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Measuring the impacts of a major metro disruption in Montréal, Canada, on riders' satisfaction and willingness to recommend the service to others

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ABSTRACT

On October 3rd, 2024, three stations along the east end of Montreal's blue metro line were closed, resulting in a seven-day service disruption. While previous studies have examined the operational impacts of such disruptions, their effects on user experiences remain underexplored. To address this gap, we measure the impacts of the closure on user satisfaction and their willingness to recommend transit services. Using data from a bilingual online survey launched the day after the disruption began, we analyzed responses from blue line users (N = 655) by employing ordered probit models. The survey included a treatment group of riders directly impacted by the closure (N = 361) and a control group of those unaffected (N = 294). Additionally, we incorporate data from a secondary survey conducted one year prior to the closure, which included riders living close to blue line stations (N = 161), as a secondary control. Our findings reveal a significant decrease in both user satisfaction and willingness to recommend transit services among those impacted by the metro closure. However, these negative impacts can be mitigated when users perceive the availability of reliable and suitable transit alternatives. The findings from this research can be of interest to practitioners and policymakers as they highlight the broader implications of metro disruptions.

1. Introduction

Large-scale transport infrastructure projects, such as metro systems, are designed to serve millions of residents over several generations. Once operational, they typically become an essential part of the regional public transit system, offering reliable, high-capacity service. Consequently, any unplanned disruption in metro operations can have substantial ripple effects on the transit network and negatively influence user satisfaction and public trust in the system.

Disruptions to metro service may be derived from a range of factors, including infrastructure failures (structural, electrical, or mechanical) or passenger-related incidents, such as people or objects on the tracks or police interventions (Abolfazli et al., 2024). These disruptions can vary in duration and intensity, lasting anywhere from a few minutes to several days, and may impact thousands of users. Although prior research has established that metro users generally report higher satisfaction levels compared to users of other transit modes (Cao et al., 2016), interruptions in service tend to reduce travel time reliability. Alternative modes, such as shuttle buses or adjacent bus routes, are often slower and more crowded, leading to negative travel experiences. In particular, metro users have been found to be highly sensitive to reliability issues, such as inconsistent waiting and travel times, as well as negative service experiences more broadly, all linked to decreased ridership (Le et al., 2020; Lunke, 2020).

While metro service disruptions have been studied extensively, most of the existing literature has focused on the operational aspects of disruptions (Zhang et al., 2020), such as forecasting, detection, and management, rather than on the user perspective. As a result, there remains a limited understanding of how passenger experience and perceive sudden service interruptions, particularly in high-use corridors. Understanding how users respond to the disruption is essential to transit agencies seeking to provide better service during such events, whether through more effective communication or improved alternative service while mitigating the impact of the disruption on perceptions of transit.

On October3rd, 2024, the Société de transport de Montreal (STM), the agency responsible for operating Montreal's public transit system,

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announced the immediate closure of three stations at the eastern end of the city's blue metro line — Iberville, Fabre, and St-Michel — due to critical structural issues at the terminal station (CBC News, 2024). The closure lasted seven days and prompted STM to introduce temporary shuttle bus services throughout the affected segment starting October 4th 2024. The blue line, which spans over 9.7 km and includes twelve stations, served an average of 125,947 daily passengers in 2019, and despite pandemic-related declines in ridership, still recorded approximately 79,209 passengers per day in 2022. Importantly, St-Michel station alone registered over 330,000 entrances in October 2022, making it the third most used station on the line. This underscores the magnitude of the disruption, given that a high-volume segment of the network was suddenly made inaccessible.

1.1. Research objectives

The objectives of this study are to investigate the immediate impact of the 2024 blue line disruption on (i) passengers' overall satisfaction with transit services and (ii) their willingness to recommend the transit system to others. Using a treatment–control group design, the study compares perceptions from a post-disruption survey launched one day after the closure with a baseline sample collected one year earlier. This paper contributes to the literature by offering empirical insight into how a real-world disruption affects user satisfaction and loyalty, via willingness to recommend transit services, a critical indicator of sustained transit ridership (Carvalho et al., 2021; van Lierop & El-Geneidy, 2016; Zhao et al., 2014).

Rather than limiting the analysis to perceptions of the metro line itself, the study assesses how a localized negative event can shape broader perceptions of the overall transit system, which could have significant implications for user loyalty and long-term ridership. While the direction of the effect may be expected (i.e., disruptions will reduce satisfaction), this study provides a rare opportunity to understand the magnitude of the effect using real-world data collected during and prior to the event. These findings offer practical guidance for transit agencies aiming to maintain user confidence and adapt their response strategies during unforeseen service interruptions. However, the study is limited to short-term effects and does not examine whether these perceptions persist beyond the disruption period.

