UNIVERSITY OF CALGARY

The Complexities of Walking and Rolling: Using Crowdsourced Data to Understand and Analyze the Mobility Barriers Vulnerable Populations Experience as Pedestrians

by

Amanda B. Bishop

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

GRADUATE PROGRAM IN GEOGRAPHY

CALGARY, ALBERTA

SEPTEMBER, 2024

Abstract

Decades of vehicle dominated mobility policy has created streetscapes that endanger pedestrians. Pedestrian-vehicle collisions disproportionately impact older adults (aged 65+), with fatality rates three times higher than younger age groups. Similarly, factors such as episodic or permanent disability, and gender increase overall exposure times and collision risks. Despite this awareness, physical infrastructure and transportation policies inadequately address environmental hazards that create mobility barriers for vulnerable populations. This thesis identifies critical gaps in mobility policy, data, and street design, highlighting the inadequacies of current civic infrastructure in serving diverse populations and understanding pedestrian challenges. While policy directives often target the demographic majority, they overlook those facing the greatest risks. To address this policy mismatch, this study conducts a segment and thematic analysis of crowdsourced data to identify common barriers to pedestrian safety and accessibility. Over 3000 reports (missing amenity, incident, hazard and concerns) from WalkRollMap.org, collected between May 2021 and December 2023, were analyzed to explore demographic variability in barriers to pedestrian mobility. The segment analysis revealed common barriers, such as the need for adequate pedestrian infrastructure, as indicated by missing amenity reports. Incident reports suggested that vehicle-centric street designs create conditions where pedestrians are not visible to moving vehicles. Hazard and concern reports highlighted issues with inadequate crosswalks, poor sidewalk conditions, and motorist entitlement. The thematic analysis provided clearer demographic insights. Women and non-binary respondents identified safety concerns due to inconsiderate street users. Youth reported unsafe conditions from aggressive motorists in school zones. Older adults emphasized difficulties with unpredictable cyclist speeds and volumes. Disabled individuals expressed fear and caution regarding steep or obstructed sidewalks. The study's findings underscore the need for inclusive data collection and policy formulation processes. Achieving inclusively designed cities requires engaging directly with vulnerable populations to understand their diverse needs. By bridging this gap, cities can better support the health and active mobility of all residents.

Keywords: Accident Analysis, Barriers, Built Environment, Crowdsource Data, Demographic Segmentation, Disabled Individual, Disabling Environment, Environmental Characteristics, Pedestrian Experience, Pedestrian Mobility, Pedestrian Safety, Pedestrian Accessibility, Representative Data, Urban Planning and Policy, Volunteered Geographic Information

Preface

This thesis is an original, unpublished, and independent work by A. B. Bishop.

Acknowledgements

I would like to thank WalkRollMap.org for their data contribution, collaboration on our research paper, and support from their community of researchers dedicated to pedestrian safety and accessibility. The completion of this thesis would not have been possible without your drive and commitment.

My deepest gratitude goes to Dr. Victoria Fast, whose expertise, mentorship, and unwavering support truly pushed the bounds of my knowledge. Your practiced lines of inquiry, engagement with my exploration of different research topics, and focus on strategic capacity building greatly enriched my graduate experience.

I would also like to thank Dr. Byron Miller, Dr. Trisalyn Nelson, and Dr. Joseli Macedo for serving as my committee members. I am grateful for your time, excellent feedback, and suggestions, each of which continues to support new research possibilities.

To the University of Calgary's Faculty of Graduate Studies and Department of Geography, I am thankful for the facilities, personal development programs, and funding opportunities that supported my graduate journey. These provided opportunities to build an academic community, time to grow, and space to explore my curiosities.

I extend my thanks to my research colleagues and friends, Hawjin Falahatkar and Paul Walter, who challenged me to connect more deeply with my research and generously offered their time for insightful discussions and problem-solving. Your companionship has been invaluable.

I would like to acknowledge my family for supporting every aspect of this journey. Mike, your care, commitment, and love continuously uplifts me. To my mother, your daily sacrifice drives my desire to succeed. My grandma, whose spirit and resilience inspire me. Your unwavering convictions are my greatest motivation.

Dedication

To all the devoted pedestrians who advocate for beautiful, well-maintained, and safe public spaces, and to those who wish to join in but are hindered by car-dominated development. May the outcomes of this work create more accessible spaces for these journeys.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

Abbreviation	Definition
OSM	Open Street Map
UCSB	University of California, Santa Barbara
UD	Universal Design
UVic	University of Victoria
VGI	Volunteered Geographic Information
WRM	WalkRollMap.org

1.0 Introduction

My 80-year-old grandmother recently explained why she doesn't walk alone anymore. Pain in her knees and hips is a constant reminder that daily life has caught up with her. The pain appears as searing flare-ups after walking a short distance from home, forcing frequent stops. Ideally, a bench would offer her a recovery from the inflammation build-up, but her sprawling suburban neighborhood only offers light poles and fences for short respites. This lack of amenities paired with busy intersections, poorly maintained sidewalks, and distracted drivers leaves her with an extreme sense of unease every time she thinks about leaving the house. So, she waits until an escort is available.

Sadly, my grandmother's experience is not unique. Her situation highlights larger, more pressing issues pedestrians experience daily. Statistics Canada (2023) estimates over 300 pedestrian fatalities occur annually on average. Older adults and men are overrepresented within these collisions, with older adults facing fatality risks at triple the rate of younger cohorts (Transport Canada, 2019). Whereas rates of pedestrian fatalities among men are 1.7 times higher compared to women (Statistics Canada, 2023). Collision statistics are not simple numbers; they represent a significant disruption in life and family. Yet, such statistics likely underreport other dangerous conditions occurring from near-misses, or hazards that force pedestrians to interact with vehicles. The reality is pedestrian safety and accessibility are about more than ensuring convenience – they are critical for maintaining the health and well-being of our lives and communities. Despite advancements in vehicle safety, pedestrian fatalities are a constant threat to human life, exposing the inadequacies of our current civic infrastructure and mobility policies.

After decades of constructing car-dominated societies pedestrian accessibility and mobility are being taken seriously. Pedestrian accessibility means the ease and ability of all pedestrians to move freely and safely in an environment (Forsyth, 2015). This includes the availability and quality of pedestrian infrastructure, like crosswalks, bridges, signage, and sidewalks that are clear, wide and protected.

Pedestrian mobility, on the other hand, generally refers to the patterns of pedestrian movement through space. In its simplest form, this involves the physical movement of bodies (Sheller, 2018), representations of movement, and different ways of practicing movement (Creswell in Miller & Ponto, 2016). Considering these various aspects of movement includes examining how external dynamics and sociospatial relationships can enable or constrain a pedestrian's ability to move.

For example, car-domination imposes threats and barriers to pedestrian safety, which are associated with fear as vulnerable populations attempt to move outdoors or avoid doing so (Amabile et al., 2019;

Rantanen, 2013). Barriers represent environmental (uneven sidewalks, vehicle speeds or volumes, street furniture, crime, etc.) or individual (age, gender, presence of a disability) characteristics that can expose pedestrians to undue risk. Fear of moving and the accompanied stress, embarrassment, and anxiety has the effect of inducing social withdrawal; further, increasing risks of loneliness and isolation (Lyu & Forsyth, 2022), and introducing higher risks of chronic disease (Delgado-Ortiz et al., 2023; Frehlich et al., 2022). Addressing these urgent challenges is paramount for creating safer pedestrian conditions and more accessible environments for people of all ages, genders, and abilities.

In addition to addressing these barriers, promoting physical activity through walkable environments can yield numerous health benefits. Such as improving memory loss associated with dementia (Berchicci et al., 2013), cardiovascular health (Kerr et al., 2012), and, among other benefits, increasing social connectivity through increased community and civic participation. Achieving these outcomes, however, is dependent on creating pedestrian environments that acknowledge, plan for, and support the diverse needs of vulnerable populations. Therefore, this research is about establishing more effective ways to measure the scale of problems to pedestrian safety and accessibility. A first step is identifying specific barriers with community feedback and understanding what shifts when accounting for different population demographics.

The following sections further introduce the focus of this study - barriers to pedestrian safety and accessibility. Section 1.1 introduces concepts related to the pedestrian experience, followed by a summary of the current state of research and existing research gaps (1.2). Section 1.3 introduces the research aims and objectives, then research questions are introduced in section 1.4. Finally, an overview of the study is outlined in section 1.5.

1.1 Pedestrian Experience

Transportation geography research often informs transportation policy and perspectives about pedestrian experiences. The pedestrian experience reflects unique firsthand accounts of physical or perceived threats to safety and accessibility. Data collected to understand or model these experiences examines the walking frequencies, and behaviors (jaywalking, red light violations, etc.) or activities (commuting, recreating, using park amenities, etc.) pedestrians engage in when moving through different environments.

Middleton (2011) and Sheller (2018) suggest past pedestrian research focuses too narrowly on pedestrian movement, or environmental characteristics that pose safety risks versus the embodied experience of walking – what they may feel, think, or how they react to threats. Middleton (2011) argues this type of discursive construction often diminishes pedestrians in planning and policy language to lifeless forms who move through space rather than experience space. The author further indicates policy can fail to acknowledge walking as a behaviour that looks or feels different when accounting for demographics. Not understanding how individual characteristics affect pedestrian experiences can reinforce injustices and create infrastructure that benefits only the most capable.

The following sections expand on the pedestrian experience by discussing the current state of research. This starts with contextualizing aspects of the pedestrian experience, followed by an overview of the barriers and exposure risks pedestrians' encounter. Additionally, evidence regarding the experiences of different demographics with pedestrian safety and accessibility is introduced.

1.1.1 Psychological Stress

Despite the failings of policy language to recognize the pedestrian experience, other academic disciplines seek to address gaps by analyzing the role of psychology in pedestrian mobility. For example, psychology plays a crucial role in behavioral geography and transportation research by providing insights into phenomenological changes in different environmental landscapes (Charlton & Starkey, 2017; Novaco, 2015).

For instance, with phenomenology researchers can observe what sensory and cognitive information individuals use to navigate through or across busy streets. Information about what is seen, heard, or felt helps pedestrians attach positive, neutral, or negative associations with pedestrian space. Montgomery (2013) observed unpleasant walking environments can introduce feelings of alienation or depression among some older adults. He also suggests negative associations from sharp angles and blank walls on buildings can increase feelings of fear and discourage vulnerable pedestrians from engaging with such spaces. Recognizing what perceptual cues are at play can provide insights into how different demographics navigate pedestrian spaces, interact with other users, recognize symbols, or assess how environmental characteristics may affect their mobility.

1.1.2 Pedestrian Barriers and Exposure Risks

Environmental characteristics are external features that may endanger pedestrian safety and accessibility. These features create barriers to pedestrian mobility by preventing individuals from moving through urban settings. Barriers include physical hazards (street furniture, bollards, narrow pathways), the absence of pedestrian infrastructure (sidewalks, crosswalks, curb cuts), and other external features that diminish the quality of pedestrian spaces. Reviewing these features and their impact on pedestrian mobility is essential for understanding what can influence an individual's decision and ability to walk.

For example, Sallis et al. (2006) use an ecological model to study walking behaviors. The authors categorize walking purposes (commuting, leisure, social or household obligations, or active transport) and identifies the environmental characteristics that influence and support walking behaviors. Factors facilitating safe and accessible pedestrian mobility include comfortable pedestrian infrastructure, diverse land-use and zoning, investments in multi-modal transportation, and efficient traffic demand management practices. In contrast, factors that expose pedestrians to barriers or collision risks include incidents in shared spaces (intersections, crosswalks, bike lanes) and missing or poorly maintained pedestrian infrastructure.

Street design and function are additional environmental characteristics impacting pedestrian safety and accessibility. Evidence from Svensson and Hydén (2006), suggest road function and widths can increase pedestrian-vehicle collisions mid-block and at intersections when pedestrians attempt to cross. Dumbaugh (2008) found that while collision risks decrease at signalized intersections, the severity of collisions is higher compared to non-signalized intersections (Svensson & Hydén, 2006). These findings suggest that infrastructure used to control pedestrian street access does not fully remove safety risks. Therefore, it is important to understand levels of pedestrian exposure to dangerous conditions to identify and implement appropriate safety measures.

In fact, high rates of pedestrian-vehicle conflicts are also recorded within marked crosswalks. Painted lines in crosswalks are used to enhance pedestrian visibility, however, Cloutier et al. (2017) suggest collisions still occur due to high traffic and pedestrian volumes. In Huybers et al.'s (2004) experiment with different crosswalk configurations, vehicle stopping distances, and traffic calming measures, they found associations with decreased collision risks. However, these findings are limited because the authors only focused on pedestrian exposure in road-based landscapes rather than within pedestrian spaces. Therefore, more data and research are required to understand barriers within pedestrian spaces and how these vary by demographics.

1.1.3 Demographic Variation

Pedestrian vulnerability varies significantly when individual characteristics – demographics that are internal to pedestrians such as their gender, age, and ability – are considered. Stoker et al. (2015) and Cloutier et al. (2017) discovered middle-aged men experience higher risks due to prolonged exposure to traffic (have different commuting patterns and/or a higher degree of independent mobility than females in some countries). Whereas other studies have found women experience higher exposure rates due to inequitable car access (Grise et al., 2022; Palm, Allen, et al., 2021; Palm, Farber, et al., 2021), and higher rates of care-based roles (child and senior care, domestic labour) (Sánchez de Madariaga, 2013).

When age variations are observed, children and older adults are overrepresented as victims in pedestrian-vehicle collisions. Children between 5-9 years old are susceptible to traffic conflicts because of underdeveloped cognitive processes, smaller physical statures, and limited experience with traffic (Cloutier et al., 2017). Children also learn behaviours through social modeling and are susceptible to mimicking dangerous crossing behaviours. Therefore, risky behaviours exhibited by parents (or older cohorts) may lead to similar behaviours and amplified collision risks in children (Stoker et al., 2015).

