Titre: Title:	Barriers to car-free streets: identifying opponents of pedestrianization in Montreal
Auteurs: Authors:	Hamed Naseri, Francesco Ciari, Marie-Soleil Cloutier, & Ashraf Uz Zaman Patwary
Date:	2025
Type:	Article de revue / Article
Référence: Citation:	Naseri, H., Ciari, F., Cloutier, M.-S., & Patwary, A. U. Z. (2025). Barriers to car-free streets: identifying opponents of pedestrianization in Montreal. Cities, 165, 106178 (13 pages). https://doi.org/10.1016/j.cities.2025.106178

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Document publié chez l'éditeur officiel
Document issued by the official publisher

Titre de la revue: Journal Title:	Cities (vol. 165)
Maison d'édition: Publisher:	Elsevier BV
URL officiel: Official URL:	https://doi.org/10.1016/j.cities.2025.106178
Mention légale: Legal notice:	©2025 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/ .
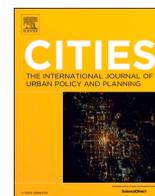
Barriers to car-free streets: Identifying opponents of pedestrianization in Montreal

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A B S T R A C T

Urban mobility has been dominated by motorized vehicles, posing many challenges related to the environment, citizens' health and safety, and traffic congestion. Pedestrianization (converting streets to car-free zones) is a practical strategy to reduce car dependency, promote active transportation, and enhance urban livability. However, many city residents and business owners have often opposed pedestrianization. Through a cluster analysis, this study examined opposition to pedestrianization in Montreal, Canada. To this end, an online survey was designed and administered. The collected data (1909 complete responses) was synchronized with five contextual data sources to form a large-scale dataset, including 121 variables. The results suggested that opposition to pedestrianization was associated with insufficient satisfaction with 2-wheelers/pedestrian cohabitation, attractiveness, urban furniture, cleanliness, and safety of pedestrianized streets. The supporters tended to change their travel behavior to spend more time in car-free streets, while opponents tried to change their route to avoid traveling in vehicle-free zones. The opponents included more non-cyclists, males, car owners, older people, and those living alone in neighborhoods with lower density. Opponents were more likely to be drivers and taxi users. This study highlights how pedestrianization can reduce motorized vehicle use while increasing active transportation. These insights can help policymakers address public concerns and create urban spaces that better accommodate all road users.

1. Introduction

The transportation sector is one of the largest sources of greenhouse gas (GHG) emissions around the world, contributing to over 24 % of global GHG emissions (Naseri, Waygood, Patterson, & Wang, 2024a). In Canada, the contribution of this sector to national GHG emissions is even more significant, and transportation is responsible for 28 % of national emissions (Environment and Climate Change Canada, 2023). The Canadian government planned to reduce the national emissions by 30 % less than 2005 levels by 2030 (Wang et al., 2023). Therefore, car use should be reduced, cars should be replaced with electric vehicles (Naseri, Waygood, Patterson, & Wang, 2024b), and an environment that encourages active transportation should be created (Din et al., 2023).

One potential strategy to decrease reliance on cars and encourage active transportation is to implement pedestrianization projects.

Pedestrianization, which is also called a car-free project or a motor-vehicle-free street, is defined as a commercial or mixed-use urban street in which all motorized vehicles are banned from the street, and the car street is shifted to walking and cycling infrastructure (Parajuli & Pojani, 2018). Although these projects provide many advantages, such as reducing car use and increasing active transportation, there is frequently some resistance or dissatisfaction toward these projects (Brownrigg-Gleeson et al., 2023). Accordingly, it is vital to investigate the potential opponents of these projects.

In terms of modeling, clustering is one of the conventional techniques to identify the characteristics of the supporters and opponents of transportation projects and policies (Soto et al., 2021). Many clustering techniques exist, such as partition-based, density-based, and hierarchical-agglomerative models (KPopat Emmanuel, 2014). Each of these techniques has different strengths and limitations depending on

the data structure and clustering objectives. Despite their widespread application, it is unclear which model performs the best in the specific context of public opinion on pedestrianization, particularly for detecting the supporters and opponents of such projects. In such cases, various clustering techniques are generally compared based on a single metric (e.g., Silhouette score, Calinski-Harabasz index, or Davies-Bouldin index) to identify the best clustering model for the problem (DeFreitas & Bernard, 2015). These metrics are based on different mathematical formulations and capture different dimensions of clustering performance, often leading to varying evaluations of clustering techniques. Therefore, this study introduces a new framework for systematically comparing clustering techniques based on multiple performance indicators, which can capture different dimensions of clustering performance simultaneously in selecting the best-performing clustering technique. This methodological contribution not only enhances the rigor of the analysis but also ensures that the most suitable model is selected to inform data-driven policy design.

The objectives of this study are as follows:

- Identify the supporters and opponents of car-free streets in Montreal, Canada, along with their profiles, including socioeconomic, mobility, and contextual characteristics.
- Capture the influences of over a hundred contextual variables (e.g., built environment, accessibility, socio-demographics, attitudes, previous experiences) on the level of support for pedestrianization projects.
- Compare the performance of many clustering techniques by developing a new approach based on multiple performance indicators and Grey Relational Analysis.
- Select which policy actions could be more efficient, in line with the Canada strategy for 2030.

2. Background

Different studies investigated the effectiveness, advantages, and disadvantages of pedestrianization projects. For example, Soni and Soni (2016) investigated the benefits of pedestrianization. They concluded that pedestrianization enhances accessibility for sustainable mode users and safety, reduces vehicle congestion, noise generated by motorized vehicles, and parking requirements, and increases public transportation usage and social interactions. However, they did not investigate the opposition to these projects. Yassin (2019) stated that pedestrianization has positive impacts on accessibility, safety, and cities' livability, which makes the city a livable place for residents.

Pedestrianization can positively influence the quality of life by improving the health of citizens (Allirani et al., 2024). Concerning health, these car-free streets can increase the physical activity of residents, which can lead to fat loss, inhalation of clean air, better metabolism, and improved psychological health (Allirani et al., 2024).

Pedestrianization can also positively influence various aspects of economic growth. For example, these projects can attract tourists, enhancing the economic dynamics (Kirmizi, 2023). Further, the demand for commercial space in pedestrianized streets is higher than in other regions, e.g., the commercial space vacancy rate in car-free streets in Montreal was less than in other streets (Bilodeau, 2020). Moreover, pedestrianization can improve the economy of local shops, and many studies found that the sales record of retailers in car-free areas is generally higher than in other regions (Özdemir & Selçuk, 2017).

Although pedestrianization provides citizens with many advantages, there is often opposition to it, and some do not support pedestrianization projects for various reasons. In this regard, a few studies examined the potential supporters and opponents of car-free streets. For example, Kim et al. (2021) examined the impact of socio-demographic and individual factors, perceived street environment, perceived noise, and air quality on the level of satisfaction with a pedestrianization project in Seoul, South Korea. The results indicated that attitude toward the policy,

perceived noise and air quality, comfort, liveability, restorativeness, and lack of congestion were significant variables on the level of support or opposition to pedestrianization projects. Nonetheless, their study lacks an analysis of the influences of the level of support for pedestrianization on travel patterns. Further, they did not investigate the links between accessibility and pedestrianization support.

Nello-Deakin et al. (2024) investigated the influences of street type (e.g., secondary and recent pedestrianization), neighborhood of residence, age, gender, educational level, presence of a child in the household, having a direct room to the street, distance to pedestrianized street, frequency of interaction with neighbors, and frequency of different mode use on the support or opposition of pedestrianization projects in Barcelona, Spain. The outcomes suggested that those who used motorized vehicles, aged over 75, lived within over 500 m of the street, and had a primary or secondary education level had a negative perception toward pedestrianization. On the other hand, frequent public transit users and those living in the region for less than five years positively perceived pedestrianization.

Semple and Fountas (2023) examined the influence of socio-demographics on the perceived benefits of pedestrianization in Edinburgh, United Kingdom. The results of their study suggested that the reason for travel has the highest relative influence on perceived personal advantages of pedestrianization, followed by preferred mode of transportation to arrive at the pedestrianized street, occupation, age, residence location, annual income, and gender. Although they identified the significant variables on the perceived benefits of pedestrianization, a limited number of variables were examined, and they overlooked essential variables, such as accessibility measures.

te Boveldt et al. (2023) analyzed the support for pedestrianization among the residents of Brussels, Belgium. A survey was implemented, and the results suggested that the older population, residents of suburban areas, and car drivers were more likely to oppose pedestrianization projects. Nonetheless, they did not investigate the influence of opposition to pedestrianization on travel patterns. Brownrigg-Gleeson et al. (2023) investigated the level of support for pedestrianization in Madrid, Spain. A survey was conducted, and its outcomes showed that regular visitors (workers and residents) were less likely to be satisfied with car-free projects. One of the limitations associated with their study was to consider a few variables in modeling and ignore many essential variables.

