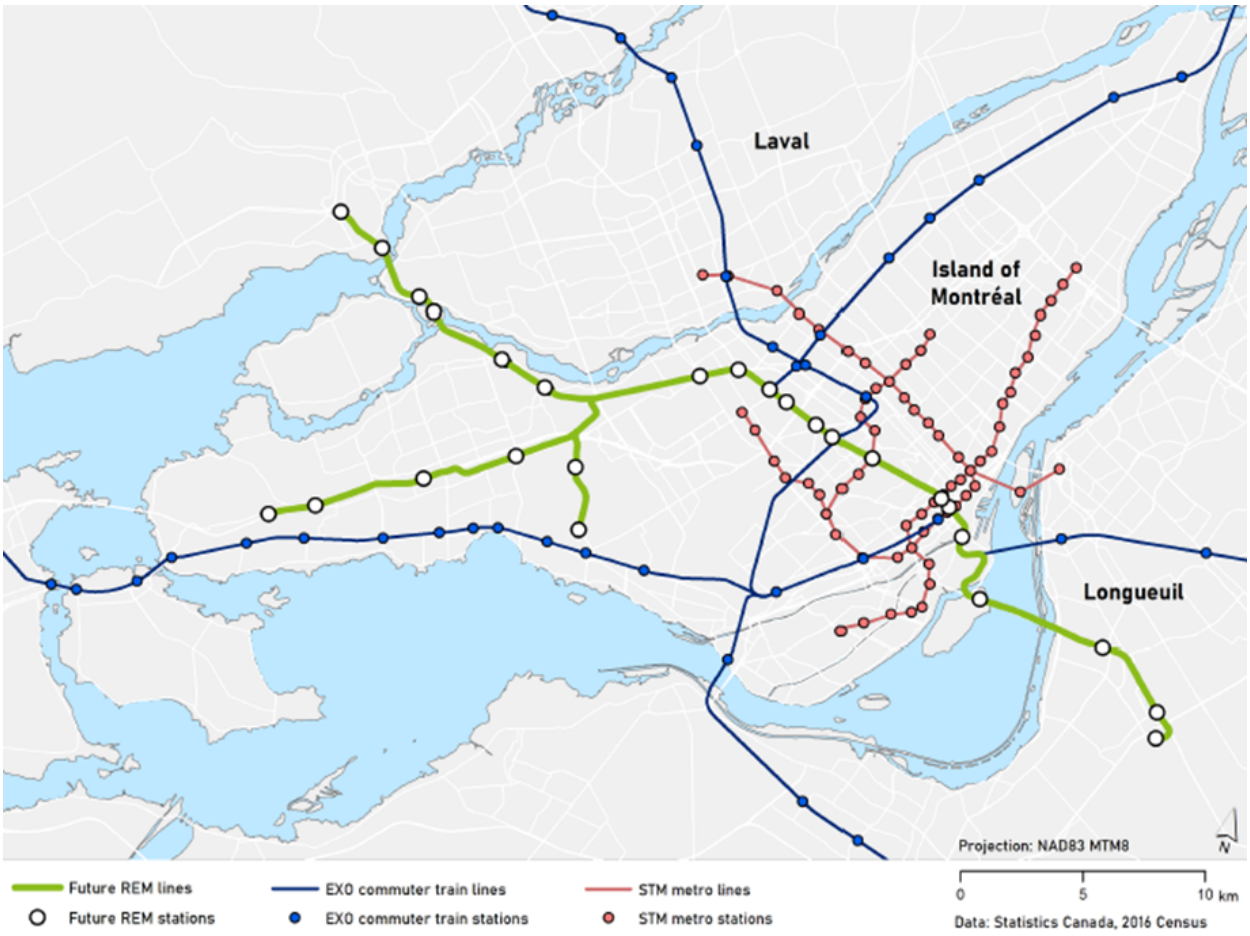

Figure 1: Map of Montreal's rapid transit and commuter rail system, including the REM.

Data

This study uses data obtained from an online bilingual (English-French) survey conducted between October 2019 and January 2020 to collect data on the REM's potential impact on travel and wellbeing. The survey, part of an ongoing study in the Montreal region, recruited participants 18 years of age and older and included questions about perceptions of the REM and the impacts of its construction. It also collected data on current travel behaviour, physical activity, and respondents' sociodemographic characteristics. To ensure a representative sample, we employed various techniques recommended by Dillman et al. (2009) and a mix of in-person and online recruitment. We used geographically targeted Facebook advertisements, recruited participants with flyers at downtown transport hubs in Montreal, engaged traditional media with press releases and interviews, and contracted a public-opinion survey company.

In total, we collected 5,942 responses, of which 4,148 were complete. We removed responses that were filled too quickly to be considered reliable. Survey duration depended on the types and complexity of reported travel behaviour. To identify unreliably fast responses, we constructed four complexity categories and removed the fastest 10% of respondents from each. Finally, we manually filtered out unrealistic responses, including birth years before 1920 and reporting spending more than 200 minutes per day commuting by walking or bicycle. Following this cleaning process, the remaining sample size of 3,683 responses was used in the next step.

For this study, we narrowed the dataset further to include only responses with complete and reliable information on key variables for our model (see Table 1). Respondents who had not heard about the REM project before were not asked whether they intended to use the REM and were therefore excluded. Following this exclusion process, we retained a sample of 2,767 for our analysis.

Methods

To model intention to use the REM and mode choice for accessing REM stations, we employed a weighted multi-level binomial logistic regression approach using the R statistical programming language. Each individual response was placed in a census tract based on the geographical information provided in the survey. We used census tracts as the second level in each multi-level model. This allows us to control for common characteristics shared in a neighbourhood that are otherwise unaccounted for in the model. To ensure the representativeness of our model, we calculated and applied observation weighting with the anesrake R package using respondents' age, income, and gender and census tract information from Statistics Canada.

Intention to use the REM was determined based on the answer to the question "How likely are you to use the REM when it is complete and operational?" This data was converted into a binary variable in which respondents indicating that they were "Very likely" or "Likely" to use the REM were coded as 1, and all other individuals (responding "Neutral", "Unlikely" or "Very unlikely") were coded as 0. Intended access mode choices were determined based on responses to the survey question "How do you plan to get to the REM?" Intention to walk, cycle, and use public transport to access the REM were all determined the same way: If the respondent ticked the response corresponding to that mode, then the corresponding dependent variable for the model was coded as 1, otherwise 0. For driving exclusively to the REM, the model variable was coded as 1 if the respondent checked any of "Drive," "Taxi or ride-hailing," and "Someone will drop me off" and did not check "Walk," "Bicycle," or "Public transport." As multiple responses were possible, we used a binomial as opposed to a multinomial logit modelling approach to investigate the variables that promote and inhibit intention to use each category of first-mile mode choice.

Our models include several independent variables either obtained directly from the survey or computed separately. These computed variables include: network distance between a respondent's home and the nearest REM station; neighborhood walkability which was obtained from Walkscore.com through an online application programming interface (API); and cumulative 45-minute weekday am peak accessibility to jobs by public transport (Hansen, 1959) based on the network as it currently exists. We calculated this measure of accessibility at the census dissemination-area level using r5r, a package for the R programming language that provides access to Conveyal's R5 java-based routing engine (R. Pereira et al., 2021). General Transit Feed Specification (GTFS) data for routing and accessibility calculations was obtained for all agencies in the metropolitan region. Travel time was calculated and averaged for every minute with departure time between 8:00 a.m. and 8:30 a.m. for Tuesday, May 14, 2019, selected as a

representative non-holiday weekday. We also calculated the projected change in accessibility with the inclusion of the completed REM but did not retain this variable in the models because it was not significant. The number of jobs at the dissemination area level was calculated based on census-tract level information on jobs from Census Work Flows (Statistics Canada, 2016b). Table 1 includes the descriptive of the variables used in our analysis and their summary statistics. Based on VIF and collinearity statistics, we found no significant collinearity between final model variables.

