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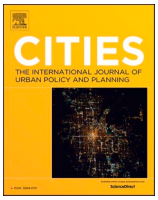

Understanding user behaviors and safety concerns on shared use paths in Edmonton, Canada

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ABSTRACT

Shared Use Paths (SUPs) allow individuals with diverse activities, including walkers, cyclists, scooterists, and skateboarders, to coexist. In this context, the behavior of one group can impact the experience of the other. Thus, this study applied an ordered logit model on survey data collected from Edmonton, Canada, to examine the six behaviors exhibited by SUP users. Results indicated that respondents were most concerned about cyclists not ringing the bell, followed by people not watching their dogs and cyclists' speed. Additionally, the model results revealed a clear pattern of concerns between walkers and cyclists. Cyclists were more likely to express concern about pedestrians spreading out and not staying to the right, while pedestrians exhibited similar concerns towards cyclists. Furthermore, older respondents expressed a greater concern regarding cyclists' speed, people passing on the right, cyclists not ringing the bell, and people neglecting their dogs. Income was associated with walkers' behavior of not staying to the right and people's attentiveness to their dogs. Conversely, home ownership, gender, and having children had a relatively minor influence on the users' experience. The practical applications of the findings are discussed for better management and design considerations to address users' concerns.

1. Introduction

Shared Use Paths (SUPs) have revolutionized urban and recreational infrastructure since their introduction in the 1960s, starting in the Netherlands (Franklin, 2023). These multifunctional pathways cater to various activities, including walking, cycling, and skating, and have seen remarkable growth worldwide. They have become vital in urban landscapes, offering sustainable and healthy transportation alternatives. SUPs are not just pathways but integral elements of city planning, reflecting a shift towards more inclusive and environmentally conscious urban designs.

Research on SUPs has evolved over the years, encompassing diverse aspects such as user interactions, safety concerns, and the range of activities occurring on these paths. Studies have explored how these paths are utilized by different groups, including cyclists, pedestrians, and recreational users (Delaney, 2016; Kutela et al., 2023, 2024). The importance of understanding user behavior and safety concerns on these paths is paramount, as it directly influences the design, management, and policies governing SUPs. This research area is particularly relevant as cities increasingly recognize the value of SUPs in promoting healthier lifestyles and sustainable urban mobility.

Most previous studies used stated preference surveys and questionnaires to obtain user perceptions on SUPs. The primary limitation of stated preference surveys is that the individual's stated preference may not closely align with their actual preferences (Kutela et al., 2022; Wardman, 1988). Moreover, for stated preferences, in certain instances, respondents may find themselves in unfamiliar situations where they lack complete information (Whitehead et al., 2008). Their limited familiarity restricts their responses in such cases, resulting in truthful yet constrained answers. In more extreme cases, respondents may provide insignificant answers due to the hypothetical nature of the scenario. These preferences are influenced by various external factors, including

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environmental conditions, social norms, and economic constraints, which might affect the interpretation of an individual's actual preference. This understanding is critical in analyzing the survey data and drawing conclusions about the users' behaviors and concerns.

This study takes a unique approach to examining user behaviors and concerns on SUPs, using data collected from the people who utilized the SUPs. The study aims to provide more understanding of how different user groups interact on SUPs and the specific concerns they face, filling a gap in the existing literature that often overlooks the intricacies of these interactions in specific urban settings. This study is guided by key research questions: What are the primary concerns of users on SUPs in Edmonton, and how do these concerns vary among user groups and activities? The objective is to identify and analyze the predominant issues faced by users of Edmonton's SUPs, ranging from safety concerns to user etiquette, and understand how these vary across different demographics and user types.

The rest of the study is structured to first present the review of previous studies, followed by the research framework, study location, and data description. The modeling methodology, which describes the analytical approach, is then presented. The results and discussion section presents the interpretation of the findings within the broader context of global SUP research, exploring their implications for urban planning and policymaking. The conclusion summarizes the key insights and suggests future research and policy development directions in this field.

2. Literature review

The research on SUPs is globally comprehensive, addressing various aspects of user interactions, safety, and cultural nuances. In the United States, studies like those of Aultman-Hall and LaMondia (2005) emphasize the complexities of managing SUPs, specifically the need to balance diverse user requirements and safety concerns. Further, Beitel et al. (2018) examined the safety aspects of shared spaces, particularly focusing on the risk of pedestrian-cyclist collisions and the effectiveness of shared space designs in urban settings. A European-based study focusing on countries like the Netherlands has been pivotal in showing how SUPs can be integrated into larger urban mobility frameworks, demonstrating their role in enhancing overall urban transport systems (Franklin, 2023). Internationally, Kaplan, Luria, and Prato (2019) work in Israel and the Czech Republic reveals interesting insights into cyclists' attitudes towards sharing roads with drivers, indicating a mix of apprehension and willingness based on perceived driver behaviors. Fruhen et al. (2019) uncover the underlying attitudes of drivers towards cyclists, highlighting how these perceptions significantly impact road-sharing behaviors. In Australia, Wood et al. (2009) researched visibility and safety issues from the perspectives of both cyclists and drivers, revealing a discrepancy in their perceptions and understanding of safety measures. Collectively, these studies add to the understanding of SUPs in various cultural and urban contexts and underscore the importance of considering the unique needs and perceptions of different user groups for inclusive and safe urban planning.

Previous studies on SUPs have predominantly relied on survey data to capture user perceptions and experiences. Surveys have been a fundamental tool, as seen in studies by Landis et al. (2004) and Kaplan, Mikolasek, et al. (2019), capturing user experiences and perceptions. These surveys often reveal the nuanced preferences and safety concerns of SUP users. As utilized by Xiao et al. (2019), traffic monitoring data provides objective insights into user behaviors on paths like the Burlington Bike Path, offering valuable information on usage patterns and potential conflict points. Kang et al. (2013), shed light on pedestrian attitudes in shared spaces, revealing how physical infrastructure and user interactions influence perceptions of safety and comfort. In another study, Kang and Fricker (2016) employed semi-automated video analysis and surrogate safety measures to delve deeper into cyclist-pedestrian interactions, providing a better understanding of these dynamics. Wood et al. (2009) highlighted the importance of subjective experiences in road safety, emphasizing how personal perceptions and attitudes can significantly influence behavior.