Melia and Shergold (2018) examined the impact of different factors on supporting or opposing pedestrianization in Brighton, United Kingdom. The results showed that full-time workers and car owners are more likely to oppose pedestrianized streets since they think pedestrianization is the reason for traffic in nearby areas. However, non-full-time workers, individuals who do not have a car, and males showed greater interest in visiting pedestrianized streets.

As seen from the above literature, only a few studies have identified the opponents of pedestrianization. Further, most of these studies analyzed different case studies in Europe, while detecting the pedestrianization opponents in North America, particularly Canada, has yet to receive enough attention in previous studies. Additionally, a few variables were generally applied to analyze the level of support for pedestrianization. To address these issues, this study aims to detect the supporters and opponents of car-free projects in Montreal, Canada. Contrary to previous studies, many variables (over 90) are used in the modeling. Moreover, a new approach is developed to compare the performance of different clustering techniques and identify the most accurate one for the mentioned transportation-based problem.

3. Data and methods

Fig. 1 illustrates the steps of this study. First, we collected the data and prepared it for the modeling. Then, different clustering techniques are applied. Subsequently, a new approach is developed to compare the techniques' performance. Finally, the supporters and opponents of
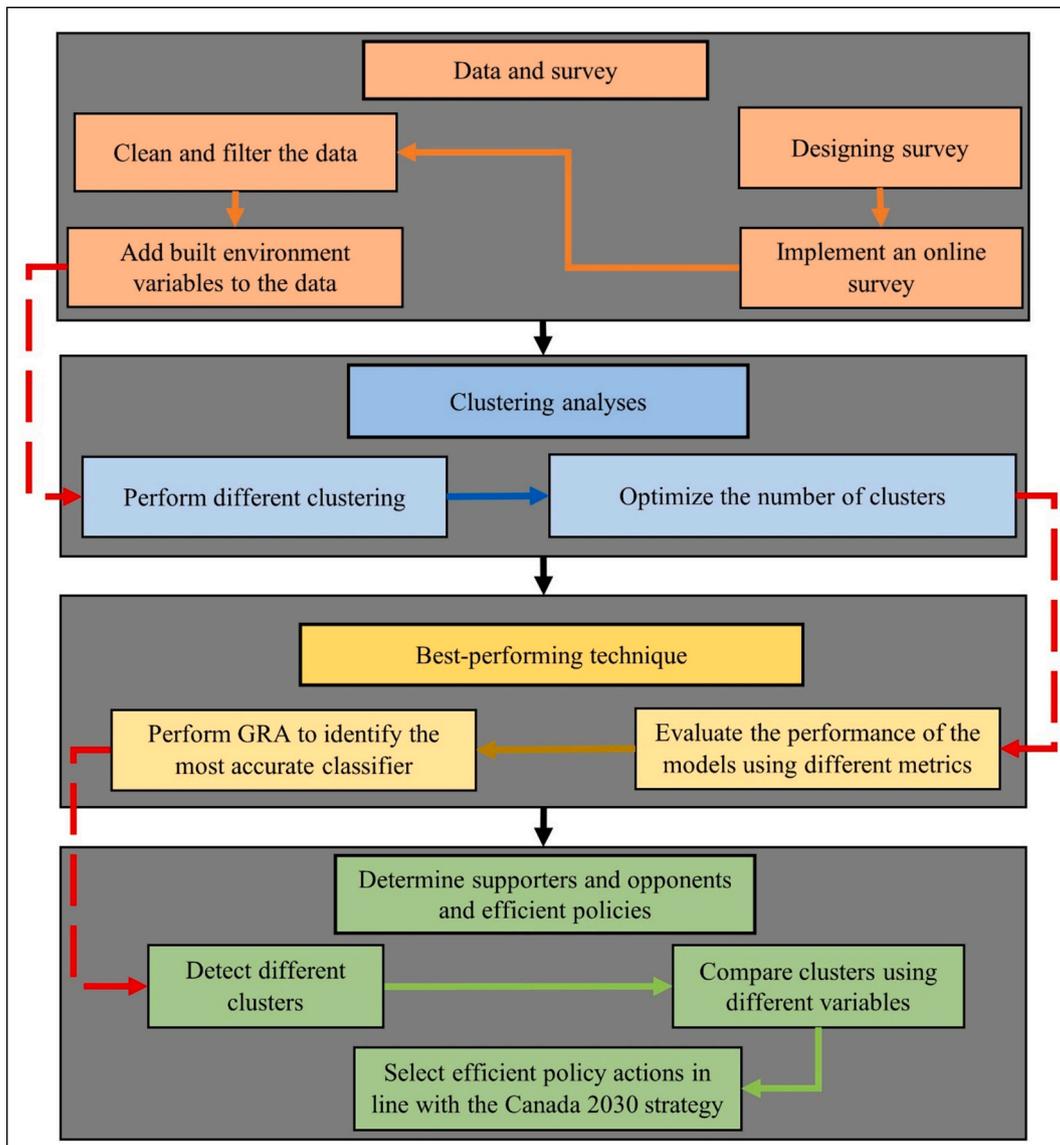
Fig. 1. Methodological steps to determine clusters of supporters and opponents to pedestrianization.

pedestrianization are identified using the best-performing technique.

3.1. Case study

The case study of this study is Montreal. Montreal is a city of over 1.7 million people located in the east of Canada (Canada Statistics, 2021). Like many other North American cities, Montreal is a car-dominated city, and the modal share of active transportation is relatively low. That is, walking and cycling represent 27.8 % and 2.4 % of children's trips (Naseri et al., 2022) and 9.2 % and 1.6 % of the overall population's trips, respectively (Naseri, Waygood, et al., 2024). The government of Canada aims to reduce the national GHG emissions by 30 % below 2005 levels by 2030 (Naseri et al., 2023). Hence, many policies have been set to reduce car trips and promote active transportation, including implementing car-free zones. Car-free projects were first implemented in 2021 and reimplemented every summer.

More than 10 car streets were pedestrianized in seven neighborhoods of Montreal, representing over nine kilometers of car-free streets at the time of the study. The locations of these streets on the Montreal map are highlighted in Fig. 2. As shown, most of these projects were implemented near the city center. The city center is the city's central business district, with major office towers, corporate headquarters, and financial institutions. Moreover, the city center has the highest number of commercial and leisure destinations in the city. A recent study showed that the life cycle transportation GHG emissions in Montreal center are much less than in other neighborhoods (Naseri et al., 2025), and one reason might be the contribution of car-free projects.

These streets are seasonal car-free projects in Montreal. That is, all motorized vehicles are banned from the streets, and car streets are transformed into walking and cycling infrastructure from mid-May to mid-October. These pedestrianized centers include markets, restaurants, boutiques, and bustling terrasses. From mid-October to mid-May, the streets open to traffic, and the car-free streets are converted to conventional car streets with sidewalks since the temperature is too cold for active transport for the general population during this period.

3.2. Survey

An online survey was designed and open to participation from October 2023 to January 2024. The pedestrianization projects were implemented from mid-May to mid-October. Hence, we collected the data in October since participants had experienced these car-free zones
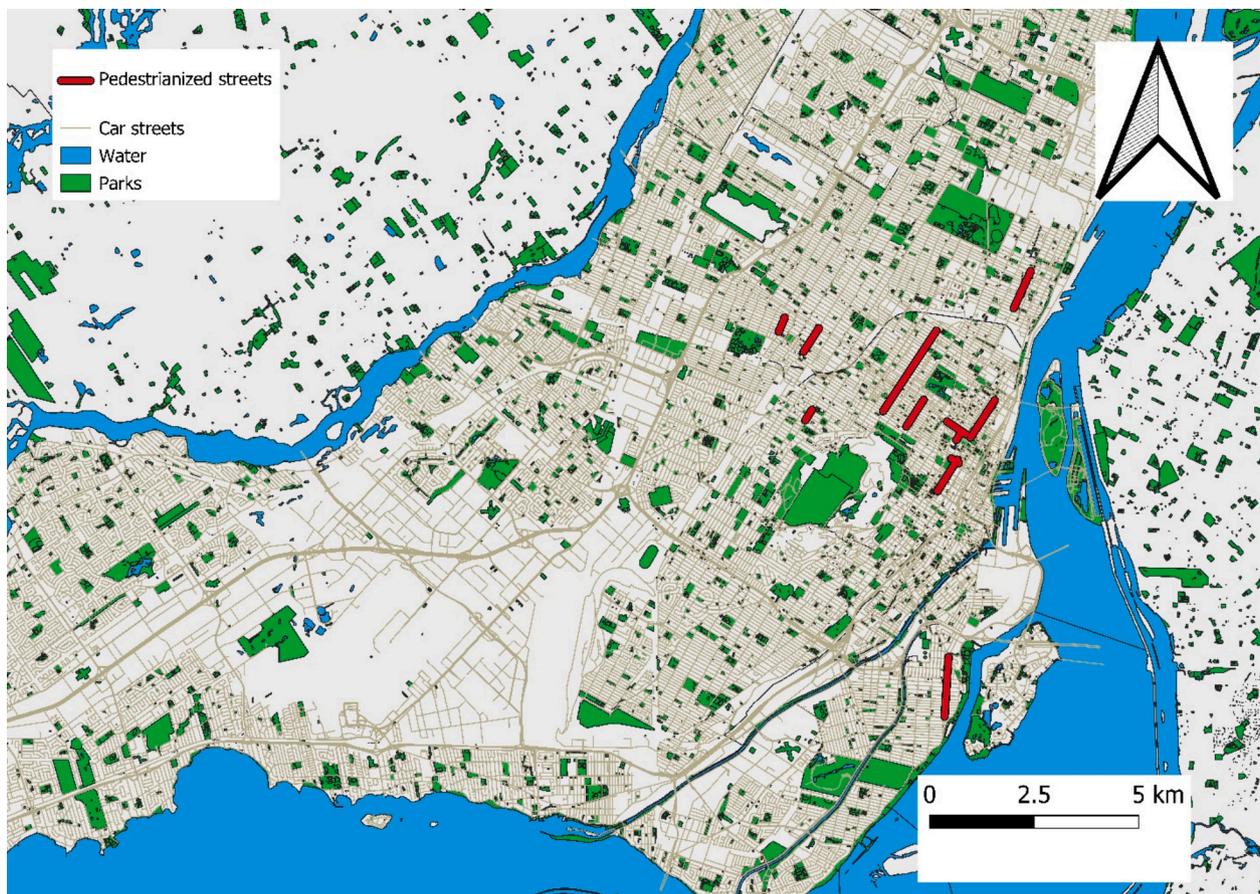
Fig. 2. The locations of pedestrianized streets in Montreal.