Table 1: Descriptive statistics of final model variables (dollar figures in CAD)

Category	Variable name	Description	Mean	St. Dev.
Dependent variables				
Dependent variables (intentions to use the REM and intended mode of accessing the REM)	Intends to use REM	Intends to use the REM	0.542	0.498
	Walk to REM (n = 1,501)	Intends to walk to access the REM	0.421	0.494
	Bike to REM (n = 1,501)	Intends to bike to access the REM	0.209	0.406
	Transit to REM (n = 1,501)	Intends to take public transit to access the REM	0.461	0.499
	Drive to REM (n = 1,501)	Intends to drive exclusively to access the REM	0.183	0.387
Independent variables				
Socio-demographic characteristics	Female	Gender [female]	0.502	0.5
	Male	Gender [male]	0.484	0.5
	Other gender	Gender [other]	0.014	0.116
	Age	Age (in years)	45.527	15.898
	Non-White	Race [non-White]	0.126	0.332
	under $30K	Household income [under $30K]	0.104	0.305
	$30K to $60K	Household income [$30K - $60K]	0.214	0.41
	$60K to $90K	Household income [$60K-$90K]	0.191	0.393
	$90K to $120K	Household income [$90K-$120K]	0.167	0.373
	over $120K	Household income [over $120K]	0.228	0.42
	High school	High school diploma or less	0.106	0.308
	College	College diploma or trade certificate	0.238	0.426
	Bachelor's	Bachelor's degree	0.37	0.483
	Graduate	Graduate degree	0.285	0.451
	Children in household	Children under 18 years old in household	0.266	0.442
	Mobility disability	Has a mobility-related disability	0.129	0.335
	Raised urban	Grew up in an urban environment	0.394	0.489
	Raised suburban	Grew up in a suburban environment	0.453	0.498
	Raised rural	Grew up in a rural environment	0.152	0.359
Spatial characteristics	Walk Score	Walk Score of home location	68.27	26.068
	Net distance	Network distance between residence and REM station (km)	6.325	6.989
	Net distance squared	Square of network distance between residence and REM station	88.833	217.589
	Accessibility by transit	Number of jobs (10,000s) accessible within 45 minutes by transit (May 2019)	27.079	26.088
	Accessibility by car	Number of jobs (10,000s) accessible within 45 minutes by car (May 2019)	76.387	35.107

Physical activity characteristics	Transport PA hrs	Hours of active transport physical activity in past week	2.788	3.229
	Work PA hrs	Hours of vigorous physical activity for work in past week	0.413	1.987
	Recreation PA hrs	Hours of vigorous physical activity for recreation in past week	1.296	2.265
	BMI	Body mass index	26.767	6.019
Mobility characteristics	Access to vehicle	Access to a vehicle	0.751	0.433
	Driver license	Driver license	0.889	0.314
	Owns bike	Owns a bike	0.658	0.474
	Bixi* member	Has a bixi* membership	0.089	0.285
	Weekly transit rides	Number of transit rides in the previous week	2.912	3.375
	Transit non-commute	Rides transit for non-commuting purposes	0.207	0.405
Attitudinal characteristics	Transit positive attitude	Would like to ride public transit more often	0.334	0.472
	Cycling positive attitude	Would like to cycle more often	0.552	0.497
	REM bad for Montreal	Believes the REM will be bad for Montreal	0.071	0.257
	REM bad for n'hood	Believes the REM will be bad for neighbourhood	0.179	0.384
Reasons for home location variables	Having a large home	Having a large home	0.571	0.495
	Familiarity with n'hood	Familiarity with neighbourhood	0.596	0.491
	Low crime	Social safety/low crime	0.769	0.422
	Near work/school	Being near my primary work/school location	0.568	0.495
	Near health services	Being near health services	0.517	0.5
	Parks	Presence of parks and green spaces	0.808	0.394
	Schools for children	Presence of good schools for my children	0.407	0.491
	Ease of car	Ease of getting around by car	0.553	0.497
	Near public transit	Being near public transport	0.806	0.396
	Near bicycle	Being near bicycle infrastructure	0.395	0.489
Intended trip purpose using the REM	Commute	Commute to work or school	0.286	0.452
	Non-commute	Non-commuting purposes	0.553	0.497
	Multiple purposes	Multiple purposes	0.393	0.489
Personal reasons for intending to choose the REM	Good for environment	Good for environment	0.321	0.467
	Shorter travel time	Shorter travel time	0.383	0.486
	More comfortable	More comfortable	0.275	0.446

**Bixi is the public bicycle sharing service in Montreal.*

Table 2: Model for intention to use the REM

Predictors	Odds Ratios	Confidence Interval
(Intercept)	6.18 ***	3.54 – 10.79
Socio-demographic characteristics		
Gender (ref cat: male)		
Female	0.62 ***	0.52 – 0.75
Other gender	0.61	0.25 – 1.46
Age	0.99 *	0.99 – 1.00
Income (ref cat: over $120K)		
under $30K	0.67 **	0.50 – 0.89
$30K to $60K	0.67 **	0.52 – 0.86
$60K to $90K	0.63 ***	0.48 – 0.82
$90K to $120K	1.00	0.75 – 1.33
Raised environment (ref cat: suburban)		
Raised urban	0.79 *	0.65 – 0.96
Raised rural	0.94	0.72 – 1.21
Spatial characteristics		
Net distance	0.82 ***	0.78 – 0.85
Net distance squared	1.004 ***	1.00 – 1.01
Walk Score of home location (ref cat: 0-49)		
Walk Score 50-69	0.91	0.68 – 1.23
Walk Score 70+	0.65 **	0.48 – 0.89
Accessibility by transit	0.98 ***	0.98 – 0.99
Physical activity characteristics		
Transport PA hrs	1.07 ***	1.04 – 1.10
Mobility characteristics		
Access to vehicle	0.79 *	0.62 – 0.99
Bixi member	1.59 **	1.15 – 2.20
Weekly transit rides	1.04 **	1.01 – 1.07
Attitudinal characteristics		
Transit positive attitude	2.17 ***	1.79 – 2.62
REM bad for Montreal	0.43 ***	0.29 – 0.63
REM bad for n'hood	0.35 ***	0.27 – 0.45
Home location characteristics		
Having a large home	0.83 *	0.69 – 0.99
Near work/school	0.74 **	0.62 – 0.89
Parks	1.37 *	1.09 – 1.72
Near public transit	2.37 ***	1.85 – 3.03
Random Effects		
σ^2	3.29	
$\tau_{00\ CT\_UID}$	0.12	
Intra-class correlation (ICC)	0.04	
N_{CT_UID}	674	
Observations	2767	
Marginal R^2 / Conditional R^2	0.289 / 0.314	

** p<0.05 ** p<0.01 *** p<0.001*

Results and discussion

Our analysis proceeds in two parts: First, we describe the data and respondents' general intentions regarding the REM. Second, we describe the results of a series of weighted multilevel logistic regression models designed to reveal the factors that influence (a) respondents' stated intention to use the REM and (b) their planned modal choice for arriving at the new train's stations. The answers to these questions have important implications for how planners and policymakers can work to ensure that major transportation investments, such as the REM, help cities and regions achieve their social and environmental goals.

Descriptive Statistics

Among the retained sample of 2,767 respondents, 1,501 (54.2%) indicated that they intend to use the REM when it becomes operational. Among those respondents who intend to use the REM, 632 (42.1%) indicated that they intend to walk to access the REM, 313 (20.9%) indicated they would bicycle, 692 (46.1%) indicated they would take public transport and transfer onto the REM, and 275 (18.3%) indicated that they would exclusively drive or otherwise use automobiles. Other than exclusive car users, the other categories of respondents are not mutually exclusive as respondents were allowed to select more than one access mode. Thus, a respondent can appear in more one than one model.

All Aboard? Modelling Who Will Use the REM

We first explore respondents' intention to use the REM. Broadly speaking, three principal categories of variables appear to exert an important influence on the binary decision of whether to use the REM: attitudes and perceptions regarding public transport generally and the REM, in particular; individual sociodemographic and physical activity attributes; and neighborhood and transport system characteristics (Table 2).

Eye of the Beholder: Attitudes and Perceptions

Individual perceptions and attitudes play a decisive role, as indicated by odds-ratio magnitude and statistical significance. A stated desire to ride public transport more often increased odds of intending to use the REM by 2.17 times, all else being equal. Meanwhile, a perception that the REM would be bad for Montreal reduced the odds of intending to use the REM by 57%. Similarly, a perception that the REM would be bad for one's neighbourhood reduced odds by 65%. This predominance of attitudes towards public transport in predicting propensity to use LRT over socio-demographic, environmental, and mobility characteristics reflects findings in several other recent studies (Kitamura et al., 1997; Lai & Chen, 2011; Sener et al., 2020; Şimşekoğlu et al., 2015).

Individual Characteristics and Upbringing

Identifying as female and having lower household income are both associated with a lower intention to use the REM, confirming previous research (Hsu et al., 2019). Females have 38% lower odds of intending to use the REM than males, all other variables held constant at their mean. Respondents living in households with incomes below $90,000 per year had between 33% and 37% lower odds of intending to use the REM compared to individuals living in households earning more than $120,000 per year, all else being equal. This finding suggests that the REM succeeds in incentivizing choice riders to use public transport, but also that the REM may not adequately serve lower income groups. It is important to note that the fare cost of using the REM has not been finalized so potential concerns over the cost of using the system may be at play, where respondents with lower household income may be less inclined to state that they would use the REM if they perceive that fares will be more expensive then they are

currently. Other individual characteristics, including employment status and marital status, were not found to be significant and were excluded from the final model.

