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Understanding socio-demographic factors associated with shared-use-paths (SUPs) utilization

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A R T I C L E I N F O

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A B S T R A C T

Shared Use Paths (SUPs) are becoming very popular in North America due to the current initiatives that promote active travel. SUPs can accommodate different types of users, including pedestrians, bicyclists, scooterists, and skateboarders. Although the interest in SUPs continues to increase, relatively less research has been performed on their utilization, especially using revealed preferences. Therefore, this study utilizes the survey data collected from Edmonton, Canada, between June 12th to 19th 2018 to explore the likelihood of utilizing the SUPs and the associated frequency of use. Results indicate that not all variables associated with the likelihood of utilization are also associated with the frequency of use. Specifically, higher levels of education influence the likelihood of SUP utilization, while the higher frequency of SUP usage is influenced by the secondary modes of transportation. On the other hand, as the age increases, the likelihood and frequency of SUP usage decreases. Further, households with higher income are associated with a higher likelihood of SUP utilization, male residents are likely to use the SUPs more frequently compared to their female counterparts. Other variations are also observed for home ownership and whether the resident resides in a downtown area. The application of the findings to the city planners and active travel initiatives have been provided to improve the planning and installation/construction of the SUPs facilities.

1. Background

In recent years, the economic and health benefits associated with active transportation have sparked increased interest both in the United States and around the world. As a result, there has been a surge in the development of facilities and initiatives to promote active transportation. One such facility that has gained popularity is the Shared Use Path (SUP). SUPs are dedicated paths designed to accommodate a wide range of users and are constructed either alongside vehicular traffic roadways or separate from vehicular traffic altogether (Kutela et al., 2023; Patten et al., 2006). The SUP users may include pedestrians, bicyclists, scooterists, and skateboarders among others. When appropriately designed, these paths provide convenient infrastructure for all users. The increasing adoption of SUPs reflects the recognition of the importance of providing inclusive and accessible facilities that cater to the diverse needs of active transportation users. The first SUP was constructed in 1965 in the Netherlands (Franklin, 2023). Since that time, the SUPs have extended around the globe, including Spain, Canada, and the United States (Murray, 2021). SUPs are preferred over other single-user facilities (such as bicycle lanes) because they can accommodate a variety of users at the same time (VTTPI, 2016).

Since SUPs' inception, various studies have been performed to understand their safety and operations (Hummer et al., 2006). Researchers concluded that SUPs are safe, although some users do not feel comfortable sharing the path with others (Delaney et al., 2017). Further, most previous studies have used a survey-based approach to collect

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information and explore factors associated with SUP utilization. The results of these studies have shown that several factors can affect SUP utilization. Such factors include the SUP design, social-demographic factors, and the availability of alternative modes of transportation. A Venter et al. (2020) study emphasized the influence of SUP space availability and design on utilization rates. The research demonstrated users were more inclined to use SUP with higher greenviews and tree canopy cover. On the other hand, Manning (2021) found that population, job density, car ownership, and residential density are influential factors in the latent demand for bike and pedestrian facilities. Their study indicated that areas with a low percentage of car ownership, a large proportion of people aged 65 years or older, and low job density have low scores of latent demands. Burmester and LaMondia (2018) conducted a study using a year-long bike share Global Positioning System (GPS) dataset to examine cyclists' preferences between bicycle lanes and road-adjacent SUP. They employed a binary logistic regression model to identify the factors influencing facility choice, including user demographics, annual travel patterns, and trip characteristics. The findings confirmed that confident and experienced cyclists favored on-street bicycle lanes, while less confident cyclists preferred protected facilities away from traffic, even if it meant sharing the path with pedestrians and taking a slightly longer route.

Furthermore, fewer studies utilized either revealed preferences or both (stated preferences and revealed preferences). A study by Burmester and LaMondia (2018) utilized a combination of methods, including a stated preference survey and analysis of a revealed bike share dataset, to investigate user perceptions of road-adjacent SUPs to develop a new framework for implementing these paths in rural and suburban communities. The findings revealed that most users preferred road-adjacent SUPs over non-separated options, particularly among less confident users who desired safer and more accommodating conditions for active travel. Scott et al. (2021) investigated factors influencing bike share users' route choices. The study utilized 132,397 hub-to-hub GPS trajectories collected over a 12-month period from 750 bicycles provided by Hamilton Bike Share (HBS). A Geographic Information System (GIS)-based map-matching algorithm was employed to determine the shared path taken by users within the cycling network of Hamilton, Ontario. Multiple attributes were generated for each route, including distance, directness, the average distance between intersections, the number of turns, intersections, and unique road segments.

Despite the progress made in understanding and exploring SUP utilization, several research gaps and limitations persist in the existing literature. One prominent gap is the limited focus on the utilization, particularly in terms of both the likelihood and frequency of SUP use. The use of revealed preferences utilization data, which captures the actual behavior and choices of individuals, allows for a more accurate and comprehensive understanding of SUP utilization patterns (Hulland and Houston, 2021; Kutela et al., 2022). This approach provides valuable insights into the factors that influence the likelihood and frequency of SUP use, enabling a more precise prediction of SUP utilization. By incorporating revealed preferences into the study of SUP utilization, researchers can gain deeper insights into user behavior, inform policy decisions, and contribute to the development of more effective strategies for promoting sustainable and active transportation options. In addition to addressing the gap in revealed preferences, this study aims to conduct a comprehensive investigation into the determinants of SUP usage, with a specific focus on demographic factors.