and could still recall their experiences accurately. A survey company cooperated to hire respondents. To submit their responses, the participants had to respond to 94 questions (93 questions for the following information and a question to collect postal codes). The questions collected the following information:

- Experiences in visiting pedestrianized streets in the previous summer (e.g., which streets, at what frequency, trip purpose, visit time, with whom).
- Level of satisfaction with different elements of pedestrianization (e. g., cohabitation of cyclists-pedestrians, security, and urban furniture).
- Availability of different modes (e.g., driving permit, car ownership, subscription to shared modes, and transit pass).
- Travel pattern and mode usage in different times and conditions (e. g., in winter (non-pedestrianized), in summer (non-pedestrianized), and in summer (pedestrianized).
- Questions about their attitude toward the behavior of cyclists (e.g., cyclists' speed and their respect for pedestrians' priority).
- Experience of cycling in pedestrianized streets and their attitude toward the behavior of pedestrians as a cyclist (e.g., sharing the road with cyclists and being respectful of cyclists).
- The influence of pedestrianization on travel behavior change (e.g., stay more time, visit with higher frequency, spend more time in street shops in a location that is pedestrianized).
- Socio-demographics (e.g., age, gender, income, and mobility restrictions).
- Attitude toward pedestrianization (e.g., level of interest in these projects, redoing them every year, and extending them).

The postal code of the resident's location was also collected. Using

the postal code, five aggregated data sources, including Montreal proximity measure data, a national deprivation index, Montreal census-tract data, Walk Score, and Can-BICS, were used to add 28 variables to each participant's responses at the neighborhood level. From Montreal proximity measure data (Statistics Canada, 2020), six variables were collected: proximity to employment centers, childcare centers, health care centers, grocery stores, parks, and transit stations. These metrics provided gravity-based accessibility measures to different centers.

From the deprivation index (Institut national de santé publique du Québec (INSPQ), 2016), two variables were added, including the material deprivation index (e.g., housing, car ownership, internet access) and the social deprivation index (e.g., single-person homes, single parents). These deprivation indices indicate deprivation levels in different neighborhoods.

From Montreal census-tract data (Statistics Canada, 2021a), 16 variables were collected related to population density, apartment types (e.g., percentage of apartments with five or more stories), distribution of household size (e.g., percentage of households with one, two, and three members), distribution of age in the neighborhood (e.g., percentage of people aged over 65), and the median income of households.

Walk Score dataset (Walk Score, 2021) provides information about the accessibility to different centers by walking, bike, and transit, using three indices: Walk Score, Bike Score, and Transit Score. Canadian Bikeway Comfort and Safety (Can-BICS) is a measure to evaluate the quality and quantity of cycling infrastructure in a neighborhood (Winters et al., 2022). This variable was also added to the dataset. All in all, the data included 121 variables.

Montreal proximity measure data, the national deprivation index, Montreal census-tract data, and Can-BICS are aggregated data and provide information at the dissemination area level. A dissemination area is a standard geographic unit in Canada, defined by having at least

one neighboring dissemination block, making it the smallest standard geographic unit in Canada (Statistics Canada, 2021b). Hence, using the postal code, we identified the dissemination area of participants' residential locations and added these datasets (at the neighborhood level) to the survey. We also used postal codes to directly collect the Walk Score, Bike Score, and Transit Score of residential locations of participants using the Walk Score API.

3.3. Respondents

All survey respondents who were residents of Montreal visited one of these streets at least once during the summer. Some trap questions were available in the survey to determine who did not pay attention to all parts of the survey. After removing them, 1909 complete responses were in the final data set. Some attributes and socio-demographics of survey respondents are presented in Table 1. As shown, most respondents were males in the middle-income group (i.e., household income of 50,000 \$-100,000\$), aged between 31 and 45, who had visited three different pedestrianized streets the previous summer and visited those a few times per week. In this survey, males are over-represented since they include nearly 50 % of the population of Canada (Canada Statistics, 2021).

Table 1
Participants' general characteristics ($n = 1909$).

Variable	Frequency (%)	Variable	Frequency (%)
Gender		How many pedestrianized streets did you visit this summer?	
Female	37.56	1	14.51
Male	60.35	2	14.25
Other	1.10	3	17.71
Prefer not to answer	1.00	4	17.44
Household income		5	14.77
0\$ - 50,000\$	17.08	6	10.21
50,001\$ -100,000\$	32.16	7	5.40
100,001\$ - 150,000\$	20.80	8 and more	5.71
150,001\$ - 215,000\$	12.57	Main reason of visiting pedestrianized streets	
215,000\$ and more	8.49	Shopping	36.83
Prefer not to answer	8.91	A bar, cafe, or restaurant	9.95
Mobility aid use		A service or business (e.g., dentist, hairdresser)	5.19
No	97.43	Study or work	6.34
Yes	2.15	Exercise, walk, or relax	22.63
Prefer not to answer	0.42	Access the residence	15.72
Age (years)		Prefer not to answer	0.26
Under 18	0.05	Other	3.09
18–30	11.31	Limitation in cycling	
31–45	42.69	Yes	4.19
46–60	25.51	No	94.55
61–75	16.66	Prefer not to answer	1.26
Over 75	2.10	Limitation in using public transit	
Prefer not to answer	1.68	Yes	1.89
Frequency of visit		No	97.43
Every day	36.14	Prefer not to answer	0.68
A few times a week	44.53	Limitation in walking	
A few times a month	18.33	Yes	2.83
Only once	0.84	No	96.49
Prefer not to answer	0.16	Prefer not to answer	0.68

3.4. Modeling

First, a Variance Inflation Factor (VIF) analysis was performed to address any potential multicollinearity issue in the dataset. The VIF of all variables was calculated, and it was assumed that VIF values of over 5 imply multicollinearity (Akinwande et al., 2015). To this end, an iterative process was applied. First, the variable with the highest VIF was removed, and the VIF of other variables was recalculated. Then, the variable with the highest VIF in the new run was eliminated, and the VIF of the remaining variables was recalculated. This process was continued until the maximum VIF was below 5. After running the iterative VIF analysis, 93 variables remained, and 28 variables were removed. Therefore, 93 variables were used in the modeling.

Eight different clustering techniques were used for the modeling. These techniques were selected from different groups of partitioning (K-Means and Bisecting K-Means), hierarchical (Agglomerative Clustering and Birch), density-based (OPTICS), model-based (Gaussian Mixture), and graph-based methods (Affinity Propagation). Affinity Propagation automatically finds the optimal number of clustering. But, for other techniques, three metrics were used to optimize the number of clusters: Silhouette score, Calinski-Harabasz score, and Davies-Bouldin score.

These three metrics were also applied to compare the performance of clustering techniques and identify the best-performing method. Since there are multiple metrics for comparison, it is impossible to compare clustering methods. In some cases, a method is better than another based on a metric, while it is worse when considering another metric. To address this, a multi-criteria decision-making process called Grey Relational Analysis (GRA) is employed.

GRA is an efficient technique for prioritizing various choices based on multiple criteria (here, performance metrics). GRA is a parametric method transforming multi-dimensional information into a single value called Grey Relational Grade (GRG) (Naseri, Aliakbari, et al., 2024). In GRA, the identification coefficient was considered 0.5 (Jahanbakhsh et al., 2024). For more details about GRA, please read Naseri et al. (2021).

