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ORIGINAL ARTICLE

# Predictors of transportation-related barriers to healthcare access in a North American suburb

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## Abstract

**Aim** To identify predictors of transportation-related barriers to healthcare access in a North American suburb.

**Subject and methods** Data from the 2022 Scarborough Survey were used, comprising n = 528 adults living in Scarborough, which is a subu<rb of Toronto, Canada, recruited through iterative sampling. Log binomial regression models identified demographic, socioeconomic, health and transportation predictors of a composite of: (1) delaying a primary care appointment, (2) missing a primary care appointment or (3) postponing or declining a vaccination due to transportation issues.

**Results** Of the sampled individuals, 34.5% experienced the outcome. In the multivariable model, younger age (RR = 3.03), disability (RR = 2.60), poor mental health (RR = 1.70) and reliance on public transit (RR = 2.09) were associated with greater risk of experiencing the outcome. Full-time employment, reliance on active travel and reliance on others for transportation were specifically associated with greater risk of experiencing a transportation-related barrier to vaccination.

**Conclusion** In suburban areas such as Scarborough, transportation-related barriers to healthcare access have a disproportionate impact on groups defined by important demographic, health and transportation-related characteristics. These results corroborate that transportation is an important determinant of health in suburban areas, the absence of which may exacerbate existing inequities among the most vulnerable individuals in a given population.

**Keywords** Healthcare disparities · Health care quality, access, and evaluation · Transportation · Suburban health · Suburban population

## Introduction

The availability of transportation is an important determinant of health. A lack of viable transportation options can prevent individuals from accessing healthcare services, such as clinics and pharmacies (Mattson 2011). Transportation-related barriers to healthcare access are associated with missing medical appointments and reduced access to specialist care and prescription refills (Syed et al. 2013; Wolfe et al. 2020). The underutilization of healthcare may contribute to the earlier onset and exacerbation of disease outcomes if complications go unnoticed (Starbird et al. 2019). Notably, transportation-related barriers to healthcare access are often unevenly distributed in society, with studies in the United States and Canada identifying a greater prevalence of barriers among women, recent immigrants, those with physical disabilities, and those of lower socioeconomic status (Syed et al. 2013; Mirza and Hulko 2022).

However, it is unclear how transportation-related barriers to healthcare access present in suburban areas, which comprise two-thirds of the Canadian population and more than half of the American population (Gordon et al. 2018). Suburban environments in Canada can be distinguished from their urban and rural counterparts by an automobile-dependent form characterised by segregated land use patterns, arterial roads and low-density sprawl (Filion 2018). Consequently, those without access to personal vehicles tend to be disadvantaged in suburban environments (Filion 2018). For instance, Mitra et al. (2015) noted that suburban-dwelling

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seniors who relied on active travel (e.g. walking or biking) struggled to access services because of the poor walkability of their neighbourhoods. Similarly, Linovski et al. (2021) found that the residents of suburban areas tend to underutilize public transit because of the length of trips and lack of stops within walking distance. These constitute a transportation-related barrier to healthcare access for residents of suburban areas. This has become an especially pertinent concern in recent years, as the COVID-19 pandemic has contributed to the perception of public transit as 'unsafe', creating another barrier for those who rely on public transit to access healthcare services (Kamga and Eickemeyer 2021).

Despite the growing body of literature investigating the association between transportation barriers and inadequate healthcare access, there is a paucity of research investigating how these barriers may present in suburban areas. To address this gap in the literature, this study aimed to identify the demographic, socioeconomic, health and transportation predictors of transportation-related barriers to healthcare access in the context of the North American suburb of Scarborough, Ontario. Since its incorporation into Metropolitan Toronto in 1954, Scarborough has rapidly developed to take on many traits associated with the automobile-dependent form of suburbs: segregated land use, wide arterial roads and low-density sprawl (Sorensen and Hess 2015). Consequently, the majority of trips in Scarborough are conducted by car, with 69% of all trips under 5 km being dependent on the use of personal vehicles (Sorensen et al. 2021). This arrangement has left the one-quarter of Scarborough households without reliable access to a personal vehicle at a significant disadvantage (Sorensen and Hess 2015). As an inner suburb to the fourth largest city in North America, Scarborough offers an opportunity to understand how transportation-related barriers to healthcare access may present in North American suburban environments.

## Methods

### Data collection

Data from the Scarborough Survey, carried out by the Suburban Mobilities Cluster, were used for this analysis. The Scarborough Survey is a multidisciplinary, cross-sectional survey consisting of six modules, spanning the topics of: (i) mobility and the built environment, (ii) the driveability of cities, (iii) health, (iv) social capital, (v) values and (vi) sociodemographic information. Participants were asked to complete the first two models, and were randomly assigned to complete two of the remaining modules. This survey was administered from April 2022 to August 2022 and disseminated over Facebook, Twitter and Reddit. The Scarborough Survey used an iterative sampling process (in which data analysis occurred concurrently with data collection) to ensure the sample was representative of the population of Scarborough, using Census data. Of the 1004 respondents to the Scarborough Survey, 528 met the following eligibility criteria for inclusion in our study: (i) they were 18 years of age or older, (ii) they resided in Scarborough at the time of participation and (iii) they had completed the 'Health Outcomes' module of the survey.