Controlling for other variables, if an individual grew up in an urban environment they were less likely to intend to use the REM than those who grew up in suburban environments. One explanation may be that the REM is designed to serve suburban communities and has already been found to appeal to suburban riders, including those who do not already use public transport (N. Dent et al., 2021). Only certain residential self selection variables were found to be significant, namely, the importance of having a large home and proximity to work or school seem to reduce the odds of intending to use the REM. Those who wish to have a larger home may be more accepting of a more car-oriented lifestyle and therefore will be less likely to express an interest in using the REM. On the other end of the spectrum, those who value living close to their work or school may not want to rely on transit to access these locations, and would perhaps walk or bike instead of taking the REM. Expectedly, the importance of proximity to transit increases the odds of the intention to use the REM. Interestingly, self selecting for proximity to parks and green spaces exerts a positive influence on the odds of intending to use the REM. This may infer a more active and environmentally conscious lifestyle of individuals who would be interested in taking transit despite living in a more suburban area.

Existing travel behaviour is closely related to future intentions to use the REM. Access to a vehicle had a statistically significant and negative association with intention to use the REM and every additional public transport ride in the previous week increased the odds of using the REM by 4%, all else held equal. Both of these findings are supported by existing research (Sener et al., 2020; Yazdanpanah & Hosseinlou, 2017). Possessing a Bixi (Montreal's bike share system) membership exerted a statistically significant and positive impact on the odds of intending to use the REM. We can interpret this as an indicator of how active lifestyles contribute to light-rail transit ridership, and additionally as a proxy for propensity to adopt new sustainable travel behaviours.

The model provides evidence for the positive impact of physical activity and active travel on public transport adoption: Time spent doing active transport physical activity was significantly and positively associated with intention to use the REM. All else held constant, every additional hour of active transport physical activity in the previous week increased the odds of intending to use the REM by 7%. Other variables related to physical activity carried out at work or for leisure where not significant and therefore excluded from the final model.

Location, Location, Location: Home Location, Built Environment & Transport Network

Up to a point, the further someone's home is from a station, the less likely that person is to plan on using the REM. Holding all other variables constant, every additional kilometer that a respondent lives from the closest REM station reduces their odds of intending to use the REM by about 18% while at the same time, this reduction in odds of intending to use the REM with increasing distance from the station decreases at a rate of 0.4% with every kilometer until at around 51 kilometers, where afterwards increasing distance increases the odds, as indicated by the direction and statistical significance of the squared term. However, it is unlikely that individuals living 50 kilometers away from the REM will use it so we can generally conclude a negative relationship between distance and the odds of intending to use the REM.

Higher existing values for local (i.e. Walk Score) and regional accessibility are both associated with decreased odds of intending to use the REM, all else held equal. This is reasonable considering that the REM's network design provides benefits mainly in outlying areas not as well-served by existing public

transport. People in amenity-dense neighborhoods or areas already served by frequent Metro and bus service, may have less incentive to use the REM. Population density was tested as an explanatory variable but was not statistically significant and was excluded from the model.

How Will They Get There: Access-Mode Intention

How travellers plan to reach the REM is equally important for achieving Montreal's transportation-related social and environmental goals. With this second series of models, we investigate the factors that influence self-avowed future riders' planned mode choice for accessing the REM. This analysis relies on four weighted multi-level binary logit models explaining intention to (a) walk, (b) bicycle, (c) take other public transport; and (d) drive. As discussed above, respondents, other than those who indicated they would drive exclusively, were able to indicate multiple modes and thus can appear in multiple models. Insignificant variables in each model were removed from the final models presented in Table 3.

Trip Purpose

Intended trip purpose for using the REM exerts significant influence on the choice of an active mode for accessing the REM. All else held constant, an intention to use the REM for commuting to work or school more than doubles the odds of intending to walk to complete the first-mile journey to the REM compared to using the REM for only other purposes. Intending to use the REM for multiple trip purposes also exerts a strong positive and statistically significant impact on intending to walk or bike to access the REM compared to intending to use it for only commute or for only other purposes. For non-active mode users, an intention to use the REM for other purposes influences the odds of using transit and car to access the REM in opposite ways, where the intention to use the REM for other purposes almost triples the odds of intending to use transit but halves the odds of intending to drive to access the REM compared to intending to use the REM for commute trip only. This implies that those who intend on accessing the REM using a car are more likely to be making commute only trips using the REM and potential users who will be using active modes as well as other forms of transit to access the REM are interested in using the REM for more than just commute only trips.

Personal Characteristics, Attitudes, and Existing Behaviors

Identifying as female as opposed to male was negatively associated with intention to bicycle to the REM, all else being equal. The negative association is consistent with previous research investigating the impact of gender on bicycle mode choice for first-mile trips to public transport (de Souza et al., 2017; Ji et al., 2017). Women have 44% lower odds of intending to bicycle to the REM than men. Being older has a statistically significant and negative impact on intention to cycle to the REM, corroborating findings by Ji et al. (2017). Older age had a statistically significant and positive correlation with intention to exclusively drive to the REM, potentially pointing to the general trend of changing travel behavior as ones ages due to reduced mobility, increased income or changing personal values which would promote the use of private vehicles to access the REM. Having children in the household reduced the odds of intending to walk to the REM which is supported by McCarthy et al. (2017)'s review of the literature of the factors that influence mode choice for families with young children. Ethnicity and education level were only significant in the drive-only model, where being non-white and having a bachelor's degree, compared to a graduate degree, increases the odds of intending to drive to access the REM. The influence of an individual's upbringing on future travel behavior is evident in the active mode models where when compared to growing up in a suburban environment, growing up in an urban environment increases the odds of intending to walk or bike to access the REM and growing up in a rural environment decreases the odds of intending to bike.

Table 3: Models for modes of accessing the REM (among respondents who already intend to use the REM)

	Intention to walk to REM		*Intention to bicycle to REM*		*Intention to take public transit to REM*		*Intention to exclusively drive to the REM*	
Variable name	**Odds Ratios**	**Confidence interval**	**Odds Ratios**	**Confidence interval**	**Odds Ratios**	**Confidence interval**	**Odds Ratios**	**Confidence interval**
(Intercept)	0.81	0.42 – 1.57	0.27 **	0.12 – 0.59	0.04 ***	0.02 – 0.10	0.01 ***	0.003 – 0.06
Socio-demographic characteristics								
Gender (ref cat: male)								
Female			0.56 ***	0.41 – 0.77				
Other gender			1.00	0.24 – 4.18				
Age			0.96 ***	0.95 – 0.97			1.03 ***	1.02 – 1.04
Non-White							1.79 *	1.09 – 2.95
Educational attainment (ref cat: graduate)								
High school							1.57	0.83 – 2.98
College							1.63	0.98 – 2.70
Bachelor's							1.89 **	1.18 – 3.01
Children in household	0.64 *	0.45 – 0.90						
Mobility disability	0.58 *	0.37 – 0.92						
Raised environment (ref cat: suburban)								
Raised urban	1.37 *	1.01 – 1.86	1.41 *	1.03 – 1.95				
Raised rural	0.99	0.65 – 1.51	0.44 **	0.26 – 0.74				
Spatial characteristics								
Net distance	0.59 ***	0.53 – 0.65			1.32 ***	1.22 – 1.43	1.12 *	1.03 – 1.22
Squared of Net distance	1.014 ** *	1.01 – 1.02			0.992 ** *	0.99 – 1.00	0.997 *	0.99 – 1.00
Walk Score of home location (ref cat: 0-49)								
Walk Score 50-69	1.05	0.65 – 1.69						
Walk Score 70+	1.75 *	1.14 – 2.69						
Accessibility by transit					1.03 ***	1.03 – 1.04	0.95 ***	0.94 – 0.97
Physical activity characteristics								
Transport PA hrs							0.94 *	0.88 – 0.99
Work PA hrs	1.09 *	1.01 – 1.17						
Mobility characteristics								
Access to vehicle					0.48 ***	0.34 – 0.69	3.79 **	1.45 – 9.88

Driver license							3.31 *	1.26 – 8.71
Owns bike	1.63 **	1.20 – 2.22	3.15 ***	2.08 – 4.76	1.88 ***	1.40 – 2.53	0.48 ***	0.33 – 0.70
Bixi member			1.92 **	1.25 – 2.96			0.09 *	0.01 – 0.86
Weekly transit rides					1.13 ***	1.09 – 1.18		
Transit non-commute					0.26 ***	0.18 – 0.38		
Attitudinal characteristics								
Transit positive attitude	0.72 *	0.54 – 0.96						
Cycling positive attitude			1.77 **	1.25 – 2.51				
Self-selection characteristics								
Having a large home					0.50 ***	0.38 – 0.65		
Familiarity with n'hood	0.72 *	0.54 – 0.95						
Near work/school					0.73 *	0.56 – 0.96	1.50 *	1.05 – 2.13
Near health services								
Schools for children								
Ease of car			0.56 ***	0.41 – 0.76			1.73 **	1.15 – 2.62
Near public transit			0.51 **	0.32 – 0.81	2.28 ***	1.48 – 3.50	0.50 **	0.33 – 0.76
Near bicycle			2.96 ***	2.14 – 4.10				
Intended trip purpose using the REM								
Commute	2.31 ***	1.69 – 3.16						
Non-commute					2.73 ***	1.73 – 4.30	0.41 ***	0.26 – 0.65
Multiple purposes	1.58 **	1.16 – 2.15	2.09 ***	1.48 – 2.95				
Personal reasons for intending to use the REM								
Good for environment	1.79 ***	1.34 – 2.39						
Shorter travel time	1.45 *	1.08 – 1.94						
More comfortable			1.35 *	1.00 – 1.82	1.41 *	1.08 – 1.84		
Random Effects								
σ^2	3.29		3.29		3.29		3.29	
τ_{00}	1.15 $_{CT\_UID}$		0.14 $_{CT\_UID}$		0.73 $_{CT\_UID}$		0.67 $_{CT\_UID}$	
Intra-class correlation (ICC)	0.26		0.04		0.18		0.17	
N	524 $_{CT\_UID}$		524 $_{CT\_UID}$		524 $_{CT\_UID}$		524 $_{CT\_UID}$	
Observations	1501		1501		1501		1501	
Marginal R^2 / Conditional R^2	0.334 / 0.506		0.397 / 0.421		0.348 / 0.466		0.626 / 0.689	