To achieve these research objectives, this paper presents the following: the next section provides the methodology and data description, outlining the approach used to collect and analyze the data. The descriptive analysis section presents the initial insights from the data. Results provide insights into the relationships between predictor variables and SUP usage likelihood. Study limitation, which shows the items deemed important but not covered in this study will then be presented. The conclusion summarizes the main findings, highlights the contributions of the study, and suggests avenues for future research.

2. Methodology

This section presents the methodology applied in this study by covering the modeling methodology and the data description. To aid in the understanding of the modeling methodology, the data description is first presented.

2.1. Data description

This study utilized survey data collected in Edmonton, Canada, and stored in the city's open data portal (Edmonton - Open Data Portal, 2023) According to the details supplied with the data, the data was collected for one week between the 12th and 19th of June 2018 through a survey questionnaire. The response to the survey questionnaire was collected through Insight Community Members where 8431 invitations were sent. A total of 2323 members completed the survey. Moreover, an addition of 10 respondents from the call-to-action button on the Edmonton website and 23 respondents who accessed the survey through the anonymous link(s) on *edmonton*.ca/*surveys* which did not have demographic information participated in the survey making a total of 2356 respondents equivalent to 27.9% of the total invitations.

The survey questionnaire included several SUP-related questions, which included utilization, interactions, concerns, and characteristics of SUP users. Respondents were also asked to indicate various socio-demographic factors which include age, gender, income, primary and secondary modes of transportation, education level, home ownership, and whether the respondent has children.

This study focused on the SUPs utilization-related question. Specifically, the survey asked the respondents this question.

"*How often do you travel on shared use paths in a typical summer week?*"

Based on this question, respondents were supposed to select one of the five options, which are, *I do not use shared use paths, less than once per week, 1–2 times, 3–4 times,* and *5 times or more.* The next section presents the statistical modeling approach to SUP utilization.

After the final data screening, a total of 2232 observations responses were available for further analysis. These responses were from 36 out of all 39 postal codes in Edmonton. Most of the respondents (142) were residing in postal code T6J, other postal codes have a fair distribution of respondents (ranging from 138 to 26). On the other hand, T6S, T6P, and T8N had a relatively low number of respondents (Table 1). Thus, the sample is representative of almost all Edmonton residents.

2.2. Data analysis approach

The approach to data analysis is twofold. Firstly, the study aims to understand whether residents will use the SUP irrespective of the frequency by employing a binary model. This model separates respondents into users and non-users of SUPs, providing insights into the socio-demographic variables likely influence the SUP usage. Secondly, the study examines the frequency of SUP usage, offering a detailed expected frequency of use compared to the general results provided by the binary model.

2.3. Selection of variables

The independent variables incorporated in the analysis are chosen to encompass a diverse range of socio-demographic variables, each with a significant rationale for inclusion. *Age, gender, income, education level, home ownership,* and *the presence of children* are integral, as they are proven determinants of transportation behavior and preferences, influencing the likelihood and frequency of SUP utilization. Specifically, the 'motorized ' variable is defined to encompass only individually owned or leased motorized vehicles, thereby meticulously excluding shared vehicles and bicycles. This distinction is crucial for isolating the impact of private motorized transportation on SUP usage. Individuals who

Table 1
Distribution of respondents by postal codes.

Postal code	Respondents count	Postal code	Respondents count	Postal code	Respondents count	Postal code	Respondents count
T6J	142	T5Y	74	T5N	51	T5Z	38
T6E	138	T6W	73	T5W	51	T6X	31
T6H	136	T5H	67	T5X	50	T6B	30
T5K	128	T5A	63	T5B	45	T6V	29
T5T	125	T6A	63	T6K	45	T5C	27
T6C	122	T6G	63	T5E	44	T5J	26
T6L	110	T5M	60	T5P	42	T5S	6
T6R	87	T6M	56	T6T	39	T6P	4
T5R	80	T5L	51	T5G	38	T8N	1

predominantly walk are categorized separately as 'walkers,' ensuring a clear differentiation and analysis of this unique mode of transportation. The inclusion of these variables is grounded in their ability to provide insights into the diverse transportation behaviors and preferences of the population, thereby contributing to a comprehensive understanding of SUP utilization patterns.

2.4. Binary logistic regression

Logistic regression models are employed to analyze the impact of predictor variables on binary outcomes. In the study, utilization of the SUP was first divided into two outcomes; if the resident used the SUP the outcome was 1 otherwise 0. Thus, a binary logistic model was applied to identify influencing demographic variables associated with the likelihood of utilizing the SUP. The selection of the logit over probit model was due to its flexibility in interpreting odds ratios (Kutela and Teng, 2018; Mwende and Kutela, 2020; Woodridge, 2012). The logit regression model is defined as follows:

$$logit(P_i) = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_{i1} \quad X_{i1} + \ldots + \beta_k \quad X_{ik} + \varepsilon \tag{1}$$

where P_i is the likelihood of a user utilizing the SUP. The variables X_i represent the explanatory variables that influence the utilization of the SUP in the study. The variables can be categorical such as gender and house ownership, or continuous such as age and household income. However, for the purpose of the study, all analyzed predictor variables were categorized in various groups. The $\boldsymbol{\beta}$ values represent the fixed-effects constraints or coefficient estimate value and the epsilon (ε) represents the matrix of error terms (Kitali et al., 2019; Kutela, 2022).