### Variable definitions

The main outcome of this study was the occurrence of any transportation-related barrier to healthcare access, defined as the respondent answering 'yes' to at least one of the following three questions: (i) 'do you ever delay scheduling a primary care doctor's appointment because transportation is too much trouble?'; (ii) 'have you ever had to postpone or decline a vaccination appointment due to transportation issues?'; and (iii) 'have you ever missed a doctor's appointment because of transportation problems?'. These three barriers were also assessed individually, as separate outcomes.

Based on our review of the literature, several characteristics were evaluated as potential predictors of these transportation-related barriers to healthcare access. These characteristics were organised into demographic, socioeconomic, health and transportation characteristics. Demographic characteristics were age, gender and length of residence in Canada and Scarborough. Socioeconomic characteristics were educational attainment, employment status and household income adjusted for household size (using the square root equivalence scale) (Aaberge and Melby 1998). Health characteristics included disability (based on the Washington Group Short Set on Functioning), physical health and mental health (the latter two dichotomized as 'excellent, very good or good' vs 'fair or poor') (Loeb 2016). Finally, transportation characteristics were the modes of transportation used to access medical services, and perceived dependence on other household members for transportation.

### Statistical analysis

Missingness in the independent variables was handled through multiple imputation by fully conditional specification (Van Buuren and Groothuis-Oudshoorn 2011). Twenty imputed datasets were created in this process, with the number of burn-in iterations being set to 100. This imputation comprised 17 variables, including the 13 model variables listed above as well as 4 auxiliary variables – variables which were not included in the model, but were included in the imputation process to bolster its accuracy: ethnicity, unadjusted household income, household size and transportation ownership. This analysis was carried out using SAS version 9.4, software (SAS Institute, Inc., Cary, North Carolina).

From these imputed datasets, a log binomial regression model was constructed to analyse the association between demographic, socioeconomic, health and transportation characteristics and the occurrence of a transportation-related barrier to healthcare access. Additional models were created to analyse the association between these same independent variables and the occurrence of each specific type of transportation-related barrier to healthcare access: (i) delaying a primary care doctor's appointment due to transportation issues; (ii) postponing or declining a vaccination appointment due to transportation issues; and (iii) missing a doctor's appointment due to transportation issues. Because of their theoretical importance with the outcome, all demographic, socioeconomic, health and transportation characteristics were included in the final models.

**Table 1** Baseline characteristics of the study population

| Characteristic | N (%) |
|---|---|
| Age (n (%)) | |
| 18 to 34 years | 224 (42.4) |
| 35 to 49 years | 126 (23.9) |
| 50 to 64 years | 106 (20.1) |
| 65 years or older | 72 (13.6) |
| Gender (n (%)) | |
| Men | 211 (40.0) |
| Women | 286 (54.2) |
| Non-binary/other | 14 (2.7) |
| Missing | 17 (3.2) |
| Has resided in Canada for less than 11 years (n (%)) | 69 (13.1) |
| Has resided in Scarborough for less than 11 years (n (%)) | 158 (29.9) |
| Educational attainment (n (%)) | |
| Secondary school diploma or below | 138 (26.1) |
| Post-secondary degree below bachelor level | 150 (28.4) |
| Post-secondary degree at bachelor level or above | 240 (45.5) |
| Employment status (n (%)) | |
| Employed full time | 260 (49.2) |
| Employed part time | 72 (13.6) |
| Unemployed | 57 (10.8) |
| Other | 139 (26.3) |
| Household income | |
| Lowest quantile (< $23k) | 113 (21.4) |
| Middle-low quantile ($23k to $44k) | 113 (21.4) |
| Middle-high quantile ($44k to $69k) | 112 (21.2) |
| Highest quantile (> $69k) | 113 (21.4) |
| Missing | 77 (14.6) |
| With disability (n (%)) | 80 (15.1) |
| Fair or poor physical health (n (%)) | 226 (42.8) |
| Fair or poor mental health (n (%)) | 237 (44.9) |
| Accesses medical services by car (n (%)) | 293 (55.5) |
| Accesses medical services by taxi/ride hailing (n (%)) | 35 (6.6) |
| Accesses medical services by public transit (n (%)) | 153 (29.0) |
| Accesses medical services by active travel (n (%)) | 97 (18.4) |
| Accesses medical services remotely (n (%)) | 28 (5.3) |
| Dependence on other household members for transportation (n (%)) | |
| Agree | 154 (29.2) |
| Neither agree or disagree | 78 (14.8) |
| Disagree | 296 (56.1) |