Similarly, older adults suffer fatality risks at triple the rate compared to younger cohorts (Transport Canada, 2019), even in collisions occurring at slow speeds (Dumbaugh, 2008). Increased injury risks are attributed to declining health conditions, which can impact how individuals perceive and assess risks (Lachapelle & Cloutier, 2017), or lead to altered decision-making processes. Lord et al. (2018), for example, suggest older adults may fail to recognize complex spatial information and may inaccurately judge their capacity to safely assess gaps in traffic. In contrast, Dumbaugh (2008) observed older adults are generally more cautious about crossing, preferring to walk greater distances to access higher quality intersections. Walking longer distances, however, puts undue pressure on people with mobility impairments that require assistive devices or frequently available seating elements to recover after travelling longer distances.

Likewise, episodic or permeant disability can also impact the pedestrian experience. For example, people with vision impairments are less likely to look at traffic and often accept smaller gaps between vehicles when crossing streets (Stoker et al., 2015). Likewise, Lachapelle and Cloutier's (2017) research observing the crossing behaviours of individuals with cognitive impairments shows that they often exhibit lower levels of concentration and attention to traffic. The authors find an increase in risky crossing behaviours (jaywalking, crossing at red lights) as individuals with deteriorating physio-cognitive capabilities may overestimate their walking speeds, gaps in traffic, or vehicle speeds. Therefore, with an understanding of how environmental and individual characteristics contribute to pedestrian safety and accessibility, urban policy and spaces can be designed to accommodate a diversity of needs.

1.2 Underreporting and Data Blind-Spots

A wide body of literature is dedicated to understanding and analyzing pedestrian safety. However, past research has focused on pedestrian behaviours (Svensson & Hydén, 2006), collision risks in intersections

(Ma et al., 2022; Shirazi & Morris, 2017), or used autocentric inputs as proxy measures for understanding the pedestrian experience (Yasmin et al., 2016).

Cloutier et al. (2017) argue that previous research on pedestrian-vehicle collisions is limited because it overlooks the relationship between individuals and their environment in traffic conflicts. The authors use an analytical model to explore this relationship, analyzing how it varies among different age groups. However, they rely on autocentric data as quantitative surrogate measures to describe and analyze the pedestrian experience. This practice reflects a gap in the availability and analysis of qualitative data used to describe the pedestrian experience. Qualitative data is unique because it can provide additional context when interpreting the factors contributing to pedestrian-vehicle conflicts, such as an individual's positionality, or their physical and psychological state during an event (Creswell, 2018).

Similarly, crowdsource platforms are providing opportunities for individuals to contribute information about their barriers to safety and accessibility. BikeMap.org, for example, is a tool that has received contributions about dangerous travel conditions from cyclists around the globe. Contributing to a large body of literature about cycling behaviours, BikeMap.org operates as a practical, accessible, and user-oriented database, also offering many research applications (Branion-Calles et al., 2017; Nelson et al., 2015). Despite the emergence and popularity of crowdsource platforms, Lee & Sener (2017) found few opportunities for users to contribute information regarding pedestrian activities, safety, or accessibility. WalkRollMap.org, as a recently introduced crowdsource platform, provides a space for pedestrians to report micro-scale barriers (WalkRollMap, 2024). Users can describe conditions that either facilitate or impede their journeys, providing a unique and firsthand perspective on barriers to pedestrian safety and accessibility.

Data collected through the WalkRollMap.org (hereafter, WRM) platform includes demographic information, environmental characteristics associated with pedestrian-vehicle conflicts, and qualitative insights related to the pedestrian experience. Together, these data points from WRM can enhance our understanding of the environmental factors contributing to pedestrian-vehicle conflicts. This level of detail is often underreported in official data sources (police and insurance reports), which typically track only injuries from incidents and not near-misses. Crowdsourced information offers an empowered and participatory approach to gathering more comprehensive data on the risks to pedestrian safety and accessibility.

1.3 Research Aims and Objectives

This study aims to contribute knowledge on pedestrian safety and accessibility in two ways. First, by using crowdsourced data to identify what environmental characteristics are reported as barriers to pedestrian safety and accessibility; and identifying the demographic characteristics associated with such experiences. Second, by exploring textual themes used to describe the pedestrian experience of older adults and other underrepresented groups.

To achieve these aims, this study is separated into quantitative and qualitative objectives, used to segment and structure the research approach:

Quantitative Objectives:

- **a.** To identify common barriers to pedestrian safety and accessibility.
- **b.** To determine who within the data is reporting barriers to pedestrian safety and accessibility.

Qualitative Objective:

- **a.** To identify and describe the themes older adults and other underrepresented groups use to define barriers to pedestrian safety and accessibility.

1.4 Research Questions

The research questions for this study are:

Quantitative:

- **a.** What environmental characteristics are reported as barriers to pedestrian safety and accessibility?
- **b.** What are the top barriers reported by different age groups, genders, and disabled individuals?

Qualitative:

- **a.** When analyzing crowdsourced data to understand how older adults and underrepresented populations respond to threats to pedestrian safety and accessibility, what themes are used to describe their pedestrian experience with barriers?

1.5 Overview of Thesis

This thesis is organized into five sections, each is used to expand on the research aims and seeks to derive answers to the research questions. Section 2 opens with a literature review. It is used to describe the state of research and highlight the bodies of knowledge used to direct this research. Section 3 provides a detailed overview of the data, research strategy (including tools used for direction and analysis), and research methods. Section 4 presents explanations, tables, and visualizations of results. Section 5 discusses the significance of the findings and how each demographic segment describes barriers to pedestrian mobility. Section 6 concludes with a summary of the research and offers recommendations for further studies.

2.0 Literature Review

A brief overview of the key bodies of knowledge used to inform my research is presented in this section. Section 2.1 summarizes over 10 years of research trends on pedestrian safety. Section 2.2 discusses known challenges to pedestrian safety and accessibility. Lastly, section 2.3 examines the types of data available to support pedestrian planning and policy.

2.1 Pedestrian Safety and Parameters of Measurement

As a field of study, accident analysis is often used to understand accident severity (Svensson & Hydén, 2006), travel behaviour and associated collision risks (Cloutier et al., 2017; Dommes et al., 2015; Lord et al., 2018), and the factors contributing to unsafe pedestrian conditions. Ma et al. (2022) map the evolution of pedestrian safety research trends in a review of pedestrian safety literature. Using scientometrics to methodically analyze thematic shifts, the authors found approximately 76% of pedestrian safety publications were published after 2010; likely following the World Health Organization's Decade of Action for Road Safety program. The authors track four distinct research trends throughout this decade.

The first stage emerged between 2010-11. Ma et al. (2022) find popular studies during this period focused on vehicle-pedestrian crash analyses, with an emphasis on crash severity and the impacts of vehicle improvements on collision rates. The latter emphasizes how the addition of new vehicle safety features, such as back-up cameras, blind-spot and forward-collision warnings, mitigate vehicle-pedestrian crashes. The second stage occurs between 2013-14, the authors notice thematic shifts where new studies seek to understand and evaluate "pedestrian behavior, distractions, head-injury countermeasures, and national [safety] policies" (p. 7). In Abdel-Aty et al.'s (2013) study, for example, different crash models are tested to determine what macro-level variables contribute to vehicle-pedestrian collisions. These include explanatory variables such as different socio-demographics (income, race, educational attainment), traffic and/or roadway features (signalized intersections, traffic signs), and temporal factors (peak verses non-peak commuting periods) that may contribute to increased vehicle-pedestrian collision risks.

Research trends in pedestrian safety, again shift between 2015-2017, where crossings at signalized intersections is evaluated and simulated for different situations (Ma et al., 2022). Here, researchers use new technologies to model pedestrian flows and anticipate behaviours (Chen et al., 2018), and detect pedestrians in intersections (Shirazi & Morris, 2017). Lastly, within recent years, Ma et al. (2022) find research trends are now investigating pedestrian safety and their trajectory of travel within signalized intersections, and beginning to observe how new technologies can further evaluate pedestrian safety.

Throughout this evolution in pedestrian safety, a large amount of research has centred on vehicle-pedestrian conflicts within intersections. This trend, for example, collects and analyzes data for those situations where pedestrians are entering *vehicle* space. However, limited research explores reverse situations where vehicles pose risks to pedestrians mid-block (Lee & Sener, 2017; Truong & Somenahalli, 2011), or encroach on pedestrians' space. By focusing attention on conflicts within vehicle space, the burden of responsibility is placed heavily on pedestrian behaviours instead of motorist behaviour, road design, or vehicle speeds. An alternative view is to evaluate how design features in the built environment or within transportation infrastructure can create dangerous or disabling conditions for pedestrians. Additionally, there is limited research analyzing how safety risks vary among different age groups (children, adults, and older adults). Pedestrian mobility and behaviour, are therefore, assumed to be homogenous. This type of thinking creates challenges for current and future studies because diversity within the pedestrian experience, whether this entails walking speeds, mobility impairments, or cognitive constraints, is not accounted for.

2.2 The Planning and Building of Barriers

There are a multitude of factors that contribute to an individual's decision or ability to move freely. Barriers to pedestrian mobility can occur in the planning and designing of conventional streetscapes, and result in disabling environments. Similarly, seasonal weather patterns introduce new forms of risk. Nevertheless, barriers whether they're built within streetscapes, or occur from individual and temporary factors, strategies like universal design are used to minimize risks.

2.2.1 Conventional Streetscapes: Road Speed, Volumes, and Widths

Barriers to pedestrian mobility are often built into streetscapes through long-standing industrial practices or policy standards. In his seminal paper, Patton (2007) argues mandates within the Highway Capacity Manual – a North American-based reference guide for setting transportation standards and practices – lead traffic engineers to value, plan, and design streets for uninterrupted vehicular traffic flow. In practice, this results in subtle design choices such as few intersections, traffic lights, or crosswalks, which prioritize vehicle movement above other travel modes. Consequently, design hierarchies that prioritize vehicle mobility diminish pedestrian access, comfort, mobility, and safety. Patton (2007) states that design decisions made by traffic engineers are imbued with biases inherent to their professional training; these "are widely regarded [to create barriers] to more walkable cities" (p. 931). As professionals who often lead streetscape design and decision-making processes (Marohn Jr., 2021), the values and priorities of transportation engineers frequently misalign with walkability.

Street design comprises a series of trade-offs seeking to balance road improvements with user mobility. This balance involves choices of defined speed limits, capacity, safety potential, and overall cost (Marohn Jr., 2021). Once vehicle speed limits are defined, the associated base conditions needed to provide uninterrupted vehicle flow are then determined (Roess & Prassas, 2014). These base conditions may specify minimum widths for lanes and clear zones (areas beside roadways devoid of obstacles like trees, fences, etc.) needed to adhere to set transportation standards. Capacity selection involves calibrating parameters (traffic flow and volumes) to estimate average daily vehicle counts. Like speed, safety relates to the conditions needed to minimize conflict between road users. Lastly, costs measure the infrastructure spending required to achieve the desired speed and capacity estimates. It is important to note that within this design paradigm, "safety is optimized *after* mobility goals are achieved" (Martinson & Golly, 2023, emphasis added). Therefore, where vehicle mobility and speed are prioritized first, designs for pedestrian safety and accessibility become secondary and/or expendable considerations.

High traffic volumes and road widths are predictors of increased pedestrian injury risks. For example, Roberts et al. (1995) found child pedestrians are 13 times more likely to suffer injuries in communities with high traffic volumes, compared to those with low volumes. In another study, the probability of pedestrian injuries occurring from left-turning vehicles varied "as a function of traffic volume" (Stoker et al., 2015, p. 384), a risk found to be considerably higher at signalized intersections. Similarly, there's long-standing evidence that road widths above 11 ft. are correlated with increased frequency of pedestrian crashes (Hauer, 1999). Evidence from Stoker et al. (2015) further suggest wide street lanes significantly increase risks for both pedestrians and motorists, where street widths are positively correlated with fatalities. Therefore, design processes that also consider modal priority can mitigate safety risks.

During the street design process, Marohn Jr. (2021) states that traffic engineers consider whose mobility is more important in a particular context. For example, the author indicates this involves determining movement priority between different street users by asking if maintaining high vehicle speed during rush hours is a greater priority than pedestrian safety. Prioritizing speed ensures vehicle movement is smooth and uninterrupted. This often results in designs that create easy turns at intersections for vehicles by using slip lanes as road features. Slip lanes ensure vehicles can avoid delays by not stopping to take right turns (Roess & Prassas, 2014), however such features result in additional pedestrian exposure because they extend the overall crossing distance. Conversely, designs prioritizing pedestrian safety feature streets with frequent crossings, slowing vehicles with tight turns, and providing ample opportunities for social and commercial exchange (Patton, 2007).

2.2.2 Disabling Environments

Disabling and exclusionary environments can be created by planning, policy, and engineering practices. Müller (2023) states disabling environments are defined through a gap or relational model, suggesting disability is a relationship that exists "between individual capabilities and surrounding" environmental demands (p. 39). For example, streetlights are commonly built within, on, or near sidewalks. The placement and construction of streetlights can create environmental demands which require individuals to navigate around them. The demand in this example, requires individuals to have a full range of motion, good balance, and situational awareness. Whereas individuals without such capabilities can be completely immobilized by such barriers.