The model can be interpreted using the odds ratios and the significance values (*p-values*). The odds ratios, obtained by exponentiating the coefficient estimate of a particular variable, measure the association between a predictor variable and the likelihood of the outcome occurrence by using the ratio of the odds of the outcome happening in one variable compared to another variable.

2.5. Ordered logit model (OLM)

The demographic variables influencing the frequency of utilization of the SUPs were examined using the ordered logistic model (OLM). The OLM, also known as the proportional odds model, is applied for ordinal response variables by considering the cumulative probabilities associated with each response category (Grilli and Rampichini, 2014). It assumes that the logarithm of each cumulative probability follows a linear relationship with the covariates, with consistent regression coefficients across all response categories. The OLM with target variable y is defined by:

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

Where X_i denotes explanatory variables (such as household income and education level) that influence the degree of SUP use; y^* is a hidden reliant variable demonstrating the extent of likelihood and frequency of SUP use; β_i are coefficients of X_i; whereas ε expresses the error term. Let y be the variable representing the observed likeliness and frequency. The unobserved variable y^* in the OLM model can help determine the observed likeliness and frequency y as follows:

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

The variables μ are unknown and need to be determined along with the coefficients β. Two assumptions are necessary for the error term: (1) the error term follows a normal distribution across observations, and (2) the mean and variance of the error term are standardized to *0* and *1*, respectively. By calculating the probabilities for y, the parameters of β can be estimated using the maximum likelihood method.

Note that the OLM is developed to explore the key variables for the frequency of utilizing the SUPs, and it was estimated exclusively on respondents who indicated a preference for using SUPs. By estimating the OLM on respondents with a preference for SUP usage, we aimed to avoid inconsistencies and accurately analyze the variables influencing high-frequency trips among different demographic groups.

In both models, the interpretation of the results is based on the odds ratios (ORs), relative risk ratios (RRRs), and the statistical significance of the variable. Both OR and RRR are obtained by exponentiating the coefficient estimates of a particular variable. The OR/RRR greater than one suggests an increase in the unit of the predictor variable is associated with an increased likelihood of the outcome. On the other hand, the OR/RRR of less than one indicates that an increase in the unit of the predictor variable is associated with a decreased likelihood of the outcome.

3. Descriptive analysis

As indicated earlier, a total of 2232 observations responses were available for further analysis. Among the respondents, 405 (18.1%) did not use SUPs, while the remaining 1827 (81.9%) used SUPs. SUP utilization can be influenced by several variables. The following descriptive analysis in Table 2 presents different variables of interest. The variables of interest are house ownership, gender, having children, mode of transportation, income, education, and age.

According to the descriptive analysis in Tables 2, 85.4% of respondents rent houses and 81.2% of those who own houses utilize SUPs. Further, about 33.3% of respondents who rent their houses use SUPs five times or more per week compared to those who own houses (24.6%) in the same category. The difference of the SUP users across genders is relatively small (3.3%), whereby 83.7% of males used SUP compared to 80.4% of females. Across the frequency of use, the largest proportion of females (32.9%) used SUPs less than once per week compared to males (28.1%), showing a difference of 4.8%. The education level was also of interest to this study. The results indicate that a large proportion of professional school graduates or post-graduate degree graduates

Table 2
Descriptive analysis results of the variables.