SUPs research methodologies encompass both quantitative and qualitative approaches, each contributing uniquely to understanding the dynamics of these spaces. Quantitative methods, particularly ordered logistic regression models, are widely used to analyze survey data, offering insights into users' satisfaction based on demographic and behavioral factors (Burmester, 2020). In contrast, qualitative methodologies like interviews and observational studies provide a more profound understanding of the user experience, uncovering aspects that quantitative data might overlook (Delaney, 2016). Innovative methodologies have also emerged in recent studies. (Beitel et al., 2018) developed a semi-automated method for analyzing pedestrian-cyclist interactions, integrating surrogate safety measures to estimate interaction risks. This approach yielded significant insights into the dynamics and safety of shared spaces. Similarly, Nikiforiadis and Basbas (2019) introduced a novel method for assessing shared space level of service, utilizing regression tree models to predict interaction frequencies and assigning weights based on user comfort and safety perceptions. Focusing on specific user groups, Havik et al. (2015) conducted a comparative field study to understand how visually impaired persons navigate shared spaces, combining observational data with interviews. This study highlighted the unique challenges faced by visually impaired users. Furthermore, Kang & Fricker (2016 explored pedestrian attitudes toward sharing sidewalks with bicyclists through an analysis of urban sidewalk video clips using a random parameter-ordered probability model. Their findings emphasized the importance of pedestrian perspectives in shared space planning.

While the existing body of research on SUPs is extensive and offers valuable insights into user behaviors, safety concerns, and infrastructure design, there is a need for further research. Most of the existing studies utilized stated preference data whereby respondents were asked to state their preferences for the hypothetical SUPs. While this approach can provide some relevant information for planning purposes, the actual experience of the SUPs may differ significantly. Thus, it is important to understand SUP users' experience from the actual users. Such an approach may lead to more tailored, user-centered design and policy interventions, which are crucial for enhancing the functionality, safety, and overall user experience of SUPs.

This study aims to fill this gap by utilizing data collected from SUP users to capture a broad spectrum of user experiences and concerns. Doing so contributes to a better understanding of urban SUP usage and offers locally relevant insights applicable to other urban settings. This research will also provide valuable data to inform city planners and policymakers in developing strategies to enhance the safety and user experience of SUPs.

3. Research conceptual framework and research hypothesis

The conceptual framework for this study is guided by the Theory of Planned Behavior (TPB) and environmental psychology, integrating these perspectives to examine user behaviors and concerns on SUPs. This framework suggests that individual behavior on SUPs is influenced by attitudes, subjective norms, and perceived behavioral control. Attitudes include personal beliefs about SUPs, including safety and convenience. Subjective norms involve the perceived social pressures or expectations related to using SUPs, and perceived behavioral control reflects the individual's perceived ease or difficulty of using these paths.

The main hypothesis of this study stems from this conceptual framework and argues that individual behaviors and concerns on SUPs are significantly influenced by a combination of demographic factors (age, gender, education, income), environmental factors (design and condition of SUPs, signage, user density), and psychosocial factors (personal attitudes towards SUPs, perceived norms, and control). This hypothesis is operationalized through several sub-hypotheses:

- Demographic factors such as age, gender, and socioeconomic status significantly influence user concerns and behaviors on SUPs. For instance, older users may have different safety concerns compared to younger users.
- Environmental factors, including the physical design and condition of SUPs, significantly impact user behavior and concerns. Well-designed and maintained paths are hypothesized to lead to more positive user experiences and fewer concerns.
- Psychosocial factors, including personal attitudes towards SUPs and perceived social norms, play a crucial role in shaping user behavior. For example, users who view SUPs positively are hypothesized to have fewer concerns and more responsible behavior on these paths.
- The interaction of these factors leads to varied user experiences and concerns on SUPs. For example, a user with a positive attitude towards cycling but who perceives SUPs as unsafe due to poor design may still have significant safety concerns.

This study aims to test these hypotheses using a mixed-methods approach, combining quantitative data from surveys with qualitative insights from interviews and observations. The dependent variable in this study is the level of user concern about various behaviors on SUPs, ranging from safety issues to etiquette breaches. This variable is operationalized as an ordinal measure derived from survey responses. The independent variables include demographic factors (age, gender, income, education), environmental factors (SUP design, signage, condition), and psychosocial factors (attitudes, perceived norms).

4. Study location and data description

4.1. Study location

Edmonton, Canada, the location of this study, presents a unique urban setting for exploring user behaviors and safety concerns on SUPs. Edmonton has a burgeoning cycling culture, with the city actively promoting cycling as a sustainable mode of transportation. SUPs in Edmonton form a crucial part of the city's transportation infrastructure, accommodating a variety of users including cyclists, pedestrians, and others. The city's approach to SUPs reflects its commitment to inclusive and environmentally conscious urban design.

Edmonton's SUP users represent a diverse and evolving demographic, reflecting the city's growing population and commitment to active transportation. While statistics on specific usage demographics are currently limited, available data and trends offer valuable insights: According to a 2018 survey by the City of Edmonton, 59 % of residents who reported using SUPs were aged 18–44, highlighting the popularity of these paths among younger adults. However, a growing number of older adults and families are also choosing SUPs for recreation and commuting (Riebe, 2022). While traditionally male-dominated, cycling and SUP usage in Edmonton are experiencing a noticeable gender shift. The 2018 City survey found that 41 % of SUP users were women, indicating a significant increase from previous years. This upward trend aligns with national data showing a rise in female cyclists across Canada (Statistica, 2024). SUP usage in Edmonton cuts across income and education levels. Studies suggest that users tend to be from higher-income households and have higher levels of education, possibly due to factors like access to bikes or e-scooters and awareness of sustainable transportation options (Jaber et al., 2023). However, initiatives like Edmonton's Bike Share program and subsidized helmet programs are making SUPs more accessible and inclusive for diverse socioeconomic groups. The rise of e-bikes and e-scooters adds another layer to the SUP user demographic. While their usage on Edmonton's SUPs is not explicitly defined, the growing popularity of these micromobility options is likely to attract younger users and those seeking alternative commutes.