Consequently, disabling barriers result from a combination of environmental and individual characteristics. Together these can create real or perceived barriers, heighten collision risks or reduce pedestrian mobility. Environmental characteristics impede movement with external conditions that create hazards and diminish the quality of the pedestrian realm (Lachapelle & Cloutier, 2017). For example, different types of roads and sidewalk infrastructure, street signs, signalized intersections, weather conditions, or changes in traffic volumes can impede pedestrian movement. Whereas individual characteristics internal to a pedestrian, may contribute to how an individual accesses, or not, a streetscape. In studying the effects of age and crossing behaviours, for example, Lord et al. (2018) found a positive correlation between cognitive maturity and travel speeds. They found both children (≤12) and older adults (65+ years) were susceptible to slower walking speeds and therefore, experienced more exposure risks and disabling environments.

2.2.3 Weather-Related Barriers

Seasonal weather patterns can also create barriers for pedestrians. Vergouwen et al. (2021) examined the relationship between weather conditions, seasonal variations, and volumes of emergency orthopaedic surgeries over a 10-year period in Calgary, Alberta. Orthopaedic surgeries commonly treat hip, ankle, and wrist-related injuries (bone breaks or fractures) resulting from trips, slips, or falls. Within their study, winter-related weather conditions (December to March) were the most significant predictor of orthopaedic injuries, with hip and ankle fractures accounting for approximately half of the injuries within their dataset. Prolonged ice conditions, for example, significantly contribute to "overall orthopaedic trauma and ankle fracture surgeries" where injuries occurred when ice was "present for multiple days and when it was snowing" (p. 2875). Younger cohorts (74 years or less) were susceptible to a decreased risk (17%) of hip fractures within one day of ice formation, whereas ice remaining over two days was a predictor of increased (21%) hip fractures in younger cohorts. The authors suggest, older cohorts (75 years and older) take increased precautions to avoid travel or are more dependent on others during winter periods which may explain why a significant relationship was not seen between weather conditions and hip fractures in older cohorts.

Perceived fall risks from weather-related barriers are also associated with fear as older adults attempt to or avoid moving outdoors during inclement weather (Amabile et al., 2019; Rantanen, 2013). Fear of moving and the accompanied stress, embarrassment, and anxiety has a long-term effect of inducing social withdrawal; further increasing risks of loneliness and isolation among older adults (Lyu & Forsyth, 2022), and overall health declines with higher risks of chronic disease (Delgado-Ortiz et al., 2023; Frehlich et al., 2022).

2.2.4 Universal Design and User Categorization

Universal design (UD) is a process of correcting impedances that lead to disabling environments. As a design strategy, UD creates spaces that enable access for people of all ages and abilities. Grisé et al. (2019) suggest this includes minimizing environmental obstructions that reduce the overall functionality of spaces. UD also provides access to services (Grisé et al., 2019), products, and programs to purposefully integrate specialized functionality into space (Connell in Müller, 2023).

However, Nelischer and Loukaitou-Sideris (2022) argue such specialized integration can inadvertently isolate target groups by creating spaces exclusively for children or older adults. The authors contend specialized design can reinforce group or age-based stereotypes and lead to conflict, fear, or annoyance when different users inevitably interact. Therefore, achieving UD aims requires a nuanced understanding of specific-use cases, user contexts (how and why space is used), and the overlapping needs among diverse users.

Planning necessitates early contextualization of user experiences, like identifying and categorizing potential users while also assuming their needs. Categorization includes collecting demographic information and identifying data trends. For example, children are reported to feel connected to places in which they have experienced friendly social encounters. Therefore, Bourke (2017) reasons spaces that encourage sensory, social, or imaginative engagement make children feel safe.

Similarly, Dumbaugh (2008) found older adults are more cautious about street crossings, tending to walk greater distances in search of quality crossings. However, increased walking distances place additional pressure on individuals with mobility impairments, who may require assistive devices or public benches to recover after traveling long distances.

Falahatkar and Fast (2023) find spatial safety and equity are key considerations for establishing comfortable public spaces for women. Their application of feminist theory indicates gender inclusive urban design features include "adequate lighting, open design layouts, adequate windows and entrances, diverse and feminine functions, mixed-use spaces, and feminine symbols that enhance" visibility in space, and effectively enhance women's perception of safety (p. 4). Each of these examples demonstrates how categorization can lead to inclusively designed pedestrian spaces.

User categorizations are useful for planning and policy development (Müller, 2023; Müller et al., 2021), but can introduce professional bias regarding the interaction of users in space (Nelischer & Loukaitou-Sideris, 2022). For example, the probability of bias is higher when it is derived from non-representative data compared to direct community-based engagement to inform design decisions. This generalized bias represents forms of normative thinking that effectively prioritize dominant or assumed perspectives while also silencing others (Müller, 2023).

Normative thinking also extends to digital space. Chu et al. (2022) argue older adults are often excluded from product and/or technology development. The authors suggest the invisibility of older adults creates digital ageism where their perspectives, values, and preferences are absent or inaccurate. Consequently, digital services are harder for older adults to access and are increasingly dominated by young perspectives, furthering the digital divide already excluding older adults.

2.4 Data Availability

Compounding the barriers introduced by our streetscapes, weather, and universal design, there is a lack of data (and representative data), to support research and/or studies on understanding and removing barriers. Here I explore official and crowdsourced data available, and the limits of each.

2.4.1 Official Data Collection Mechanisms

Municipalities rely on official data collection mechanisms to measure, understand, and evaluate threats within the built environment. These often include inputs from traffic counters, or 311, police, and insurance reports to determine how and where resources are best positioned to minimize environmental threats.

Popular approaches to data collection include the use of stationary or passive methods. For example, traffic and site counters utilize cameras and sensors to track various travel modes moving through intersections (Lee & Sener, 2017). These stationary counters observe traffic volumes and behaviours but are not used to monitor entire street networks. Correspondingly, vehicle-pedestrian collisions are often recorded at high-priority sites, or in areas with high traffic volumes. However, evidence suggests pedestrians avoid areas with high traffic volumes, making traffic counters placed in these locations ineffective tools to capture all areas of risk (DEKRA, 2023; Wilson, 2024). Therefore, more information is required to supplement knowledge gaps about additional pedestrian risks experienced throughout urban street networks (Branion-Calles et al., 2017).

For example, 311 databases provide additional ways to bridge knowledge gaps. As an information service owned and operated by municipalities, 311 provides City operators with avenues to facilitate, track, and manage citizen service requests. These datasets include "fine-grained information" regarding details about civic concerns (White & Trump, 2018, p. 796); and proxy information about neighbourhood conditions or civic engagement (Minkoff, 2014). However, evidence reveals that 311 usage is not even in all communities.

Uneven civic participation is associated with distrust, limited knowledge of services, or negative experiences with municipal governments. For example, Lerman and Weaver (2014) found a negative association between 311 usage and concentrated policing (stop and frisk activities). They argue that situations with high levels of citizen disempowerment also incentivize "disengagement with government" (p. 204). Therefore, communities facing slow government responses to 311 service requests are less likely to report challenges to pedestrian mobility.

Similarly, Minkoff (2014) found neighbourhood conditions are useful for evaluating political engagement. With 311 data, the author determined that poorer quality and distribution of public goods (parks, libraries, schools) and services (transportation infrastructure) was correlated with high political disengagement. Therefore, 311 can provide supplemental information about pedestrian safety and accessibility, but again, is susceptible to information gaps due to uneven civic participation.

Consequently, non-representative data can re-enforce injustices and immobility by distributing resources shaped with biased data trends. This practice refers to populational-neutral decision-making or a process that fails to address systematic inequality. For instance, by measuring race-based transportation inequality, Golub et al. (2013) found neutral decision-making can lead to inequitable infrastructure spending, with transit investment favouring affluent white neighbourhoods while simultaneously disinvesting in networks serving historically black communities.

Similarly, Roy et al. (2019) argue there is a strong chance of generalized biases forming from non-representative data, which are then translated into policy or implemented in public space. Using data on cyclist ridership trends, the authors found Strava contributions, a GPS-based fitness application, overwhelmingly captures inputs from young, white, males. This represents a problematic sample size, as the authors argue the data was biased towards recreational riders. Müller et al. (2021) identified similar inequalities and biases in Swedish mobility policies. The policies were found to favour young, male, and highly educated cyclists while neglecting the needs of older adults and disabled populations due to a lack of representation. Therefore, if data trends are used to inform policy and infrastructure planning, few alternative perspectives are available to ensure services support a diverse range of users.

2.4.2 Volunteered Geographic Information for Crowdsourcing Pedestrian Data

Volunteered geographic information (VGI) can bridge information gaps where intentional or unintentional data omissions occur. OpenStreetMap (OSM), an editable mapping platform operated and maintained by volunteers, is a prime example. As a global crowdsourcing platform, OSM often contains more "detailed and accurate [data] than the authoritative maps produced by national mapping agencies" (Fast & Rinner, 2014, p. 1280). Authoritative bodies may lack the required resources – personnel, funding, approval processes – to maintain real-time maps or datasets. In contrast, coordinated crowdsourced efforts can sustain VGI data sources when authoritative resources are limited.

VGI databases can be created through active or passive processes. With passive processes, data are automatically scraped from participant devices (smartphones) when authorized by the user (Lee & Sener, 2017). Such is the case with Google Maps, which commonly scrapes metadata to provide real-time traffic updates. In contrast, active VGI processes ask participants to share information about their experiences with researchers. Fast and Rinner (2014) indicate active VGI models offer beneficial “experiential and exploratory learning” opportunities and collaboration with researchers and community members (p. 2211). Therefore, as a participatory tool, VGI creates powerful pathways to amplify diverse or missing perspectives.

Several participatory tools have emerged to actively crowdsource user data. These include app-based location trackers (Google Maps), physical activity applications (Strava, Apple Fitness), mobility-as-a-service platforms (Uber, Lime, Bird), and user-feedback-based map inventories (OSM). These tools allow users to track and report preferred travel routes, collisions, and points of interest. Government agencies also employ applications for public purposes (Lee & Sener, 2017). For example, CycleTracks supports the monitoring of pedestrian and cyclist behaviours and trip trajectories. However, Lee and Sener (2017) argue this application is limited because it cannot determine how and/or why cyclist volumes change. Whereas other tools like BikeMap.org enable users to provide more contextual information about collisions, injuries, or near-misses with other street users (Boss et al., 2018; Branion-Calles et al., 2017). While these tools enhance the efficiency of cycle networks, few offer similar opportunities for pedestrian networks.

Existing tools record recreational activities (Qiao, n.d.; Santos et al., 2016), or support disaster planning by modeling pedestrian evacuation routes (Chen et al., 2018). However, there is a need for more comprehensive information on pedestrian safety and accessibility. Emerging datasets like Strava and WalkRollMap.org (WRM) could help bridge this data gap. Strava, while promising, is restricted by a paywall and limited by aggregated data formats (Lee & Sener, 2017), which add layers of data privacy but limits demographic insights. Conversely, WRM is an open-source data platform that provides tools for mapping permanent and temporary barriers. Laberee et al. (2023) conducted a preliminary analysis of WRM data, introducing the platform to researchers and individuals experiencing microscale barriers. Their research, including a literature review and stakeholder interviews, helps identify known barriers to pedestrian safety and accessibility. Key information from these efforts was used to categorize barriers and report types within WRM, such as incidents with other road users, missing pedestrian amenities, and environmental hazards. Demographic data is collected with reports and available to researchers upon request. This study aims to use this demographic information to provide population-level insights on the risks pedestrians face under various environmental conditions.

3.0 Methods

Given that the aims of this research are both quantitative and qualitative, a mixed methods approach was used. This approach integrates quantitative and qualitative data, revealing insights that are otherwise hard to derive or justify.

Positivistic research methods can obscure the mobility challenges different populations face by aggregating data. For example, Golub and Martens (2014) find that aggregated data inadequately captures variations in travel behaviours, thereby minimizing the risks and barriers encountered by different populations. This aggregation can conceal the potential exclusions that vulnerable groups face by assuming that dominant pedestrian perspectives are representative of all street users. Therefore, by selecting a mixed methods approach, I remain mindful of the need to explore demographic variability. My goal with this approach is to highlight and elevate often underrepresented narratives.

Therefore, the following sections describe and discuss the methods I selected to process and analyze WRM data. Section 3.1 opens with an overview of the research data; then discusses the research strategy (3.2) including the data workflow and summary, and the research methodology (3.3). This section closes with a discussion of the ethical considerations (3.4) for the data collection.

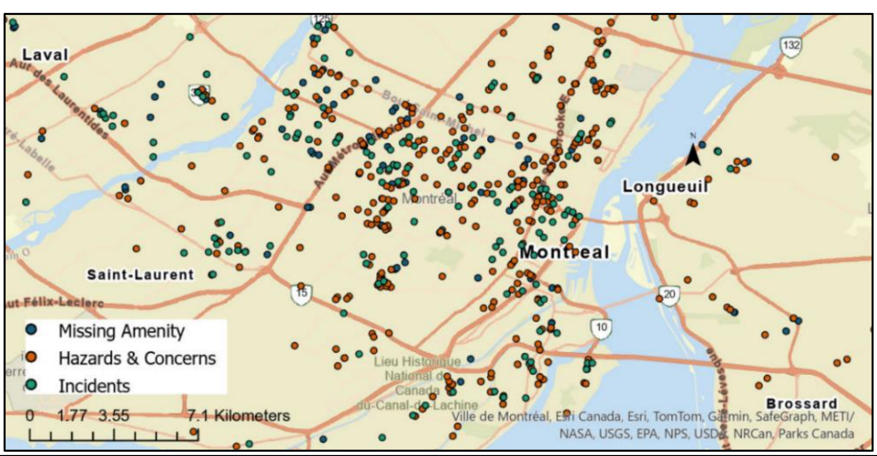
3.1 Research Data

My research uses data collected on WalkRollMap.org (WRM). As a crowdsource data platform, contributors are encouraged to report their experiences with (1) incidents, (2) hazards and concerns, or (3) missing amenities they encounter as pedestrians. WRM was established by researchers at the University of Victoria (UVic) and the University of California, Santa Barbara (UCSB). The platform was organized with the support of the Public Health Agency of Canada to map microscale barriers to walking and rolling[1]. Microscale refers to environmental conditions (cracked sidewalks, lack of benches, and crime or harassment) which can impede an individual's ability to walk and/or roll.