Variable	Used SUP				Frequency of SUP use/week							
	Yes		No		Less than once		1-2 times		3-4 times		5 times or more	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
House ownership												
Rent	356	85.4%	61	14.6%	77	21.8%	80	22.6%	79	22.3%	118	33.3%
Own	1477	81.2%	341	18.8%	484	32.9%	337	22.9%	289	19.6%	363	24.6%
Gender												
Female	995	80.4%	243	19.6%	327	32.9%	231	23.2%	203	20.4%	234	23.5%
Male	832	83.7%	162	16.3%	234	28.1%	186	22.4%	165	19.8%	247	29.7%
Secondary mode of transportation												
Vehicular	800	76.6%	245	23.4%	269	33.6%	195	24.4%	136	17.0%	200	25.0%
Public transit	384	82.2%	83	17.8%	135	35.2%	95	24.7%	77	20.1%	77	20.1%
Bicycle	215	96.4%	8	3.6%	28	13.0%	39	18.1%	56	26.0%	92	42.8%
Walk	428	86.1%	69	13.9%	129	30.1%	88	20.6%	99	23.1%	112	26.2%
Household income												
Below $30,000	92	77.3%	27	22.7%	25	27.2%	17	18.5%	17	18.5%	33	35.9%
$30,000 - $49,999	141	77.9%	40	22.1%	44	31.2%	34	24.1%	22	15.6%	41	29.1%
$50,000 - $79,999	308	77.6%	89	22.4%	97	31.5%	76	24.7%	58	18.8%	77	25.0%
$80,000 - $99,999	233	84.7%	42	15.3%	81	34.8%	54	23.2%	40	17.2%	58	24.9%
$100,000 - $149,999	419	86.7%	64	13.3%	127	30.3%	92	22.0%	83	19.8%	117	27.9%
$150,000 and above	374	88.6%	48	11.4%	93	24.9%	89	23.8%	91	24.3%	101	27.0%
Prefer not to mention	260	73.2%	95	26.8%	94	36.2%	55	21.2%	57	21.9%	54	20.8%
Education level												
High school and below	227	70.9%	93	29.1%	95	41.9%	49	21.6%	30	13.2%	53	23.3%
College / technical school	448	75.5%	145	24.5%	171	38.2%	105	23.4%	76	17.0%	96	21.4%
Bachelor's degree	674	86.2%	108	13.8%	189	28.0%	164	24.3%	142	21.1%	179	26.6%
Post-graduate degree	405	89.0%	50	11.0%	89	22.0%	83	20.5%	103	25.4%	130	32.1%
Professional school graduate	73	89.0%	9	11.0%	17	23.3%	16	21.9%	17	23.3%	23	31.5%
Age												
Below 30 years	220	94.0%	14	6.0%	50	22.7%	52	23.6%	45	20.5%	73	33.2%
30 - 39	442	90.2%	48	9.8%	115	26.0%	99	22.4%	90	20.4%	138	31.2%
40 - 49	323	84.8%	58	15.2%	86	26.6%	80	24.8%	65	20.1%	92	28.5%
50 - 59	398	79.8%	101	20.2%	130	32.7%	102	25.6%	72	18.1%	94	23.6%
60 - 69	327	73.3%	119	26.7%	129	39.4%	64	19.6%	68	20.8%	66	20.2%
70 years and above	117	64.3%	65	35.7%	51	43.6%	20	17.1%	28	23.9%	18	15.4%
SUP network within postal code												
Well-connected network	621	78.5%	170	21.5%	213	34.3%	136	21.9%	129	20.8%	143	23.0%
Scattered network	548	83.8%	106	16.2%	157	28.6%	113	20.6%	122	22.3%	156	28.5%
Scattered paths	572	86.1%	92	13.9%	150	26.2%	144	25.2%	108	18.9%	170	29.7%
Few short paths/No paths	92	73.0%	34	27.0%	43	46.7%	23	25.0%	10	10.9%	16	17.4%
Downtown postal codes												
No	1657	81.2%	383	18.8%	542	32.7%	374	22.6%	335	20.2%	406	24.5%
Yes	176	90.3%	19	9.7%	21	11.9%	42	23.9%	34	19.3%	79	44.9%

(89.0%) used the SUPs, while about 71% of high school and lower level of education did the same.

Further in the secondary mode of transport variable, according to the results in Table 2, individuals who use bicycles used SUPs the most (96.4%) and vehicles (76.6%) the least, expressing a decrease of 19.8%. A variance of 22.7% is seen for Cyclists (42.8%) and public transit (20.1%) using SUPs more than five times a week. Furthermore, Table 2 shows that individuals with an income of $150,000 or more (88.6%) are more likely to use SUPs, while Respondents who preferred not to mention their household income (73.2%) had comparable lower use rates varying by 15.4%. Those who didn't disclose their income had a 20.8% utilization rate, the lowest equated to 35.9% observed for users with an income of below $30,000, expressing a 15.1% difference for five times or more per week frequency of usage of SUPs.

SUP Networks within postal codes data were also analyzed to capture the influence of geographical location with SUP networks with short or no paths expressed the lowest usage (73.0%) compared to other categories of SUP networks. Few short paths or no paths showed the highest (46.7%) frequency of usage less than once per week compared to other network categories. Additionally, areas with downtown postal codes showed a 90.3% usage of SUP compared to those without (81.2%), presenting a difference of 9.1%. Five times or more frequency of use per week showed downtown postal codes (44.9%) having the highest usage frequency compared to those without (24.5%), expressing a difference of 20.4%.

Lastly, Table 2 shows SUP usage difference (29.7%) was highest among respondents under 30 years old (94.0%). Respondents who used SUPs less than once per week had the highest frequency of use, with 70 years and above (43.6%) and below 30 years (22.7%).

The descriptive analysis provided a summary of the data collected. To understand the relationship between the SUP usage likelihood and frequency of usage, statistical models were developed. The next section presents the statistical model results and discussions.

4. Model results and discussion

Table 3 presents the variable relationship model results for SUPs utilization based on the binary logit and ordered logit models. The results cover all variables presented in the descriptive analysis. According to the results, not all variables that are statistically significant in the binary logit model are also statistically significant for the ordered logit model (OLR). The results suggest that the likelihood of utilization of SUPs is not equally influenced by the same variables for the frequency of utilization. Moreover, the odds on the binary model are higher than the OLR model odds in most cases. The implication is that the binary logit results can only give the planner/policymaker the general picture of the expected usage but cannot be generalized to the frequency of use. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) for both models were computed and presented in Table 2. The AIC for the binary logistic regression and the OLR were found to be 1878 and

Table 3
Binary and Ordinal Logistic Regression Results for Socio-Demographic Variables Associated with Shared-Use-Paths (SUPs) Utilization.