Then, GRG is used to detect the optimal number of clusters in each method and compare different clustering methods to identify the best-performing method. A higher GRG value signifies a better performance, and the maximum possible GRG value is one, implying the method outperforms all other methods based on all performance metrics.

4. Results

4.1. Clustering performance

First, the number of clusters for different methods was calculated. The performance metrics, GRG, and number of clusters of optimized clustering methods are presented in Table 2. For some clustering methods, there are two models with different numbers of clusters. For example, there is a K-Means model with two clusters (K-Means-2) and another with four clusters (K-Means-4) because these models are non-dominated. K-Means-2 outperforms K-Means-4 when comparing Silhouette and Calinski-Harabasz scores, while K-Means-4 performs better based on the Davies-Bouldin score.

The top six models include two clusters, and hence, the optimal number of clusters is two for this case study. The best-performing model is Affinity Propagation with a GRG of 0.654, followed by Bisecting K-Means, K-Means, and Birch. On the other hand, OPTICS's performance is the worst. Hence, it would be worth mentioning that most methods (except OPTICS) perform well, particularly when their number of clusters equals two.

The best-performing model (Affinity Propagation with two clusters) was chosen to identify supporters and opponents of pedestrianization, and its results are presented in the following sub-sections.

Table 2
The performance of clustering methods.

	Number of clusters	Silhouette	Calinski-Harabasz	Davies-Bouldin	GRG	Rank
Ideal level		Maximum	Maximum	Minimum	Maximum	
Affinity Propagation	2	0.127	140.635	2.939	0.654	1
Bisecting K-Means	2	0.114	149.680	3.159	0.650	2
K-Means	2	0.113	149.658	3.174	0.648	3
Birch	2	0.147	107.429	2.750	0.644	4
Agglomerative Clustering	2	0.147	107.429	2.750	0.644	4
Gaussian Mixture	2	0.163	55.105	4.595	0.587	6
Agglomerative Clustering	5	0.122	69.200	2.186	0.582	7
OPTICS	2	0.085	8.074	1.821	0.556	8
K-Means	4	0.105	95.097	2.730	0.523	9
Gaussian Mixture	4	0.115	35.466	4.377	0.394	10

4.2. Supporters and opponents

We identified two distinct clusters: supporters and opponents of pedestrianization, comprising 79.5 % and 20.5 % of the population, respectively. In the following sub-sections, we compare various characteristics of these two groups to better understand their perspectives.

4.2.1. Socio-demographics

Fig. 3 shows the gender and mode availability of opponents and supporters of pedestrianization. As can be seen, opponents included a higher percentage of males. Supporters were more likely to be cyclists, subscribe to shared modes (car-sharing and bike-sharing) and transit passes, own bicycles, and have a driving permit. However, the opponents included a higher car, truck, and motorcycle ownership rate.

Fig. 4 presents the other socio-demographics and limitations of using different modes. As shown, the lowest income group (0-50 k CAD) was more likely to oppose car-free projects. For both clusters, the share of the middle-income group (50-100 k CAD) was approximately the same (i.e., around 35 %). The distribution of supporters in the highest income groups is higher than that of opponents of pedestrianization.

The supporters generally included the younger population, as over 62 % of supporters were aged under 45, which was 37 % higher than opponents. Conversely, 75 % of those who opposed car-free projects were aged over 45. The percentage of opponents who were under 30 was relatively low. Likewise, the share of supporters aged over 75 was minor. Hence, the level of support for pedestrianization projects was significantly higher in younger groups than the older ones.

Approximately 75 %, 13 %, and 31 % of supporters lived with at least an adult, a teenager, and a child in their residence. These rates for opponents were 57 %, 12 %, and 17 %. Accordingly, the availability of other members in the household, particularly children and adults, was associated with a higher level of support for car-free streets. The opponent group contained a significantly higher percentage of people with mobility limitations. The share of those who use mobility aids, who have limitations in walking, cycling, and using a bus, was over four, four, nine, and four times higher than supporters, respectively.

4.2.2. Level of satisfaction and attitudes toward pedestrianization

The differences between opponents and supporters of pedestrianization in terms of attitudes toward pedestrianization and the level of satisfaction with these projects are shown in Table 3. As shown, 79.5 % of respondents were supporters, while 20.5 % opposed pedestrianization. Therefore, a larger proportion of respondents (who at least once visited one of these projects) had positive attitudes toward pedestrianization. The supporters visited four pedestrianized streets in the previous summer, which is double the number of pedestrianized streets opponents visited. The primary reason for the visit was shopping for opponents, while it was exercising, walking, and relaxation for the supporters.

Supporters of pedestrianization were satisfied or very satisfied with the cohabitation of cyclists or skateboard users and pedestrians, safety, accessibility, attractiveness of pedestrianized streets, cleanliness, and urban furniture. However, the pedestrianization opponents were dissatisfied or not very satisfied with these items, except safety and accessibility (satisfied). The level of satisfaction with the cohabitation of pedestrians and electric 2-wheel users is the only question that supporters were not very satisfied with. Moreover, the level of satisfaction of supporters in all questions was higher than opponents, indicating the importance of satisfaction levels related to safety, cohabitation with 2-wheel users, and the attractiveness of pedestrianized streets.
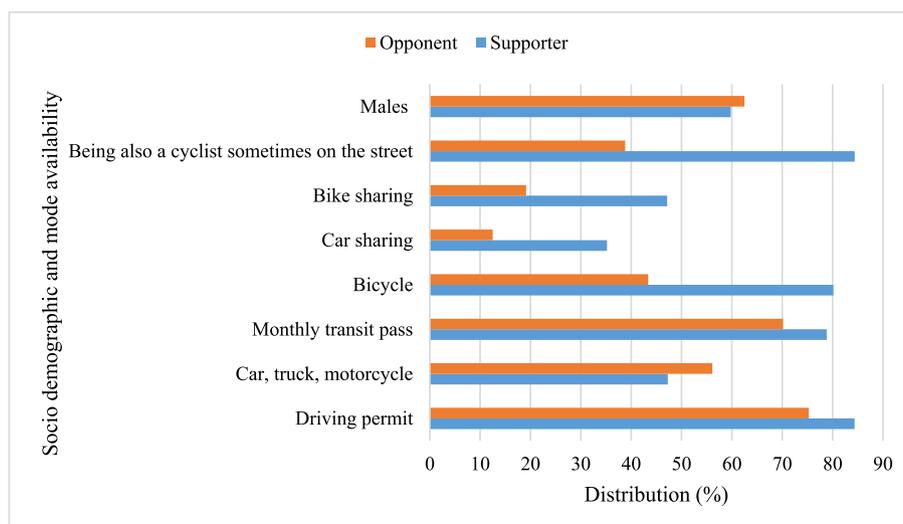

Fig. 3. The differences between clusters on gender and mobility (n = 1909).
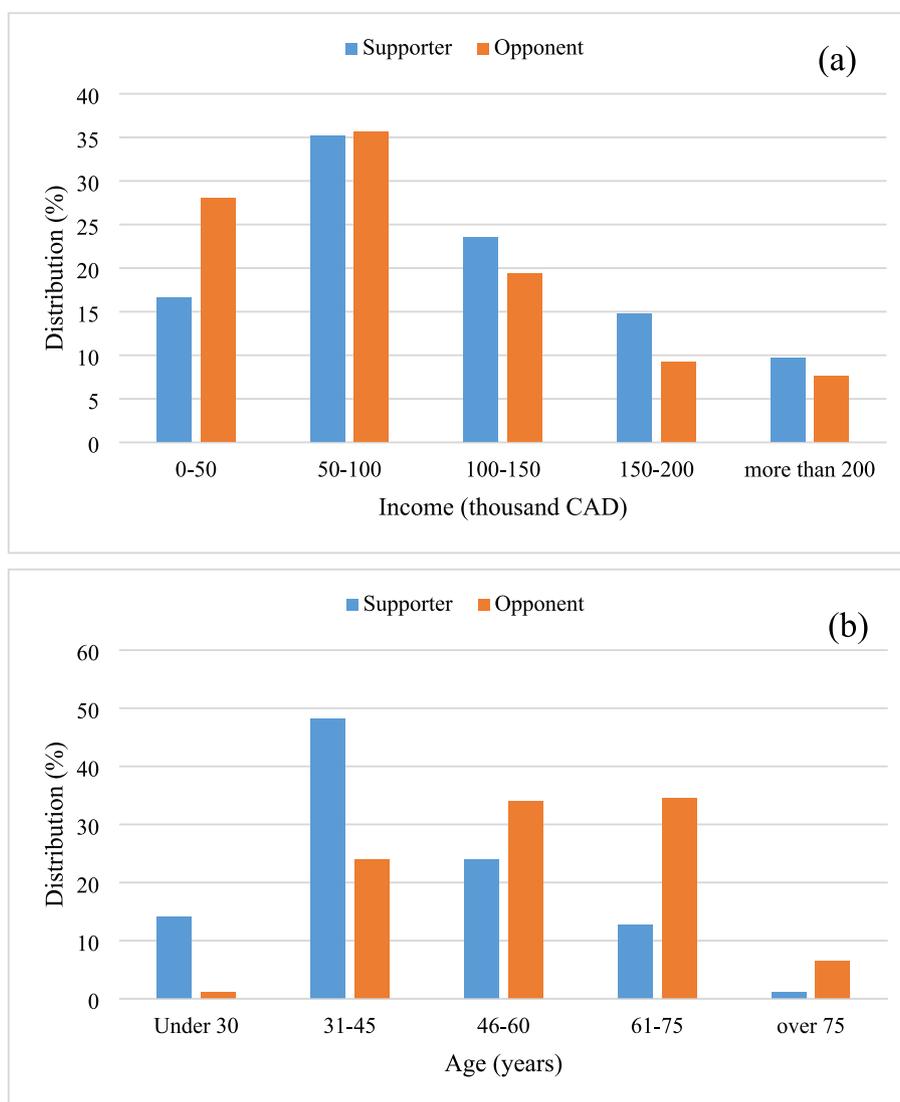
Fig. 4. The socio-demographic of clusters (*n* = 1909). (a): household income, (b): age, (c): people in the household, (d): mobility limitations.