In Edmonton, users of SUPs are expected to adhere to specific rules and guidelines to ensure safety and harmony among different users. These include yielding the right of way to slower-moving people, alerting others before overtaking and traveling at a speed suitable for the path's conditions. The city does not enforce a strict legal requirement for cyclists or pedestrians to keep to the right on SUPs, nor are there specific speed limits for cyclists. E-bikes and e-scooters, equipped with safety features like bells and brakes, are allowed on roads with speed limits of 50 km/h or less in Edmonton, but their allowance on SUPs is not explicitly mentioned (City of Edmonton, 2024; Edmonton police, 2024).

4.2. Data description

This study utilized data collected from Edmonton, Canada, whereby Edmonton residents expressed their concerns regarding the behaviors of SUP users. The data were sourced from a survey conducted through the Edmonton Insight Community, a diverse group of Edmonton residents who volunteer to provide input on urban issues. The survey did not specify whether the SUPs were segregated or non-segregated. The responses were collected through a call-to-action button on a webpage and anonymous links (Edmonton - Open Data Portal, 2023). In June 2018, approximately 2346 responses were collected from a diverse pool of residents. The survey collected demographic information from the respondents, including income, homeownership status, presence of children, length of residence in Edmonton, primary and secondary modes of transportation, frequency of SUP usage, and education levels.

4.3. Survey questions

The survey had over twenty questions, but for this study, the focus was on question number 3, which wanted to understand the SUP users' perception of other users' behaviors. Respondents were supposed to show their level of concern by indicating that they are either not at all concerned, a little concerned, somewhat concerned, or very concerned about each of the following behaviors:

i. Cyclists going fast
ii. Other users spreading out on the path
iii. Walkers not staying to the right
iv. People passing on the right rather than the left
v. Cyclists not ringing the bell to pass
vi. People not preventing their dog from lunging at me

Additionally, the survey had several social demographic questions such as income, age, gender, education level, and modes of transportation. Further, the survey also gathered respondents' perceptions of the importance of behaviors such as keeping to the right, passing on the left, ringing bells, and slowing down. The frequency of observing certain behaviors in the month prior to the survey (May 2018) was also captured, including cyclists and other users speeding, people spreading across the path, walkers not staying on the right, people passing on the right rather than the left, cyclists not ringing bells, and people failing to control their dogs from lunging.

5. Modeling methodology

The ordered logit model was used to examine the association between residents' concerns and the independent variables. The ordered logit model is normally employed when the dependent variable has an ordinal nature and has more than two levels. In this study, respondents were asked to express their level of concern for each of the six behaviors, ranging from very concerned to not at all, as indicated in Fig. 1.

The model assumes that the connection between the independent factors and the dependent variable is linear in the log-odds. It estimates the coefficients related to each independent variable and offers details on the magnitude and direction of their impacts on the ordered categories of the dependent variable. To explain further, the model introduces a continuous, unmeasured variable denoted as Y*, which

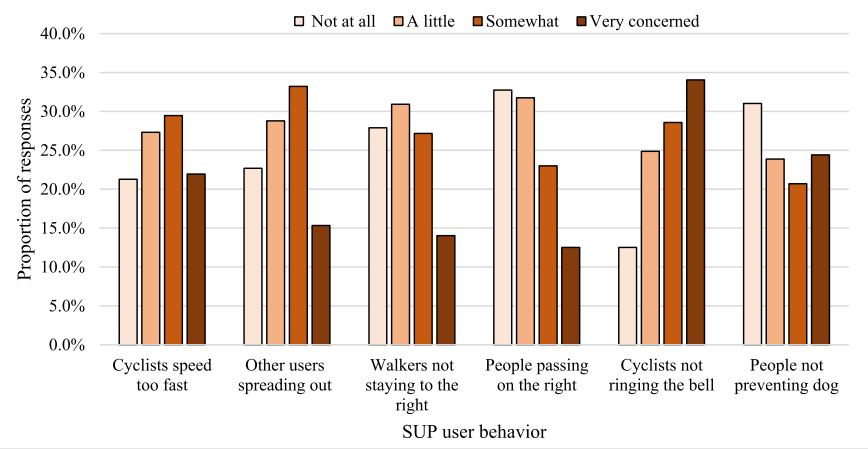

Fig. 1. Proportions of responses of revealed concerns.

includes several threshold points. This variable is a function of the ordinal variable Y, representing the observed levels of concern. The following formulas demonstrate how the value of the observed variable relies on whether it crossed a specific threshold:

$$\begin{aligned} Y &= 1 \ \text{if} \ y^* \le 0, \\ &= 2 \ \text{if} \ 0 < y^* \le \mu_1, \\ &= 3 \ \text{if} \ \mu_1 < y^* \le \mu_2, \\ &= 4 \ \text{if} \ y^* \ge \mu_2, \end{aligned} \tag{1}$$

The continuous latent variable Y* is equal to:

$$y^* = \sum \beta_i X_i + \varepsilon, \tag{2}$$

which has a randomly distributed disturbance term that is normally distributed. The error term reflects the possibility that certain essential variables may not have been included in the calculation or that the variables may not have been measured exactly. The maximum likelihood approach is used to estimate the vector of parameters (Eboli & Mazzulla, 2009). Variables are evaluated statistically based on the Wald test P-values (Eboli et al., 2016). In this study, the variable with a p-value of 0.1 is considered statistically significant.