2. Literature review

2.1. Disruptions in metro service

Most of the literature on metro service disruptions has focused on operational aspects, with relatively few studies addressing user experiences. In a review of the literature, Zhang et al. (2020) categorizes research in this area into three main streams, (i) system preparation for disruptions, (ii) management of disruptions within the system (e.g., timetable, rolling stock, and crew scheduling), and (iii) optimization of bus shuttle (bridging) services. Much of this research focus on the Chinese context while employing optimization models aimed at improving real-time responses to metro disruptions. These models typically focus on providing dynamic, flexible service based on passenger demand to reduce operational costs and delays (Gu et al., 2018; Hu et al., 2020; Zhen et al., 2025; Zheng et al., 2022), optimizing alternative service scheduling to reduce waiting times and the number of passengers stranded (Sun et al., 2024; Wang et al., 2019), and enhancing metro-bus service coordination (Wu et al., 2022; Yuan et al., 2025). While these approaches offer valuable insight into minimizing the delay and cost impacts of metro disruptions, they often rely on simulated passenger flows and rarely incorporate user perceptions or behavioral data, leaving a disconnect between operational recovery strategies and actual passenger experiences.

A smaller but growing body of research has started to examine passenger behavior during metro disruptions, primarily through stated preference data. For instance, Pnevmatikou et al. (2015) found that modal shifts in Athens, Greece were influenced by disposable income, with lower-income families more likely to shift towards bus services during a disruption. In Toronto, Canada, Liu et al. (2020) observed that metro disruptions disproportionately affected routes serving disadvantaged neighborhoods due to bus reallocation practices, exacerbating socio-spatial inequalities. Studies from cities such as Chongqing, China and Athens, Greece have used hypothetical disruption scenarios to examine user adaptations in departure time, trip chaining, or mode choice (Pnevmatikou et al., 2015; Zheng et al., 2025). While these studies provide insights into user preferences and constraints, they rely heavily on hypothetical behavior, making it difficult to fully assess the real-world impact of the disruption on transit perceptions and satisfaction.

Metro disruptions can also generate indirect, system-wide impacts. In Washington, D.C., Yap and Cats (2020) found that service interruptions at central trunk, terminal, and transfer stations can significantly increase travel times across the network. Similarly, in Toronto, service interruptions on the subway were shown to reduce travel speeds on surface modes such as buses and streetcars (Diab & Shalaby, 2018). In Montreal, Canada – the focus of this study – most metro incidents are classified as medium severity, lasting between 5 and 20 minutes. These are primarily caused by passenger-related factors (e.g., sick passengers, objects on track, or police interventions) or power failures (Abolfazli et al., 2024).

While travel time is an important determinant of travel satisfaction (Ye et al., 2020), few studies have explored how metro service disruptions influence users' perceptions of the broader transit system — beyond the affected line or a single disrupted trip. In particular, the magnitude of these disruptions' impact on overall satisfaction and user loyalty, known determinants of continued transit ridership, remain underexplored. This gap is particularly relevant in the case of full-line or station closures, which forces the system and users to adapt on a very short notice through rerouting or mode shifts, which may undermine trust in the system. To better understand the impact of disruptions on user experiences, the following section reviews the literature on travel satisfaction and willingness to recommend, with special focus on how they respond to negative experiences or service disruptions.

2.2. The impact of negative experiences on transit satisfaction and willingness to recommend transit to others

Travel satisfaction refers to an affective evaluation comparing expected and perceived performance (Ameer, 2013), reflecting users' enjoyment of transit experiences (Lu & Lu, 2009) with a particular trip, mode, or system-wide service. Higher satisfaction is closely linked to continued use and a greater willingness to recommend transit services, both determinants of user loyalty (Carvalho et al., 2021). For example, Diab et al. (2017) found that among bus users in Montreal, those with higher levels of satisfaction regarding waiting time were three times more likely to recommend the service to others.

Critical incidents, such as planned or unplanned service disruptions, anomalies, delays, or crowding, have been shown to reduce travel satisfaction and user loyalty (Allen et al., 2019; Friman et al., 2001; Friman & Gärling, 2001; Zhang et al., 2019). One key reason is that disruptions introduce unreliability, a factor known to strongly influence user experience and public trust in transit services (Al-Sahar et al., 2024; Soza-Parra et al., 2019). Metro users, in particular, tend to have higher service expectations and are therefore more sensitive to disruptions than bus users, increasing their likelihood of switching to other modes or canceling trips altogether (Rahimi et al., 2020).

Tolerance for waiting during unplanned disruptions is influenced by other factors, such as socio-demographics, attitudes, trip characteristics, and the built environment. For instance, using a combination of stated and revealed preference surveys, Rahimi et al. (2019) found that passengers with higher trust in transit authorities were more willing to wait

for the service to resume, while those with tight schedules or knowledge of alternatives were less tolerant. Adding nuance to the role of trust in disruption scenarios, El-Diraby et al. (2019) analyzed social media responses to service interruptions in Vancouver's transit system and found that while unclear or inconsistent communication during disruptions negatively impacted user satisfaction, trust in the transit agency mitigated the effects on loyalty, highlighting the importance of clear and effective communication strategies.

Insights from psychology can further explain the impacts of negative experiences on user satisfaction. Research has shown that negative experiences are recalled more strongly than positive ones (Kahneman, 2011), and that negative emotions play a strong role in shaping decision-making (Charpentier et al., 2016). Consequently, even temporary disruptions can have long-lasting effects on user perceptions and behaviors.