[1] Rolling in an inclusive term used to describe pedestrians who may use wheeled mobility (scooters, wheelchairs, walkers, etc.) devices to complete daily activities.

Table 1. Summary of data collected from all report types.

<table>
<tr><th>Report Type[1]</th><th>Variables of Interest</th></tr>
<tr><td>Incident</td><td>• Hit
• Near-Miss
• Fall</td></tr>
<tr><td>Hazard or Concern</td><td>• Sidewalk issue
• Crossing issue
• Weather and/or seasonal related issue
• Safety and/or comfort concerns</td></tr>
<tr><td>Missing Amenity</td><td>• Type of missing amenity
• Description of the concern
• Description of ideal solution</td></tr>
<tr><td colspan="2">Population Level Data</td></tr>
<tr><td rowspan="4">Demographic Characteristics</td><td>• Age</td></tr>
<tr><td>• Gender</td></tr>
<tr><td>• Disability</td></tr>
<tr><td>• Race</td></tr>
<tr><td colspan="2">Report Locations</td></tr>
<tr><td colspan="2">Canada and the United States</td></tr>
<tr><td colspan="2">


</td></tr>
<tr><td colspan="2">Montreal, Quebec, Canada[2]</td></tr>
<tr><td colspan="2">


</td></tr>
</table>

[1] Each report type provides an opportunity for respondents to explicitly map and describe details about their experience.
[2] A subsect of data reported about areas around Montreal, QB, Canada is shown.

The data used in this study includes over 3000 reports from three report types (see Appendix A for a full list of questions included in reports) submitted between May 28, 2021, and December 31, 2023. The data includes reports from respondents in Canada and the United States, and a small number of contributions from respondents in Europe and Oceania. These reports collect quantitative and qualitative inputs (summarized in Table 1) to describe firsthand experiences with barriers or related events, and demographic information of respondents (race, age, gender, or disability). The inputs are summarized by report type, feature type, attribute, and a description of the event to contextualize the conditions leading to the reports (see Appendix B for more details).

Spatial information (latitude and longitude) is also captured using points to map locations associated with reports. However, as spatial analysis is outside the scope of this study, an inset map is included in Table 1 to provide an example of how spatial information appears in WRM. The points in Table 1 both map and describe multiple respondent concerns. The maps include data points in Canada and the United States, with a subset of data reported around Montreal, Quebec illustrating how barriers may cluster around similar areas.

The following sections discuss the barrier categories and report types used for my study.

3.1.1 Missing Amenities

Missing amenity reports contain information describing situations where pedestrian infrastructure was not available. Respondents were asked to identify (1) what type of amenity was missing (the infrastructure and/or service required to support the pedestrian experience), (2) describe their concern, and (3) desired solution.

3.1.2 Incidents

Incident reports contain information detailing conflicts between pedestrians and other road users. These are categorized as a conflict resulting in a (1) hit, (2) near-miss, or (3) fall. Within these reports, respondents were asked to describe the event conditions by identifying who the conflict was with (animal, vehicle, cyclist, other), if an injury occurred, and the date of the incident. If the incident involved a fall (category 3), event conditions identified the type of fall the respondent experienced or witnessed (slip, trip, other).

3.1.3 Hazards and Concerns

Hazard and concerns reports contain information identifying specific environmental characteristics that may decrease a respondent's sense of safety. Environmental characteristics are broadly categorized as issues with (1) sidewalks, (2) street crossings, (3) inclement weather, (4) other environmental factors (other forms of micromobility, street furniture, inappropriate/unwanted attention, etc.). Respondents were also asked to describe the environmental characteristics creating the concern. For example, if a crossing issue was identified, a secondary description of the contributing environmental characteristics (drivers don't yield, or signal needs audio) were also identified.

3.2 Research Strategy

This section describes the ethical considerations of this study, and the steps I took to explore, clean, and process the WRM data (Figure 1) for further analysis. I then summarize the data included for analysis within the study.

3.2.1 Ethical Considerations

Ethical standards consistent with the University of Calgary Conjoint Research Ethics Board (REB) were considered in the preparation of this study. Since the data involves humans and contains information directly related to their personal experiences with risk, ethics approval was sought in addition to the main REB held by UVic and UCSB to collect data before this study started. This supplementary approval supports local data collection in conjunction with previous data collected by WRM. The University of Calgary REB approved data collection for this study (See REB22-1104 at the University of Calgary for more information).

While designing this study, ethics considerations identified respondents could experience potential physical risks or discomfort from providing information about past trauma on WRM. These risks included potential physical or emotional stress from recalling events leading to a report. Additionally, respondents could experience minor mental fatigue by completing online reports. Therefore, prior to completing a report respondent were advised their participation was voluntary and that their data would remain anonymous. No personal identifiers (name, IP address, DOB, etc.) were collected alongside report responses to ensure data privacy.

3.2.2 Data Workflow

During the data exploration phase, I examined the data in Excel to identify the types of data and inputs included in each report type (Table 1). The full dataset comprised both nominal and categorical data (see Appendix B for a complete list of data inputs). I then determined what variables of interest were best suited to answer my thesis questions. These variables include the report date (numeric – discrete), report type (categorical – nominal), feature type (categorical – nominal), feature subtype (categorical – nominal), disability (Y/N) (categorical – nominal), disability type (categorical – nominal), gender class (categorical – nominal), age class (numeric – discrete), and description (Text – descriptive).

Selected variables were then cleaned by checking for missing values and/or inconsistent formats. Values with “NA” were changed to “No Response” for all variables. Gender classes were already sorted into four categories (men, women, no response, non-binary). Non-binary represents reports where the respondent identified as “Other” (they/them, agender, any/all, etc.). Disability was also collapsed into two categories (Y/N) using Boolean operators. Where if respondents identified with “NA” or “No Response” in the dataset, the input was changed to “No”. Lastly, I translated all textual descriptions to English as over half (n = 1737) were provided in French. To complete the translations, I exported all descriptions to Google Sheets to first identify the language used in the description, then translated French reports using the translation function available within this software.

The cleaned dataset (n = 3440) was processed to exclude duplicates and/or bike-related entries from the final analysis. Duplicates were identified in two ways. First, using conditional formatting, I highlighted reports submitted with the same date (of report and event) and timestamp. Secondly, conditional formatting was also used to identify duplicate textual descriptions. I manually reviewed all other fields (age, gender, etc.) to determine if duplicates were present. Using this method 52 duplicate reports were removed.

Bike-related entries – indicative of a cyclist’s perspective rather than a pedestrian’s – were identified using Boolean Operators (IF, AND, OR) to search for keywords. Keywords included two lists, one for bike-related terms and another for pedestrian-related terms (Table 2). Two lists were required due to similar terms occurring in the descriptions. Once potential “Bike-Related” or “Pedestrian-Related” reports were identified, I read through each description manually to determine what perspective was reported. For example, reports where the respondent identified they were on a bike, had their bike hit, or where riding were excluded from the analysis. 302 bike-related reports were identified using this method. Lastly, data was inserted into Excel pivot tables to perform the segment analysis.

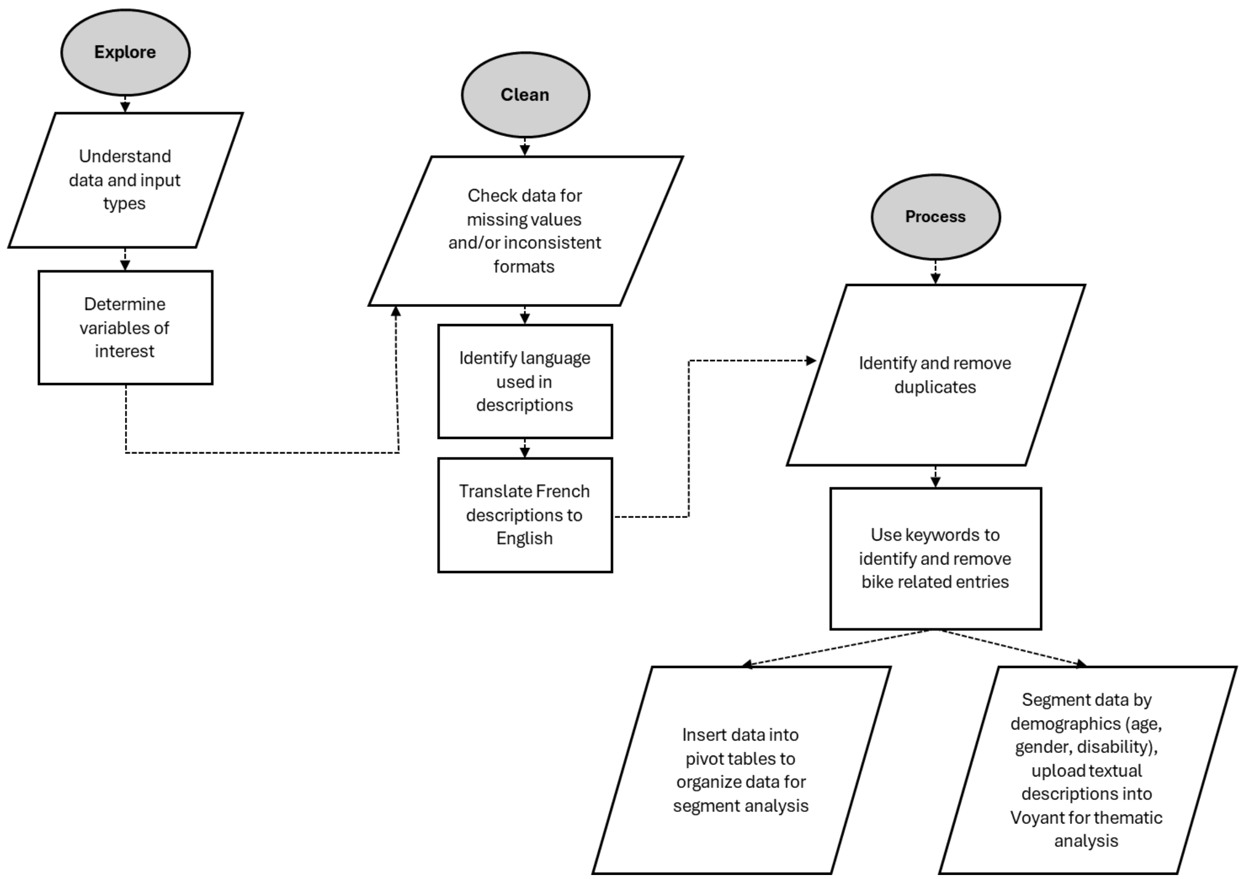


Figure 1. An overview of the workflow used to explore, clean, and process the WRM data.

Table 2. Keywords used to identify bike- and pedestrian-related reports.

Keywords List	
1) Bike-Related Terms	2) Pedestrian-Related Terms
Bike	Feet
Bicycle	Foot
Bike Lane	Multi
Bike Path	Pedestrian
Cycle Lane	Share
Cycle Path	Sidewalk
Cycling	Stroller
Cyclist	Wheeling
On my	Walking
Parking in	
Ride	
Riding	

3.2.3 Data Summary

Table 3 summarizes the number of reports received about pedestrian safety and accessibility between May 28, 2021, and December 31, 2023. After removal of duplicates (n = 52) and bike-related reports (n = 302), 3086 reports were included for analysis in this study. Hazard and concern reports represent over half (n = 1741) of the data; these indicate specific environmental conditions (crossing issues, weather issues, sidewalk issues, etc.) that create and present barriers to pedestrian safety and accessibility. Over a quarter (n = 911) of the data identifies situations where pedestrian infrastructure was either unavailable, missing, or needed to facilitate safe and accessible pedestrian mobility. Within 14.1% (n = 434) of the data, there are also incident reports that provide details about conflicts pedestrians experienced with other road users.

Table 3. Summary of WRM reports received between May 28, 2021, and December 31, 2023.

Report Type	**n (%)**
Missing Amenity	911 (29.5)
Hazards and Concerns	1741 (56.4)
Incidents	434 (14.1)
All Responses	**3086 (100)**

To explore the data, segment analysis was used to answer questions about what environmental characteristics were reported as barriers and by who. To analyze the textual descriptions within the data, a thematic content analysis was used to answer questions about how older adults and underrepresented populations may respond to threats to pedestrian safety and accessibility.

3.3 Segment Analysis

As was briefly discussed in Section 3.0, aggregated data can obscure and silence differing perspectives and the risks pedestrians encounter. With segment analysis, variability between pedestrian experiences can be observed. Dolnicar et al. (2018) state this method is commonly used in market research to understand and match consumer needs with their desires. Segment analysis is also used as a decision-making tool to assist in the development of strategic plans.

Utilizing a segment analysis requires determining what segmentation criteria are used to collect and process data. Dolnicar et al. (2018) define four data categories useful for this analysis, including geographic (location), demographic (age, gender, income), psychographic (beliefs, preferences, motivations), or behavioural (experience with and/or knowledge of a topic). Demographic segmentation is used within this study because it responds most appropriately to the proposed research questions.

Following the data pre-processing (Section 3.2), the data was arranged into demographic segments using the Pivot Tables tool in Excel. This tool allows for seamless data sorting and filtering, as well as the creation of data displays based on variable selection. For each report type (incidents, hazards and concerns, missing amenities), data was segmented in four ways:

Segment 1 – Report Type, Summary of All Responses: All reported barriers

Segment 2 – Report Type, Summary of Responses by Age: Top five reported barriers

Segment 3 – Report Type, Summary of Responses by Gender: Top five reported barriers

Segment 4 – Report Type, Summary of Responses by Disability Type: Top five reported barriers

After segmenting the data, I created frequency tables to show the counts and relative percentages of reported barriers within each demographic group. These totals are normalized to account for intra-group responses. Each table summarizes how different demographic segments responded to report questions related to submitting a WRM report (see Appendix A for all report questions).