Contrary to opponents, supporters sometimes cycled on the street. Supporters agreed that cyclists traveled at an acceptable speed, were respectful of pedestrian priority, and pedestrians shared the road with cyclists and were respectful of cyclists during their passage, while opponents disagreed with these statements. Thus, one of the significant differences between the two clusters was the attitude toward the behavior of cyclists and pedestrians in shared spaces. In addition, supporters seemed to increase the frequency of visits and duration of stay on streets and their shops, and they were more likely to change their route to visit there. On the other hand, the opponents said they agree that pedestrianization made them change their route to avoid a street if it was pedestrianized. The supporters were very favorable to implementing, reimplementing, and extending pedestrianization to other neighborhoods and thought that pedestrianization positively influenced their mobility.

4.2.3. Built environment and neighborhood characteristics

The built environment and neighborhood characteristics of the home location of opponents and supporters are presented in Table 4. As can be perceived, supporters were more likely to live in neighborhoods with better accessibility to different centers (employment, childcare, and healthcare), grocery stores, and transit stops. On the other hand,

opponents lived in locations with higher park accessibility. Supporters lived in neighborhoods with higher material deprivation rates (e.g., housing, car ownership, internet access), while opponents were residents of locations with higher social deprivation rates (e.g., single-person homes, single parents).

Supporters were likelier to live in neighborhoods with higher density and tall buildings, while opponents lived in regions with less density and a higher percentage of small buildings. Opponents lived in areas with higher rates of single-person households. However, those who live in neighborhoods with a higher percentage of multi-person households were more likely to be supporters. Accordingly, supporters were the residents of neighborhoods with larger average household sizes.

Those who live in neighborhoods with a higher percentage of children (aged less than 15) were more likely to support pedestrianization projects. Nonetheless, opponents generally lived in neighborhoods containing higher rates of adults and older people. There is not a significant difference in the average household income of both clusters' neighborhoods. Regarding active transportation infrastructure, supporters were residents of neighborhoods with higher walkability, while the quality and quantity of bikeways were slightly higher in the opponents' neighborhoods.
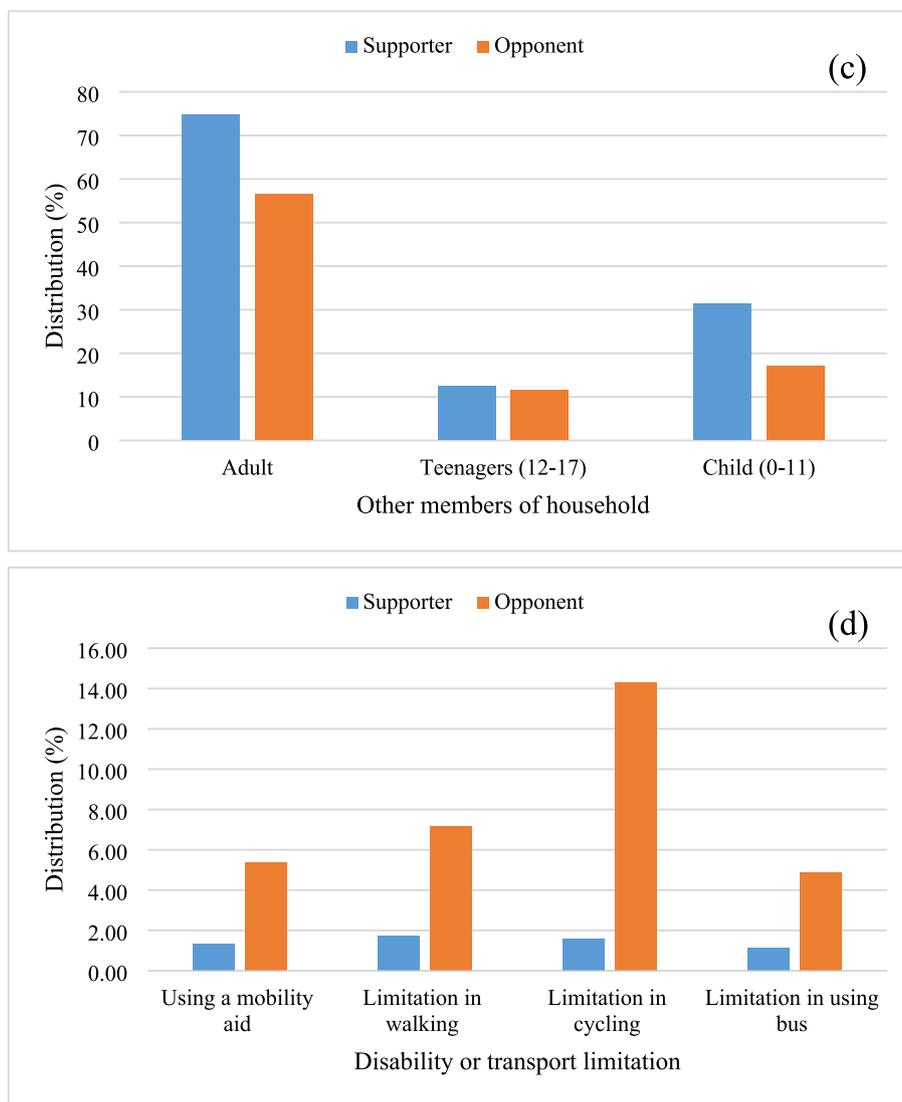
Fig. 4. (*continued*).

4.2.4. Travel pattern

In the survey, the respondents needed to answer the following questions:

- What modes of transport did you use most often to get to "location A" in the summer when it was pedestrianized?
- What modes of transport did you use most often to get to "location A" in the summer when it was NOT pedestrianized?"

In the initial part of the survey, the respondents selected the pedestrianized street that they most frequently visited, and in the above questions, the name of that street was shown instead of "location A". Moreover, the participants could select multiple choices. The responses to these questions for supporters and opponents of pedestrianization are presented in Fig. 5.

As can be seen in Fig. 5, pedestrianization increased the share of walking trips, and this increment was higher for supporters. That is, during the pedestrianization, the share of walk trips increased by 5.3 % for supporters and 2.3 % for opponents, respectively. The percentage of people who biked to get to a location increased by 3.6 % for supporters, while it was reduced by 2.6 % for opponents when that location was pedestrianized. In both cases (during and outside the pedestrianization period), the bike usage rate of supporters was much higher than that of

opponents. Although pedestrianization increased the share of walking trips for opponents, it reduced their share of bike trips.

Pedestrianization also reduced the share of public transportation for both groups, which was more significant for opponents. Likewise, pedestrianization considerably reduced the percentage of respondents who used motorized vehicles to get to the location. Over 11 % of supporters frequently used motorized vehicles to visit a street, and approximately 67 % stopped using motorized vehicles to get there when it was shifted to a car-free street. Interestingly, nearly 38 % of opponents replaced their motorized vehicle trips with other modes to arrive there during pedestrianization. Opponents were more likely to use a motorized vehicle to arrive during and outside pedestrianization.

Implementing pedestrianization projects increased the share of 2-wheelers (e.g., scooters, caster boards, skates), and this increment was higher for supporters. Pedestrianization did not influence the share of adapted transport usage, and all the adapted transport users were within the opponent cluster. Pedestrianization noticeably reduced the use of taxis and car-sharing to reach pedestrianized locations. Opponents used taxis more than supporters to get there, while supporters reported a higher rate of car-sharing usage.

Table 3
The cluster centroid of opponents and supporters of pedestrianization.