* p<0.05 ** p<0.01 *** p<0.001

Personal travel priorities are also closely associated with first-mile mode choice. For example, indicating a desire to take the REM for environmental reasons and shorter travel times were correlated with 79% and 45% higher odds of walking to the REM, respectively. Intending to use the REM for increased comfort had a positive and statistically significant association with intending to bicycle and use public transport to access the REM.

Existing patterns of physical activity appear to be closely related to mode-choice intention for accessing the REM. As expected, active-transport-related physical activity has a statistically significant and negative association with intention to exclusively drive to the REM. Controlling for all other variables, performing vigorous physical activity at work has a statistically significant and positive association with intention to walk to the REM. This requires further investigation as it is possible that jobs requiring more physical exertion tend to be lower income and as such, individuals may be more likely to walk instead of drive. However, there are also many exceptions to this including jobs in the trades industry.

These models show that existing mobility characteristics of the individual exert a strong influence on what mode a future REM user would choose for their first-mile journey. Interestingly, bicycle ownership does not merely possess a statistically significant and positive relationship with intention to bicycle to the REM as it is also strongly associated with greater odds of walking and using public transport to travel to the REM, controlling for all other variables. It also bears a strongly negative association with the intention to exclusively drive to the REM. We hypothesize that this is an indication of how bicycle ownership is indicative of active lifestyles, which encourage active modes of accessing the LRT and discourage exclusively driving. Moreover, being a Bixi member also increases the odds of intending to bike and, as expectedly, decreases the odds of intending to drive to access the REM. Car access and possession of a driver's license both increase the odds of intending to drive the REM. The former also decreases the odds of intending to use transit. These results confirm the findings from De Witte et al. (2013) and Kim et al. (2007).

Finally, attitudinal and residential self-selection characteristics also influence the intention to use different modes to access the REM in different ways. Interestingly, having a transit positive attitude (i.e. expressing a desire to ride transit more) has a negative influence on the intention to walk to access the REM. It is possible that those who walk to access the REM are doing so because they are constrained by the modes that they can take for reasons like affordability or time, so they are using transit for practical reasons and may not actually want to take transit more than they need to. On the other hand, having a positive cycling attitude does increases the odds of biking to access the REM which may imply that those who wish to bike to access the REM are choosing to bike, rather than biking because they need to. The influence of most of the self-selection variables on the intention to use a particular mode to access the REM are clearly consistent with expectations. There are a couple interesting results to be pointed out. For example, valuing familiarity with the neighborhood in residential selection seems to decrease the likelihood of walking to access the REM. While one could expect that those who walk would want to feel more comfortable walking in their neighborhood, but it may be that those who would walk to the REM may not be walking very far so would not need to be familiar with their neighborhoods but rather just the area close to their home.

Spatial Characteristics

While higher Walk Scores were negatively associated with intention to use the REM, we find that living in an area with a high Walk Score (70+) improves odds of choosing to walk to the REM by 75% among those who do intend to use it, relative to individuals who live in areas with a Walk Score below 50. This finding is consistent with research that has determined that higher local accessibility and better

pedestrian infrastructure encourages walking to public transport and for longer distances (De Witte et al., 2013; Lu et al., 2021). While accessibility by transit has a significant and positive influence on potential riders' intention to use transit to access the REM, it exhibits a significant and negative influence on the intention to drive.

The influence of the distance between the home and the REM is different depending on the intended mode used to access the REM. For intending to walk to the REM, the influence of distance is negative, where for every additional kilometer that a respondent lives from the closest REM station, the odds of intending to walk to the REM decreases by about 42%. At the same time, this reduction in odds of intending to walk to the REM with increasing distance decreases at a rate of 1.5% with every kilometer until around 37 kilometers, where the trend reverses and increasing distance begins to increase the odds of intending to walk to the REM. However, very few people will walk more than a couple of kilometers to access the REM, so the general influence of distance is negative.

For potential riders intending to take transit or drive to the REM, the influence of distance is positive, up to a certain threshold. Every additional kilometer that a respondent lives from the closest REM station, increases the odds of intending to take transit to the REM by about 32% and driving by around 12%. At the same time, the increase in odds with increasing distance decreases at a rate of 0.8% and 0.3% with every kilometer until around 36 kilometers and 38 kilometers, respectively for intending to take transit and for intending to drive, where the trend reverses. Furthermore, using the quadratic relationship that we have hypothesized between network distance and odds of intending to use a certain mode to access the REM, the distances at which the odds of intending to take transit or drive to the REM are maximized are calculated to be around 18 kilometres and 19 kilometers, respectively.

Conclusion

This study on the determinants of intention to use the REM and determinants of intended first-mile mode choice yields insights that can contribute to efforts to promote shared and active modes of transport through better planning and design of LRT. Five general findings from this research are notable for policy and future research. First, like several previous studies (Lai & Chen, 2011; Sener et al., 2020; Şimşekoğlu et al., 2015), we found that while sociodemographic and environmental variables tend to be directly associated with propensity to use public transport, attitudes towards public transport appear to dominate. Second, we found that in the case of the REM, there is disparity in intention to use the new infrastructure across gender categories and income strata. Accounting for differences in geography, women are less likely to intend to use the REM than men, and lower income groups are less likely to plan on using the REM than higher income groups. Third, local accessibility, as measured by Walk Score, as well as regional accessibility seem to be negatively associated with the intention to the use the REM which could be attributed to the design of the REM which would provide benefits mainly to outlying areas not already well-served by existing public transport. Fourth, we also found that higher Walk Score is positively associated with choosing to walk to access the new LRT. Fifth, we find that increased physical activity and active lifestyles contribute positively to both intentions to use the new LRT and to choose an active mode of transport to fulfill the first-mile journey.

While our modelling approach benefits from a balance of simplicity, replicability, and rigor, it is limited in that it does not account for the complex causal links that are known to exist between various sociodemographic, spatial, and psycho-social factors that ultimately inform intention and then behaviour (De Vos et al., 2021). This study nevertheless offers important practical insights that planners and policymakers may use to inform current and future projects. Key policy recommendations to promote system uptake and active modes of access include:

- ***Plan public relations, communications strategies, and consultations to improve attitudes towards new LRT projects***: Our study and others like it have found evidence that positive attitudes towards public transport and towards specific projects strongly encourage ridership, and negative ones inhibit it. Designing responsive consultations and communications strategies that address the root of concerns and amplify public enthusiasm are not only responsible activities but ones that can meaningfully promote ridership, according to our research. Attitudes are fundamentally rooted in personal values (Paulssen et al., 2014), which are more difficult to change and critical to understand in order to effectively alter future travel behaviour.
- ***Support efforts to increase physical activity and active lifestyles***. Our study provides evidence that physical activity and existing active lifestyles improves adoption of LRT and improves likelihood of using a sustainable mode of transport to fulfill the first-mile journey to the station. Policies that promote physical activity, especially active travel, will benefit public transport ridership. These can include public health and design efforts through education, better transport infrastructure, and subsidies for facilitators of active lifestyles like bicycles. Our findings suggest that these efforts could be framed in terms of not only the benefits they afford to public health and wellbeing but also to more efficient and sustainable urban transport systems.
- ***Promote more walkable design and mixed land use around stations.*** According to our findings, higher walkability strongly encourages walking to LRT stations. More walkable station areas can benefit ridership through their contribution to promoting active lifestyles, which improves LRT ridership. Additionally, the built environment may play an important role in shaping attitudes that also benefit public transport ridership (De Vos et al., 2021).

In future research, gender and income disparities in intended use of this LRT system should be investigated to ensure that this LRT systems and others contribute to the achievement of equitable transport systems. An equitable transport system is one that distributes the economic benefits of a project towards groups that are systemically disadvantaged through existing transport systems or otherwise (Pereira et al., 2017). Gender differences could be caused by a possible gender difference in perceptions of safety of LRT (Hsu et al., 2019) and additionally by differences in how well the REM fulfills demand for desired trip purposes by gender category.