The top five barriers were selected to examine specific environmental factors affecting pedestrian safety and accessibility and to understand potential demographic differences in reporting patterns (see Section 4). Analyzing demographic reporting trends from the top five barriers, which are most frequently reported by respondents, aligns with the methods used in Laberee et al.'s (2023) preliminary study (see Appendix C for full tables of responses). Finally, the data was displayed using 100% stacked bar charts. These charts visually summarize areas of agreement and variability among demographics regarding the top five barriers.

3.4 Thematic Analysis

Given the tendency for unrepresentative data availability in traditional and/or crowdsourced data, thematic analysis was used as a method. I applied it to understand how older adults and other populations respond to threats to pedestrian safety and accessibility. Thematic analysis has been described as a "flexible and useful research tool" for exploring textual data that is complex, rich, and detailed (Vaismoradi et al., 2013). This means respondent descriptions are taken at face value, with limited researcher interpretation applied during data analysis. Within my research, thematic analysis is used to explore, identify, and analyze language patterns respondents use to describe their pedestrian experience. Light interpretation is only used to elicit contextual information needed to understand the narrator's point of view.

Thematic analysis systematically extracts "narrative materials from [personal] stories by breaking the text into relatively small units of content" then submits these for analytical treatment (Vaismoradi et al., 2013, p. 400). As a common qualitative method, thematic analysis interprets results with realist and constructivist paradigms (Braun & Clarke, 2006), which suggest themes arise from reoccurring patterns about the ways respondents interact with others or explain barriers. Vaismoradi et al. (2013) indicate this approach allows researchers to combine analysis of themes with meanings related to "their particular context" (p. 401). The authors further state thematic analysis assumes a factist perspective, where the provided data is "more or less accurate [with] truthful indexes of the reality" being described (p. 401). Therefore, within my study, thematic analysis was operationalized to identify and interpret behaviours and sentiments, as well as the facts used to describe barriers.

My data processing approach closely follows the six thematic analysis steps presented by Braun and Clarke (2006) (See Table 4). Due to the large sample size, I adapted my process to conduct a "distant reading" with Voyant – a free text mining software installed locally – instead of a "close reading" of the data. Distant readings can, as Hendrigan (2019) argues, identify common themes and motifs in descriptive texts.

However, this is not a selective literary analysis that provides a detailed micro-scale view of a few textual descriptions. Instead, distant readings facilitate more macro-scale overviews with large amounts of text (Hendrigan, 2019). Therefore, Voyant offers a means to identify descriptive themes on a macro-scale with large amounts of data, which can then inform more narrowly scoped research in future studies. The process phases used to conduct the thematic analysis are discussed in the following sections.

Table 4. Summary of process phases used within the thematic analysis.

#	Process phase	Key information about the process phase
1.	Explore the textual data	Segment data and conduct a distant reading with the "Summary" tool in Voyant.
2.	Generate initial codes	Use the "Phrases" tool in Voyant to perform and identify inductive codes.
3.	Search for themes	Use the "Collocate" tool in Voyant to identify where codes are represented together throughout the text.
4.	Review and evaluate themes	Use the "Links" tool in Voyant to explore and/or map the relationships observed in process phase 3.
5.	Name and define themes	Analyze and summarize results in Section 4.
6.	Discuss themes	Discuss results in Section 5.

Note: Phases were adapted from Braun and Clarke (2006).

3.4.1 Explore the Textual Data

To process the textual descriptions, the data included in the segment analysis (Section 3.3) was further refined by filtering the data to only include reports from older adults and other underrepresented populations. The inclusion criteria for each of the four segments is as follows:

Segment 1 – Age, Older Adults: Include report if respondent is ≥ 65 years (n = 135)

Segment 2 – Age, Youth: Include report if respondent is ≤17 years (n = 48)

Segment 3 – Gender: Include report if respondent is female or non-binary (n = 496)

Segment 4 – Disability: Include report if respondent is a disabled individual (n = 102)

All report types (incident, hazard and concerns, and missing amenities) were retained within the data for analysis. Note, within Segment 2 – Gender, respondents who identified with "No Response" were excluded from analysis to ensure process rigidity. I then excluded the top five barriers already recorded in the segment analysis. This step was considered important because all demographics (and presumably their perspectives) are captured within the top five reported barriers. Therefore, to capture the perspectives of older adults and underrepresented populations it was essential to review responses from perspectives typically omitted or absent from policy and planning (the outliers) versus those found within the dominant population. Lastly, before uploading data to Voyant, I excluded all categorical values from the data and only retained the textual descriptions for analysis. This was completed to protect the data and respondent anonymity.

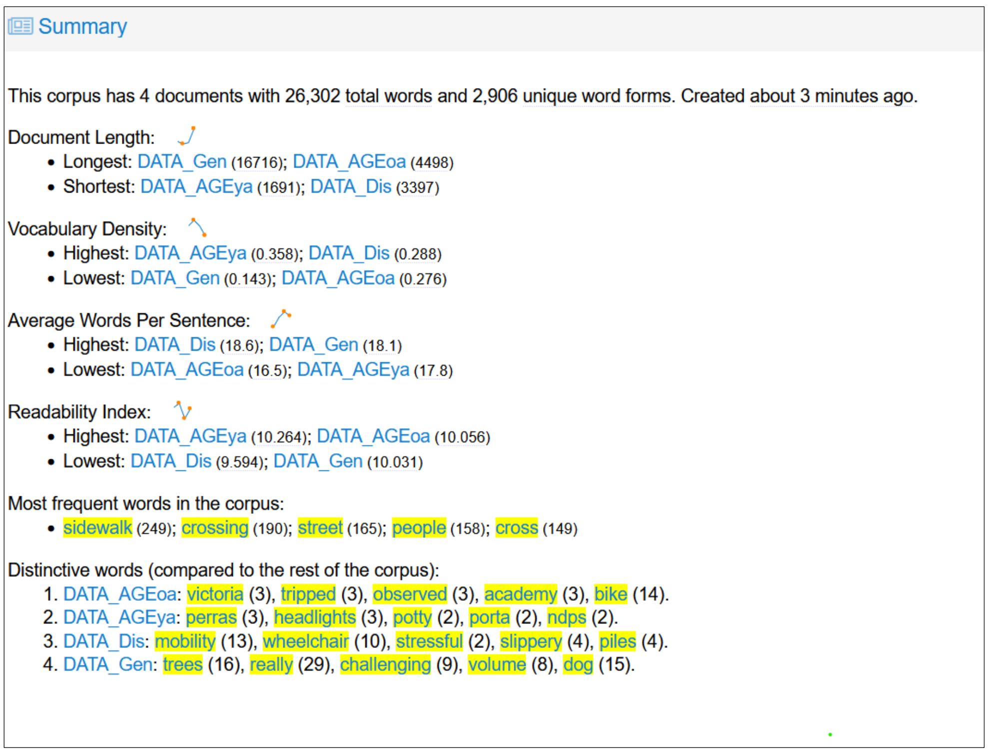
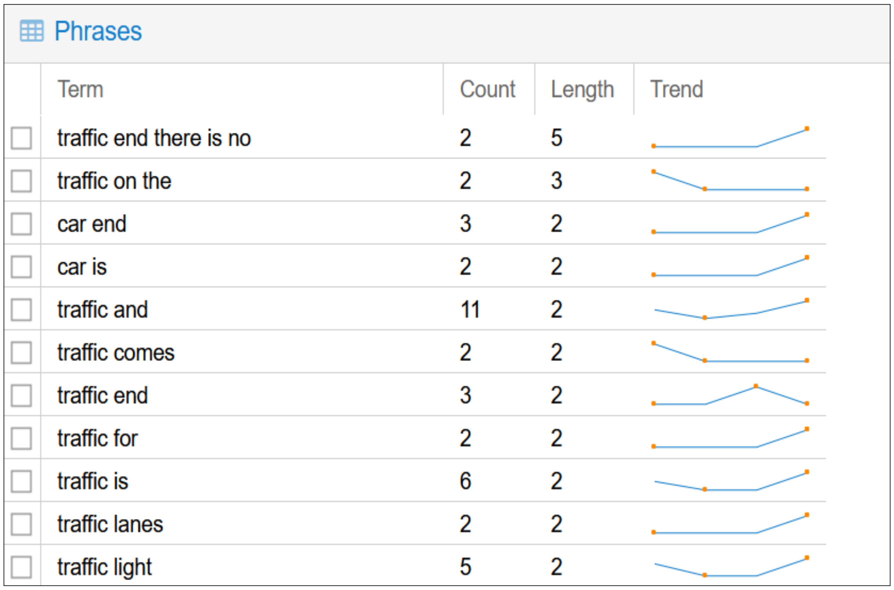


Figure 2. Summary tool in Voyant.

All data segments were uploaded to Voyant to create a corpus – a display of the whole selection of textual descriptions for each segment. In my exploration, I reviewed the data with the summary tool (Figure 2). This tool provides a simple, text-based, overview of the full corpus, including tags of frequently used words throughout the corpus and distinct words occurring within each segment (Voyant, 2024). Tags were expanded to include the 15 most frequently used words (those reflective of behaviours, sentiments, barriers, etc.) across the corpus, and distinctive words from each segment. Stopwords were applied to exclude insignificant words from the analysis. These refer to words that do not carry much meaning and create noisy results (Voyant, 2024). Voyant includes an automated stopword list for prepositions and determiners (the, to, and, etc.) and I added stemming forms of “pedestrian*” and “walk*” because the pedestrian perspective is already assumed within the data. This list was also refined to exclude street names (tr, road, Treanor, Jacque, Orleans, etc.). With a clean of tags, I then explored the most interesting words to help inform the inductive coding in process phase 2.



Phrases

Term	Count	Length	Trend
traffic end there is no	2	5	
traffic on the	2	3	
car end	3	2	
car is	2	2	
traffic and	11	2	
traffic comes	2	2	
traffic end	3	2	
traffic for	2	2	
traffic is	6	2	
traffic lanes	2	2	
traffic light	5	2	

Figure 3. Phrases tool in Voyant.

3.4.2 Generate Initial Codes

Using the phrases tool (Figure 3), I generated and explored data-derived codes for further analysis. Like the summary tool, the phrases tool looks for commonly used sequences of words in the corpus. Through inductive coding, Braun and Clarke (2006) state, data-driven codes help identify data features, like semantic content or latent themes which appear to create interesting patterns. With the codes identified in this way, I was able to filter and organize the data into meaningful groups. These groupings reflected recurrent patterns in identified barriers, behaviors of respondents or other road users, and general pedestrian sentiments. Findings were then used to inform the search for themes in process phase 3.

Collocates

Term	Collocate	Count (context)
vehicle*	turn	14
vehicle*	right	14
traffic	street	13
vehicle*	turning	12
vehicle*	left	12
traffic	lights	12
traffic	heavy	12
vehicle*	street	10
vehicle*	speed	9
vehicle*	high	8
vehicle*	vehicles	7
vehicle*	stop	7
traffic	stop	7

Figure 4. Collocate tool in Voyant.

3.4.3 Search for Themes

The themes that emerged from recurring phrases represent a broad unit of analysis (Braun & Clarke, 2006). Identified themes were then used to respond to the questions and arguments presented in Sections 1 and 2. Using the corpus collocate tool (Figure 4) in Voyant, I further investigated the patterns and trends identified in process phase 2. This tool displays areas where codes and/or common tags may overlap or be represented together in the corpus (Braun & Clarke, 2006; Voyant, 2024). Figure 4 shows how the collocate tool displays the data. Words that occur in proximity to each other can be reviewed and/or evaluated to assess if the interpreted themes fit with the codes identified in process phase 2.

3.4.4 Review and Evaluate Themes

I used the links tool (Figure 5) in Voyant to review and evaluate the themes. This review was required to understand how themes were connected to each other with collocation, and to determine both their relevance and validity to the study. Braun and Clarke (2006) describe this phase as completing two levels of review. In level one, the authors suggest reviewing all coded data and the recurrent patterns to determine if a coherent pattern is appearing. As clear patterns emerged, I moved to level two by considering if the identified themes worked with the argument and question, and if anything appeared to be missing before moving onto process phase 5.

3.4.5 Name and Define Themes

After completing all the above process phases, I moved to analyze the results by summarizing and interpreting the themes and narratives found in the data (Section 4). The results are discussed in Section 5.