	Binary Logistic Regression			Ordinal Logistic Regression		
	Estimate (SE)	OR (95% CI)	P-value	Estimate (SE)	OR (95% CI)	t-value
House ownership						
Rent						
Own	-0.001(0.18)	1.00(0.70-1.42)	0.996	***-0.318(0.128)***	***0.73(0.57-0.93)***	***-2.49***
Gender						
Female						
Male	0.060(0.123)	1.06(0.83-1.35)	0.624	***0.220(0.088)***	***1.25(1.05-1.48)***	***2.50***
Secondary mode of transportation						
Motorized personal vehicle						
Public transit	***0.524(0.153)***	***1.69(1.25-2.28)***	***< 0.001***	-0.141(0.113)	0.87(0.70-1.09)	-1.24
Bicycle	***2.038(0.376)***	***7.68(3.68-16.02)***	***< 0.001***	***0.935(0.145)***	***2.55(1.92-3.39)***	***6.46***
Walk	***0.862(0.162)***	***2.37(1.72-3.25)***	***< 0.001***	**0.188(0.112)**	**1.21(0.97-1.50)**	**1.68**
Household income						
Below $30,000						
$30,000 - $49,999	0.155(0.311)	1.17(0.64-2.15)	0.618	-0.262(0.251)	0.77(0.47-1.26)	-1.04
$50,000 - $79,999	0.058(0.277)	1.06(0.62-1.82)	0.833	-0.349(0.225)	0.71(0.45-1.10)	-1.55
$80,000 - $99,999	**0.591(0.309)**	**1.80(0.99-3.30)**	**0.056**	-0.364(0.239)	0.69(0.44-1.11)	-1.52
$100,000 - $149,999	***0.719(0.293)***	***2.05(1.15-3.65)***	***0.014***	-0.166(0.227)	0.85(0.54-1.32)	-0.73
$150,000 and above	***0.851(0.308)***	***2.34(1.28-4.28)***	***0.006***	-0.056(0.233)	0.95(0.60-1.49)	-0.24
Prefer not to mention	0.098(0.282)	1.10(0.64-1.92)	0.727	-0.291(0.236)	0.75(0.47-1.19)	-1.23
Education level						
High school and below						
College / technical school	0.166(0.166)	1.18(0.85-1.64)	0.319	-0.011(0.153)	0.99(0.73-1.34)	-0.07
Bachelor's degree	***0.580(0.174)***	***1.79(1.27-2.51)***	***< 0.001***	**0.284(0.146)**	**1.33(1.00-1.77)**	**1.95**
Post-graduate degree	***1.003(0.207)***	***2.73(1.82-4.09)***	***< 0.001***	***0.656(0.156)***	***1.93(1.42-2.62)***	***4.21***
Professional school graduate	***0.911(0.415)***	***2.49(1.10-5.61)***	***0.028***	**0.439(0.252)**	**1.55(0.95-2.54)**	**1.74**
Age						
Below 30 years						
30 - 39	***-0.689(0.328)***	***0.50(0.26-0.96)***	***0.036***	-0.039(0.157)	0.96(0.71-1.31)	-0.25
40 - 49	***-1.264(0.327)***	***0.28(0.15-0.54)***	***< 0.001***	-0.089(0.170)	0.91(0.66-1.28)	-0.53
50 - 59	***-1.447(0.316)***	***0.24(0.13-0.44)***	***< 0.001***	-0.264(0.167)	0.77(0.55-1.06)	-1.58
60 - 69	***-1.816(0.315)***	***0.16(0.09-0.30)***	***< 0.001***	***-0.497(0.172)***	***0.61(0.43-0.85)***	***-2.89***
70 years and above	***-2.196(0.338)***	***0.11(0.06-0.22)***	***< 0.001***	***-0.580(0.222)***	***0.56(0.36-0.87)***	***-2.61***
SUP Network Within Zip Code						
Well-connected network						
Scattered network	0.178(0.149)	1.20(0.89-1.60)	0.231	0.082(0.110)	1.09(0.88-1.35)	0.75
Scattered paths	0.382(0.157)	1.47(1.08-1.99)	***0.015***	0.049(0.111)	1.05(0.84-1.31)	0.44
Few short paths/No paths	-0.043(0.238)	0.96(0.60-1.53)	0.855	***-0.414(0.212)***	***0.66(0.44-1.00)***	***-1.96***
Downtown						
No						
Yes	0.309(0.274)	1.36(0.80-2.33)	0.261	***0.737(0.157)***	***2.09(1.54-2.85)***	***4.68***
Intercepts	***1.453(0.373)***	***4.27(2.06-8.87)***	***< 0.001***			
<1/week |1-2/week				-0.981(0.252)	0.38	-3.90
1-2/week |3-4/week				0.052(0.251)	1.05	0.21
3-4/week |5 or more				1.009(0.252)	2.74	4.01

Key: SE = Standard Error, CI = Confidence Interval, ***Bolded and italic text*** = Statistically significant at a 95% confidence interval, **Bold text** = Statistically significant at a 90% confidence interval.

4888, respectively. The BIC for the binary and OLR models were found to be 2020.763 and 5036.885, respectively. Lower AIC and BIC values translate better fitting models (Wagenmakers and Farrell, 2004). From the values, the binary logistic regression is observed to perform better than the OLR, explained by its lower values. However, as the binary model was used to determine the likelihood of SUP usage while the OLR was used to estimate the frequency of usage. The two models are not directly comparable or applicable in the context. The next section presents the influence of each variable on the likelihood of use and the frequency of SUP usage.