Clusters	Supporters	Opponents
Frequency (%; n=1909)	79.5	20.5
How many pedestrian streets did you visit this summer?	4	2
What is the main reason for attending pedestrian streets?	Walk, exercise, and relax	Shopping
What is your satisfaction with the cohabitation of pedestrians and "traditional" cyclists?	Satisfied	Dissatisfied
What is your satisfaction with the cohabitation of pedestrians and non-electric 2-wheels users (e.g., skateboard)?	Satisfied	Dissatisfied
What is your satisfaction with the cohabitation of pedestrians and electric 2-wheels users (e.g., electric scooter)?	Not very satisfied	Dissatisfied
What is your satisfaction with the safety at intersections with streets where vehicles are permitted?	Very satisfied	Satisfied
What is your satisfaction with the universal accessibility to facilities and businesses?	Very satisfied	Satisfied
What is your satisfaction with attractiveness (shops, atmosphere, layout)?	Satisfied	Not very satisfied
What is your satisfaction with personal safety (fear of strangers, lack of lighting, etc.)?	Very satisfied	Not very satisfied
What is your satisfaction with cleanliness?	Very satisfied	Not very satisfied
What is your satisfaction with urban furniture (aesthetics, comfort, positioning, number)?	Very satisfied	Not very satisfied
As a pedestrian, to what extent do you agree that the cyclists travel at an acceptable speed?	Agree	Disagree
As a pedestrian, to what extent do you agree that the cyclists are respectful of pedestrian priority?	Agree	Disagree
Are you also a cyclist sometimes on the street?	Yes	No
To what extent do you agree that pedestrians share the road with cyclists?	Neither agree nor disagree	Completely disagree
To what extent do you agree that the pedestrians are respectful of cyclists during their passage?	Agree	Completely disagree
Do the pedestrianization encourage you to go there more times?	Completely agree	Disagree
Do the pedestrianization encourage you to stay there for longer times?	Completely agree	Disagree
Do the pedestrianization encourage you to spend more in the street shops?	Agree	Disagree
Do the pedestrianization encourage you to change your route to get there?	Completely agree	Disagree
Do the pedestrianization encourage you to change your route to avoid getting there?	Completely disagree	Agree
In general, are you more favorable or unfavorable to implement pedestrianization projects?	Very favorable	Slightly favorable
In general, are you more favorable or unfavorable to redo the pedestrianization projects every year?	Very favorable	Slightly favorable
In general, are you more favorable or unfavorable to extend pedestrianization to other neighborhoods?	Very favorable	Slightly favorable
In your opinion, what is the impact of the pedestrianization on your mobility?	Very positive	Neutral

Table 4
The neighborhood characteristics of the resident location of two clusters.

Clusters	Supporters	Opponents
Frequency (%; n=1909)	79.5	20.5
Proximity of home location to employment centers (from 0 to 1 (highest))	0.39	0.32
Proximity of home location to childcare centers (from 0 to 1 (highest))	0.23	0.17
Proximity of home location to healthcare centers (from 0 to 1 (highest))	0.30	0.26
Proximity of home location to grocery stores (from 0 to 1 (highest))	0.18	0.17
Proximity of home location to parks (from 0 to 1 (highest))	0.20	0.29
Proximity of home location to transit stops (from 0 to 1 (highest))	0.12	0.10
Material deprivation (from 1 (least deprived) to 100 (most deprived))	37	10
Social deprivation (from 1 (least deprived) to 100 (most deprived))	71	95
Population density per square kilometre	13893.70	10867.70
Percentage of apartments in a building with five or more storeys in the neighborhood	3.52	0.00
Percentage of row house in the neighborhood	3.52	0.44
Percentage of apartment or flat in a duplex in the neighborhood	9.55	6.58
Percentage of apartment in a building with fewer than five storeys in the neighborhood	80.90	93.42
Percentage of single-person households in the neighborhood	43.94	53.07
Percentage of two-person households in the neighborhood	33.33	28.07
Percentage of three-person households in the neighborhood	12.63	12.28
Percentage of four-person households in the neighborhood	7.07	5.26
Percentage of five-or-more-person households in the neighborhood	3.03	1.32
Average household size (members)	1.90	1.70
Percentage of people aged less than 15 in the neighborhood	16.00	11.60
Percentage of people aged from 15 to 64 in the neighborhood	78.00	82.00
Percentage of people aged over 64 in the neighborhood	6.00	6.90
Median total income of households in the neighborhood	51520.00	52416.00
Walk Score of home location (from 1 to 100 (highest))	99.00	93.00
CanBICS of home location (weighted km of bikeways within one km)	11.92	13.88

5. Discussion

Two approaches are generally used to identify the opponents of car-free zones: supervised learning and unsupervised learning. In the first approach (supervised learning), we need to ask people directly about their level of support for pedestrianization. However, what people say often differs from what they do (Hausman, 2012). Moreover, the statistical methods used for supervised learning (e.g., *t*-tests, ANOVA, regression) often assume specific distributions and predefined relationships, limiting their ability to detect emergent patterns within complex datasets (Cohen et al., 2013). Unsupervised learning can be applied to address these limitations. Clustering techniques are the conventional methods for unsupervised learning.

However, different clustering methods exist, and they should be compared to detect the best-performing method for transportation-based datasets since applying different metrics leads to different solutions. For instance, Bisecting K-Means outperformed other methods based on the Calinski-Harabasz score, while the Gaussian Mixture was the best method when comparing the Silhouette score. Accordingly, this study developed a new approach to identifying the best-performing clustering method based on multiple metrics. Affinity Propagation was the best-performing model, with a GRG of 0.654. In a previous study (Refianti et al., 2012), Affinity Propagation was found to be more accurate and effective than K-Means (the widely used clustering algorithm in transportation studies), which is in line with the results of this study.

The outcomes of the best-performing method suggest that the participants could be clustered into two groups: supporters (79.5 %) and opponents (20.5 %) of pedestrianization. As expected, supporters visited more pedestrianized streets than opponents. Pedestrian streets are convenient places for self-regulating exercise with no need for special equipment. They are also good places to relax and walk since people feel safe due to the low chance of crashes (Soni & Soni, 2016). Hence, the main reasons for supporters to get to car-free areas were exercise, walking, and relaxation.

Cohabitation with electric and non-electric 2-wheel users and a lack of feeling of safety were important differences between supporters and opponents. Although the coexistence of pedestrians and 2-wheel users in pedestrianized streets posed a low risk to the safety of users (Cloutier et al., 2022), lower safety perception could reduce the satisfaction of opponents (Campos Ferreira et al., 2022). This is why our results are informative for decision-makers trying to gain supporters. Similarly, the urban environment, its functionalities, and the availability of leisure activities impact the attractiveness of a public location and the preferences of individuals to visit and stay there (Guedoudj et al., 2020). Therefore, increasing the attractiveness and improving the urban furniture and cleanliness of pedestrianized areas can be helpful strategies to increase support for car-free projects.

Travel behavior is a function of transportation infrastructure, and new infrastructure for active transportation increases the number of walking and cycling trips (Heinen et al., 2015). In this study, the same trend could be seen, and pedestrianization encouraged supporters to increase the number of visits, the duration of visits, and the duration of
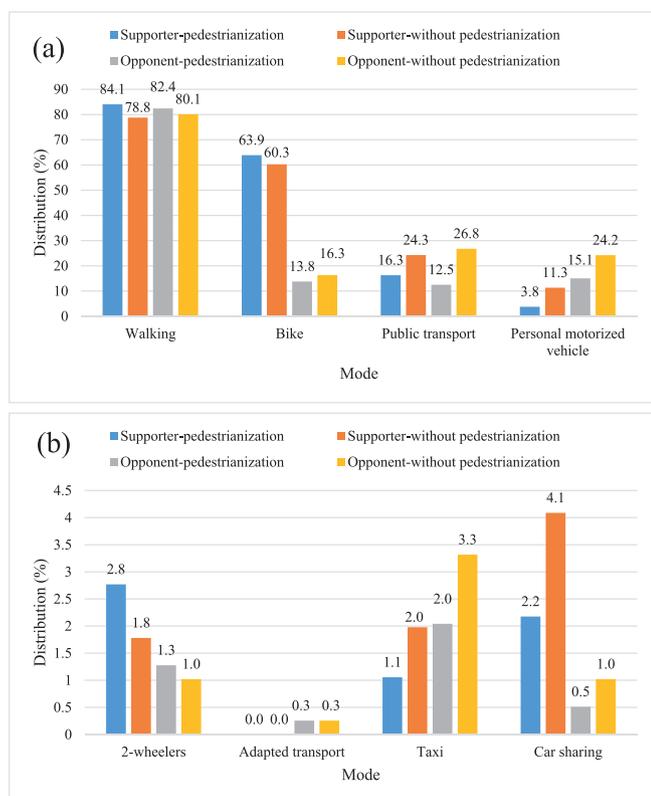
Fig. 5. Transportation mode of opponents and supporters of pedestrianization, during and outside the pedestrianization period.

shopping during trips. Supporters lived in neighborhoods closer to different centers and services and in neighborhoods with higher densities and tall buildings. These results align with previous studies saying that higher proximity to services was associated with participation in regular active transportation (McCormack et al., 2008), while high population density consistently promotes cycling and walking (Grasser et al., 2013), and sidewalk density is positively associated with walking (Eldeeb et al., 2021). Hence, it can be postulated that pedestrianization could be more effective when implemented in denser neighborhoods and where accessibility to centers and services is higher.