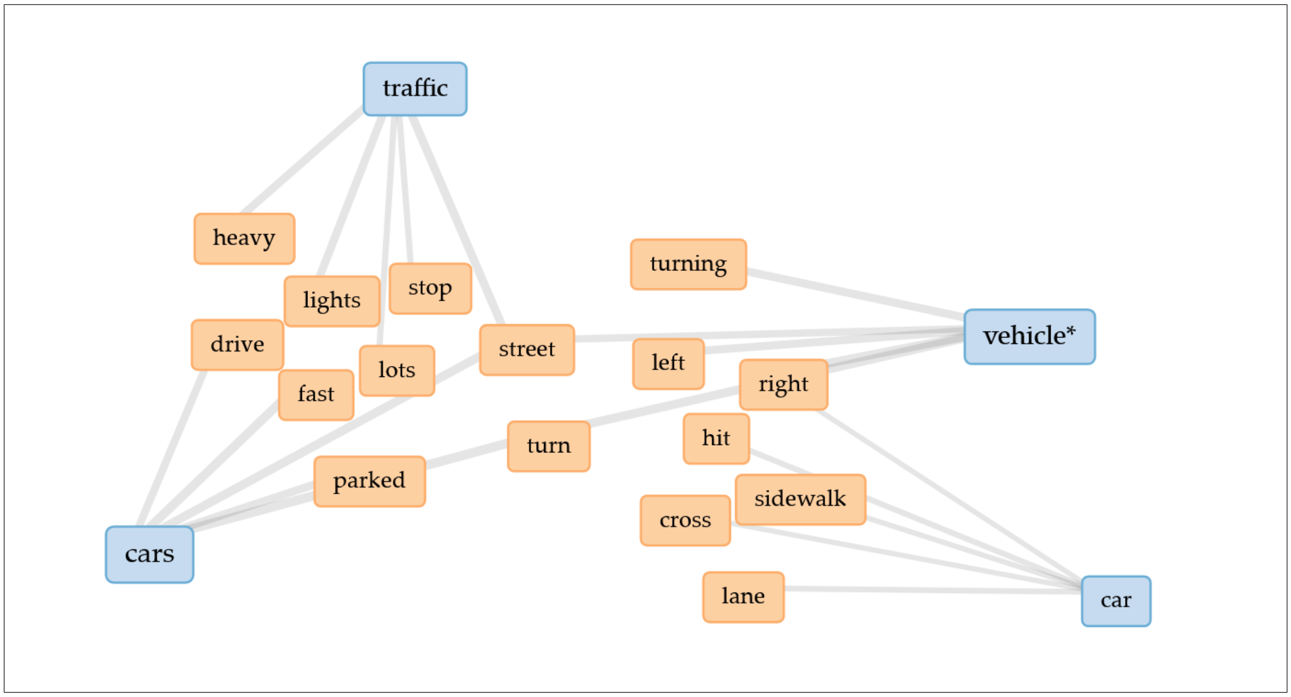


Figure 5. Links tool in Voyant.

4.0 Results

Results are presented in four ways. Bar graphs (Section 4.1) are used to visualize the demographic distribution of all responses by report type (collectively missing amenities, incidents, hazards and concerns). Frequency tables and 100% bar graphs (Sections 4.1 and 4.2) are used to display the number and relative percentage of responses received for each report type. These provide a basis for identifying common barriers and understanding reporting patterns. Responses from each report type were then reviewed independently to understand the specific barriers to pedestrian safety and accessibility reported by gender, age group, and disabled individuals, and to identify any variability in reporting patterns among each demographic segment. Lastly, thematic trends found within report descriptions are presented in Section 4.3.

Table 5. Summary of the demographic characteristics for all WRM respondents.

Demographics Characteristics	n (%)
All	3086 (100)
Age Group	
≤12	45 (1.5)
13-17	119 (3.9)
18-24	314 (10.2)
25-34	641 (20.8)
35-44	912 (29.6)
45-54	385 (12.5)
55-64	309 (10)
65-74	232 (7.5)
75+	129 (4.2)
Gender	
Men	1103 (35.7)
No Response	542 (17.6)
Non-Binary	42 (1.4)
Women	1399 (45.3)
(Dis)ability Status and Type	
Disabled	229 (7.4)
Cognitive	33 (14.4)
Hearing	8 (3.5)
Mobility	145 (63.3)
No Response	13 (5.7)
Other	24 (10.5)
Visual	6 (2.6)
Non-disabled	2857 (92.6)

4.1 Demographic Characteristics

Table 5 shows the demographic characteristics for all WRM respondents included in this study. Canadian population distribution data is used as a point of comparison to analyze the WRM data. Respondents aged 25-44 years (n = 1553) represent roughly 50% of all WRM respondents, compared to 27% of the Canadian population (Figure 6). Whereas the most vulnerable age groups (older adults aged 65 years and older), account for approximately 11% of WRM respondents, compared to approximately 20% of the Canadian population.

Women account for almost half (n = 1399) of all WRM respondents, whereas men represent roughly 35% (n = 1103) of respondents, 17.6% (n = 542) of respondents chose not to identify their gender, and 1.4% (n

= 42) of respondents identify as non-binary. Approximately 7% (n = 299) of all respondents identified as disabled individuals. Of these respondents, over 60% (n = 145) of disabled individuals identified they have mobility impairments, and about 15% (n = 33) expressed they have cognitive impairments. This is the largest notable gap, as a recent Canadian survey on disability reports 27% of Canadian adults are living with a disability (Statistics Canada, 2024).

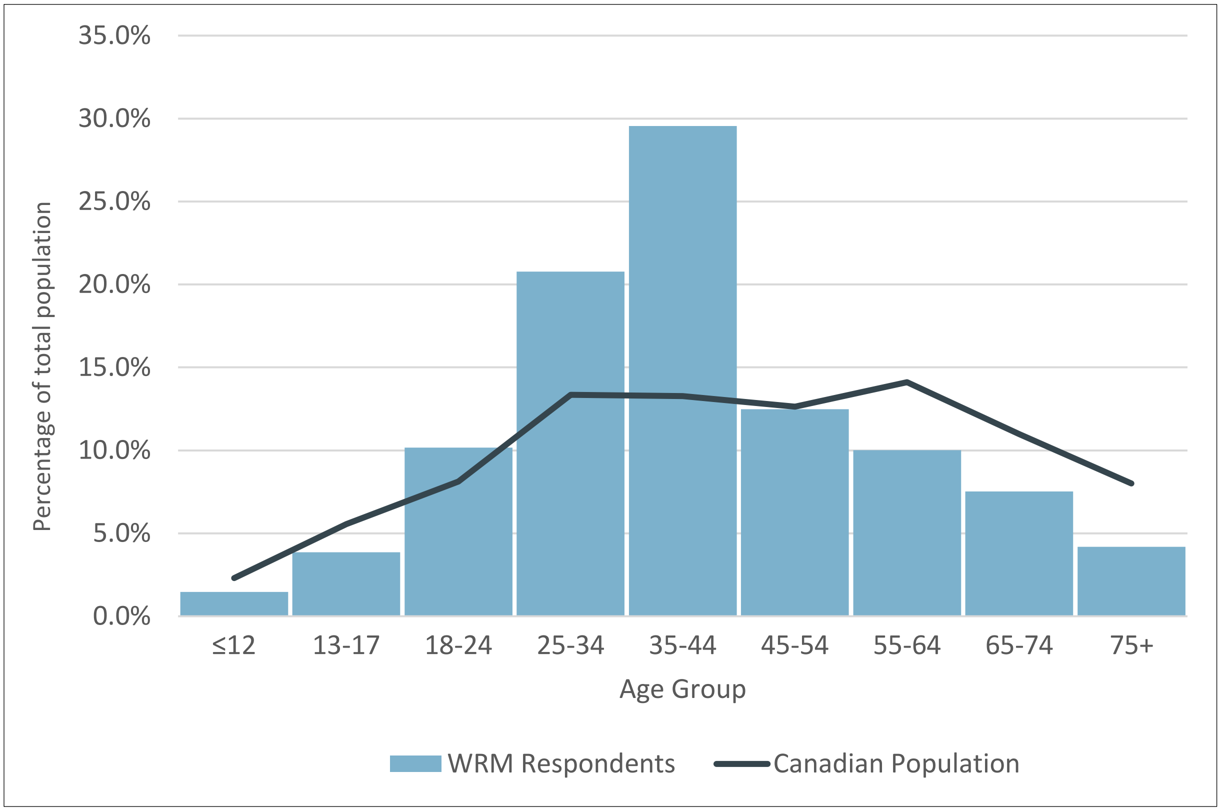


Figure 6. WRM contributions compared to the Canadian population distribution.

Figure 7 provides a visual summary of the demographic characteristics of WRM respondents, these are represented as a percentage of all reports received during the study period (n ÷ 3086). Similar age distributions are displayed in all report types (Figure 7A). Respondents between 35-44 years contributed the most data for each report type and represent the peak of the data distribution. Whereas, again, data availability declines for older adults for all report types.

Men and women (Figure 7B) responded in comparative ways to both the missing amenities and incident reports, but women represent a higher overall percentage of respondents for hazard and concern reports. Similarly, looking only at reports from disabled individuals, it is clear most issues with pedestrian safety and accessibility were identified using the hazards and concerns report (Figure 7C). When accounting for types of disabilities, respondents with mobility impairments represent the peak of the data distribution for all report types.

4.2 Commonly Reported Barriers

Results from the segment analysis are discussed in the following sections. A summary of responses for each report type is provided, followed by a separate discussion of the most frequently reported responses observed for each demographic segment (gender, age, disability type). A full table of responses for each demographic segment is available in Appendix C.

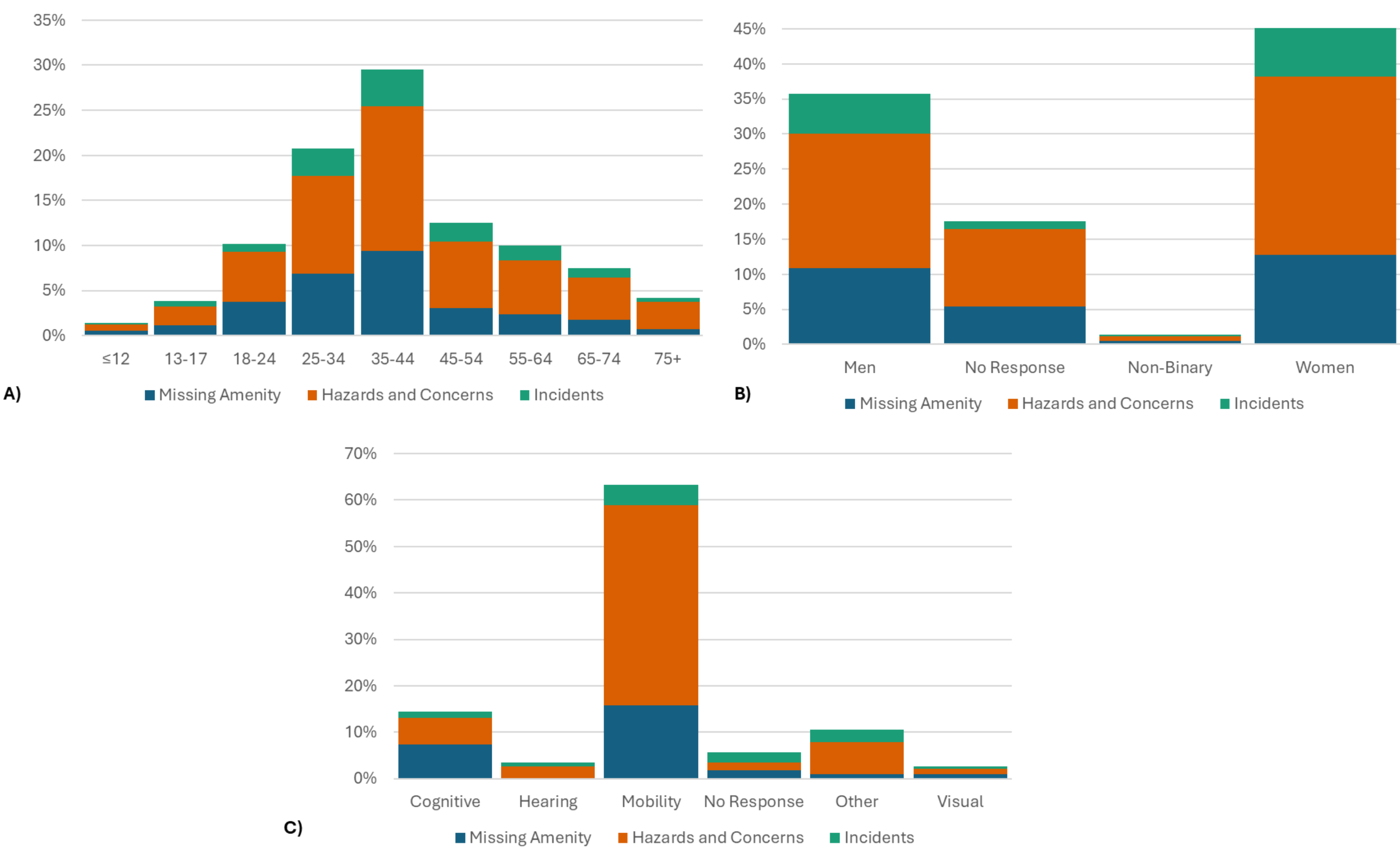


Figure 7. The distribution of demographic characteristics from each report type.

4.2.1 Missing Amenity Reports

Table 6. Summary of all Missing Amenity reports submitted during the study period.

Missing Amenity	**n (%)**
Access to Transit Stop	6 (0.7)
Audible	2 (0.2)
Benches	33 (3.6)
Connections (Cut-Through Needed)	32 (3.5)
Curb Cut	27 (3)
Lighting or Additional Lighting	48 (5.3)
Marked Crosswalk	201 (22.1)
Other	61 (6.7)
Shade in Summer	14 (1.5)
Sidewalk	371 (40.7)
Stop Sign	25 (2.7)
Traffic or Pedestrian Signal	57 (6.3)
Transit	1 (0.1)
Washroom	12 (1.3)
Water Fountain	2 (0.2)
Wayfinding Signs	19 (2.1)
All Responses	**911 (100)**

Table 6 shows a summary of missing amenity reports submitted by respondents during the study period. "Missing Amenity" denotes the specific type of environmental characteristic respondents suggested they needed to feel safe and comfortable or to complete their journey as pedestrians. The top five types of missing amenities identified by respondents were selected for further review of possible demographic variability.

Missing sidewalks (40.7%, n = 371) was the most reported barrier to pedestrian mobility within the missing amenity report. This was followed by respondents identifying the need for marked crosswalks (22.1%, n = 201), traffic and/or pedestrian signals (6.3%, n = 57), adequate lighting (5.3%, n = 48), and benches (3.6%, n = 33). It should be noted, respondents identified the need for “Other” amenities in roughly 7% (n = 61) of missing amenity reports. Common themes from “Other” report descriptions suggest traffic calming devices (speed bumps), accessibility features (ramps where only stairs exist), and winter maintenance can significantly improve pedestrian safety and accessibility.