4.1. Secondary mode of transportation

Table 3 shows that the secondary mode of transportation plays a significant role in individuals' likelihood and frequency of using SUPs. The binary logistic regression analysis reveals that residents who use public transit as their secondary mode of transportation are nearly twice (1.7 times) as likely to use SUPs compared to those whose secondary mode is a motorized personal vehicle. This finding suggests that individuals who rely on public transit may see SUPs as a convenient extension of their travel options, allowing them to reach their destinations efficiently while enjoying the benefits of active transportation. Moreover, residents who utilize bicycles as their secondary mode of transportation exhibit a substantial increase in the likelihood of using SUPs. The odds of SUP usage for bicycle users are over seven times (7.7) higher than those who primarily rely on motorized personal vehicles (Campbell and Wittgens, 2004; Patten et al., 2006). This finding aligns with the idea that individuals who already engage in active transportation are more inclined to take advantage of SUPs, which are designed to accommodate cyclists and promote active mobility. Similarly, residents whose secondary mode of transportation is walking (2.3) show a significant increase in the likelihood of utilizing SUPs. This result suggests that individuals who prioritize walking as a means of transportation and seek cost-effective alternatives are drawn to the accessibility and convenience offered by SUPs. In terms of the frequency of use, individuals using public transit as their secondary mode of transportation exhibit a slight decrease (13%) compared to motorized personal vehicle users however, this decrease is not statistically significant at the 90% confidence level.

On the other hand, individuals with bicycles as their secondary mode of transportation show substantially higher odds (2.55) of utilizing SUPs at higher frequency, reflecting their preference for active transportation and the seamless integration of SUPs into their travel routines. Similarly, individuals who prioritize walking as their secondary mode of transportation have higher odds (21%) of SUP usage frequency, highlighting the appeal of SUPs as a cost-effective and accessible option for their active commuting needs. Overall, individuals who rely on non-vehicle transportation modes, such as public transit, bicycles, or walking, are more likely to utilize SUPs as an alternative and complementary means of travel (Campbell and Wittgens, 2004).

4.2. Respondent's age

The age variable shows a statistically significant effect on the likelihood of SUP usage. The likelihood is a decreasing pattern whereby residents aged between 30 - 39 show a 50% decrease in the likelihood of usage of SUPs, while the age between 40 – 49 and the age between 50 - 59 shows a 72% and 76% decrease in the possibility of using SUPs respectively. Moreover, age between 60 - 69 shows an 84% decrease in the odds of using SUPs, while age above 70 shows an 89% decrease in the usage of SUPs. The findings translate that older residents are less likely to use SUPs compared to younger residents. In the frequency of use, results show that older residents are likely to use at low frequency. This is indicated by the decreasing odds ratios on the SUP usage frequency model. This decreasing pattern in the usage of SUPs with age can be due to the decrease in physical activities such as running, walking, and cycling as age increases. It has been noted that active transportation preference usually increases to the age of 10 years for children before it starts decreasing, and this trend verifies the decreasing trend (Pabayo et al., 2011; Yang et al., 2011). Furthermore, the decreasing trend can also be attributed to the perceived safety and comfort when using the facilities. Since SUPs incorporate various modes of transportation (i.e., walking, biking, skateboarding, inline skating), older residents are likely to perceive such interaction as confusing and difficult to negotiate and hence unsafe (Edquist and Corben, 2012).

4.3. Household income

In Table 3, household income shows a slightly higher prospect of using SUPs on the binary model but is not statistically significant for the SUP frequency of use. The implication is that as the income increases, residents are likely to use SUP. To be specific, households with income above \$100,000 show over twice more odds of SUP usage compared to residents with less than \$30,000 income. The findings from this study may sound counterintuitive, as indicated in the previous studies. A study by (Caspi, 2023) showed that SUPs have higher usage in disadvantaged areas. In these regions, users use shared bikes (cycling) for commuting, leisure, and other utilitarian purposes, while in the rest of the city, users use bikes (cycling) mainly for commuting. However, the significant increase might be due to the interest in staying healthy through exercises such as running, walking, and cycling (Mizdrak et al., 2019). It is known that SUPs promote physical exercise and public health by encouraging walking and cycling (Dartnell et al., 2021; Smith, 2021). Furthermore, the findings on the association of income and SUP usage may be influenced by other unmeasured/unobserved variables that were not evaluated in this study. It is well known that higher-income areas with features such as retail establishments, restaurants, and entertainment venues are likely to have high-quality SUP that can motivate affluent people to utilize them. On the other hand, lower-income regions may have fewer high-quality SUPs, leading to a lower likelihood of SUP usage. However, due to the lack of the built environment and the quality of the SUP data, the current study did not evaluate into detail such a scenario.