**Table 2** Predictors associated with the occurrence of any transportation-related barrier to healthcare access

| Variable | N (%) with outcome | RR (95% CI) | aRR (95% CI) |
|---|---|---|---|
| Age | | | |
| 18 to 34 years | 95 (42.4) | referent | referent |
| 35 to 49 years | 49 (38.9) | 0.86 (0.55, 1.35) | 0.86 (0.52, 1.44) |
| 50 to 64 years | 26 (24.5) | 0.44 (0.26, 0.74) | 0.52 (0.29, 0.95) |
| 65 years or older | 12 (16.7) | 0.27 (0.14, 0.53) | 0.33 (0.15, 0.76) |
| Gender | | | |
| Men | 58 (27.5) | referent | referent |
| Women | 109 (38.1) | 1.61 (1.10, 2.37) | 1.48 (0.97, 2.27) |
| Non-binary/other | 8 (57.1) | 3.04 (1.03, 8.99) | 1.87 (0.57, 6.14) |
| Residence in Canada | | | |
| Has resided in Canada for at least 11 years | 155 (33.8) | referent | referent |
| Has resided in Canada for less than 11 years | 27 (39.1) | 1.26 (0.75, 2.12) | 0.80 (0.34, 1.66) |
| Residence in Scarborough | | | |
| Has resided in Scarborough for at least 11 years | 118 (31.9) | referent | referent |
| Has resided in Scarborough for less than 11 years | 64 (40.5) | 1.45 (0.98, 2.14) | 1.24 (0.73, 2.13) |
| Educational attainment | | | |
| Secondary school diploma or below | 46 (33.3) | referent | referent |
| Post-secondary degree below bachelor level | 52 (34.7) | 1.06 (0.65, 1.73) | 1.09 (0.62, 1.93) |
| Post-secondary degree at bachelor level or above | 84 (35.0) | 1.08 (0.69, 1.68) | 1.32 (0.77, 2.62) |
| Employment status | | | |
| Employed full time | 96 (36.9) | referent | referent |
| Employed part time | 25 (34.7) | 0.91 (0.53, 1.57) | 0.69 (0.36, 1.34) |
| Unemployed | 24 (42.1) | 1.24 (0.69, 2.23) | 0.93 (0.47, 1.87) |
| Other | 37 (26.6) | 0.62 (0.39, 0.97) | 0.70 (0.38, 1.29) |
| Household income (CAD) | | | |
| Lowest quantile | 60 (31.6) | referent | referent |
| Middle-low quantile | 41 (36.3) | 1.17 (0.68, 2.02) | 1.32 (0.70, 2.48) |
| Middle-high quantile | 46 (41.1) | 1.33 (0.79, 2.25) | 1.68 (0.87, 3.24) |
| Highest quantile | 35 (31.0) | 0.87 (0.50, 1.52) | 0.98 (0.47, 2.05) |
| Disability status | | | |
| Without disability | 137 (30.6) | referent | referent |
| With disability | 45 (56.3) | 2.92 (1.80, 4.74) | 2.60 (1.51, 4.50) |
| Physical health | | | |
| Excellent, very good, or good | 73 (32.3) | referent | referent |
| Fair or poor | 109 (36.1) | 1.20 (0.82, 1.70) | 0.89 (0.58, 1.36) |
| Mental health | | | |
| Excellent, very good, or good | 66 (27.9) | referent | referent |
| Fair or poor | 116 (39.9) | 1.72 (1.19, 2.48) | 1.70 (1.12, 2.58) |
| Accesses medical services by car | | | |
| No | 101 (43.0) | referent | referent |
| Yes | 81 (27.7) | 0.51 (0.35, 0.73) | 0.79 (0.51, 1.24) |
| Accesses medical services by taxi/ride hailing | | | |
| No | 165 (33.5) | referent | referent |
| Yes | 17 (48.6) | 1.88 (0.94, 3.74) | 1.34 (0.61, 2.95) |
| Accesses medical services by public transit | | | |
| No | 108 (28.8) | referent | referent |
| Yes | 74 (48.4) | 2.32 (1.57, 3.41) | 2.09 (1.29, 3.38) |
| Accesses medical services by active travel | | | |
| No | 134 (31.1) | referent | referent |
| Yes | 48 (49.5) | 2.17 (1.34, 3.40) | 1.58 (0.95, 2.62) |

**Table 2** (continued)

| Variable | N (%) with outcome | RR (95% CI) | aRR (95% CI) |
|---|---|---|---|
| Accesses medical services remotely | | | |
| No | 173 (34.6) | referent | referent |
| Yes | 9 (32.1) | 0.90 (0.40, 2.02) | 0.77 (0.31, 1.91) |
| Dependence on other household members for transportation | | | |
| Agree | 67 (43.5) | referent | referent |
| Neither agree or disagree | 84 (28.4) | 0.86 (0.49, 1.49) | 0.83 (0.45, 1.53) |
| Disagree | 31 (39.7) | 0.51 (0.34, 0.77) | 0.64 (0.40, 1.02) |

## Results

The study sample included 528 respondents, 182 (34.5%) of whom had experienced some form of transportation-related barrier to healthcare access (Table 1). Of the respondents who reported experiencing any transportation-related barrier: 144 (27.3%) reported delaying scheduling a primary care appointment due to transportation issues; 81 (15.3%) reported declining or delaying a vaccination appointment due to transportation issues; and 74 (14.0%) reported missing a doctor's appointment due to transportation issues.

The sample had an average age of 41.9 years (SD = 17.3) and predominantly consisted of women (54.2%), those who had lived in Canada for 11 years or more (86.9%), and those who had lived in Scarborough for 11 years or more (70.1%). The sample had a median household income of $72,169 CAD (SD = 48,095), with just under half of participants having at least a bachelor's degree (45.5%) and/or full-time employment (49.2%). With regard to health characteristics, 15.1% reported having a disability; however, many participants reported 'poor or fair' physical health (42.8%) and mental health (44.9%). Regarding transportation characteristics, the most common method of accessing medical services was by car (55.5%), followed by public transit (29.0%), active travel (18.4%), and taxi or ride hailing services (6.6%). The least common method of accessing medical services was by remote access (5.3%). Finally, 56.1% of participants were not dependent on other members of their household for their transportation needs.