Table 7. Summary of the top five missing amenities reported by gender.

Gender	Men n (%)	No Response n (%)	Non-Binary n (%)	Women n (%)	All Responses n (%)
Missing Amenity					
Benches	12 (4.7)	6 (4.8)	2 (15.4)	13 (4.2)	33 (4.6)
Lighting or Additional Lighting	9 (3.5)	23 (18.3)		16 (5.1)	48 (6.8)
Marked Crosswalk	85 (32.9)	32 (25.4)	5 (38.5)	79 (25.2)	201 (28.3)
Sidewalk	133 (51.6)	51 (40.5)	5 (38.5)	182 (58.1)	371 (52.3)
Traffic or Pedestrian Signal	19 (7.4)	14 (11.1)	1 (7.7)	23 (7.3)	57 (8)
Total Responses within Group	**258 (100)**	**126 (100)**	**13 (100)**	**313 (100)**	**710 (100)**

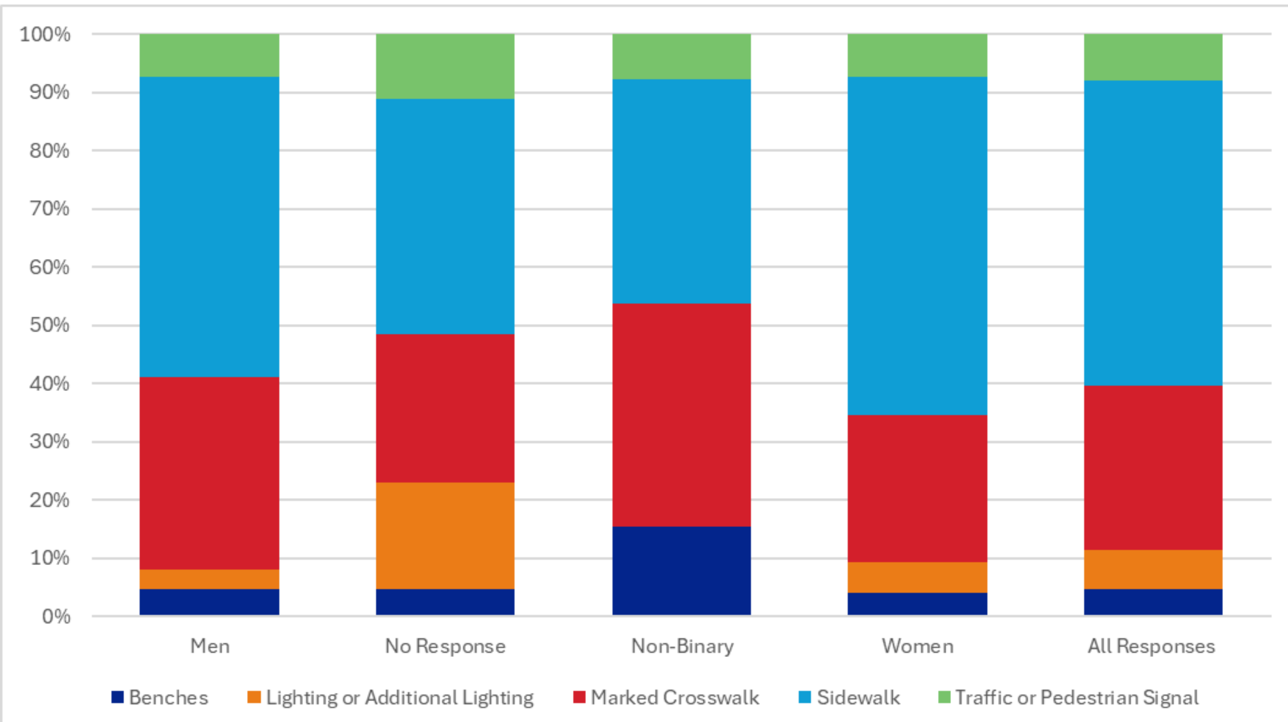


Figure 8. A visual summary of the top five missing amenities reported by gender.

Missing Amenities Reported by Gender

Table 7 shows a breakdown of the top five missing amenities by gender. The distribution of these results is further visualized in Figure 8. A clear need for sidewalks is identified across all gender groups: nearly 60% of women (n = 182) reported missing sidewalks, compared to 51.6% of men (n = 133), 40.5% (n = 51) of respondents who did not identify their gender, and 38.5% (n = 5) of non-binary respondents. Due to the relatively small sample size for non-binary respondents, it is difficult to measure or determine the scale of these concerns.

Other notable demographic variability is seen in reports identifying a need for marked crosswalks. Both men (32.9%, n = 85) and non-binary respondents (38.5%, n = 5) reported missing marked crosswalks at slightly higher rates than women (25.2%, n = 79) and respondents who did not identify their gender (25.4%, n = 32).

Missing Amenities Reported by Age

Table 8 shows a breakdown of the top five missing amenities by age. The distribution of these results is further visualized in Figure 9. Significant variability is observed in how each age group reported missing amenities. While sidewalks, again, are identified as the primary concern when considering age. 64.9% (n = 50) of respondents within the 45-54-year group reported issues with missing sidewalks, compared to other age groups where missing sidewalks account for approximately half of responses within these age groups. A notable exception is the 75 years and older group (29.4%, n = 50), where missing crosswalks, rather than missing sidewalks, are identified as the top barrier.

Additionally, notable demographic shifts are seen in reporting patterns for traffic and/or pedestrian signals, benches, and additional lighting. Reports for traffic and/or pedestrians signals are seen at higher rates from respondents within the 13-17 years group, representing 21.4% (n = 6). Comparatively, the need for traffic signals is reported within less than 10% of responses from other age groups. Missing benches are reported at higher rates by respondents 12 years and younger (18.2, n = 2), 18-24 years (12.2%, n = 10), 65-74 years (9.8%, n = 4), and 75 years and older (17.6%, n = 3). The need for additional lighting is notably highest among respondents 18-24 years, with 22% (n = 18) identifying it as a concern. However, the scale of these issues is hard to discern with relatively small sample sizes for respondents 12 years and younger, 13-17 years, and 75 years and older.

Missing Amenities Reported by Disabled and Non-Disabled Individuals

Table 9 shows the top five missing amenities identified by disabled individuals. This demographic segment is compared to the total responses from non-disabled respondents. Figure 10 provides a visual summary of how responses vary by disability types.

The "Mobility" group represents the largest sample size within this segment (n = 27) and contains the most complete data. There is little discernible variability in how individuals with mobility impairments reported barriers with missing amenities compared to non-disabled individuals. One exception, however, is seen in 22.2% (n = 6) of respondents with mobility impairments identifying missing traffic or pedestrian signals as a barrier to pedestrian safety and accessibility, compared to 7.6% (n = 51) of non-disabled respondents.

Additionally, respondents with cognitive impairments (45.5%, n = 5) identified intersections without marked crosswalks as create disabling environments at a higher rate than all other disabled (32.6%, n = 14) and non-disabled individuals (28%, n = 187).

Note, due to incomplete data and small sample sizes it is difficult to measure how all disabled individuals are impacted by missing amenities. More data is needed to determine how individuals with “Visual” or “Other” impairments navigate pedestrian environments which lack specific amenities.

Table 8. Summary of the top five missing amenities reported by age.

Age Group	≤ 12 n (%)	13-17 n (%)	18-24 n (%)	25-34 n (%)	35-44 n (%)	45-54 n (%)	55-64 n (%)	65-74 n (%)	75+ n (%)	All Responses n (%)
Missing Amenity										
Benches	2 (18.2)		10 (12.2)	8 (4.6)	2 (0.9)	2 (2.6)	2 (3.7)	4 (9.8)	3 (17.6)	33 (4.6)
Lighting or Additional Lighting		1 (3.6)	18 (22)	13 (7.4)	5 (2.2)	5 (6.5)	5 (9.3)	1 (2.4)		48 (6.8)
Marked Crosswalk	4 (36.4)	10 (35.7)	13 (15.9)	49 (28)	77 (34.2)	14 (18.2)	13 (24.1)	12 (29.3)	9 (52.9)	201 (28.3)
Sidewalk	4 (36.4)	11 (39.3)	34 (41.5)	90 (51.4)	122 (54.2)	50 (64.9)	33 (61.1)	22 (53.7)	5 (29.4)	371 (52.3)
Traffic or Pedestrian Signal	1 (9.1)	6 (21.4)	7 (8.5)	15 (8.6)	19 (8.4)	6 (7.8)	1 (1.9)	2 (4.9)		57 (8)
Total Responses within Group	**11 (100)**	**28 (100)**	**82 (100)**	**175 (100)**	**225 (100)**	**77 (100)**	**54 (100)**	**41 (100)**	**17 (100)**	**710 (100)**

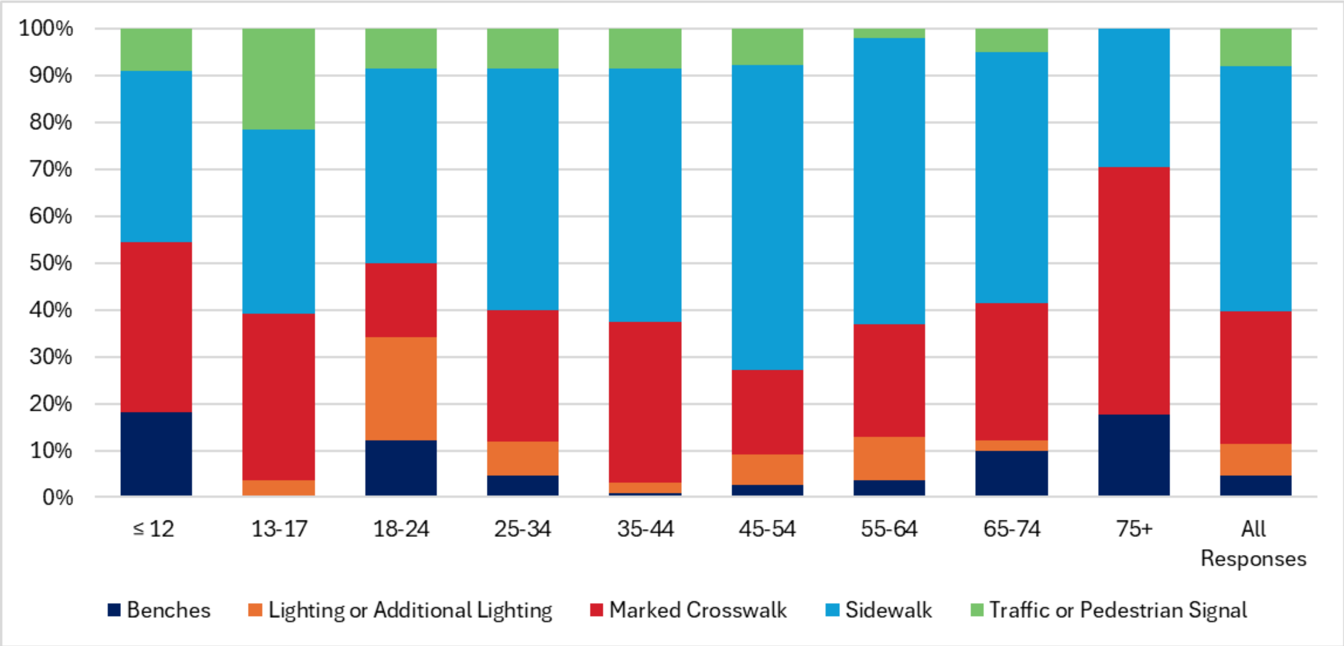


Figure 9. A visual summary of the top five missing amenities reported by age.

Table 9. Summary of the top five missing amenities reported by disabled and non-disabled individuals.

Disability Type	Cognitive n (%)	Mobility n (%)	No Response n (%)	Other n (%)	Visual n (%)	All Responses from Disabled Individuals n (%)	All Responses from Non-Disabled Individuals n (%)
Missing Amenity							
Benches							33 (4.9)
Lighting or Additional Lighting		2 (7.4)				2 (4.7)	46 (6.9)
Marked Crosswalk	5 (45.5)	7 (25.9)	1 (33.3)		1 (100)	14 (32.6)	187 (28)
Sidewalk	6 (54.5)	12 (44.4)	2 (66.7)	1 (100)		21 (48.8)	350 (52.5)
Traffic or Pedestrian Signal		6 (22.2)				6 (14)	51 (7.6)
Total Responses within Group	**11 (100)**	**27 (100)**	**3 (100)**	**1 (100)**	**1 (100)**	**43 (100)**	**667 (100)**

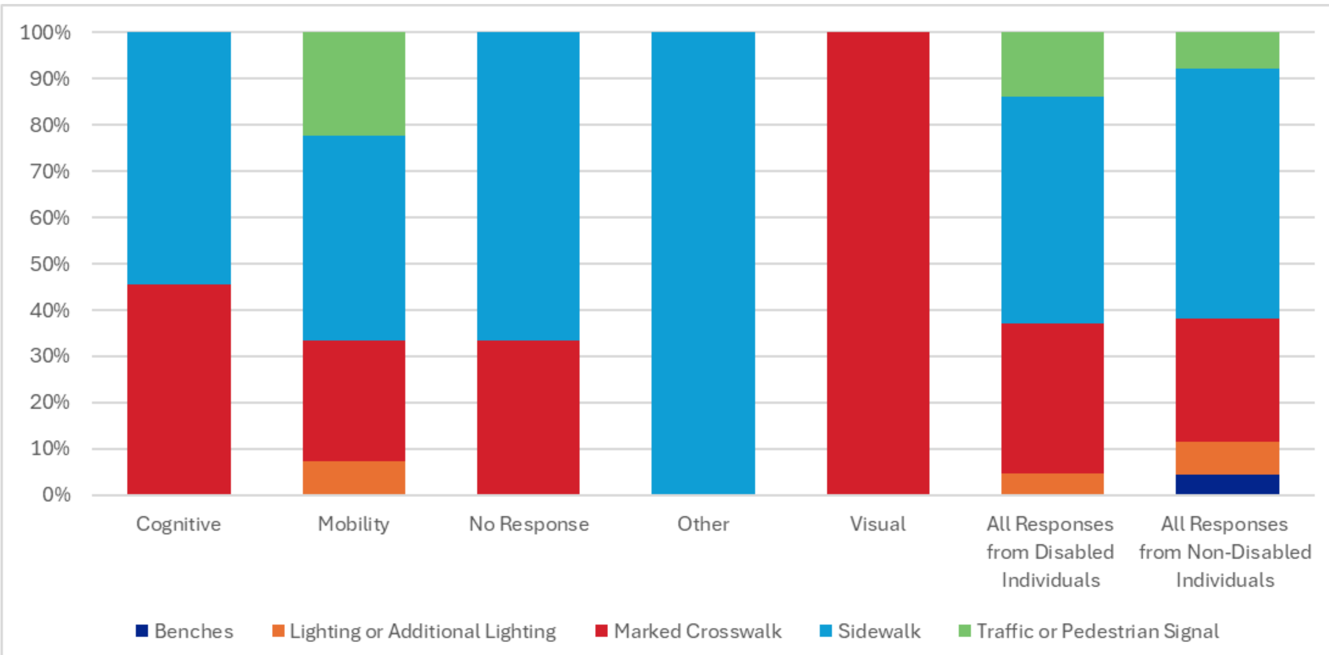


Figure 10. A visual summary of the top five missing amenities reported by disabled and non-disabled individuals.