Increasing the age reduces physical activity, and those aged between 6 and 19 generally experience the highest levels of physical activity (Varma et al., 2017). It can be one of the reasons why the younger population and those who live with a child were more likely to support pedestrianization. On the contrary, vulnerable people, such as seniors and people with disabilities, often feel threatened by passengers who travel at different speeds or patterns (Albrecher, Curnier, & Kaufmann, 2023). Therefore, those experiencing limitations in active transport and buses may prefer or have no choice but to use motorized vehicles (as a driver or passenger), finding themselves among potential opponents of pedestrianization.

These findings can help decision-makers and policymakers address public concerns and create urban spaces that better accommodate all road users. For example, improving the design of streets, improving safety, and increasing the comfort level of bikeways can help reduce the gap between supporters and opponents. Moreover, the cohabitation of pedestrians/2-wheeler users should be improved to reduce opposition against car-free zones. The conflict between pedestrians and cyclists can be related to a perceived safety issue (Gkekas et al., 2020) and pedestrians' lower perception of safety (Campos Ferreira et al., 2022). To address this, separating bikeways from pedestrian infrastructure in car-free zones (Svensson et al., 2007) or speed bump installation (Torres et al., 2020) can be useful strategies to reduce opposition to

pedestrianization projects.

Further, most of the supporters of pedestrian streets are occasional bikers. The distribution of cyclists among supporters is over two times higher than that of opponents, and promoting cycling can help increase the level of support for pedestrianization. Accordingly, launching awareness campaigns and trials for citizens to become cyclists could be a strategy to increase cycling, as well as support for pedestrianization. Supporters are more likely to use shared mobility services, and improving such services (e.g., increasing the number of bike-sharing docks and the number of vehicles in the car-sharing platforms) can increase the level of support for pedestrianization. Further, policymakers can identify the neighborhoods with the maximum level of support for pedestrianization based on their socio-demographic characteristics. Subsequently, these projects can be implemented in such neighborhoods. For example, the neighborhoods with a higher percentage of residents aged under 45 could be better regions for implementing new pedestrianization projects.

6. Conclusions

This study explored the opponents and supporters of car-free streets in Montreal, Canada. The collected survey data was merged with other contextual variables to create a comprehensive dataset. The performance of different clustering methods was compared using a novel approach (i.e., GRA), and Affinity Propagation was the best-performing model. This method was performed, and the opponents and supporters of pedestrianization were identified. The results suggested that opponents and supporters of pedestrianization differed in socio-demographics and travel patterns. Interestingly, the built environment of the residential location was influential on the level of support for pedestrianization. Pedestrianization could significantly increase the share of active transportation while reducing the number of car trips, even for opponents. These results could be useful for stakeholders to identify the opponents of car-free projects and the roots of their opposition. Hence, they could improve the projects by considering the issues identified by opponents (e.g., cohabitation of pedestrians/2-wheeler users) and making the car-free zones interesting, safe, convenient, and livable places for more population. The results can be used to guide messaging and identify important user needs that need to be considered in future designs to improve access and reduce conflict in these spaces. One of the limitations of this study is that it does not use the labeled data since it was not available among survey questions. Hence, in the next wave of the survey, we directly ask respondents about their level of support for pedestrianization. Then, we apply a classification framework for modeling and compare the results with the outcomes of this study. One of the other limitations of this study is that the data is not population-representative on gender, and males were over-represented. However, it may not significantly influence the results since the distribution of males in both groups was approximately the same (i.e., approximately 60 %).

CRediT authorship contribution statement

Hamed Naseri: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francesco Ciari:** Writing – review & editing, Supervision, Data curation, Conceptualization. **Marie-Soleil Cloutier:** Writing – review & editing, Supervision, Formal analysis, Data curation. **Ashraf Uz Zaman Patwary:** Writing – review & editing, Methodology, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

The authors declare that generative AI was not applied during the preparation of this work.

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.

Acknowledgments

Data availability

The data that has been used is confidential.

References

Akinwande, M. O., Dikko, H. G., & Samson, A. (2015). Variance inflation factor: As a condition for the inclusion of suppressor variable(s) in regression analysis. *Open Journal of Statistics, 05*(07), 754–767. https://doi.org/10.4236/ojs.2015.57075

Albrecher, R., Curnier, S., & Kaufmann, V. (2023). Cycling and walking as means of transport - current review of the research. *EPFL Scientific Publications, 40B*, 1–58. https://infoscience.epfl.ch/record/304404.

Allirani, H., Dumka, A., & Verma, A. (2024). A framework for assessment of pedestrianization impacts on quality of life: Combining subjective and objective measures. *Cities, 145*, Article 104688. https://doi.org/10.1016/j.cities.2023.104688

Bilodeau, M. (2020). *Closing the streets to cars: Bad for business?* False - Chief Scientist of Quebec and Agence Science Presse. Available at: https://www.scientifique-en-chef.gouv.qc.ca/en/research-impact/closing-the-streets-to-cars-bad-for-business-false/ https://www.scientifique-en-chef.gouv.qc.ca/en/research-impact/closing-the-streets-to-cars-bad-for-business-false/.

Brownrigg-Gleeson, M. L., Monzon, A., & Cortez, A. (2023). Reasons to pedestrianise urban Centres: Impact analysis on mobility habits, liveability and economic activities. *Sustainability, 15*(23), 16472. https://doi.org/10.3390/su152316472

Campos Ferreira, M., Dias Costa, P., Abrantes, D., Hora, J., Felício, S., Coimbra, M., & Galvão Dias, T. (2022). Identifying the determinants and understanding their effect on the perception of safety, security, and comfort by pedestrians and cyclists: A systematic review. *Transportation Research Part F: Traffic Psychology and Behaviour, 91*, 136–163. https://doi.org/10.1016/j.trf.2022.10.004

Canada Statistics. (2021). Population and demography statistics. *Canada Statistics.* https://www.statcan.gc.ca/eng/subjects-start/population_and_demography.

Cloutier, M. S., Brodeur-Ouimet, P., Lamarche, A.-A., & Pierre-Maxime, L. (2022). Making the most of a pedestrian street: Insights from a pilot-project allowing cyclist to ride along pedestrians in Montreal, Canada. *Journal of Transport & Health, 25* (Suppl), Article 101438. https://doi.org/10.1016/j.jth.2022.101438

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). Applied multiple regression/correlation analysis for the behavioral sciences, third edition. In *Applied multiple regression/correlation analysis for the behavioral sciences, third edition.* Taylor and Francis. https://doi.org/10.4324/9780203774441.

DeFreitas, K., & Bernard, M. (2015). Comparative performance analysis of clustering techniques in educational data mining. *IADIS International Journal on Computer Science and Information Systems, 10*(2), 65–78.

Din, A. U., Ur Rahman, I., Vega-Muñoz, A., Elahi, E., Salazar-Sepúlveda, G., Contreras-Barraza, N., & Alhrahsheh, R. R. (2023). How sustainable transportation can utilize climate change technologies to mitigate climate change. *Sustainability (Switzerland), 15*(12), 9710. https://doi.org/10.3390/su15129710

Eldeeb, G., Mohamed, M., & Páez, A. (2021). Built for active travel? Investigating the contextual effects of the built environment on transportation mode choice. *Journal of Transport Geography, 96*, Article 103158. https://doi.org/10.1016/j.jtrangeo.2021.103158

Environment and Climate Change Canada. (2023). National inventory report 1990–2021: greenhousegas sources and sinks in Canada. https://publications.gc.ca/collections/collection_2023/eccc/En81-4-1-2021-eng.pdf.

Gkekas, F., Bigazzi, A., & Gill, G. (2020). Perceived safety and experienced incidents between pedestrians and cyclists in a high-volume non-motorized shared space. *Transportation Research Interdisciplinary Perspectives, 4*, Article 100094. https://doi.org/10.1016/j.trip.2020.100094

Grasser, G., Van Dyck, D., Titze, S., & Stronegger, W. (2013). Objectively measured walkability and active transport and weight-related outcomes in adults: A systematic review. In *International journal of public health (vol. 58, issue 4, pp. 615–625).* Birkhauser Verlag AG. https://doi.org/10.1007/s00038-012-0435-0

Guedoudj, W., Ghenouchi, A., & Toussaint, J. Y. (2020). Urban attractiveness in public squares: The mutual influence of the urban environment and the social activities in Batna. *Urbe, 12*, Article e20190162. https://doi.org/10.1590/2175-3369.012.e20190162

Hausman, J. (2012). Contingent valuation: From dubious to hopeless. *Journal of Economic Perspectives, 26*(4), 43–56. https://doi.org/10.1257/jep.26.4.43

Heinen, E., Panter, J., Mackett, R., & Ogilvie, D. (2015). Changes in mode of travel to work: A natural experimental study of new transport infrastructure. *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), 1–10. https://doi.org/10.1186/s12966-015-0239-8

Institut national de santé publique du Québec (INSPQ). (2016). Material and social deprivation index. https://www.inspq.qc.ca/en/deprivation/material-and-social-deprivation-index.