The results of the log binomial regression analysis are displayed in Table 2. After controlling for all other predictors, the following variables were significantly associated with the occurrence of a transportation-related barrier to healthcare access: age, disability, mental health, and mode of transportation used to access healthcare services. Age was negatively associated with the outcome, with each increase in age group corresponding with a decrease in the relative risk of a transportation-related barrier to healthcare access (35 to 49 years: aRR = 0.86 (0.52, 1.44); 50 to 64 years: aRR = 0.52 (0.29, 0.95); 65 years or older: aRR = 0.33 (0.15, 0.76) vs. 18 to 34 years). Individuals with a disability were more likely to experience a transportation-related barrier to healthcare access than those without a disability (aRR = 2.60 (1.51, 4.50)). Similarly, individuals who described their mental health as fair or poor were more likely to experience the outcome than those who described their mental health as excellent, very good, or good (aRR = 1.70 (1.12, 2.58)). Finally, individuals who primarily accessed medical services by public transit were more likely to report a transportation-related barrier to healthcare access than those who relied on other modes of transportation (aRR = 2.09 (1.29, 3.38)).

To supplement this analysis, three additional models were created to identify the variables significantly associated with: delaying scheduling a primary care appointment due to transportation issues (Table 3); postponing or declining a vaccination appointment due to transportation issues (Table 4); and missing a doctor's appointment due to transportation issues (Table 5). The findings were generally consistent across the three models, with disability status and primary mode of transportation consistently significant predictors. However, for postponing or declining a vaccination appointment due to transportation issues, several other variables were found to be significantly associated with the outcome: part-time employment, active travel and dependence on others for transportation were all found to be significantly associated with a greater relative risk of experiencing the outcome (Table 4).

## Discussion

The results of this large, cross-sectional survey suggest that transportation-related barriers to healthcare access are not evenly distributed among the residents of the North American suburb of Toronto, Scarborough, Ontario. Age, disability, mental health and public transit use were identified as significant predictors for the occurrence of a transportation-related barrier to healthcare access. These findings add to the limited published literature investigating the unique implications of transportation-related barriers to healthcare access in suburban environments.

**Table 3** Predictors associated with delaying a primary care appointment due to transportation issues

| Variable | N (%) with outcome | RR (95% CI) | aRR (95% CI) |
|---|---|---|---|
| Age | | | |
| 18 to 34 years | 81 (36.2) | referent | referent |
| 35 to 49 years | 40 (31.8) | 0.82 (0.52, 1.31) | 0.86 (0.51, 1.45) |
| 50 to 64 years | 18 (17.0) | 0.36 (0.20, 0.64) | 0.43 (0.23, 0.82) |
| 65 years or older | 5 (6.9) | 0.13 (0.05, 0.34) | 0.15 (0.05, 0.44) |
| Gender | | | |
| Men | 46 (21.8) | referent | referent |
| Women | 85 (29.7) | 1.49 (0.99, 2.32) | 1.44 (0.91, 2.26) |
| Non-binary/other | 7 (50.0) | 3.49 (1.17, 10.43) | 1.96 (0.62, 6.15) |
| Residence in Canada | | | |
| Has resided in Canada for at least 11 years | 119 (25.9) | referent | referent |
| Has resided in Canada for less than 11 years | 25 (36.2) | 1.62 (0.95, 2.77) | 1.07 (0.51, 2.27) |
| Residence in Scarborough | | | |
| Has resided in Scarborough for at least 11 years | 92 (24.9) | referent | referent |
| Has resided in Scarborough for less than 11 years | 52 (32.9) | 1.48 (0.99, 2.23) | 1.04 (0.59, 1.84) |
| Educational attainment | | | |
| Secondary school diploma or below | 36 (26.1) | referent | referent |
| Post-secondary degree below bachelor level | 41 (27.3) | 1.07 (0.63, 1.80) | 1.06 (0.58, 1.93) |
| Post-secondary degree at bachelor level or above | 67 (27.9) | 1.10 (0.68, 1.76) | 1.34 (0.76, 2.36) |
| Employment status | | | |
| Employed full time | 76 (29.2) | referent | referent |
| Employed part time | 19 (26.4) | 0.87 (0.48, 1.56) | 0.62 (0.30, 1.23) |
| Unemployed | 20 (35.1) | 1.31 (0.71, 2.40) | 0.96 (0.47, 1.95) |
| Other | 29 (20.9) | 0.64 (0.39, 1.04) | 0.76 (0.40, 1.45) |
| Household income (CAD) | | | |
| Lowest quantile | 34 (30.1) | referent | referent |
| Middle-low quantile | 32 (28.3) | 0.99 (0.58, 1.69) | 1.16 (0.62, 2.16) |
| Middle-high quantile | 34 (30.4) | 1.05 (0.62, 1.78) | 1.18 (0.60, 2.31) |
| Highest quantile | 27 (23.9) | 0.76 (0.44, 1.30) | 0.71 (0.34, 1.48) |
| Disability status | | | |
| Without disability | 109 (24.3) | referent | referent |
| With disability | 35 (43.8) | 2.42 (1.48, 3.95) | 2.30 (1.31, 4.02) |
| Physical health | | | |
| Excellent, very good, or good | 59 (26.1) | referent | referent |
| Fair or poor | 85 (28.2) | 1.11 (0.75, 1.64) | 0.81 (0.51, 1.27) |
| Mental health | | | |
| Excellent, very good, or good | 57 (24.1) | referent | referent |
| Fair or poor | 87 (29.9) | 1.35 (0.91, 1.99) | 1.27 (0.82, 1.98) |
| Accesses medical services by car | | | |
| No | 81 (34.5) | referent | referent |
| Yes | 63 (21.5) | 0.52 (0.35, 0.77) | 0.76 (0.48, 1.21) |
| Accesses medical services by taxi/ride hailing | | | |
| No | 130 (26.4) | referent | referent |
| Yes | 14 (40.0) | 1.86 (0.92, 3.77) | 1.36 (0.60, 3.07) |
| Accesses medical services by public transit | | | |
| No | 85 (22.7) | referent | referent |
| Yes | 59 (38.6) | 2.14 (1.43, 3.21) | 1.83 (1.11, 3.00) |
| Accesses medical services by active travel | | | |
| No | 111 (25.8) | referent | referent |
| Yes | 33 (34.0) | 1.49 (0.93, 2.38) | 0.96 (0.56, 1.63) |