In this analysis, the odds ratio represents the change in the odds of moving from one level of concern to a higher one for a one-unit increase in the predictor variable. An odds ratio >1 indicates an increase in the odds of expressing a higher level of concern, while an odds ratio <1 signifies a decrease. However, it's important to note that these ratios indicate the direction and magnitude of the relationship between predictors and the ordered categories of concern, rather than specifying the exact category of concern such as 'not at all' to 'very' concerned.

6. Results and discussion

6.1. Descriptive analysis results

The survey collected a total of 2346 responses; after cleaning the data to remove incomplete responses, a total of 1918 complete responses were retained for further analysis. The survey results provide valuable data on the prevalence of specific concerns among participants regarding various aspects of SUPs. Table 1 presents the descriptive statistics of the variables used in the analysis.

It can be observed that most of the respondents own their houses, do not have children, and have personal vehicles as their primary modes of transportation. Further, the secondary mode of transportation is a vehicle for most respondents. In terms of the total household income, a relatively small proportion of respondents come from the household with below $30,000, while the majority belong to the $100,000 - $149,999 group. Furthermore, most of the respondents had a bachelor's degree, and prefer either walking only or walking and cycling. The respondents' ages showed two peaks whereby both 30–39 years and elderly (60 years and above) had equal proportions.

Table 1
Descriptive statistics of the variables.

Variable	Category	Count	Percent
House ownership	Rent	352	19.4 %
	Own	1465	80.6 %
Gender	Female	991	54.5 %
	Male	826	45.5 %
Respondent has children(s)	No	1414	77.8 %
	Yes	403	22.2 %
Primary mode of transportation	Personal vehicle	1264	69.6 %
	Non- personal vehicle	553	30.4 %
Secondary mode of transportation	Motor vehicle	796	43.8 %
	Public transit	380	20.9 %
	Bicycle	215	11.8 %
	Walk	426	23.4 %
Household income	Below $30,000	91	5.0 %
	$30,000 - $49,999	140	7.7 %
	$50,000 - $79,999	306	16.8 %
	$80,000 - $99,999	233	12.8 %
	$100,000 - $149,999	417	22.9 %
	$150,000 and above	374	20.6 %
Education level	Prefer not to mention	256	14.1 %
	High school and below	224	12.3 %
	College / technical school	444	24.4 %
	Bachelor's degree	673	37.0 %
	Post-graduate degree	403	22.2 %
	Professional school graduate	73	4.0 %
Age	Below 30 years	220	12.1 %
	30–39	439	24.2 %
	40–49	323	17.8 %
	50–59	396	21.8 %
	60 years and above	439	24.2 %
SUP's user activity	Walking only	615	33.8 %
	Walking and Cycling	451	24.8 %
	Walking & Walk pets	186	10.2 %
	Walk, Cycling & walk pet	123	6.8 %
	Walking, Running, & Cycling	167	9.2 %
	Cycling only	91	5.0 %
	Other Combination	184	10.1 %

Moreover, Fig. 1 shows the proportions of responses to the levels of concern for each SUP user's behavior. It can be observed that respondents were very concerned with cyclists not ringing the bell. This behavior received the highest proportion of very concerned responses (34 %) and the smallest proportion of those not at all concerned (12.5

%).

On the other hand, the behaviors of people not passing on the right had the smallest proportion of people who were very concerned (12.5 %) and the highest proportion of respondents who were not at all concerned (32.7 %). The remaining behaviors had varying proportions of responses. For instance, the largest proportion of respondents (33.2 %) showed some concern with the other SUP users spreading out, while the largest proportion of respondents showed no concerns with people not preventing their dogs.

The insights from the descriptive statistics can be valuable for stakeholders involved in path planning, education, and enforcement, enabling them to address the identified issues and ensure a safer and more enjoyable experience for all users. However, the findings from the descriptive analysis may be applicable to only the sample or population where the data was collected (Stapor, 2020). To make the findings applicable to a greater population, inferential statistics is necessary. Thus, the next section presents the model results and discussion.

6.2. Model results and discussion

Table 2 (a) and (b) present the Ordered Logit model results for the concerns of the Edmonton residents on the behaviors observed on the SUP. Table 2 (a) for concerns "Cyclists speed too Fast", "Other users spreading out," and "Walkers not staying to the right" while Table 2(b) for concerns "People passing on the right", "Cyclists not ringing the bell" and "People not controlling dog". As indicated earlier, six behaviors are discussed here with respect to the respondent's concerns, which are cyclist speed, walkers spreading, walkers not staying to the right, passing on the right, cyclists not ringing the bell, and people not controlling their dogs.

6.2.1. House ownership

According to the study results in Table 2 (a), the variable house ownership is only statistically significant at a 90 % level for the concern about people not controlling their dogs. For this, people who own a house are about 25 % more likely to report being somewhat concerned about this behavior. This observation could suggest that individuals who own houses might have more opportunities to engage with and train their pets, potentially influencing their perceptions of untrained or unleashed pets encountered on SUPs. However, this interpretation remains speculative in the absence of direct evidence linking house ownership with pet training practices.

6.2.2. Respondent with children

The presence of children was also among the factors associated with concerns related to SUP activities. The inclusion of this factor was due to the fact that people with children might go to the SUP with them, which could influence their behavior and the way they perceive the actions of other users. According to the results in Table 2 (a), the variable "Respondent has children" is a statistically significant factor for concerns regarding cyclists' speed, spreading out, and walkers not staying to the right at 90 % level. The results indicate that respondents with children are less likely to be concerned about cyclists' speed, users spreading out, and walkers not staying to the right. While the findings align with common thinking regarding spreading out and walkers not staying to the right, the results for cyclists' speed are counterintuitive. It was expected that respondents with children would be concerned about cyclists' speed due to the potential danger posed to their children. However, the reduced likelihood of being concerned about spreading out and staying to the right may be explained by the challenges parents face in controlling their children's behavior when utilizing SUPs. This behavior may result from the difficulty of managing children while using the paths. Overall, the presence of children appears to influence SUP concerns, with respondents who have children being less concerned about cyclists' speed, users spreading out, and walkers not staying to the right. However, further research is needed to explore the underlying factors and provide a deeper understanding of these dynamics.