Jahanbakhsh, H., Moghadas Nejad, F., Khodaii, A., Karimi, M. M., & Naseri, H. (2024). Sustainable induction-heatable cold patching using microwave and reclaimed asphalt pavement. *Journal of Materials in Civil Engineering, 36*(3), Article 04023607. https://doi.org/10.1061/jmcee7.mteng-16143

Kim, U., Lee, J., & He, S. Y. (2021). Pedestrianization impacts on air quality perceptions and environment satisfaction: The case of regenerated streets in downtown Seoul. *International Journal of Environmental Research and Public Health, 18*(19), 10225. https://doi.org/10.3390/ijerph181910225

Kirmizi, M. (2023). The daily mobility of residents and retailers during the pandemic in a pedestrianised Paris. *A/Z ITU Journal of the Faculty of Architecture, 20*(3), 659–672. https://doi.org/10.58278/0.2023.26

KPopat Emmanuel, S. M. (2014). Review and comparative study of clustering techniques. *International Journal of Computer Science and Information Technologies, 5*(1), 805–812. www.ijcsit.com.

McCormack, G. R., Giles-Corti, B., & Bulsara, M. (2008). The relationship between destination proximity, destination mix and physical activity behaviors. *Preventive Medicine, 46*(1), 33–40. https://doi.org/10.1016/j.ypmed.2007.01.013

Melia, S., & Shergold, I. (2018). Pedestrianisation and politics: A case study. *Proceedings of the Institution of Civil Engineers: Transport, 171*(1), 30–41. https://doi.org/10.1680/jtran.16.00104

Naseri, H., Aliakbari, A., Javadian, M. A., Aliakbari, A., & Waygood, E. O. D. (2024). A novel technique for multi-objective sustainable decisions for pavement maintenance and rehabilitation. *Case Studies in Construction Materials, 20*, Article e03037. https://doi.org/10.1016/J.CSCM.2024.E03037

Naseri, H., Ehsani, M., Golroo, A., & Moghadas Nejad, F. (2021). Sustainable pavement maintenance and rehabilitation planning using differential evolutionary programming and coyote optimisation algorithm. *International Journal of Pavement Engineering, 0*(0), 1–18. https://doi.org/10.1080/10298436.2021.1873331

Naseri, H., Waygood, E. O. D., & Patterson, Z. (2025). Household transportation lifecycle greenhouse gas emission prediction. *Transportation Research Part D: Transport and Environment, 141*, Article 104660. https://doi.org/10.1016/j.trd.2025.104660

Naseri, H., Waygood, E. O. D., Patterson, Z., Alousi-Jones, M., & Wang, B. (2024). Travel mode choice prediction: Developing new techniques to prioritize variables and interpret black-box machine learning techniques. *Transportation Planning and Technology.*. https://doi.org/10.1080/03081060.2024.2411611

Naseri, H., Waygood, E. O. D., Patterson, Z., & Wang, B. (2024a). Which variables influence electric vehicle adoption? *Transportation, 1–38.* https://doi.org/10.1007/s11116-024-10525-1

Naseri, H., Waygood, E. O. D., Patterson, Z., & Wang, B. (2024b). Who is more likely to buy electric vehicles? *Transport Policy, 155*, 15–28. https://doi.org/10.1016/J.TRANPOL.2024.06.013

Naseri, H., Waygood, E. O. D., Wang, B., & Patterson, Z. (2022). Application of machine learning to child mode choice with a novel technique to optimize hyperparameters. *International Journal of Environmental Research and Public Health, 19*(24), 16844. https://doi.org/10.3390/ijerph192416844

Naseri, H., Waygood, E. O. D., Wang, B., & Patterson, Z. (2023). Interpretable machine learning approach to predicting electric vehicle buying decisions. *Transportation Research Record: Journal of the Transportation Research Board, 036119812311695.* https://doi.org/10.1177/03611981231169533

Nello-Deakin, S., Sancho Vallvé, C., & Sila Akinci, Z. (2024). Who's afraid of pedestrianisation? Residents' perceptions and preferences on street transformation. *Habitat International, 150*, Article 103117. https://doi.org/10.1016/j.habitatint.2024.103117

Özdemir, D., & Selçuk, İ. (2017). From pedestrianisation to commercial gentrification: The case of Kadıköy in Istanbul. *Cities, 65*, 10–23. https://doi.org/10.1016/j.cities.2017.02.008

Parajuli, A., & Pojani, D. (2018). Barriers to the pedestrianization of city centres: Perspectives from the Global North and the Global South. *Journal of Urban Design, 23* (1), 142–160. https://doi.org/10.1080/13574809.2017.1369875

Refianti, R., Mutiara, A. B., Juarna, A., & Ikhsan, S. N. (2012). Analysis and implementation of algorithm clustering affinity propagation and K-Means at data student based on GPA and duration of bachelor-thesis completion. *Journal of Theoretical and Applied Information Technology, 35*(1), 69–76.

Semple, T., & Fountas, G. (2023). Demographic and behavioural factors affecting public support for pedestrianisation in city centres: The case of Edinburgh, UK. *International Journal of Transportation Science and Technology, 12*(1), 103–118. https://doi.org/10.1016/j.ijtst.2021.12.001

Soni, N., & Soni, N. (2016). Benefits of pedestrianization and warrants to pedestrianize an area. *Land Use Policy, 57*, 139–150. https://doi.org/10.1016/j.landusepol.2016.05.009

Soto, J. J., Cantillo, V., & Arellana, J. (2021). Market segmentation for incentivising sustainable transport policies. *Transportation Research Part D: Transport and Environment, 99*, Article 103013. https://doi.org/10.1016/j.trd.2021.103013

Statistics Canada. (2020). *Proximity measures database - early release. [Data Set]. Https://Www150.Statcan.Gc.ca/N1/Pub/17-26-0002/ 172600022020001-Eng.Htm.*

Statistics Canada Census of Canada: Census profiles tables/ profile of census dissemination areas. (2021a) [Data set]. Http://Datacentre.Chass.Utoronto.Ca/

Statistics Canada. (2021b). Dissemination Block (DB), dictionary, census of population, 2021. https://www12-2021.statcan.gc.ca/census-recensement/2021/ref/dict/az/definition-eng.cfm?ID=geo014.

Svensson, A., Hydén, C., & Jonsson, L. (2007). Separation between pedestrians and bicyclists. *3rd urban street symposium*, 1–10. https://portal.research.lu.se/en/publications/separation-between-pedestrians-and-bicyclists.

te Boveldt, G., De Wilde, L., Keseru, I., & Macharis, C. (2023). Pedestrianisation as a step in a societal transformation? An analysis of support and opposition in Brussels. *Cities, 143*, Article 104577. https://doi.org/10.1016/J.CITIES.2023.104577

Torres, J., Cloutier, M. S., Bergeron, J., & St-Denis, A. (2020). 'They installed a speed bump': Children's perceptions of traffic-calming measures around elementary schools. *Children's Geographies, 18*(4), 477–489. https://doi.org/10.1080/14733285.2019.1685075

Varma, V. R., Dey, D., Leroux, A., Di, J., Urbanek, J., Xiao, L., & Zipunnikov, V. (2017). Re-evaluating the effect of age on physical activity over the lifespan. *Preventive Medicine, 101*, 102–108. https://doi.org/10.1016/j.ypmed.2017.05.030

Walk Score [dataset]. Available at: *Https://Www.Walkscore.Com/CA-QC/Montr%C3%A9al*.

Wang, B., Waygood, E. O. D., Ji, X., Naseri, H., Loiselle, A. L., Daziano, R. A., … Feinberg, M. (2023). How to effectively communicate about greenhouse gas emissions with different populations. *Environmental Science & Policy, 147*, 29–43. https://doi.org/10.1016/J.ENVSCI.2023.05.015

Winters, M., Beairsto, J., Ferster, C., Laberee, K., Manaugh, K., & Nelson, T. (2022). The Canadian Bikeway Comfort and Safety metrics (Can-BICS): National measures of the bicycling environment for use in research and policy. *Health Reports, 33*(10), 3–13. https://doi.org/10.25318/82-003-x202201000001-eng

Yassin, H. H. (2019). Livable city: An approach to pedestrianization through tactical urbanism. *Alexandria Engineering Journal, 58*(1), 251–259. https://doi.org/10.1016/j.aej.2019.02.005