**Table 3** (continued)

| Variable | N (%) with outcome | RR (95% CI) | aRR (95% CI) |
|---|---|---|---|
| Accesses medical services remotely | | | |
| No | 136 (27.2) | referent | referent |
| Yes | 8 (28.6) | 1.07 (0.46, 2.49) | 0.86 (0.34, 2.19) |
| Dependence on other household members for transportation | | | |
| Agree | 53 (34.4) | referent | referent |
| Neither agree or disagree | 28 (35.9) | 1.07 (0.60, 1.89) | 1.04 (0.55, 1.94) |
| Disagree | 63 (21.3) | 1.94 (0.33, 0.79) | 0.68 (0.42, 1.10) |

Of the demographic characteristics, only age was a significant predictor of the outcome. In contrast to much of the existing literature, this study identified a negative association between age and the occurrence of a transportation-related barrier to healthcare access. This contradicts prevailing attitudes in transportation planning, in which seniors are generally regarded as a particularly vulnerable subpopulation (Gorman et al. 2019). However, a review by Syed et al. (2013) surmised that seniors were less likely to regard transportation as a significant barrier to healthcare access, possibly due to the tendency for seniors to have higher rates of car ownership and a lower likelihood of sharing a personal vehicle with household members with differing travel behaviours. The negative association of age may also be explained by other variables that were not accounted for in our analysis, such as the proximity of residences to healthcare facilities and the existence of programs dedicated to alleviating transportation barriers among seniors.

Of the health characteristics assessed as independent variables, only disability and mental health were found to be significant predictors of the outcome. Consistent with previous research, individuals with a disability were more likely to experience the outcome than those without a disability (Wolfe et al. 2020). This finding is especially pertinent given the high level of automobile-dependence of suburban settings, as individuals with disabilities that prevent them from independently operating a personal vehicle may find little recourse in alternative modes of transportation, which tend to be underdeveloped relative to personal vehicle infrastructure. For instance, even when public transit is available, existing facilities may not provide sufficient accommodation to individuals with disabilities. Furthermore, while there is a lack of research investigating the role of mental health – with much of the existing literature instead focusing on physical health – our study found that individuals reporting poorer mental health were more likely to experience the outcome than those who reported comparatively better mental health. These results corroborate a study by Coombs et al. (2021), which reported that absence of transportation posed a significant barrier for 12.0% of respondents with psychological distress, but only 1.1% of respondents without psychological distress. Further research is needed to not only validate mental health as a predictor of transportation-related barriers to healthcare access, but to also investigate how different mental health outcomes, such as depression and anxiety, may be associated with the outcome.

Of the transportation characteristics assessed as independent variables, only the respondent's mode of transportation for accessing healthcare services was a significant predictor of the outcome. Individuals who relied on public transportation were more likely to experience any transportation-related barrier to healthcare access, delay a primary care appointment due to transportation issues, and miss a doctor's appointment due to transportation issues. In contrast, individuals who relied on active travel were more likely to decline or postpone a vaccination due to transportation issues. These findings seem to be consistent with the existing literature, in which individuals who rely on public transit and active travel tend to be constrained by the walkability and availability of public transit services in their neighbourhoods (Syed et al. 2013). This is further corroborated in a study by Paez and Higgins (2021), which surmised that modest additions to the list of vaccination centres in the city of Hamilton, Canada, lead to a greater reduction in travel time for travel by walking or transit relative to travel by car. It should be noted that only active travel was relevant in the context of transportation-related barriers to vaccine access, potentially reflecting individuals who avoided public transit due to concerns relating to the transmission of COVID-19. The significance of these two modes of transportation is relevant in the context of Scarborough, in which over a quarter of households are either unable to drive or lack full-time access to a personal vehicle – causing many residents to rely on these alternative modes of transportation (Sorensen et al. 2021). In underserved areas, a lack of public transit and active travel infrastructure, and the poor quality of said facilities, may exacerbate existing disparities in transportation access (Sorensen et al. 2021).