6.2.3. The primary mode of transportation

The primary mode of transportation was the key factor for this study. Two options for the primary modes of transportation, personal vehicles and non-personal vehicles, were created. The personal vehicles are private vehicles/cars used by the individual for non-commercial purposes. According to the results in Table 2 (a), respondents whose primary mode of transportation is not personal motor vehicles were found to be statistically significant, with a 95 % confidence level, in their concerns about other users spreading out and walkers not staying to the right. Conversely, they were less likely to express concerns about people not controlling their dogs. Specifically, respondents in this group showed a 26 % higher likelihood of being concerned about others spreading out and a 32 % higher likelihood of being concerned about walkers not staying to the right. The presence of these concerns can be explained by the fact that respondents whose primary mode of transportation is cycling (an example of non-personal vehicle mode) may find the behavior of others spreading out to be disruptive to their cycling experience. This distraction can shift their focus from enjoying the leisure of cycling to avoiding potential crashes. As for walkers not staying to the right, this behavior may hinder the smooth flow of cycling traffic and lead to safety concerns for cyclists. In contrast, respondents in this group showed a lower level of concern regarding people not controlling their dogs. This can be attributed to the relatively brief interaction between cyclists and dogs on shared paths. As cyclists pass by, the interaction with dogs is typically short-lived and may not significantly impact their overall experience. These findings highlight the importance of considering the primary mode of transportation when designing and managing shared user paths. For cyclists, measures should be implemented to discourage spreading out among other users and promote adherence to staying on the right side of the path. By addressing these concerns, the cycling experience can be enhanced, ensuring a safer and more enjoyable environment for all users.

It is important to note that these reasonings considered that people who use non-personal vehicles would most likely be the more frequent users of the SUPs and face different SUP challenges more frequently than those with personal vehicles as their mode of transportation. Because of this, the likelihood of expressing different SUP concerns was higher for people with non-personal vehicles compared to those with personal vehicles. Statistically, it does not mean that those with personal vehicles will not have concerns at all, but compared to those with non-personal vehicles as their primary mode, they would be less likely to show more concerns.

6.2.4. The secondary mode of transportation

Moreover, the association between the secondary mode of transportation and the SUP concerns was evaluated. This analysis reveals that respondents who primarily utilize public transit as their secondary mode of transportation exhibit a statistically significant concern, at a 90 % confidence level, about cyclists speeding on SUPs, being 26 % more likely to report such concerns compared to those who use personal vehicles. This highlights a pronounced perception of cyclist speed as a significant issue among individuals who depend on public transit, suggesting that their experiences and concerns are influenced by the urban context. Specifically, the proximity to downtown areas, where SUP usage may be higher and interactions with cyclists are more frequent, appears to impact user perceptions. Acknowledging the urban setting and SUP density as influential factors allows for a deeper understanding of the varied experiences of SUP users. This approach underscores the complexity of navigating shared spaces in different urban contexts and emphasizes the necessity for future research to look into how these environmental variables shape users' concerns and behaviors on SUPs. On the other hand, respondents whose secondary mode of transportation is bicycle showed a contrasting pattern relative to those using personal vehicles. This group of individual was 34 % and 38 % less likely

Table 2
Ordered logit results for SUPs users' concerns.

a

	Cyclists speed too fast			Other users spreading out			Walkers not staying to the right		
	Coef	OR	P-value	Coef	OR	P-value	Coef	OR	P-value
House ownership									
Own	−0.055	0.95	0.673	−0.110	0.90	0.391	0.020	1.02	0.879
Gender									
Male	***−0.419***	***0.66***	***<0.001***	−0.014	0.99	0.877	−0.011	0.99	0.899
Respondent with children									
Yes	**−0.201**	**0.82**	**0.085**	**−0.207**	**0.81**	**0.075**	***−0.256***	***0.77***	***0.028***
The primary mode of transportation									
Non-personal vehicle	0.126	1.13	0.238	***0.230***	***1.26***	***0.028***	***0.278***	***1.32***	***0.008***
Secondary mode of transportation									
Public transit	**0.233**	**1.26**	**0.052**	0.201	1.22	0.088	0.190	1.21	0.107
Bicycle	***−0.416***	***0.66***	***0.008***	***0.332***	***1.39***	***0.032***	***0.459***	***1.58***	***0.003***
Walk	0.099	1.10	0.395	−0.021	0.98	0.856	−0.097	0.91	0.398
Household income									
$30,000 - $49,999	−0.275	0.76	0.273	−0.353	0.70	0.144	***−0.583***	***0.56***	***0.019***
$50,000 - $79,999	−0.143	0.87	0.525	−0.172	0.84	0.432	***−0.451***	***0.64***	***0.042***
$80,000 - $99,999	0.004	1.00	0.987	**−0.385**	**0.68**	**0.098**	***−0.573***	***0.56***	***0.014***
$100,000 - $149,999	−0.153	0.86	0.498	−0.300	0.74	0.176	***−0.632***	***0.53***	***0.005***
$150,000 and above	−0.242	0.78	0.300	−0.371	0.69	0.106	***−0.711***	***0.49***	***0.002***
Prefer not to mention	0.041	1.04	0.861	−0.247	0.78	0.286	***−0.598***	***0.55***	***0.010***
Education level									
College / technical school	0.158	1.17	0.305	***0.442***	***1.56***	***0.004***	0.139	1.15	0.359
Bachelor's degree	0.163	1.18	0.269	0.197	1.22	0.174	−0.043	0.96	0.768
Post-graduate degree	0.082	1.09	0.608	0.212	1.24	0.179	−0.008	0.99	0.962
Professional school graduate	0.068	1.07	0.791	0.390	1.48	0.137	−0.077	0.93	0.754
Respondent' age (years)									
30–39	**0.300**	**1.35**	**0.060**	0.071	1.07	0.652	0.117	1.12	0.463
40–49	***0.812***	***2.25***	***<0.001***	−0.096	0.91	0.585	−0.017	0.98	0.923
50–59	***1.353***	***3.87***	***<0.001***	0.237	1.27	0.163	0.133	1.14	0.437
60 and above	***1.733***	***5.66***	***<0.001***	0.130	1.14	0.440	−0.038	0.96	0.821
SUP's user activity									
Walking and Cycling	***−0.940***	***0.39***	***<0.001***	***0.625***	***1.87***	***<0.001***	***0.743***	***2.10***	***<0.001***
Walking & Walk pets	***0.392***	***1.48***	***0.014***	−0.174	0.84	0.268	**−0.297**	**0.74**	**0.059**
Walk, Cycling & walk pet	**−0.335**	**0.72**	**0.069**	0.235	1.26	0.202	**0.312**	**1.37**	**0.089**
Walking, Running, & Cycling	***−0.934***	***0.39***	***<0.001***	***0.788***	***2.20***	***<0.001***	***0.615***	***1.85***	***<0.001***
Cycling	***−1.280***	***0.28***	***<0.001***	***0.949***	***2.58***	***<0.001***	***1.274***	***3.57***	***<0.001***
Other Combination	−0.219	0.80	0.181	0.355	1.43	0.028	0.192	1.21	0.240
Intercepts									
Not at all|A little	−1.254	0.29	<0.001	−0.933	0.39	<0.001	−1.122	0.33	<0.001
A little|Somewhat	0.258	1.29	0.332	0.427	1.53	0.100	0.289	1.33	0.268
Somewhat|Very concerned	1.859	6.42	<0.001	2.137	8.47	<0.001	1.831	6.24	<0.001