While previous studies have assessed the effects of negative incidents, they have typically focused on system-wide occurrences and relied on self-reported data about the frequency of these events. As a result, these studies were often unable to link their findings to specific types of incidents, such as metro service interruptions, and therefore could not capture the immediate effects of major service disruptions on user satisfaction and loyalty-related factors, such as willingness to recommend transit services. To address this gap, the present study employs a treatment–control group design to offer empirical evidence on how a real-world seven-day metro disruption influenced users' satisfaction and willingness to recommend the transit system, contributing to transit planning, service recovery, and rider communication strategies.

3. Case study: The blue line disruption

Montreal is the second largest metropolitan region in Canada, with a population of over four million people. Its public transit system is primarily operated by Société de Transport de Montreal (STM), which runs a four-line metro system, an extensive bus network, and several dedicated bus corridors. The blue line, the focus of this study, is the smallest of the four lines (9.7 km), running east–west across several residential neighborhoods. Despite its size, the blue line plays a vital role in local accessibility, providing connection to other metro lines and bus services.

On October 3rd, 2024, STM announced the closure of three stations at the east end of the blue metro line for an undetermined period. The following day, on October 4th, 2024, a shuttle bus service was introduced to transport passengers between the closed stations and the operating section of the blue line. On October 7th, 2024, STM optimized the shuttle bus service to increase its efficiency. Service was partially restored on October 9th, 2024, with two of the three closed stations reopening. Full service resumed at the last remaining station on October 10th, 2024, though one of its entrances remained closed as of November 2024. This disruption was atypical in both duration and scope, as it was unplanned, announced with limited notice, and involved a full closure of a key segment of the line — conditions not usually observed in routine maintenance-related incidents. Fig. 1 illustrates the timeline of the blue line closure and the data collection process.

4. Data sources

This study relies on two primary data sources. The first is a special version of the Canadian Mobility Survey (CMS) administered the day following the disruption, which gathered perceptions about the transit network during the event. The second is the Montreal Mobility Survey (MMS), a longitudinal panel study conducted one year prior to the disruption, which captures baseline perceptions of public transit and serves as a control for comparison.

A consistent data-cleaning strategy was applied to both samples. The exclusion criteria included a short completion time, incomplete responses, and multiple responses from the same email address or IP address. Those who placed a pin representing their home, school, and/or work location outside of the Montreal metropolitan area were also excluded.

4.1. Post-disruption data: Canadian Mobility survey (CMS)

The Canadian Mobility Survey (CMS) is a bilingual online survey administered by the Transportation Research at McGill (TRAM) research group to assess perceptions of and satisfaction with public transit service across thirteen Canadian metropolitan regions. A special version of the CMS was launched on October 4th, 2024 — the day after the Blue Line closure — and remained open until October 15th, 2024. This version of the survey included additional questions related specifically to the closure of the Fabre, Iberville, and St-Michel stations.

To reach affected and unaffected blue line users, the survey was distributed via a targeted social media campaign. In total, 796 complete and valid responses were collected, and only those living within three kilometers from the line were retained for analysis (N = 655). This 3 km threshold was selected to reflect a reasonable catchment area for metro users who may access the line by walking, cycling, or feeder bus services. To avoid priming effects, questions regarding the Blue Line closure and its impacts were asked only after respondents had provided their general perceptions of and satisfaction with transit services in Montreal. This approach was intended to ensure that responses regarding general transit satisfaction and perceptions were not unduly influenced by prior mention of the disruption, allowing for a more accurate assessment of baseline attitudes.

The CMS involved questions on travel satisfaction, perceptions of public transit service, and socioeconomic characteristics. For the disruption-specific version, the following four items were added:

1. Have you used the Blue Line in the past 12 months? (Yes/No)
2. Have you been impacted by the emergency closure of the Fabre, d'Iberville and Saint-Michel stations along the Blue Line? (Yes/No)
3. Public transit in my region is a reliable way of traveling (4-point Likert scale)
4. Public transit in my region provides me with suitable alternatives in case of major service disruptions (4-point Likert scale)

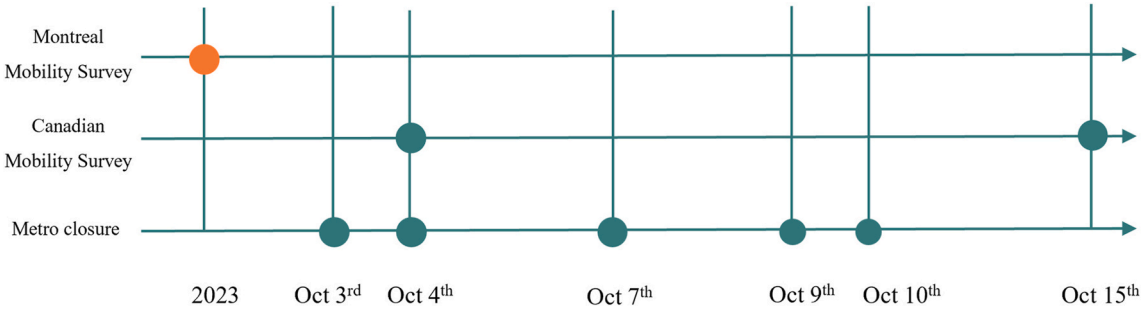

Fig. 1. Timeline of the blue metro line disruption and the data collection process.