Chapter 2: Who does light rail serve? Light-rail transit and gendered mobilities in Montreal

Abstract

Investment in light rail transit (LRT) has been one of the main strategies of large metropolitan areas in the last decade to tackle environmental, economic, and social issues. In Montreal, Canada, a CAD$6.9 billion LRT system is currently under construction and is expected to significantly impact mobility patterns across the metropolitan region. It is crucial to identify the ways in which the impacts of such large public investment vary across societal groups to assess whether the distribution of benefit is fair and equitable. Using data from an online survey and a binary logistic modelling approach, we investigate the ways in which intentions to use this new LRT system differ across gender identities. First, we found that women are less likely to have an intention to use LRT compared to men. Our modelling results show that there are statistically significant differences across gender identities in the effect of certain sociodemographic and travel-behavior characteristics that explain the intention to use the LRT system. In terms of trip purpose, whilst women and men intend to use LRT for work trips to the same extent, men intend to use LRT for leisure and discretionary travel more than women. Our findings can help in guiding further research into gender gaps in transport studies and inform practitioners on how gender can be considered in LRT policy decisions so that the benefits of major public-transport investments are more equitably distributed.

Introduction

Given the pressing need for sustainable-transport transitions (Sovacool & Axsen, 2018), policy makers are increasingly working to invest in Light Rail Transit (LRT). The *Réseau Express Métropolitan* (REM), a CAD$6.9B, 67-km LRT system currently under construction in Montreal, Canada, is one of the largest infrastructural interventions currently being built in North America. As a monumental public-transport investment, the REM aims to significantly alter the way that people move within the metropolitan area by reducing car dependency and increasing public-transit ridership (Nicolette Dent et al., 2021). In addition to delivering environmental benefits, transport-infrastructure projects of this scale also promise to significantly enhance local neighbourhoods and provide substantial economic benefits to residents through increased access to opportunities (Ferbrache & Knowles, 2017).

Beyond these environmental and economic goals, LRT projects should also strive to foster equitable transport systems, which means ensuring that the social and economic benefits of major infrastructure investments are fairly distributed across society (DeWeese et al., 2022; Manaugh et al., 2015; Manaugh & El-Geneidy, 2012; Pereira et al., 2017). There are major gaps, however, in knowledge about how these public-transport investments serve the wants and needs of different segments of society, particularly with regards to LRT and gender (Mandhani et al., 2021). While gender-disaggregated information on LRT ridership remains scare, some studies have found that women have less propensity to use LRT than men (Creemers et al., 2012). Additional research is needed to understand how gender differences in intended LRT ridership change across diverse geographical contexts as well as to characterize the phenomena that generate these gender differences.

To address this gap, this research draws from survey data from Montreal to examine residents' intentions to use the REM, how these intentions vary across genders, as well as factors that generate gaps in perceived utility. Our study poses the following research question: to what extent and in what ways do women's intentions to use light-rail transit vary from men's?

Literature Review

Studies on gendered mobilities have long revealed that transport systems are not gender neutral (Crane, 2007; Hanson & Hanson, 1980; Uteng & Cresswell, 2016; Walsh, 2009). For example, urban-planning decisions that prioritize infrastructure for car travel, or that relate to bus routes and street lighting, often have immense gender consequences (Gauvin et al., 2020; Kern, 2021). Feminist research has revealed that men tend to travel at a faster pace (relying more on car travel) in comparison to women, whose mobilities have often been restricted to slower speeds, especially when travelling with children (Soto Villagrán, 2016). Because gender-differentiated roles place a higher burden on women for family-care activities (Jirón, 2017; Ravensbergen et al., 2022), women's mobilities tend to be much more complex, often encompassing multiple travel modes (Plyushteva & Schwanen, 2018; Soliz, 2021; Soto Villagrán, 2016). Although women's trips are often shorter than men's (Crane, 2007), on average, women make significantly more trips (Miralles-Guasch et al., 2016; Nosal Hoy & Puławska-Obiedowska, 2021), and engage in more non-work related travel (Miralles-Guasch et al., 2016). As for travel patterns, the literature finds that women tend to walk more than men do (Miralles-Guasch et al., 2016) and that they rely more heavily on public transport (Nosal Hoy & Puławska-Obiedowska, 2021; Preston & McLafferty, 2016).

While the literature on light-rail transit (LRT) has vastly increased in recent years (Ferbrache & Knowles, 2017), discussions on the gendered dimensions of LRT ridership remain limited, and at times lack consensus. For example, a study from Flanders, Belgium (Creemers et al., 2012) found that women were less inclined than men to use LRT, whereas a study from Huston Texas (Sener et al., 2020) found that gender was not been associated with more or less intention to use LRT when controlling for other variables. In their research on how gender-specific factors mediate different mode choices, Hsu et al. (Hsu et al., 2019) found that safety concerns were more negatively associated with the number of LRT trips for women than for men.

The limited reach of studies on gender and LRT is of course reflective of wider trends in transport studies and planning, which often neglect to incorporate discussions on gender, or that engage with these questions in only limited ways (Kern, 2021; Uteng & Cresswell, 2016). Although feminist research has brought attention to women's and girl's unique travel patterns and safety concerns, these considerations have only been sparsely integrated in urban transport planning (Gauvin et al., 2020). While this neglect can be related to such issues as gender-based barriers in urban-planning professions and wider power relations (Kern, 2021), there is also a great need for more comprehensive data about women's lives, mobilities, and travel preferences (Gauvin et al., 2020). With the rapid implementation and expansion of LRT in cities across the globe, this paper addresses the urgent need for more detailed research on the gendered dimensions of light rail.

Study Context

The REM is an automated LRT system currently under construction in Montreal, Canada that is expected to begin operations progressively in phases between 2022 and 2024. When complete, the REM will connect Montreal's downtown, its international airport, and suburban destinations with high-frequency service (Figure 1). With a predicted initial ridership of 190,000 passengers per day (Steer Davies Gleave, 2017), the REM has the potential to radically alter mobility and land-use and transport patterns across the Greater Montreal Area, as LRT projects have done elsewhere (Lee & Sener, 2017). The impacts of the REM on social wellbeing are potentially significant as well, as the project may have broad public health, environmental, and economic impacts within the metropolitan area (Topalovic et al., 2012; Wali et al., 2022).

At the same time, LRT investments of that scale will need to pay careful attention to local household realities and gender dynamics if they are to support social-equity goals. For example, recent quantitative research on travel patterns in Montreal has found that women disproportionately bear the burden for care mobilities, including such activities as grocery shopping, escorting children, and other forms of travel associated with unpaid care labour (Ravensbergen et al., 2022). Other studies have revealed that single-parent households and elderly individuals in Montreal have more geographically limited travel patterns (Morency et al., 2011; Roorda et al., 2010). Low-income groups in Montreal have also been found to travel less than higher income groups (Páez et al., 2010). These findings underscore the importance of accounting for socio-demographic differences in sustainable-transport planning, including gender. In this context, it is highly relevant to study the differing perceptions and intended uses of the REM between genders, both for this LRT project in Montreal, as well as for future LRT projects elsewhere.

Data and Methods

This study's primary data source is an online bilingual (English-French) survey conducted between October and November 2019. This survey was administered in the Greater Montreal Area to participants of 18 years of age and older to collect data on people's intention to use the REM for different purposes, to study the project's potential impact on travel patterns and wellbeing. The survey collected data on respondents' sociodemographic characteristics, attitudes towards the REM and transit in general, current and past travel behaviour, and physical activity levels. Additionally, the survey collected residential choice factors, which allow us to control for residential self-selection.

To ensure the representativeness of the sample, we employed various recruitment techniques recommended by Dillman et al. (2014), including the distribution of flyers at various residences and downtown transport hubs, as well as targeted online recruitment through paid and un-paid advertisements on various social media platforms. Incentives were included in the survey such as the possibility of winning a prize based on a draw. A public opinion survey company was also hired to help in recruiting part of the sample.

We collected a total of 4,148 complete answers, to which we applied a thorough filtering validation process. We removed responses that were filled too quickly to be considered reliable, excluding the fastest 10% from the sample depending on the number of questions answered. It must be noted that different groups of respondents, depending on their answers, were presented different sets of questions. Each of these groups were validated according to their own respective top 10% speed. We also filtered out unrealistic responses, including birth years before 1920 and reporting spending more than 200 minutes per day commuting by walking or bicycle. Furthermore, respondents who had not heard about the REM project before were not asked whether they intended to use the REM and were therefore excluded. We also excluded survey responses if the home location the respondent provided was outside the Montreal Census Metropolitan Area. Following this exclusion process, we retained a sample of 2,778 responses for our analysis.

To calculate regional accessibility to jobs by transit, and travel distance through the city network to REM stations, we used the r5r package in R (R. H. M. Pereira et al., 2021). Job location data was acquired through Statistics Canada, from the 2016 Census, in the form of commute trips for the Montreal Census Metropolitan Area (CMA). Using the projected travel times for the REM, we calculated the improvement in job accessibility that will be brought by the project. To account for local accessibility, we used

WalkScore data, which focuses on the number and diversity of activities that can be reached within walking distance. This measure has been tested repeatedly in the land use and transport literature (Hall & Ram, 2018), showing reliability as a walkability indicator (Manaugh & El-Geneidy, 2011).