Finally, several variables were uniquely associated with the occurrence of transportation-related barriers to accessing a vaccination appointment: employment, active travel, and dependence on others for transportation. This discrepancy

**Table 4** Predictors associated with postponing or declining a vaccination appointment due to transportation issues

| Variable | N (%) with outcome | RR (95% CI) | aRR (95% CI) |
|---|---|---|---|
| Age | | | |
| 18 to 34 years | 46 (20.5) | referent | referent |
| 35 to 49 years | 22 (17.5) | 0.82 (0.47, 1.44) | 0.82 (0.43, 1.59) |
| 50 to 64 years | 8 (7.6) | 0.32 (0.14, 0.70) | 0.38 (0.16, 0.91) |
| 65 years or older | 5 (6.9) | 0.26 (0.11, 0.76) | 0.44 (0.14, 1.36) |
| Gender | | | |
| Men | 28 (13.3) | referent | referent |
| Women | 49 (17.1) | 1.44 (0.87, 2.37) | 1.26 (0.72, 2.22) |
| Non-binary/other | 2 (14.3) | 1.14 (0.24, 5.38) | 0.44 (0.07, 2.71) |
| Residence in Canada | | | |
| Has resided in Canada for at least 11 years | 68 (14.8) | referent | referent |
| Has resided in Canada for less than 11 years | 13 (18.8) | 1.33 (0.69, 2.57) | 1.03 (0.41, 2.59) |
| Residence in Scarborough | | | |
| Has resided in Scarborough for at least 11 years | 52 (14.1) | referent | referent |
| Has resided in Scarborough for less than 11 years | 29 (18.4) | 1.37 (0.84, 2.26) | 1.21 (0.59, 2.46) |
| Educational attainment | | | |
| Secondary school diploma or below | 22 (15.9) | referent | referent |
| Post-secondary degree below bachelor level | 24 (16.0) | 1.00 (0.53, 1.89) | 0.84 (0.40, 1.75) |
| Post-secondary degree at bachelor level or above | 35 (14.6) | 0.90 (0.50, 1.61) | 1.00 (0.50, 2.02) |
| Employment status | | | |
| Employed full time | 47 (18.1) | referent | referent |
| Employed part time | 6 (8.3) | 0.41 (0.17, 1.01) | 0.26 (0.09, 0.72) |
| Unemployed | 11 (19.3) | 1.08 (0.52, 2.25) | 0.78 (0.32, 1.91) |
| Other | 17 (12.2) | 0.62 (0.35, 1.15) | 0.58 (0.25, 1.31) |
| Household income (CAD) | | | |
| Lowest quantile | 15 (13.3) | referent | referent |
| Middle-low quantile | 21 (18.6) | 1.26 (0.65, 2.44) | 1.39 (0.61, 3.17) |
| Middle-high quantile | 21 (18.8) | 1.14 (0.58, 2.21) | 1.24 (0.51, 3.03) |
| Highest quantile | 14 (12.4) | 0.88 (0.44, 1.74) | 0.80 (0.30, 2.17) |
| Disability status | | | |
| Without disability | 54 (12.1) | referent | referent |
| With disability | 27 (33.8) | 3.72 (2.16, 6.40) | 3.13 (1.66, 5.89) |
| Physical health | | | |
| Excellent, very good, or good | 33 (14.6) | referent | referent |
| Fair or poor | 48 (15.9) | 1.11 (0.68, 1.79) | 0.83 (0.47, 1.47) |
| Mental health | | | |
| Excellent, very good, or good | 30 (12.7) | referent | referent |
| Fair or poor | 51 (17.5) | 1.47 (0.90, 2.39) | 1.51 (0.86, 2.66) |
| Accesses medical services by car | | | |
| No | 44 (18.7) | referent | referent |
| Yes | 37 (12.6) | 0.63 (0.39, 1.01) | 1.01 (0.57, 1.80) |
| Accesses medical services by taxi/ride hailing | | | |
| No | 72 (14.6) | referent | referent |
| Yes | 9 (25.7) | 2.02 (0.91, 4.50) | 1.42 (0.56, 3.61) |
| Accesses medical services by public transit | | | |
| No | 48 (12.8) | referent | referent |
| Yes | 33 (21.6) | 1.87 (1.15, 3.06) | 1.80 (0.97, 3.34) |
| Accesses medical services by active travel | | | |
| No | 53 (12.3) | referent | referent |
| Yes | 28 (28.9) | 2.89 (1.71, 4.89) | 2.25 (1.23, 4.12) |