4.2. Pre-disruption baseline: Montreal Mobility survey (MMS)

The Montreal Mobility Survey (MMS) is a bilingual longitudinal panel survey conducted annually by TRAM since 2019. The MMS collects d'etailed data on travel behavior, perceptions of transit service, and the impacts of transport projects in the Montréal region (Victoriano-Habit et al., 2024). In October 2023, the MMS recorded 5,312 complete and valid responses, from which a subsample of 161 metro users was selected for this study. These respondents were matched to the CMS sample based on residential location to ensure both groups (CMS and MMS respondents) came from the same areas along the Blue Line. Although the groups were not randomly assigned, this spatial consistency supports a valid comparison between pre- and post-disruption responses.

While the MMS was not specifically designed to study the 2024 Blue Line closure, it includes several of the same key variables as the CMS, including overall satisfaction and willingness to recommend transit services. This overlap makes it possible to conduct a quasi-experimental comparison of perceptions before and after the disruption, within the same geographic corridor. The MMS was broadly advertised through social media, a market research company, various mailing lists, and well as radio and television interviews to ensure a large and diverse sample following the guidelines proposed by Dillman et al. (2014).

Fig. 2 illustrates a map of the blue line, highlighting the section closed (three stations in the east) on October 3rd, 2024, and the home location of complete and valid survey responses from the CMS and MMS.

4.3. Comparability of sample characteristics

Table 1 summarizes the socio-demographic characteristics of the MMS (2023) and the CMS (2024) samples.

While the two groups are similar in terms of gender distribution, car availability, residential distance to the blue line, and modal share of weekly trips, significant differences are observed in age and household income. On average, CMS respondents were younger and reported lower household incomes compared to MMS respondents. These differences may reflect the recruitment strategy for this special version of the CMS, which relied more heavily on social media advertising to enable timely data collection immediately after the disruption. Despite these differences, both samples represent metro users living near the blue line sharing similar travel patterns — such as weekly transit and driving shares. Moreover, the geographic matching between groups helps ensure spatial consistency. Still, variations in age and income may influence how disruptions are experienced and will need to be controlled for in the statistical modeling to reduce any biases they might introduce.

Table 1
Comparison of socio-demographic and behavioral characteristics.

Variable	Type	MMS (2023)	CMS (2024)	Difference
Age	*Mean (SD)*	41.2 (12.2)	27.7 (9.6)	<0.001 ***
Gender	*Man*	34.80 %	27.50 %	0.175
	Woman	61.50 %	69.00 %	
	Other	3.70 %	3.50 %	
Household Income	*Under CAD 60 k*	19.90 %	43.40 %	<0.001 ***
	CAD 60 to 120 k	50.90 %	34.40 %	
	Over CAD 120 k	29.20 %	22.30 %	
Cars available	*Mean (SD)*	0.7 (0.8)	0.6 (0.8)	0.454
Distance to the blue line	*Mean (SD)*	559.7 (660.5)	602.8 (649.9)	0.458
Transit share (weekly trips)	*Mean (SD)*	50 % (20 %)	50 % (30 %)	0.348
Driving share (weekly trips)	*Mean (SD)*	10 % (20 %)	10 % (20 %)	0.341

*Significance levels: *p < 0.1; **p < 0.05; ***p < 0.01.*

5. Methods

To explore the influence of the closure of the blue metro line on user satisfaction and their willingness to recommend transit services to others, we employed a series of ordered probit models. We selected this modelling technique for three main reasons. First, it minimizes Type I and II errors (i.e., detecting non-existing effects or failing to detect existing ones) when analyzing Likert Scales, as opposed to converting the scale into a continuous variable (Liddell & Kruschke, 2018). Second, the adoption of ordered probit modelling has been increasing in the transportation field, especially among transit satisfaction studies (Choi et al., 2021; Fielbaum & Tirachini, 2020; Fu & Juan, 2017). Finally, although the test of parallel assumptions can be applied to ordered probit modelling (Greene & Hensher, 2010), meeting this assumption is not required for their use (Williams, 2016). Table 2 provides a detailed description of the dependent and independent variables used in the models.