To analyze this dataset and achieve this work's goal, we estimated a weighted multi-level binary logistic regression model using the lme4 R package (Bates et al., 2015). Using this model, we estimate the probability of intending to use the REM as a function of several independent variables that may affect this intention. These variables include a series of sociodemographic characteristics, distance to the nearest REM station, local and regional accessibility levels, current physical activity levels, past and current transit use, and current access to different transport modes. Additionally, we control by attitudes towards the REM and transit in general, as well as for residential self-selection.

In order to investigate the gendered effects that our studied factors have on the probability of using the REM, we tested interactions between the independent variables and gender, and included those that were statistically significant in the final model. Finally, to inquire into gendered differences in the intention to use the REM depending on trip purpose, we conducted three Welch two-sample t-tests. The three tested trip purposes were going to work, leisure, and going to the airport. For this, we only considered the sample of women (n = 699) and men (n = 791) who indicated that they intended to use the REM in general.

For the multilevel model, we considered the census tract of the home location as the higher level to control for shared characteristics in a neighborhood that are otherwise unaccounted for. The weightings in the model were calculated for all valid responses using the anesrake R package (Pasek, 2018). The weights were calculated to match our sample to census tract information of age, income, and gender from Statistics Canada 2016 census (Statistics Canada, 2016a), retrieved through the cancensus R package (von Bergmann et al., 2021). This weighting process is key to ensure that model results are not affected by biases from the survey sampling.

Results and Discussion

Descriptive statistics

The descriptive statistics of the cleaned and validated sample that we retained for our analysis (n = 2,778) is presented in Table 1. Around 54.2% of this sample indicated that they intended to use the REM. Whilst 50.2% of respondents in this sample identified as a man, 48.4% identified as a woman, and 1.4% (38 individuals) identified as another gender. A smaller proportion of women than men indicated that they intended to use the REM: 50.1% of women compared to 58.8% of men. A two-sample Welch t-test confirms that this difference is statistically significant ($p < 0.001$).

Gendered factors influencing intention to use LRT

The results of our model estimating the probability of intending to use the REM are presented in Table 2. We found several factors that have a significantly different effect for women than men by identifying statistically significant interactions between gender and other independent variables. First, we found that intention to use the REM for women is less negatively affected by increased age than men. While men's probability of intending to use the REM is reduced by 2% for each additional year of age, for women this effect is less than 1%. In other words, women's intention to use the LRT declines less with age, and the gender gap between intended use is narrower for older individuals than for younger individuals.

Second, immigrating to Canada within the last 5 years has a strongly positive effect on intention to use the REM for women, but does not have this effect for men and other respondents. All else held equal, recent immigrant women are 2.4 times more likely of intending to use the REM than women who are not recent immigrants. This effect could be partially explained by higher public transit use by women in other countries (Uteng & Lucas, 2018), but merits further research.

Table 1. Descriptive statistics of the sample

			Total (n = 2778)		Female (n = 1395)		Male (n = 1345)	
Category	**Variable name**	**Description**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
	Dependent variable							
Dependent variable	Intends to use REM	Intends to use REM	0.542	0.498	0.501	0.5	0.588	0.498
	Independent variables							
Socio-demographic characteristics	Female	Gender [female]	0.502	0.5				
	Non-binary	Gender [other]	0.014	0.116				
	Age	Age (in years)	45.527	15.898	44.394	15.689	46.997	16.024
	Employed	Employed	0.685	0.464	0.689	0.463	0.685	0.465
	New immigrant	Immigrated to Canada in the last 5 years	0.042	0.201	0.036	0.186	0.048	0.215
	under $30K	Household income [under $30K]	0.104	0.305	0.097	0.296	0.106	0.308
	$30K to $60K	Household income [$30K - $60K]	0.214	0.41	0.23	0.421	0.198	0.398
	$60K to $90K	Household income [$60K-$90K]	0.191	0.393	0.196	0.397	0.187	0.39
	$90K to $120K	Household income [$90K-$120K]	0.167	0.373	0.166	0.372	0.169	0.375
	over $120K	Household income [$120K+]	0.228	0.42	0.192	0.394	0.271	0.445
	Used transit in childhood	Used public transit in childhood	0.684	0.465	0.599	0.49	0.774	0.418
	Raised urban	Grew up in an urban environment	0.394	0.489	0.352	0.478	0.438	0.496
	Raised suburban	Grew up in a suburban environment	0.454	0.498	0.481	0.5	0.427	0.495
	Raised rural	Grew up in a rural environment	0.152	0.359	0.167	0.373	0.135	0.342
Spatial characteristics	AccessDist	Access network distance between home and REM station (km)	6.325	6.989	6.183	6.751	6.543	7.299
	Sq of AccessDist	Square of network distance between home and REM station	88.833	217.589	83.774	210.202	96.048	227.523
	Accessibility by transit	Number of jobs (10,000s) accessible within 45 minutes by transit (May 2019)	27.079	26.088	26.865	26.129	26.729	25.956
Physical activity characteristic	Transport physical activity	Hours of active transport physical activity in past week	2.788	3.229	2.68	3.03	2.872	3.373
Mobility characteristics	Access to vehicle	Access to a vehicle	0.751	0.433	0.75	0.433	0.76	0.427
	Bixi member	Has a bixi membership	0.089	0.285	0.072	0.258	0.107	0.309
	Weekly transit rides	Number of transit rides in the previous week	2.912	3.375	2.9242	3.397	2.893	3.359
Attitudinal characteristics	Transit positive attitude	Would like to ride public transit more often	0.334	0.472	0.309	0.462	0.366	0.482
	REM bad for Montreal	Believes the REM will be bad for Montreal	0.071	0.257	0.069	0.253	0.073	0.26
	REM bad for n'hood	Believes the REM will be bad for neighbourhood	0.179	0.384	0.177	0.382	0.181	0.386
Residential selection characteristics	Having a large home	Residential self-selection [having a large home]	0.571	0.495	0.573	0.495	0.577	0.494
	Near work/school	Self-selection [being near my primary work/school location]	0.568	0.495	0.581	0.494	0.554	0.497
	Parks	Self-selection [presence of parks and green spaces]	0.808	0.394	0.83	0.376	0.788	0.409
	Near public transit	Self-selection [being near public transportation]	0.806	0.396	0.816	0.388	0.796	0.403

Table 2. Model for intention to use the REM including interactions with gender.

Predictors	Odds Ratios	Confidence interval	*p*
(Intercept)	12.08 ***	5.79 - 25.19	**<0.001**
Gender (ref cat: man)			
Woman	0.27 ***	0.14 – 0.51	**<0.001**
Non-binary	0.52	0.22 - 1.25	0.141
Factors with gender interactions			
Age	0.98 ***	0.98 – 0.99	**<0.001**
Woman x Age	1.01 *	1.00 – 1.03	**0.01**
New immigrant	0.97	0.55 – 1.77	0.925
Woman x New immigrant	2.45 *	1.00 – 5.99	**0.049**
Used transit in childhood	0.94	0.71 – 1.26	0.675
Woman x Used transit in childhood	1.55 *	1.05 – 2.29	**0.026**
Weekly transit rides	1.07 **	1.03 – 1.11	**0.001**
Woman x Weekly transit rides	0.95 ·	0.90 – 1.00	0.058
Socio-demographic characteristics			
Employed	0.74 **	0.60 – 0.91	**0.005**
Income (ref cat: over $120K)			
under $30K	0.58 ***	0.43 – 0.78	**<0.001**
$30K to $60K	0.63 ***	0.49 – 0.81	**<0.001**
$60K to $90K	0.61 ***	0.47 – 0.80	**<0.001**
$90K to $120K	1.01	0.76 – 1.35	0.944
Childhood environment (ref cat: suburban)			
Raised urban	0.79 *	0.65 – 0.96	**0.018**
Raised rural	0.92	0.71 – 1.20	0.535
Spatial characteristics			
Accessdist	0.82 ***	0.78 – 0.85	**<0.001**
Sq of Accessdist	1.00 ***	1.00 – 1.01	**<0.001**
Accessibility by transit	0.98 ***	0.98 – 0.99	**<0.001**
Walkscore of home location (ref cat: <50)			
Walkscore 50-69	0.92	0.68 – 1.23	0.564
Walkscore 70+	0.66 *	0.48 – 0.91	**0.011**
Physical activity characteristics			
Transport physical activity	1.07 ***	1.04 – 1.10	**<0.001**
Mobility characteristics			
Access to vehicle	0.8 ·	0.63 – 1.01	0.058
Bixi member	1.56 **	1.12 – 2.17	**0.009**
Attitudinal characteristics			
Transit positive attitude	2.16 ***	1.78 – 2.62	**<0.001**
REM bad for Montreal	0.42 ***	0.28 – 0.63	**<0.001**
REM bad for n'hood	0.35 ***	0.27 – 0.45	**<0.001**
Self-selection characteristics			
Having a large home	0.81 *	0.68 – 0.98	**0.029**
Near work/school	0.73 **	0.61 – 0.88	**0.001**
Parks	1.38 **	1.10 – 1.74	**0.005**
Near public transit	2.38 ***	1.86 – 3.05	**<0.001**
Random Effects			
σ^2	3.29		
$\tau_{00\ CT\_UID}$	0.13		
ICC	0.04		
N_{CT_UID}	674		
Observations	2767		
Marginal R^2 / Conditional R^2	0.303 / 0.330		