4.4. Education level

According to the results in Table 3, education level is a statistically significant predictor in the usage of SUPs at a 95% confidence interval for some of the education levels. Individuals with bachelor's degrees, postgraduate degrees, and professional school graduates are significant and have higher odds of SUP usage. Post-graduate degrees and Professional school graduates show twice the likelihood of the usage of SUPs at 2.73 and 2.49 odds, respectively. This observed increase can be due to an increase in awareness to reduce emissions and save on gas and insurance costs among the educated population (Campbell and Wittgens, 2004; De Carvalho Bastone et al., 2022). Additionally, highly educated individuals may be well informed of the importance of active transportation to their health and to their societies such as reduction in road congestion and improvement of air quality. A study by Cutler and Lleras-Muney (2010) supports this finding as it identified a positive correlation between the number of years of education and the performance of rigorous or moderate activity. The study findings indicate that each year of education is associated with a 1.9% higher probability of light exercise such as walking and jogging (Cutler and Lleras-Muney, 2010). In addition to that, education has been associated with awareness in global warming and emission reduction, as a research study revealed that compared with primary education, secondary education is associated with a tendency to decrease CO_2 emissions (Alkhateeb et al., 2020). Further binary model results showed that there is not enough evidence to suggest respondents with college/technical school have the possibility to use SUPs.

For the frequency of use model, Table 3 shows that no level of education is a statistically significant predictor for the usage frequency of SUPs at a 95% confidence interval moreover, post-graduate degree individuals have the highest frequency (93%) of using SUPs compared to high school students (Cutler and Lleras-Muney, 2010). This is similar to the odds in the binary regression model, where the odds were the highest for postgraduate degree holders too (2.73). The odds ratio for residents with bachelor's and professional school degrees was observed to be 1.33 and 1.55, respectively, showing an increase in frequency by 33% and 55%, respectively. These similarities show the equivalence between the binary model and the OLR model, but the odds in the binary model are higher, indicating the usage frequency odds and likelihood odds are quite different. College/technical school individuals had the lowest likelihood among the classes under consideration in education level. It can be noted that both models show individuals with education lower than a bachelor's degree are not mostly informed on the importance of active transportation hence lower SUP utilization odds (Cutler and Lleras-Muney, 2010).

4.5. Family, gender, and home ownership

Family, gender, and home ownership explanatory variables were also evaluated. Gender is not a statistically significant predictor of the likelihood of SUP usage but showed a positive association. According to the results, the frequency of male residents using SUP is about 25% more likely compared to female residents. This is revealed by the 1.25 odds ratio for males in the OLR model results. The association of males and the high frequency of utilization of SUP can be attributed to the fact that males are less likely to focus on safety issues associated with SUPs. For instance, females were reported to be less likely to utilize e-micro mobility compared to males in the UK, citing family and community roles, safety and perceived safety, ergonomic standards, mobility needs, and user behavior as the key reasons (Parnell et al., 2023). The use of micro-mobility devices is highly associated with the use of SUPs, and hence a connection to the findings of this study. Other studies also pointed out similar findings. Delaney (2016) reported a higher number of male cyclists than female cyclists in the UK, while (Pucher et al., 2011) found that the vast majority of cycling rate increase in the US has occurred among men. Contrarily, (Gong et al., 2020) identified an opposite trend in China, where women were identified to be more users of active modes of transportation such as cycling and walking (which mostly include the use of SUPs) compared to males. Females were observed to be 2.5 times more likely to use active transportation than males, (Gong et al., 2020). Further analysis results show house ownership is a statistically insignificant variable at a 95% confidence level in the likelihood of usage of SUPs. Residents who own their houses have a similar likelihood as those who rent, but the frequency of utilization is 27% less than those who rent.

4.6. SUP network within postal codes

To capture the influence of geographical location, the SUP network postal code explanatory variable was used. Table 3 shows that scattered paths are statistically significant predictors of the likelihood of SUP usage and have the highest odds (47% more) compared to the well-connected networks and scattered networks in the binary model. This observation, however, is counterintuitive as it would be expected that locations with scattered networks would be associated with a lower likelihood of SUP utilization compared to well-connected networks. The possible explanation of the observed results is the interaction with other variables. More research is needed to understand the observed findings. Further, both models show postal codes with no/few SUPs have a decreasing trend in the likelihood and frequency of SUP usage. However, only the OLR model results show residents in the postal codes with few/no SUPs are statistically significantly likely to use SUPs less frequently. The observation suggests the importance of the network with the six criteria density, diversity, distance, accessibility, demand management, and design to attract active transportation (Mirzahossein et al., 2022). Additionally, the integration of scattered paths with local land use, such as connecting residential areas to schools or shopping districts, and local initiatives promoting non-motorized transportation could play key roles in influencing behavior patterns among residents in areas with scattered paths.

4.7. Downtown postal codes

Another variable for the geographical-related variable of interest added to capture the influence of land use was the downtown postal codes. Table 3 shows that the downtown postal codes are associated with the increased use of SUPs. However, it is only statistically significant at a 95% confidence level for the OLR model. The implication is that residents from postal codes located downtown are likely to utilize SUPs more frequently compared to those living outside of the downtown postal codes. The observation can be explained by the nature of downtown areas as they are usually densely populated, thus creating a high demand for non-motorists facilities including SUPs (Guo, 2009). In addition to that, the increased accessibility and connectivity in downtown spaces make these paths a convenient means of transportation for pedestrians and bicyclists, compared to other areas. The mixed land use in downtown areas, and the blend of residential, commercial, and recreational spaces further contribute to the popularity of shared use paths.

The prevalence of traffic congestion, limited parking, and environmental concerns in downtown areas may all be associated with increased use of SUPs in downtown areas. The promotion of healthy lifestyles and integration of public transit combined with esthetics appealing and greenery may also play a role on the increased use of SUPs in downtown areas.