b

	People passing on the right			Cyclists not ringing the bell			People not controlling dog		
	Coef	OR	P-value	Coef	OR	P-value	Coef	OR	P-value
House ownership									
Own	−0.147	0.86	0.247	−0.107	0.90	0.405	**0.227**	**1.25**	**0.082**
Gender									
Male	−0.004	1.00	0.961	−0.106	0.90	0.243	0.020	1.02	0.824
Respondent has children									
Yes	−0.062	0.94	0.596	***−0.411***	***0.66***	***<0.001***	**0.213**	**1.24**	**0.062**
Primary mode of transportation									
Non- personal vehicle	−0.033	0.97	0.753	0.007	1.01	0.949	***−0.305***	***0.74***	***0.004***
Secondary mode of transportation									
Public transit	0.138	1.15	0.238	0.154	1.17	0.200	0.054	1.06	0.645
Bicycle	−0.227	0.80	0.141	***−0.484***	***0.62***	***0.002***	−0.050	0.95	0.744
Walk	**−0.202**	**0.82**	**0.080**	−0.097	0.91	0.406	−0.146	0.86	0.204
Household income									
$30,000 - $49,999	−0.288	0.75	0.240	0.011	1.01	0.966	***−0.645***	***0.52***	***0.010***
$50,000 - $79,999	**−0.367**	**0.69**	**0.095**	−0.277	0.76	0.222	***−0.606***	***0.55***	***0.006***
$80,000 - $99,999	−0.163	0.85	0.487	0.069	1.07	0.774	−0.277	0.76	0.234
$100,000 - $149,999	−0.273	0.76	0.220	−0.122	0.89	0.592	***−0.557***	***0.57***	***0.012***
$150,000 and above	***−0.599***	***0.55***	***0.009***	−0.344	0.71	0.144	***−0.739***	***0.48***	***0.001***
Prefer not to mention	−0.324	0.72	0.164	−0.107	0.90	0.655	**−0.399**	**0.67**	**0.085**
Education level									
College / technical school	**0.255**	**1.29**	**0.093**	0.109	1.12	0.483	0.241	1.27	0.111
Bachelor's degree	−0.085	0.92	0.557	−0.097	0.91	0.509	0.015	1.01	0.919
Post-graduate degree	0.099	1.10	0.528	−0.074	0.93	0.643	0.081	1.08	0.606
Professional school graduate	−0.094	0.91	0.705	−0.193	0.82	0.451	0.217	1.24	0.390

(*continued on next page*)

Table 2 (*continued*)

b

	People passing on the right			Cyclists not ringing the bell			People not controlling dog		
	Coef	OR	P-value	Coef	OR	P-value	Coef	OR	P-value
Respondent' age (years)									
30–39	0.138	1.15	0.382	0.241	1.27	0.122	**0.275**	**1.32**	**0.085**
40–49	**0.319**	**1.38**	**0.068**	***0.706***	***2.03***	***<0.001***	***0.434***	***1.54***	***0.014***
50–59	***0.447***	***1.56***	***0.008***	***0.966***	***2.63***	***<0.001***	0.326	**1.38**	0.056
60 years and above	***0.620***	***1.86***	***<0.001***	***1.312***	***3.71***	***<0.001***	***0.697***	***2.01***	***<0.001***
SUP's user activity									
Walking and Cycling	−0.013	0.99	0.915	***−0.588***	***0.56***	***<0.001***	**0.203**	**1.22**	**0.087**
Walking & Walk pets	−0.038	0.96	0.810	***0.352***	***1.42***	***0.032***	***−0.757***	***0.47***	***<0.001***
Walk, Cycling & walk pet	0.102	1.11	0.579	0.144	1.15	0.435	***−0.495***	***0.61***	***0.007***
Walking, Running, & Cycling	0.054	1.06	0.749	−0.225	0.80	0.191	***0.391***	***1.48***	***0.021***
Cycling	−0.177	0.84	0.412	***−0.833***	***0.43***	***<0.001***	0.235	1.26	0.290
Other Combination	−0.035	0.97	0.829	−0.120	0.89	0.460	***−0.529***	***0.59***	***0.001***
Intercepts									
Not at all|A little	−0.909	0.40	<0.001	−2.092	0.12	<0.001	−0.850	0.43	0.001
A little|Somewhat	0.464	1.59	0.073	−0.525	0.59	0.050	0.221	1.25	0.392
Somewhat|Very concerned	1.858	6.41	<0.001	0.808	2.24	0.003	1.195	3.30	<0.001