· *p<0.1 * p<0.0 ** p<0.01 *** p<0.001*

Third, according to our results, experience of having used public transit regularly in childhood had a positive and statistically significant association with intended use of LRT for women, but did not have an effect on intended use for men. All else held equal: women who used public transit regularly in childhood had 55% greater odds of intending to use the REM than women who did not have this experience in childhood. This finding points to a gendered effect of life course on mode choice and builds on an emerging understanding of how life events affect individuals' travel patterns differentially by gender (Scheiner, 2014). A potential explanation for the lack of effect of men's childhood transit use may be related to differences in travel socialization across gender identities while growing up (Baslington, 2008).

If women's mode choice is distinctly more affected by personal childhood mobility experiences, as our model results suggest, there could be a case for prioritizing exposure to public transport in childhood, for example through public education, in order to contribute to reducing gender gaps in light-rail transit use and better understanding women's unique travel needs. However, given that women already depend more heavily on public-transit, a case could be made for finding other strategies to better foster public-transit use for boys and men, such as programs that help to discourage car use.

Finally, we found differences in terms of how existing transit use affects intention to use the REM differently for women. Overall, our model results suggest that more frequent current transit use is positively associated with intended use of LRT, which is supported by previous research (Sener et al., 2020; Yazdanpanah & Hosseinlou, 2017). For men and non-binary respondents, every additional transit ride in the previous week contributes to a 7% increase in the probability of intending to use the REM. Multiplying the odds ratio of the interaction term and the non-interaction term gives us the contribution to odds of intending to use the REM for women, which is around 2% increase. Thus, intended use of the REM is far less sensitive to additional current transit use for women than it is for men. In other words, while childhood use of transit is more deterministic of future LRT use for women, their current use of public transit predicts their future LRT use less.

The coefficient associated to non-binary people's dummy variable indicates that their intention to use the REM is not significantly different from people who identify as men. Since the model includes several interaction effects for women, the coefficient associated with women's dummy variable cannot be interpreted on its own. To integrally understand the gendered results from our logit model, Figure 2 presents two sensitivity analyses. In these analyses, we calculated the probability of intending to use the REM for men and women by fixing every independent variable to the sample's mean, except for key variables which were sensitized. In the case of the first sensitivity analysis, shown in Figure 2.a, the probability for intending to use the REM was calculated for men and women as a function of varying age. Additionally, for women, the analysis was subdivided into women who are new immigrants and those who are not. Since for men, immigration status was not a significant factor, this subdivision was not calculated for them.

Figure 2.a shows the significant difference between recent immigrant women and other women in terms of their intention to use the REM. When keeping every other variable fixed at its mean, women that are non-new-immigrants have a probability of 45% to 48% of using the REM, while new-immigrant women have a probability between 68% to 70%. Additionally, Figure 2.a shows that age has a considerably smaller effect on women than men. When keeping all else constant, women of 80 years of age have less than a 2% reduction in probability of using the REM compared to women of 20 years of age, regardless of immigration status. On the other hand, older men are considerably less likely to use the REM when compared to their younger counterparts. While men of 20 years of age have a 69%

likelihood to use the REM, for 80-year-old men this likelihood decreases to 48%, when keeping all other variables constant. This figure demonstrates how the gender gap in intention to use the REM is greatest among younger individuals.

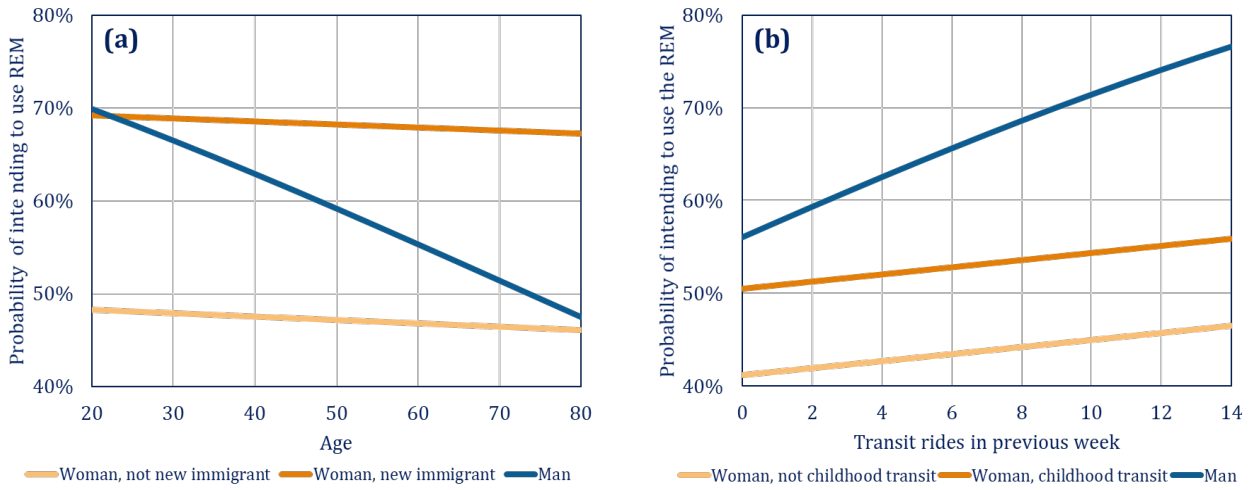

Figure 2. Sensitivity analysis of (a) age and immigrant status, and (b) current and childhood transit use.

For the second sensitivity analysis (Figure 2.b), similarly to the first analysis, the probability for intending to use the REM was calculated for men and women while sensitizing key variables. In this case, the probability was calculated while varying the number of current weekly transit rides. Additionally, we subdivided women into those who regularly used transit during their childhood and those who did not. We did not apply this distinction for men, as this variable was not significant for them.

This analysis shows that, when keeping all else fixed at its mean, women who used transit regularly during their childhood have a probability of using the REM approximately 9% larger than women who did not, regardless of current transit use. Additionally, women who have a current transit use of two daily trips have a 5% increase in probability to use the REM compared to those who currently do not use transit, when keeping all else constant. This effect is small when compared to men. For men who currently use transit twice a day, their probability of using the REM is 21% more than for men who have no current transit use, when fixing all other variables.

Non-gendered factors

Our model of intention to use the REM included several independent variables that showed not to have a significantly different effect depending on the person's gender. These include sociodemographic, life history, spatial, mobility, attitudinal, and residential self-selection independent variables. According to the model results, employed people are 26% less likely to intend to use LRT than those who are not, all else held equal. Individuals in yearly-income groups of less than $90,000 are 33% to 42% less likely to use the new LRT than those in higher income groups, which goes in line with previous research (Hsu et al., 2019). Respondents raised in rural environments had a 21% lower probability for intending to use the REM, in comparison to individuals who were raised in a suburban environment have a higher to use the REM.

As expected, increasing the access distance to the closest REM station reduces the odds of intending to use the REM. The statistical significance and positive odds ratio of the square term indicates that there is a non-linear effect of access distance on the intention to use the REM, which is illustrated in Figure 3.

The probability that a person living at a distance of 3.7km from their closest REM station intends to use the REM is half of a person living in the immediate vicinity of the REM. While previous research has found that the effect of access distance to the closest LRT station on realized use differed significantly between men and women (Hsu et al., 2019), we did not find a significant gendered difference in this relationship. Higher existing transit accessibility at the respondent's home location generates less intention to use the REM. Similarly, higher local accessibility, as measured through WalkScore, also results in lower intention to use the REM. These results indicate that the REM caters to individuals who live in areas where there are currently fewer mobility and destination options, and thus the project may fill important gaps in the transport system and change behaviour.