**Table 4** (continued)

| Variable | N (%) with outcome | RR (95% CI) | aRR (95% CI) |
|---|---|---|---|
| Accesses medical services remotely | | | |
| No | 77 (15.4) | referent | referent |
| Yes | 4 (14.3) | 0.92 (0.31, 2.71) | 1.06 (0.32, 3.54) |
| Dependence on other household members for transportation | | | |
| Agree | 37 (24.0) | referent | referent |
| Neither agree or disagree | 14 (18.0) | 0.69 (0.35, 1.37) | 0.62 (0.29, 1.33) |
| Disagree | 30 (10.1) | 0.36 (0.21, 0.60) | 0.41 (0.23, 0.75) |

may point to issues in ensuring vaccine equity in suburban areas, especially in the context of the COVID-19 pandemic. For instance, the significance of employment may be the result of the greater flexibility in working hours afforded by part-time employment relative to full-time employment. Individuals employed full-time may be restricted to booking vaccine appointments before or after typical working hours, coinciding with peak traffic flows (Huang et al. 2019). This is especially pertinent as a growing number of North American suburbanites take up employment beyond the communities in which they reside (Kneebone and Holmes 2015). Similarly, the significance of active travel may suggest that individuals who rely on walking or biking as their primary mode of transportation may be particularly disadvantaged when accessing vaccination appointments in suburban areas. This could reflect issues in the spatial availability of vaccine clinics in suburban areas, which may be located beyond comfortable distance for the individuals most likely to rely on active travel. Finally, the significance of transportation dependence may reflect the perception of certain forms of transportation – such as carpooling and ridesharing – as being unsafe due to their perceived association with the spread of COVID-19. This may contribute to a greater level of unease among individuals who, prior to the COVID-19 pandemic, were reliant on said services.

## Policy implications

Transportation-related barriers to healthcare access may disrupt regular access to routine and emergency healthcare, in turn exacerbating disparities in health and well-being (Barros and Prieto-Rodriguez 2008). Because these transportation-related barriers to healthcare access are often unevenly distributed throughout a given population, these impacts are likely to have the biggest impact on groups that already face the greatest burden of disease (Mirza and Hulko 2022). For instance, in the context of the North American suburb of Toronto, Scarborough, Ontario, this study identified individuals with disabilities and poor mental health as being particularly susceptible to the occurrence of a transportation-related barrier to healthcare access. These findings highlight the importance of reducing the need for healthcare trips when possible, for instance, by offering remote or telehealth options, to improve the availability of healthcare services among those facing transportation-related barriers.

This study also documents several predictors which appear to be uniquely associated with the occurrence of transportation-related barriers to accessing vaccine appointments: employment, active travel and dependence on others for transportation. The identification of these variables as uniquely associated with transportation-related barriers to accessing vaccine appointments, but not primary care, may highlight them as important determinants of vaccine accessibility. This is pertinent in the context of the COVID-19 pandemic, which not only disrupted health and transportation systems globally but also increased the demand for transportation to and from vaccine clinics (Barros and Prieto-Rodriguez 2008).

Even as the COVID-19 pandemic shook public confidence in the safety of some modes of transportation – namely public transit and ride hailing – there is a lack of viable alternatives for those who do not own a personal vehicle (Zhang et al. 2020). To ensure that vulnerable populations can retain access to vaccines during and after the COVID-19 pandemic, efforts should be undertaken to improve the real and perceived safety of these forms of transportation. Taking efforts to reduce the spread of disease through public transit and ride hailing, and communicating these efforts to the general public, may be crucial to mitigating their perception as unsafe or unhealthy in future pandemics. Additionally, the expansion of paratransit and non-emergency medical transportation services may increase the effective coverage area of vaccine clinics among those who rely on public transit and active travel. Finally, these findings highlight the importance of certain ongoing strategies, such as the creation of mobile and pop-up vaccine clinics, which aim to reduce the length and distance of healthcare trips.