Key: Coef = Coefficient; OR = Odds ratio; Bold and italiced text = Statistically significant at a 95 % confidence interval; Bold text = Statistically significant at a 90 % confidence interval.

to express concern about cyclist speed and cyclists not ringing the bell, respectively. This suggests that individuals who primarily use bicycles as their mode of transportation are more accustomed to cycling at higher speeds and may engage in behaviors such as not ringing the bell themselves, which reduces their perception of these as concerns. However, cyclists as a secondary mode of transportation were 39 % and 58 % more likely to express concerns about other users spreading out and walkers not staying to the right. This can be explained by the fact that spreading out among other users poses safety concerns and hampers the cycling experience. Similarly, walkers not staying to the right disrupt the flow of cycling traffic and can create safety hazards. Therefore, cyclists are more likely to view these behaviors as concerns due to their direct impact on their cycling experience. Interestingly, individuals whose secondary mode of transportation is walking were less likely to express concerns about people passing on the right. They showed an 18 % lower likelihood of perceiving this behavior as a concern. The reasoning behind this finding could be further explored, but it may be attributed to walkers being more accustomed to the dynamics of shared paths and having a better understanding of the spatial awareness required for passing on the right. In summary, the secondary mode of transportation plays a role in shaping SUP concerns. Public transit users expressed greater concern about cyclist speed, while cyclists themselves were less concerned about speed but more concerned about other users spreading out and walkers not staying to the right. Walkers, on the other hand, showed a lower concern about people passing on the right. These findings highlight the importance of considering different modes of transportation when designing and managing shared user paths to address the specific concerns and needs of each user group.

6.2.5. *Household income*

Income played a significant role in indicating the concerns related to SUPs. However, there were mixed findings for several concerns. Firstly, income showed a negative association with walkers not staying to the right and people not controlling their dogs. The negative association was consistent and statistically significant at a 95 % confidence level for walkers not staying to the right. However, for people not controlling their dogs, only the household income range of $80,000 to $99,999 was not statistically significant. This suggests that higher-income individuals are more likely to have dogs and may sometimes forget or neglect to prevent their dogs from approaching other people. Alternatively, they may even allow their dogs to approach others as a normal habit for them. Furthermore, income showed mixed findings for other concerns. For instance, income was not a statistically significant indicator for cyclists not ringing the bell and cyclists' speed. The household income range of $80,000 to $99,999 was statistically significant at a 90 % confidence level, indicating that individuals in this income range are less likely to be concerned with others spreading out. Similarly, households with incomes ranging from $50,000 to $79,999 and $150,000 and above were less likely to be concerned with people passing on the right. The reasons behind these observations can be further explored.

6.2.6. *Education level*

The education level variable showed varying associations with different SUP concerns. Let's interpret the results: In Table 1(a), the college/technical school education level was not statistically significant for concerns related to cyclists' speed and walkers not staying to the right. However, it was statistically significant at a 95 % confidence level for concerns regarding the spreading out of other users. Respondents with a college or technical school education level were 56 % more likely to report concerns about other users spreading out compared to those with lower education levels. Bachelor's degree was not statistically significant for concerns related to cyclists' speed, other users spreading out, and walkers not staying to the right. There was no significant association between this education level and the mentioned SUP concerns. Postgraduate degree and professional school graduate education levels were also not statistically significant for concerns related to cyclists' speed, other users spreading out, and walkers not staying to the right. These education levels did not significantly correlate with the mentioned SUP concerns. In Table 2 (b), the college/technical school education level was not statistically significant for concerns related to people passing on the right, cyclists not ringing the bell, and people not controlling dogs. There was no significant association between this education level and the mentioned SUP concerns. Bachelor's degree, postgraduate degree, and professional school graduate education levels were not statistically significant for concerns related to people passing on the right, cyclists not ringing the bell, and people not controlling dogs. These education levels did not significantly correlate with the mentioned SUP concerns. Overall, the education level variable did not consistently show statistically significant associations with the SUP concerns analyzed in the study. However, respondents with a college or technical school education level were more likely to report concerns about other users spreading out compared to those with lower education levels.

6.2.7. *Respondent's age*

The age variable is a statistically significant variable for four concerns, which are speed, passing on the right, cyclists not ringing bells, and people not controlling dogs. As the age increases, the likelihood of residents expressing concerns increases. Specifically compared to

residents aged under 30 years, people aged 30–39 years were about 35 % more likely to report that they were concerned with cyclists' speed. The magnitude is even higher for residents aged 60 years or above. This group of residents is over five times more likely to express concern about cyclists' speeding. Similarly, the same age group is 86 % more likely to report that they are very concerned by people passing on the right. The magnitude is significantly higher for cyclists not ringing the bell (3.71) and people not controlling dogs (2.01). For other age groups, the odds of reporting that they are very concerned increased from 15 % to 56 % for people passing on the right, 27 % to 2.63 times for cyclists not ringing the bell, and 32 % to 54 % for people not controlling their dogs. The observation can be attributed to the fact that as people age, they become less movable. Thus, anything that may force them to use more energy may be flagged as a concern.