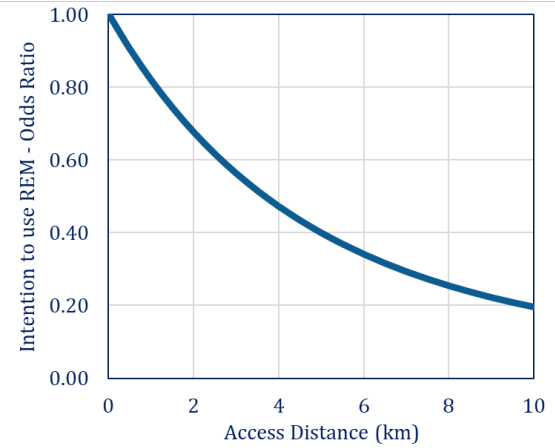

Figure 3. Effect of access distance on intention to use the REM odds

Corroborating findings by Sener et al. (2020), we found that individuals who reported doing more physical activity for transport in the previous week were more likely to intend to use the REM compared top those who reported doing less. Each additional hour of transport physical activity per week increases the likelihood to intend to ride the REM by 7%. Respondents with access to a car are 20% less likely to intend to use LRT, all else held equal. This finding is consistent with findings in previous research (Sener et al., 2020; Yazdanpanah & Hosseinlou, 2017). Members of Montreal's public bike share system, Bixi, have higher odds of intending to use the REM. We understand this as a proxy for willingness or openness to adopt new behaviours in general. Consistent with other studies on the determinants of LRT and rail use, we found that attitudes were very strongly deterministic, even when accounting for socio-demographic, environmental, and mobility characteristics (Kitamura et al., 1997; Lai & Chen, 2011; Sener et al., 2020; Şimşekoğlu et al., 2015). Pro-transit attitudes, indicated by desire to use public transit more often, had a strongly positive association on intention to use the REM, while negative attitudes towards the impact of the REM on the respondent's neighbourhood and on the city had a strongly negative association.

Use of REM by gender and trip purpose

By analyzing intended use of the REM for specific purposes, we further inquire into other important ways in which use of LRT differs for women. Considering the subset of respondents who indicated that they intended to use the REM (n = 1490), we compare intended use for three specific trip purposes between people who identify as women and those who identify as men (Table 3), other genders were excluded due to small sample size. The results of this analysis show that there is no statistically significant gender gap for travel to work by LRT. In contrast, there is a statistically significant gender gap for intention to use the REM for leisure activities and for going to the airport. These results suggest that

the REM is less useful to women than it is for men, as it does not fill women's travel needs for non-discretionary travel. We propose two explanations to this that could be investigated in future research. The first is that women may conduct different activities to fulfill leisure needs that require LRT less. This could be the case if, for example, leisure activities are conducted closer to the household for women than for men, which could be partially explained by the greater burden placed on women for household responsibilities, hindering the possibility of long-distance leisure activities. The second explanation would be that women generally have fewer opportunities to conduct non-discretionary trips, due to enduring gender inequities, such as the uneven distribution of care mobilities (Plyushteva & Schwanen, 2018; Ravensbergen et al., 2022).

Table 3. Intended trip purpose using the REM by gender, and t-test results, for respondents who intend to use the REM.

Intended trip purpose with REM	Women (n = 699)	Men (n = 791)	*p*-Value
Going to work	44.20%	44.10%	0.973
Recreation and leisure activities	54.50%	62.60%	0.002
Going to the airport	61.20%	66.60%	0.031

Conclusions

Large public transit infrastructure, such as LRT, has the potential to make transformative impacts on urban environments and the wellbeing of local populations. It is crucial to identify the ways in which these impacts vary across society, to examine whose needs are being fulfilled by LRT, and to assess whether the distribution of benefit across groups is fair and equitable. Our study examining how intended use of LRT in Montreal differs across gender builds on previous research that has illuminated gender differences in travel behaviour and public transit use in general (Hanson & Hanson, 1980; Hsu et al., 2019; Preston & McLafferty, 2016). Studies on realized and intended LRT use in other context have found differences across gender categories (Creemers et al., 2012; Sener et al., 2020), but require greater attention to the causes of gender gaps, which our paper has tried to explain.

Using a weighted multi-level logistic regression, we analyzed a survey conducted in Montreal, Canada, to understand the gender differences in factors affecting the intention to use the REM, an LRT system currently under construction in the metropolitan area. We found five major ways in which intention to use the REM differs across gender. First, and most broadly, is that women intend to use the REM significantly less than men. Second, intention to use the REM for women declines slower with their age relative to men, and thus the gap in intended LRT use is greater among young people. Third, women who recently immigrated to Canada intend to use the REM far more than non-immigrant women, whereas there is no effect of being a new immigrant on men's intention to use the REM. Thus, the gap in intended REM use is greater among people who are not recent immigrants. Fourth, increased current use of public transit contributes less to intention to use the REM for women, whereas use of public transit in childhood contributes positively to intention to use the REM for women, but not for men.

Lastly, among future REM users' intention, there is no discernable gap in intention to use the REM for work, less discretionary travel purpose. However, there are large and statistically significant gaps in intention to use the REM for leisure, with women intending to use the REM far less for this purpose. These differential intentions regarding discretionary travel could be attributed to a variety of gender dynamics discussed in the mobilities literature, from the feminization of household labour, to

differential care mobilities, to issues of unequal pay (Gauvin et al., 2020; Plyushteva & Schwanen, 2018; Ravensbergen et al., 2022; Uteng & Cresswell, 2016; Walsh, 2009). Our study brings greater attention to the potential impact of these gender inequities on travel for leisure, meriting further research and analysis.

Particularly in light of the COVID-19 pandemic, which widened the income gap and led to an increase in women's household care responsibilities (Fortier, 2020), greater attention is needed to how these dynamics impact women's access to leisure activities and other benefits associated with major public-transit investments. These inequities also underscore the need for transport planning to not only be gender responsive, but also work in alignment with calls for gender-transformative planning processes that support women and other underrepresented groups in challenging oppressive gender roles and inequities (Ortiz Escalante & Gutiérrez Valdivia, 2015; Soliz, 2021). To design transport systems that include LRT and serve people with diverse gender identities, policy makers can target their efforts on specific sub-groups and travel purposes where the gender gaps in intended LRT use are widest: younger individuals, non-immigrants, and for non-work travel purposes. The findings of our study can be used to prioritize and design behaviour change efforts.

Our study is limited in that we were not able to control for or investigate how varying perceptions of light-rail transit in general, especially with regards to personal safety on LRT, affect intention to use the REM, as our survey dataset lacked questions on this point. Additionally, as our survey dataset only included 38 non-binary individuals, we were not able to make any conclusive remarks about how the intention to use LRT for non-binary individuals might vary relative to people who identify as men and women.

Future research could inquire deeper into the social and economic phenomena that create the specific patterns that we identified with women's intentions to use LRT. Specifically, further investigations can investigate how perceived barriers, attitudes, specific travel intentions, and other factors vary for women by age cohort and immigration status. What our study revealed about how childhood experience affects intended mode choice in adulthood merits further investigation as part of a broader effort to understand how life-course events have gendered effects on mode choice (Scheiner, 2014). In particular, we suggest research on the role of gender-differentiated socialization on travel behaviour. Future research can build on our study by applying qualitative approaches, such as in-depth interviews, that can triangulate and detail the phenomena that generate the gender gaps in mode choice that we identified. Eventually, we hope that improved understanding of the interactions between gender and public transit technology, including LRT, will guide interventions that target the design of transport infrastructure and the de-construction of gender roles that produce inequities in order to realize transport systems that advance social wellbeing equitably.

Conclusion

As part of this research effort, we used a survey dataset and statistical modelling approaches to investigate determinants of use of the REM, determinants of intended first-mile mode choice, and gendered interactions that demonstrate the differences in terms of how women intend to use the REM.

Corroborating previous research on the topic of public transit, LRT and determinants of use, we found that positive attitudes and higher amounts of physical activity encourage use of the REM. Identifying potential inequities in terms of what populations this project serves, we found that people who identify as women and people earning lower incomes were less likely to intend to use the REM. Investigating the specific factors that influence intention to use the REM distinctly for women, we found that women's intention to use the REM was less sensitive to current public transit use, and more sensitive to public transit use in childhood. Importantly, we identified that among all intended users, women and men intend to use the REM to about the same extent, but women distinctly intend to use the REM less for non-work purposes.

Our findings can directly inform policy and design decisions with planning the REM and other LRT projects. Namely, our findings highlight that the REM's impact on sustainable mobility will be promoted by fostering positive attitudes towards the project through public communication efforts, and by strategically considering the REM in tandem with efforts to cultivate a physically active culture in the region. To encourage equitable impacts of the project as part of a broader effort of building an equitable transport system, policymakers can focus on better understanding the needs of those where identified gaps in utility of the REM are particularly large: younger and non-immigrant women, especially for non-work travel needs.

Future research that builds on what we found should seek to understand what generates other socio-economic gaps in intention to use the REM, for example the one that exists between high- and low-income earners. We make a call for greater investigation into the relationship between LRT and women's travel patterns. While we identified distinct patterns in what influences women's intended use relative to men's, for example with respect to age and existing and past travel patterns, it is not possible to understand the deeper intersectional phenomena that produce these differences from survey data and from one case study alone. This research needs to be reproduced in other localities, and these questions need to be examined using in-depth qualitative methods that examine the "how" and "why" beyond the "what." In order to build transport systems that advance social and economic wellbeing for all, it is critical to pursue this path of research and to mobilize the knowledge it produces to better inform policy and design decisions moving forward.

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