Table 3 presents the descriptive statistics for the dependent and independent variables included in the models. For this analysis, the 4-point Likert scale was converted to a numeric scale ranging from −2 (strongly disagree) to 2 (strongly agree). Overall, individuals not

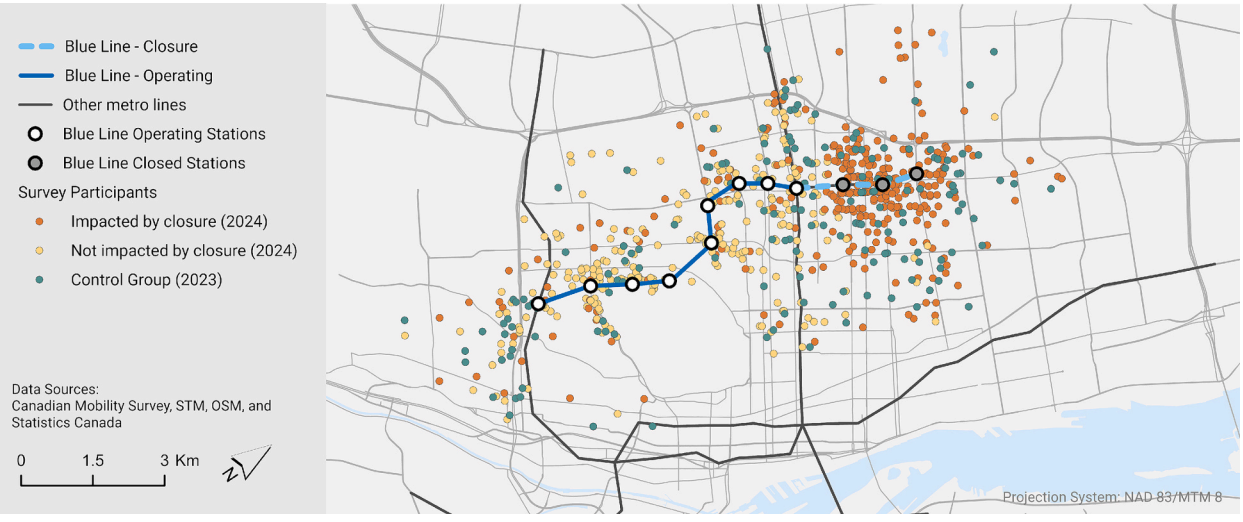

Fig. 2. Montreal's blue line metro. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 2
Variable description.

Variable	Description
Overall satisfaction[1]	Overall, I am satisfied with the public transit services in my region
Willingness to recommend[1]	I would recommend the public transport services in my region to a member of my family or friend
Impacted by the closure[2]	Equal one if yes (treatment group), zero otherwise (control group)
2023[2]	Equal one if data was collected in 2023, zero otherwise
Provision of suitable alternatives[3]	Public transit in my region provides me with suitable alternatives in case of major service disruptions
Improvement[3]	In the last 12 months, the public transit services I use have *(gotten much worse/gotten a bit worse/stayed the same/gotten a bit better/gotten much better)*
Impact on quality-of-life[3]	Public transit positively impacts my quality of life
Suitable to reach destinations[3]	Public transit is a suitable mode of travel for me to reach my desired destinations
Reliable service[3]	Public transit in my region is a reliable way of traveling
Harassment[3]	Harassment and discrimination are issues in public transit in my region
Transit share[4]	Modal share of public transit use during the past week

[1]Measured on a 4-point Likert scale (disagree and strongly disagree categories are combined for modelling purposes); [2]Dummy variable; [3]Measured on a 4-point Likert scale; [4]Continuous variable.

Table 3
Descriptive statistics.

Variable	2023	2024	
	Control[a]	Not impacted[a]	Impacted[a]
Overall satisfaction	0.87 (1.04)	1.00 (0.81)	0.61 (1.01)
Willingness to recommend	1.39 (0.87)	1.33 (0.83)	1.00 (1.06)
Provision of suitable alternatives	–	0.32 (1.19)	0.08 (1.23)
Improvement	–	−0.08 (0.65)	−0.57 (0.81)
Impact on quality-of-life	1.32 (0.94)	1.14 (0.98)	0.98 (1.06)
Suitable to reach destinations	–	1.39 (0.71)	1.18 (0.91)
Reliable service	–	0.98 (0.94)	0.55 (1.14)
Harassment	–	−0.44 (1.16)	−0.30 (1.20)
Transit share	50 % (20 %)	50 % (30 %)	50 % (30 %)

[a] *Mean (Standard Deviation)*.

impacted by the closure tend to have more positive perceptions of transit compared to those affected by the metro disruption.

For the dependent variables, preliminary analysis revealed that the "strongly disagree" category accounted for less than 2 % of responses for both satisfaction and willingness to recommend. Additionally, the intercept between the "disagree" and "strongly disagree" categories was not statistically significant in the model. As a result, these two categories were combined to improve model stability. The "agree" and "strongly agree" categories were not merged, as both were well represented in the data, and maintaining this distinction allowed for greater nuance in capturing user perceptions.

6. Results and Discussion

6.1. Trends in satisfaction and willingness to recommend over time

Fig. 3 reports the distribution of our two variables of interest: overall satisfaction with transit services in their region and willingness to recommend transit services to others. A Mann-Whitney U Test was conducted to assess differences in variable distributions between 2023 (N = 161) and 2024 (N = 655). This analysis aimed to determine whether patterns of satisfaction and willingness to recommend changed significantly during the time of the service disruption compared to a similar period in the previous year. The results revealed a statistically significant difference only for willingness to recommend. Specifically, respondents reported higher willingness to recommend transit services in 2023 (92.5 %, W = 61141, $p < 0.01$) compared to 2024 (88.5 %), indicating a temporal effect on this variable.