**Table 5** Predictors associated with missing a doctor's appointment due to transportation issues

| Variable | N (%) with outcome | RR (95% CI) | aRR (95% CI) |
|---|---|---|---|
| Age | | | |
| 18 to 34 years | 36 (16.1) | referent | referent |
| 35 to 49 years | 16 (12.7) | 0.76 (0.40, 1.43) | 0.81 (0.40, 1.65) |
| 50 to 64 years | 15 (14.2) | 0.86 (0.45, 1.65) | 1.04 (0.49, 2.21) |
| 65 years or older | 7 (9.7) | 0.56 (0.24, 1.33) | 0.61 (0.22, 1.70) |
| Gender | | | |
| Men | 25 (11.9) | referent | referent |
| Women | 44 (15.4) | 1.42 (0.85, 2.38) | 1.37 (0.78, 2.43) |
| Non-binary/other | 1 (7.1) | 0.57 (0.07, 4.57) | 0.35 (0.04, 3.31) |
| Residence in Canada | | | |
| Has resided in Canada for at least 11 years | 63 (13.7) | referent | referent |
| Has resided in Canada for less than 11 years | 11 (15.9) | 1.19 (0.59, 2.39) | 1.03 (0.40, 2.68) |
| Residence in Scarborough | | | |
| Has resided in Scarborough for at least 11 years | 48 (13.0) | referent | referent |
| Has resided in Scarborough for less than 11 years | 26 (16.5) | 1.32 (0.79, 2.22) | 1.19 (0.59, 2.37) |
| Educational attainment | | | |
| Secondary school diploma or below | 23 (16.7) | referent | referent |
| Post-secondary degree below bachelor level | 21 (14.0) | 0.81 (0.43, 1.55) | 0.82 (0.40, 1.66) |
| Post-secondary degree at bachelor level or above | 30 (12.5) | 0.71 (0.40, 1.29) | 0.76 (0.38, 1.50) |
| Employment status | | | |
| Employed full time | 37 (14.2) | referent | referent |
| Employed part time | 11 (15.3) | 1.09 (0.52, 2.26) | 0.79 (0.33, 1.88) |
| Unemployed | 9 (15.8) | 1.13 (0.51, 2.50) | 0.69 (0.28, 1.74) |
| Other | 17 (12.2) | 0.84 (0.45, 1.55) | 0.82 (0.37, 1.83) |
| Household income (CAD) | | | |
| Lowest quantile | 17 (15.0) | referent | referent |
| Middle-low quantile | 16 (14.2) | 0.73 (0.37, 1.46) | 1.00 (0.45, 2.21) |
| Middle-high quantile | 17 (15.2) | 0.86 (0.44, 1.66) | 1.22 (0.53, 2.83) |
| Highest quantile | 13 (11.5) | 0.65 (0.33, 1.29) | 1.05 (0.40, 2.78) |
| Disability status | | | |
| Without disability | 55 (12.3) | referent | referent |
| With disability | 19 (23.8) | 2.23 (1.24, 4.00) | 2.16 (1.13, 4.13) |
| Physical health | | | |
| Excellent, very good, or good | 30 (13.3) | referent | referent |
| Fair or poor | 44 (14.6) | 1.11 (0.68, 1.84) | 0.96 (0.55, 1.69) |
| Mental health | | | |
| Excellent, very good, or good | 27 (11.4) | referent | referent |
| Fair or poor | 47 (16.2) | 1.50 (0.90, 2.49) | 1.49 (0.85, 2.59) |
| Accesses medical services by car | | | |
| No | 40 (17.0) | referent | referent |
| Yes | 34 (11.6) | 0.64 (0.39, 1.05) | 1.11 (0.61, 2.00) |
| Accesses medical services by taxi/ride hailing | | | |
| No | 65 (13.2) | referent | referent |
| Yes | 9 (25.7) | 2.28 (1.02, 5.08) | 1.86 (0.75, 4.58) |
| Accesses medical services by public transit | | | |
| No | 38 (10.1) | referent | referent |
| Yes | 36 (23.5) | 2.73 (1.65, 4.51) | 2.70 (1.46, 5.00) |
| Accesses medical services by active travel | | | |
| No | 54 (12.5) | referent | referent |
| Yes | 20 (20.6) | 1.81 (1.03, 3.20) | 1.39 (0.75, 2.60) |

**Table 5** (continued)

| Variable | N (%) with outcome | RR (95% CI) | aRR (95% CI) |
|---|---|---|---|
| Accesses medical services remotely | | | |
| No | 71 (14.2) | referent | referent |
| Yes | 3 (10.7) | 0.73 (0.21, 2.46) | 0.93 (0.24, 3.57) |
| Dependence on other household members for transportation | | | |
| Agree | 25 (16.2) | referent | referent |
| Neither agree or disagree | 9 (11.5) | 0.67 (0.30, 1.52) | 0.57 (0.24, 1.36) |
| Disagree | 40 (13.5) | 0.81 (0.47, 1.39) | 0.96 (0.53, 1.75) |

## Limitations

Any sampling biases present in the administration of the Scarborough Survey may be reflected in the results of this analysis. For instance, the Scarborough Survey was disseminated over social media, which may have contributed to the overrepresentation of certain populations. This limitation was addressed through iterative sampling; however, some differences between social media users and social media non-users may not have been captured. As noted in a review by Hargittai (2020), social media users tend to be skewed towards higher socioeconomic privilege and technological familiarity. A study by Zhang et al. (2020) similarly noted that Facebook survey responses tend to overrepresent women, seniors and higher-income respondents.

Our estimate may have been biased by the lack of a distinct observation period, as participants were simply asked whether they had ever experienced the outcome with no regard for when the outcome occurred. Future studies may benefit from delineating clear observation periods to ensure consistency in interpretation across respondents. Similarly, this study did not include data on the severity of transportation-related barriers or the downstream repercussions resulting from said barriers. Future studies may benefit from employing more nuanced definitions by not only taking into account whether a transportation-related barrier to healthcare access occurred but by also addressing the severity of such occurrences.

It should also be acknowledged that the Scarborough Survey did not collect any data on the respondent's proximity to their healthcare providers. Future studies may benefit from a more thorough analysis that takes into consideration the influence of space and built environment on the occurrence of transportation-related barriers to healthcare.

## Conclusion

This paper contributes to understanding how transportation-related barriers to healthcare access manifest in suburban areas. Altogether, the results of this study point to the importance of recognizing transportation as an important determinant of health. Transportation-related barriers to healthcare access have the potential to exacerbate health disparities in suburban areas by disproportionately affecting vulnerable populations. Future studies should seek to identify the specific dimensions of transportation (e.g. accessibility, cost, availability) that culminate in these transportation-related barriers to healthcare access. This would provide greater insight into the specific impact of transportation-related barriers to healthcare access, while providing insight into needed policy interventions.

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**Data availability** The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Consent for participation** Not applicable.

**Consent for publication** Not applicable.

**Conflicts of interest** The authors have no competing interests to declare that are relevant to the content of this article.

**Ethics approval** This study received ethics approval from the University of Toronto Research Ethics Board (#34848).

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