5. Conclusions and future studies

This study used a comprehensive analysis of the utilization of Shared Use Paths (SUPs) in Edmonton, Canada, employing logistic regression and ordered logit models to discern the variables influencing SUPs utilization. The binary logistic regression elucidates the determinants of the likelihood of utilizing SUPs, while the ordered logistic regression delves into the variables affecting the frequency of SUP use. The findings reveal a discernible pattern in the associating variables influencing both the propensity and frequency of SUP utilization, particularly highlighting the role of non-vehicular modes of transportation and education level. Conversely, older residents exhibit a lower likelihood and frequency of utilization, and variables such as house ownership and having children do not significantly predict SUP use. Notably, male residents demonstrate a higher propensity for frequent utilization of SUPs. In light of the findings, several conclusions and recommendations can be drawn:

This study highlights the spatial dynamics of Shared Use Path (SUP) usage, uncovering that SUPs find their greatest efficacy in regions where non-motorized personal vehicles are predominant. This insight is crucial for urban development, advocating for a SUP allocation strategy that is in harmony with existing transportation habits and land use patterns. Additionally, the observed correlation between SUP use and areas with higher education institutions or residents with elevated education and income levels introduces a socio-economic layer to SUP accessibility and utilization. Consequently, this observation necessitates a more profound exploration into how disparities in education and income might shape access to and preferences for different transportation modes, presenting a fertile area for future scholarly inquiry.

As for gender dynamics, the study reveals notable differences in SUP usage frequency, with a pronounced inclination among males. This finding paves the way for discussions around gender-specific preferences and obstacles in urban mobility, underscoring the imperative to devise inclusive urban spaces that cater to the mobility requisites of all genders.

Furthermore, the research underscores the significance of socio-economic variables, including income levels and the quality of the built environment, in the comprehension of SUP utilization. The discerned positive relationship between higher income and increased SUP usage poses critical questions regarding the equitable distribution and accessibility of SUPs across varied income echelons. This juncture calls for future research to delve deeper into the interplay between urban design and socio-economic status in influencing individual active transportation choices.

In aggregating these insights, our study stresses the formulation of comprehensive and inclusive policy measures to bolster SUPs as a pillar of sustainable urban infrastructure. The emphasis on establishing interconnected active transport networks, with a focus on safety and accessibility, combined with proactive community engagement, is instrumental in fostering widespread SUP usage. These policy initiatives should extend beyond physical infrastructure enhancement to embrace the wider socio-economic and demographic context of urban areas.

This study aims to offer a comprehensive understanding of the variables that influence SUP utilization. This synthesis highlights the intricate interplay between urban planning, demographic diversity, and socio-economic considerations. By doing so, it establishes a robust foundation for future research, paving the way for advancements in sustainable, inclusive, and thoughtfully designed urban environments. This cohesive approach underscores the importance of integrating diverse variables and perspectives to fully grasp the complexities of SUP usage, thereby contributing significantly to the field of urban planning and sustainable development.

5.1. Study limitations

While this study offers valuable insights into the use of Shared Use Paths (SUPs) in Edmonton, Canada, it is important to recognize its limitations and the opportunities they present for future research. The study's focus on Edmonton means its findings may not be fully applicable to areas with differing demographics or geographies, suggesting a need for research in more varied locations. Its cross-sectional design captures data at a single point, limiting the ability to discern causal relationships or track changes over time, highlighting the potential benefits of longitudinal studies. The research did not include critical variables such as the built environment, SUP quality, or specific non-utilization reasons, indicating a need for more comprehensive future studies. Reliance on self-reported data could introduce biases, pointing to the value of using more objective data sources in subsequent research. The use of logistic and ordered logit models, while insightful, may not adequately handle complex variable interactions, suggesting that future studies could benefit from more advanced statistical or machine learning methods. Further, limited details of the SUP network have hindered better interpretations of the results and recommendations to policymakers. Finally, the study's conclusions, specific to Edmonton's context, might not capture SUP utilization nuances in different settings, underlining the importance of comparative studies across diverse urban and rural communities.

5.2. Future studies

Future studies should seek to explore the reasons behind the non-utilization of SUPs, incorporating options for residents to articulate their reasons and employing text mining to analyze such responses. Additionally, a more in-depth analysis of the influence of income and other variables, such as the built environment and SUP quality, is essential. More specifically, the geographical location data may be useful to understand residents' utilization of SUPs. Specific questions regarding the presence of SUPs within a walkable distance and other properties of the SUP network within a given zone should be incorporated into future surveys. Lastly, investigating inconclusive findings, particularly regarding gender, using larger datasets from varied locations with diverse demographic characteristics will further enrich the understanding of SUP utilization patterns.

CRediT authorship contribution statement

Kutela Boniphace: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Ngeni Frank:** Writing – review & editing, Writing – original draft, Data curation. **Novat Norris:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Shita Hellen:** Writing – review & editing, Writing – original draft. **Ngotonie Mark:** Writing – review & editing, Writing – original draft. **Mwekh'iga Rafael:** Writing – review & editing, Writing – original draft. **Langa Neema:** Writing – review & editing, Writing – original draft. **Das Subasish:** 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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