6.2.8. SUP's user activity

Lastly, the relationship between the SUP's user activity and the concerns was evaluated. In the variable, the base category was walking, while other combinations of activities were evaluated. It can be observed that any combination that involves cycling is not likely to be concerned with the fast speed of cyclists. Conversely, the combinations that involve cycling are more likely to be concerned with pedestrian behavior, such as spreading out, and walkers not staying to the right. The observation suggests that cyclists are more likely to be that cyclists concerned by what pedestrians do, whereas pedestrians are likely to be concerned with what cyclists do. In fact, while all combinations of activities involved in cycling are less likely to be concerned with Speeding cyclists, people who walk and walk pets are more likely to be concerned with cyclists' speed. Another observation noted in this variable is the Concern for people not controlling their dogs. In this concern, respondents who walk their pets In the SUPs are less likely to consider it as a concern. This can be explained by the fact that people who walk dogs are more likely to let dogs "greet" other people when they walk in the SUPs. Passing the right is not a key concern for any combination of activities. However, cyclists, who are more likely to behave this way, are less likely to report it as a concern. Walkers and people who walk pets are 42 % more likely to report cyclists ringing bells as a concern. The association of user activity and concerns has a great implication for the design and signage of the SUPs. Design strategies should prioritize inclusivity and equity, ensuring that SUP designs and management practices accommodate the needs and safety of all users, regardless of their mode of transport or frequency of use. For instance, If the primary users are cyclists, signage encouraging pedestrians not to spread out can be strategically placed along the SUP. Similarly, SUP, whose claimed Users are walkers, can have signages requiring cyclists to ring their bells.

7. Conclusions and study limitations

This study aimed to investigate the concerns of Edmonton residents regarding the behaviors of users on shared user paths (SUPs). The specific behaviors examined were cyclist speed, users spreading out, walkers not staying to the right, people passing on the right, cyclists not ringing the bell, and people not controlling their dogs. The study utilized an ordered logit model to analyze survey data collected in Edmonton in June 2018. Respondents were asked to express their concern for each behavior, and various socio-demographic factors such as age, gender, education, employment, household income, and home ownership were also considered. The regression results provide valuable insights for designers and policymakers to enhance the interaction between SUP users.

Several conclusions can be drawn based on the study findings and discussions. Age is a significant factor in evaluating the operational aspects of SUPs. As age increases, residents are more likely to express concerns about all six behaviors examined. This underscores the imperative for designs that prioritize inclusivity and safety, ensuring SUPs are accessible and welcoming to users of all ages and abilities. Designers should consider implementing features such as clear signage, markings, and other design elements that discourage the identified behaviors and promote a safer environment for all users. Evidence from studies like those by Nikiforiadis et al. (2020) and Kang and Fricker (2016) suggest that such design interventions can effectively improve user safety and satisfaction. Additionally, increasing the width of SUPs to provide better segregation and accommodate the diverse range of users more effectively could be beneficial, as wider paths have been shown to reduce conflicts and enhance user comfort (Beitel et al., 2018). Moreover, understanding the activities of SUP users is crucial for improving their operation. The study reveals that pedestrians/walkers are more likely to express concerns about cyclists' activities, while cyclists are more concerned about walkers' behaviors. Designers should carefully assess the expected user types and their dominant transportation modes within specific areas. Tailored designs should be implemented to minimize concerns, such as providing smooth surfaces to regulate cyclist speed, using signage to encourage the use of bells, discouraging users from spreading out, and promoting walker adherence to staying on the right side. Furthermore, modes of transportation also provide insights for accommodating users with different characteristics. Respondents who primarily use non-personal vehicles are more focused on walkers' behaviors. Designers should consider the characteristics and needs of users who rely on non-personal vehicles as their primary mode of transportation. Nonetheless, the study indicates that concerns expressed by respondents who use bicycles and walking as secondary modes of transportation align with the behaviors exhibited by their respective counterparts. This suggests that users who engage in cycling and walking are more attuned to the concerns of the opposite user group. Other socio-demographic factors, including gender, education, income, home ownership, and having children, do not exhibit strong signals of significant concerns. Designers and policymakers should approach these factors in a more targeted and specific manner to address any potential issues.

It is important to note that this study has certain limitations. The data used was collected from a single survey conducted in Edmonton in 2018, which may not fully capture the diverse perspectives and concerns of all SUP users. For instance, electric bicycles, pedelecs, and e-scooters have emerged as a new category of users on SUPs, this addition highlights the evolving nature of SUP usage and its implications for future research. Additionally, the study focused on specific behaviors and socio-demographic factors, and other potential variables that could influence SUP concerns may not have been considered. The survey did not address concerns about children's behavior and safety on SUPs, a critical aspect considering the unpredictable nature of young children's movements. This oversight limits our understanding of the usability and safety of SUPs for families with young children. The survey's response phrasing, ranging from "very concerned" to "not concerned at all," may have introduced bias. This phrasing could imply an expectation of concern, potentially influencing respondents' answers. While our study used existing data and therefore had no control over survey design, this limitation in phrasing is acknowledged. Ideally, a range from "very concerned" to "very satisfied" would offer a more balanced perspective. Future studies should consider this aspect to minimize potential bias and provide a better understanding of users' attitudes towards SUPs. Further research and analysis are needed to comprehensively understand the complex dynamics surrounding SUP concerns and to inform effective design and policy interventions. While this study employs some forms of revealed preferences as it used the data from respondents who have utilized the SUPs, it is important to recognize the inherent limitations of this approach. Revealed preferences, though reflective of actual user behavior, may not fully capture the underlying motivations or the complete spectrum of user experiences and choices. These preferences are influenced by various external factors, including environmental conditions, social norms, and economic constraints, which might affect the interpretation of an individual's true preference. As such, while revealed preferences provide valuable data on actual behaviors, they

might not always represent the preferred choices in different circumstances. This understanding is critical in analyzing the survey data and drawing conclusions about the users' behaviors and concerns about SUPs.

CRediT authorship contribution statement

Boniphace Kutela: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Norris Novat:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Abdallah Kinero:** Writing – review & editing, Writing – original draft, Formal analysis. **Oyewole Samuel:** Writing – review & editing, Writing – original draft. **Subasish Das:** Writing – review & editing, Writing – original draft.

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.

Data availability

Data will be made available on request.

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