To further investigate, the 2024 sample was divided into two groups: blue line users impacted by the closure (N = 361) and those who were not (N = 294). A Mann-Whitney U Test was conducted to assess distributional differences between the 2023 sample and the two 2024 groups. The results showed a statistically significant difference ($p < 0.01$) for overall satisfaction and willingness to recommend in two specific pairwise combinations, (i) the 2023 sample versus the impacted group, and (ii) the impacted group versus the non-impacted group. Conversely, users not affected by the disruption exhibited similar levels of satisfaction and willingness to recommend compared to the 2023 sample.

These findings informed our modeling approach. Specifically, the 2023 sample was excluded from the evaluation of the closure impacts on overall satisfaction, as no significant differences were observed over time. However, the 2023 sample was retained for the willingness to recommend model.

6.2. Modeling approach

To better understand the factors influencing satisfaction and willingness to recommend transit services, two ordered probit models were estimated (i.e., one for each outcome variable). The results are presented in Table 4, which includes coefficient estimates and confidence intervals for all predictors. Additionally, the model results include intercepts, which are thresholds that divide the latent scale into the observed response categories (i.e., strongly agree, agree, and disagree). These thresholds, in combination with the estimated predictor effects, determine the range on the latent scale associated with each response category, which is then used to calculate the probability of a respondent selecting that category. Both models demonstrate relatively strong explanatory power. The Nagelkerke's R^2 is 0.538 for the satisfaction model and 0.487 for the willingness to recommend model. The model is based on 655 observations (CMS respondents) while the willingness to

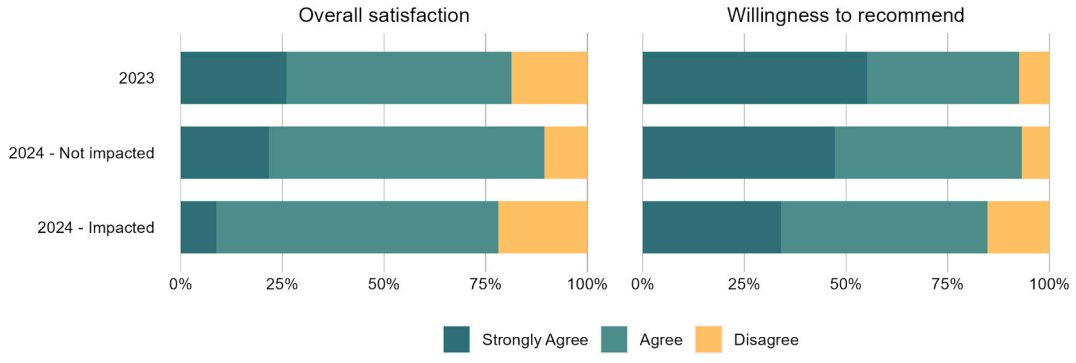

Fig. 3. Distribution of the dependent variables.

Table 4
Ordered probit model results.

Variables	Overall Satisfaction		Willingness to Recommend	
	Estimates	CI	Estimates	CI
Intercepts (Thresholds)				
Strongly agree: Agree	**−2.605*** **	**(−2.948, −2.261)**	**−1.025*** **	**(−1.311, −0.739)**
Agree: Disagree	**0.533*** **	**(0.261, 0.804)**	**1.133*** **	**(0.843, 1.422)**
Disruption impacts				
Impacted by the closure	**0.251** **	**(0.027, 0.475)**		
Provision of suitable alternatives	**−0.293*** **	**(−0.444, −0.143)**		
Disruption impacts *(relative to 2023 control group)*				
Impacted by the closure			**0.371*** **	**(0.141, 0.622)**
Not impacted by the closure			0.146	(−0.106, 0.398)
Perceptions of transit service				
Overall satisfaction			**−0.501*** **	**(−0.609, −0.394)**
Transit service is improving	**−0.296*** **	**(−0.452, −0.139)**		
Impact on quality of life	**−0.310*** **	**(−0.435, −0.185)**	**−0.669*** **	**(−0.773, −0.566)**
Suitable to reach destinations	**−0.293*** **	**(−0.444, −0.143)**		
Reliable service	**−0.536*** **	**(−0.663, −0.409)**		
Harassment	**0.257*** **	**(0.163, 0.350)**		
Travel behavior				
Transit share			**0.479*** **	**(0.178, 0.780)**
Observations	655		816	
Nagelkerke's R^2	0.538		0.487	

Significance levels: *p < 0.1; **p < 0.05; ***p < 0.01.

recommend model includes 816 observations (CMS and MMS respondents).

Since the ordered probit model estimates effects on a respondent's position on an unobserved latent scale of satisfaction and willingness to recommend, the coefficients do not translate directly into changes in the observed Likert-scale responses. Therefore, for practical interpretation of the results, marginal effects are necessary. Table 5 reports marginal effects for both models, which translate the latent model results into the change in probability of a respondent selecting each response category (e.g., strongly agree) for a one-unit increase in a given variable, all else equal.

6.3. Impacts of the disruption in transit satisfaction

The closure of the blue line stations had a small but statistically significant impact on overall transit satisfaction. As reported in Table 5, respondents who were impacted by the disruption were 2.7 percent less likely to strongly agree they were satisfied and 3.1 percent more likely to disagree, compared to those who were not affected. While research on the effects of service disruptions on user satisfaction is limited, this finding aligns with previous studies that highlight the negative effect of adverse transit experiences on satisfaction with service (Allen et al., 2019; Friman et al., 2001; Le et al., 2020). Therefore, these findings confirm that unplanned service interruptions can meaningfully reduce satisfaction, particularly among impacted users. Moreover, the results also quantify these impacts providing empirical evidence of the effect of the disruption on user experiences and perceptions.

In contrast, respondents who perceived that the transit system provided suitable alternatives during the closure were significantly more likely to report higher satisfaction. Specifically, a one-unit increase in agreement with the statement was associated with a 3.1 % increase in the probability of strongly agreeing with being satisfied, and 3.7 % decrease in the probability of disagreeing. This underscores the importance of contingency planning and the rapid provision of reliable transport alternatives to help mitigate the negative effects of service disruptions. Such outcomes are likely to be supported by strategies identified in previous research, such as clear communication (El-Diraby et al., 2019), managing crowd levels (Allen et al., 2019), and optimizing alternative service scheduling to reduce waiting times and minimize the number of passengers stranded (Sun et al., 2024; Wang et al., 2019).

Beyond disruption specific factors, the analysis reveals that broader perceptions of transit, shaped over time through user interactions with the service and social norms, remain influential on satisfaction. Respondents who believe that transit improved over time, that it was suitable for reaching destinations, that it positively impacted on their quality of life, and that it provided reliable service were all more likely to report higher satisfaction. While marginal effects for these variables ranged between 3.1 % and 5.7 % increases in the probability of strongly agreeing with satisfaction, perceived reliability had the strongest individual effect. These findings reinforce the important role of reliable service in fostering user satisfaction (Soza-Parra et al., 2019).

Conversely, respondents who perceive harassment and discrimination as issues in the transit network were less likely to express

Table 5
Marginal effects.

Variables	Overall Satisfaction			Willingness to recommend		
	(1)	(2)	(3)	(1)	(2)	(3)
Disruption impacts						
Impacted by the closure	**−2.7 %**	**−0.4 %**	**3.1 %**			
Provision of suitable alternatives	**3.1 %**	**0.6 %**	**−3.7 %**			
Disruption impacts *(2023 omitted)*						
Impacted by the closure				**−13.9 %**	**10.9 %**	**2.9 %**
Not impacted by the closure				−5.5 %	4.3 %	1.1 %
Perceptions of service						
Overall satisfaction				**19.0 %**	**−15.2 %**	**−3.7 %**
Transit service is improving	**3.1 %**	**0.6 %**	**−3.8 %**			
Impact on quality of life	**3.3 %**	**0.6 %**	**−3.9 %**	**25.3 %**	**−20.3 %**	**−5.0 %**
Suitable to reach destinations	**3.1 %**	**0.6 %**	**−3.7 %**			
Reliable service	**5.7 %**	**1.1 %**	**−6.8 %**			
Harassment	**−2.7 %**	**−0.5 %**	**3.3 %**			
Travel behavior						
Transit share				**−18.1 %**	**14.5 %**	**3.6 %**

(1) Strongly agree; (2) Agree; (3) Disagree.

satisfaction. A one-unit increase in agreement with this statement was associated with a 2.7 % decrease in the probability of strongly agreeing with being satisfied and 3.3 % increase in the probability of being disagreeing. While the magnitude of the effect is smaller than for perceived reliability or perceived improvement, it still highlights that ensuring a safe and inclusive environment is essential for maintaining user satisfaction.

6.4. Impacts of the disruption on willingness to recommend transit services

The closure of the blue line had a significant impact on users' willingness to recommend transit services to others as reported in Table 5. Respondents who were directly affected by the disruption were 13.9 % less likely to strongly agree with the statement that they would recommend transit and 3 % more likely to disagree, compared to the 2023 control sample. Users who were not impacted by the closure, however, showed willingness to recommend levels comparable to the 2023 control group, suggesting that the disruption effects were contained to directly affected users. These findings indicate that temporary service disruptions can significantly influence users' endorsement of public transit, which is a determinant of user loyalty and an indicator of continued ridership (Carvalho et al., 2021; van Lierop et al., 2018).

Similar to overall satisfaction, broader positive transit perceptions also played an important role in shaping user intentions to recommend transit services. The most influential factor was the perceived impact of transit on quality of life, where a one-unit increase was associated with a 25.3 % increase in the probability of strongly agreeing with recommending transit, and a 5.0% decrease in the probability of disagreeing. This highlights the important role that transit services can play in enabling people to reach their desired destinations and maintain daily activities. However, it is important to emphasize that while interpretations of quality of life may vary, this study does not aim to assess the construct itself. Rather, it focuses on respondents' subjective understanding of how transit affects their quality of life.

Likewise, those already satisfied with transit services were 19 % more likely to strongly agree to be willing to recommend transit and 3.7 % less likely to disagree. This finding is in line with the known strong role of satisfaction on the development of loyal behavior (Kawabata et al., 2020; Machado et al., 2018; Zhao et al., 2014). Additionally, frequent transit users (measured by mode share) were also more likely to recommend services, with a 14.5 % increase in the probability of strong agreement per one-unit increase in transit mode share.

Together, these findings highlight that positive, cumulative transit experiences, reflected in quality of life perceptions, satisfaction, and habitual use, are central to shaping users' willingness to recommend. In contrast, exposure to an unplanned service disruption was associated with a measurable and immediate reduction in users' endorsement of public transit. While the analysis does not capture long-term behavioral and attitudinal changes, the results indicate that even short-term interruptions can have a negative impact on users' willingness to recommend transit to others. These findings underscore the importance of maintaining consistent service and effectively managing disruptions to protect user confidence in the transit network.

7. Conclusion

This study offers empirical evidence of the immediate effects of an unplanned metro disruption on user perceptions of public transit in Montreal, Canada. The 7-day closure of three stations at the eastern end of the blue line was associated with a measurable reduction in both satisfaction with transit services and the willingness to recommend them to others. Specifically, affected users were 13.9% less likely to strongly agree they would recommend the service and 3.1% more likely to disagree they were satisfied with transit overall, compared to unaffected users. A temporal decline was observed in users' endorsement of transit services, with users in 2024 reporting lower willingness to recommend transit compared to a 2023 control group, further highlighting the impact of the closure on public perception.

These effects, however, were not uniform. Users who perceived the availability of suitable transit alternatives during the disruption were significantly more likely to remain satisfied. A one-unit increase in agreement with this perception was associated with a 3.1% increase in the probability of strongly agreeing with being satisfied, and a 3.7% decrease in the probability of disagreeing. Beyond disruption-specific factors, broader perceptions of transit service also played a central role in shaping satisfaction. Respondents who believed transit was improving (+3. 1 % strong agreement), reliable (+5.7%), suitable for reaching destinations (+3. 1 %), and beneficial to their quality of life (+3. 3 %) were all more likely to report strong satisfaction. Among these, perceived reliability had the strongest effect, reinforcing the role of dependable service in shaping positive user experiences. In contrast, a one-unit increase in concern over harassment and discrimination was associated with a 2.7% decrease in strong agreement and a 3.3% increase in disagreement, emphasizing the need for a safe and inclusive transit environment.

Likewise, users were more inclined to recommend transit services if they believed that transit improved their quality of life (+25.3% probability of strong agreement), were already satisfied with transit services (+19.0%), or were frequent transit users (+14.5% per unit increase in mode share). These results suggest that willingness to endorse transit is shaped by both current and past experiences with the system. Positive day-to-day interactions with transit, such as consistent reliability and comfort, contribute to building trust and loyalty over time, even in the face of temporary disruptions.

The findings contribute to a growing body of evidence exploring the impact of service disruptions on user experiences. Moreover, they underscore the importance of proactive contingency planning, reliable service provision, provision of suitable transit alternatives, and effective communication during disruptions to mitigate the impacts on user attitudes toward transit. More broadly, transit agencies must invest not only in operational resilience but also pay attention to user perceptions of transit experience to ensure sustained ridership.

That said, the study is not without limitations. First, the analysis captures only immediate, short-term effects of the disruption, and does not assess whether perceptions recover or decline further over time. Second, although spatial matching was used to improve comparability between the samples, some socio-demographic differences, such as age and income, remain and may influence how transit services are perceived. Third, while the analysis includes an indicator of general transit use frequency (i.e., transit mode share), no specific data on the frequency of metro use was collected, which may have provided additional insight into the impacts of the disruption. Fourth, while the study assesses the role of providing suitable alternatives, it does not directly evaluate satisfaction with the specific substitute mode (i.e., shuttle bus service). Finally, the Likert scales used in the survey did not include a neutral or "no opinion" option, which may have led some respondents to select an agreement or disagreement response even if they held no strong opinion. This design choice could introduce bias and should be considered when interpreting the results.

Future research should consider longitudinal follow-ups to assess whether these attitudinal shifts remain and examine user satisfaction with specific alternative services implemented during disruptions. This research could add to the understanding of the lingering effects of service disruptions on transit perceptions and offer guidance for improving contingency planning and service. As transit agencies continue to face infrastructure challenges and system upgrades, understanding the user perspective during service interruptions is essential to maintaining trust and supporting long-term ridership.

CRediT authorship contribution statement

Thiago Carvalho: Writing – review & editing, Writing – original

draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ahmed El-Geneidy:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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