4.2.2 Incident Reports

Table 10 shows a summary of incident reports submitted by respondents during the study period. The "Incident type" (Fall, Hit, Near Miss) and the corresponding sub-type denote the outcome of a conflict with another road user and the contributing conditions. The top five incidents reported from the entire dataset (n = 434) were selected for further investigation of demographic trends.

Table 10. Summary of all incident reports submitted during the study period.

Incident Type	n (%)
Fall	
Other	2 (0.5)
Slipped	7 (1.6)
Tripped	3 (0.7)
Hit By	
Animal - Dog	2 (0.5)
Cyclist	2 (0.5)
Other	4 (0.9)
Vehicle From Behind	5 (1.2)
Vehicle Turning Head-on	48 (11.1)
Vehicle Turning Left	24 (5.5)
Vehicle Turning Right	8 (1.8)
Vehicle Turning Right on Red	1 (0.2)
Near Miss	
Animal - Dog	1 (0.2)
Cyclist	6 (1.4)
Other	10 (2.3)
Vehicle From Behind	16 (3.7)
Vehicle Turning Head-on	132 (30.4)
Vehicle Turning Left	78 (18)
Vehicle Turning Right	72 (16.6)
Vehicle Turning Right on Red	13 (3)
All Responses	**434 (100)**

Near misses account for approximately 75% (n = 328) of incident reports, where 30.4% (n = 132) of respondents identified near misses with vehicles turning head-on as a key threat to pedestrian safety. This was followed by 18% (n = 78) of respondents reporting near misses with vehicles turning left and 16.6% (n = 72) with vehicles turning right. Additionally, 11.1% (n = 48) of respondents were hit by vehicles turning head-on and 5.5% (n = 24) by vehicles turning left. Overall, respondents identified threats from vehicles in over 90% of incident reports. Demographic segmentation of the top five incident types is reviewed in the following section.

Incidents Reported by Gender

Table 11 shows the top reported incident types by gender. The distribution of these results is further visualized in Figure 11. Generally, there is agreement about the types of conflicts each gender experiences with vehicles. However, two notable exceptions include 41.6% (n = 77) of women and 40% (n = 2) of non-binary respondents who reported near misses with vehicles turning head-on.

Table 11. Summary of the top five incident types reported by gender.

Gender	Men n (%)	No Response n (%)	Non-Binary n (%)	Women n (%)	All Responses n (%)
Incident Type					
Hit By					
Vehicle Turning Head-on	22 (15.7)	6 (25)	1 (20)	19 (10.3)	48 (13.6)
Vehicle Turning Left	11 (7.9)	1 (4.2)		12 (6.5)	24 (6.8)
Near Miss					
Vehicle Turning Head-on	45 (32.1)	8 (33.3)	2 (40)	77 (41.6)	132 (37.3)
Vehicle Turning Left	33 (23.6)	3 (12.5)		42 (22.7)	78 (22)
Vehicle Turning Right	29 (20.7)	6 (25)	2 (40)	35 (18.9)	72 (20.3)
Total Responses within Groups	**140 (100)**	**24 (100)**	**5 (100)**	**185 (100)**	**354 (100)**

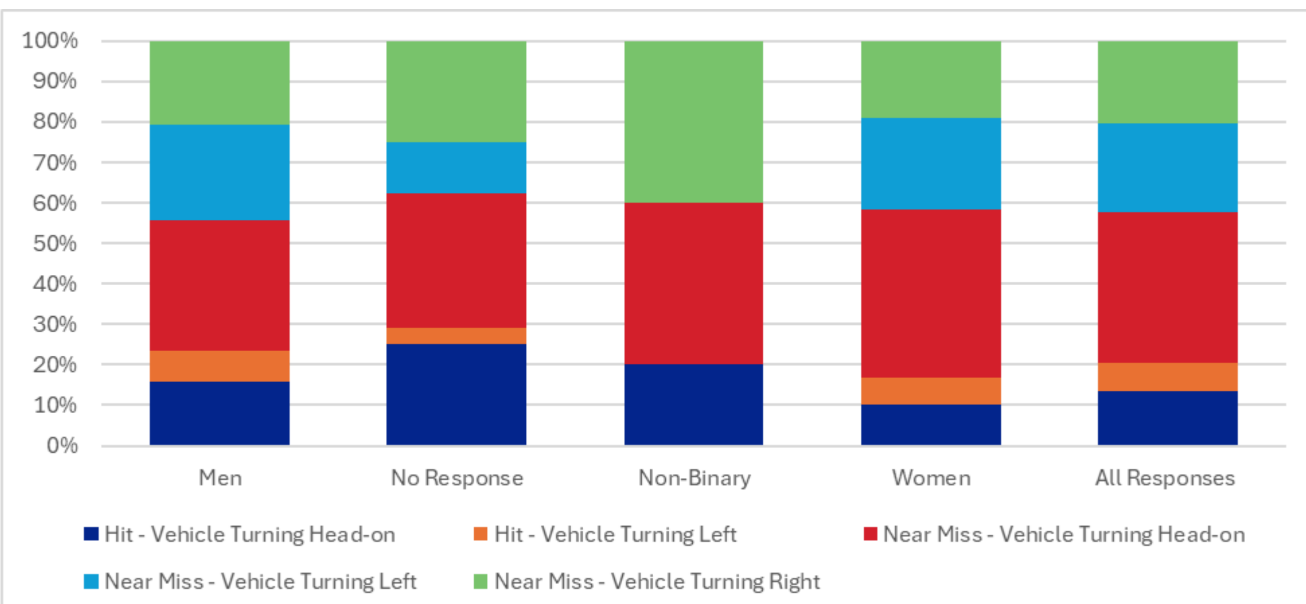


Figure 11. A visual summary of the top five incident types reported by gender.

Incidents Reported by Age

Table 12 and Figure 12 show a breakdown of the top five incidents reported by age. There is significant variability in the reported barriers within each age group compared to the whole dataset. Near misses with vehicles turning head-on account for 37.3% (n = 132) of all responses. However, nearly half of the respondents aged 18-24 years (n = 9) and 35-44 years (n = 51) reported such near misses. Similarly, hits from the same direction were reported in higher relative percentages by respondents aged 12 years or younger (80%, n = 4), 13-17 years (29.4%, n = 4), and 18-24 years (21.1%, n = 4). However, due to small sample sizes in these age groups (n < 30), it is difficult to discern the scale of this issue.

There are also notable shifts in reporting patterns for incidents with vehicles turning left. Respondents 75 years and older reported relatively higher rates of near misses (45.5%, n = 5) and hits (27.3%, n = 3) with vehicles turning left compared to other age groups.

Incidents Reported by Disabled and Non-Disabled Individuals

Table 13 and Figure 13 show the top incidents identified by disabled individuals. There is relative agreement between the types of incidents disabled and non-disabled individuals experience. However, the scale of variability seen within responses by disability types is difficult to determine due to the relatively small sample size.

Table 12. Summary of the top five incidents reported by age.

Age Group	≤ 12 n (%)	13-17 n (%)	18-24 n (%)	25-34 n (%)	35-44 n (%)	45-54 n (%)	55-64 n (%)	65-74 n (%)	75+ n (%)	All Responses n (%)
Incident Type										
Hit By										
Vehicle Turning Head-on	4 (80)	5 (29.4)	4 (21.1)	8 (10.3)	7 (6.5)	10 (19.6)	6 (15.4)	2 (7.7)	2 (18.2)	48 (13.6)
Vehicle Turning Left			3 (15.8)	4 (5.1)	4 (3.7)	3 (5.9)	3 (7.7)	4 (15.4)	3 (27.3)	24 (6.8)
Near Miss										
Vehicle Turning Head-on	1 (20)	5 (29.4)	9 (47.4)	25 (32.1)	51 (47.2)	21 (41.2)	10 (25.6)	10 (38.5)		132 (37.3)
Vehicle Turning Left		3 (17.6)	1 (5.3)	23 (29.5)	20 (18.5)	9 (17.6)	12 (30.8)	5 (19.2)	5 (45.5)	78 (22)
Vehicle Turning Right		4 (23.5)	2 (10.5)	18 (23.1)	26 (24.1)	8 (15.7)	8 (20.5)	5 (19.2)	1 (9.1)	72 (20.3)
Total Responses within Groups	**5 (100)**	**17 (100)**	**19 (100)**	**78 (100)**	**108 (100)**	**51 (100)**	**39 (100)**	**26 (100)**	**11 (100)**	**354 (100)**

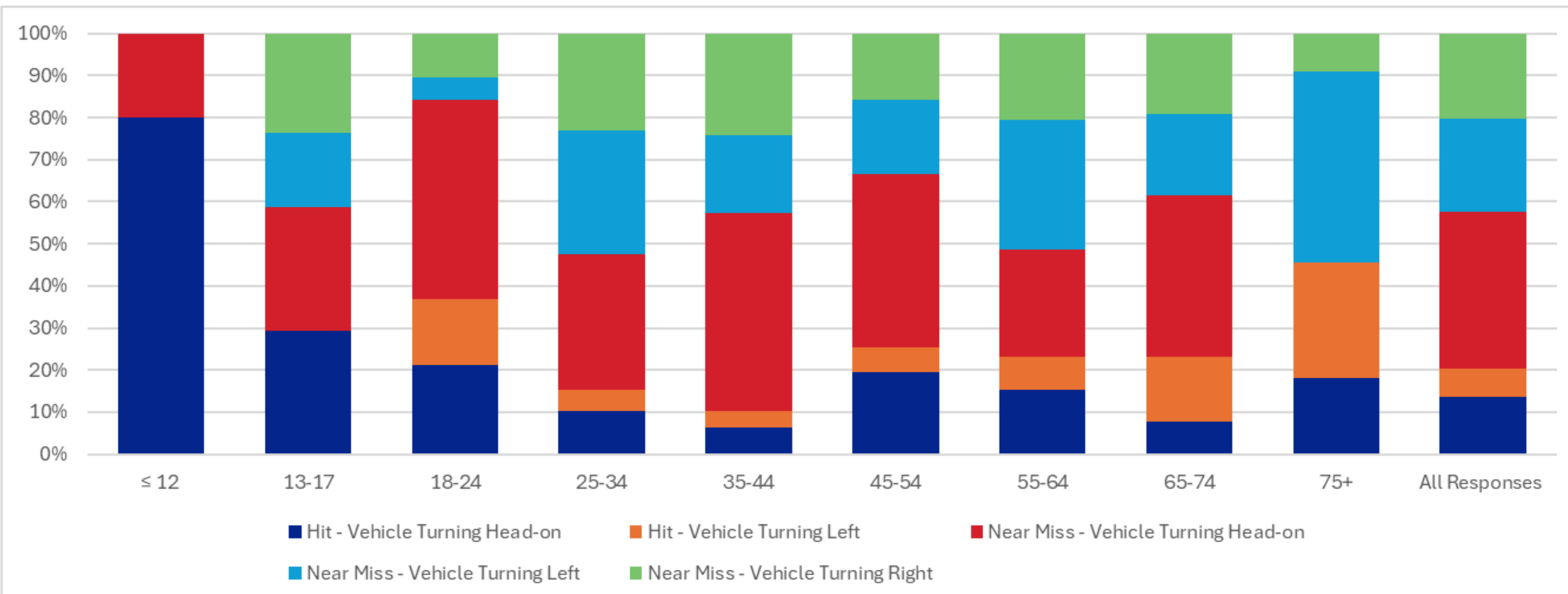


Figure 12. A visual summary of the incidents reported by age.

Table 13. Summary of the top five incidents reported by disabled and non-disabled individuals.

Disability Type	Cognitive	Hearing	Mobility	No Response	Other	Visual	All Responses from Disabled Individuals	All Responses from Non-Disabled Individuals
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Incident Type								
Hit By								
Vehicle Turning Head-On				1 (25)			1 (5)	47 (14.1)
Vehicle Turning Left						1 (100)	1 (5)	23 (6.9)
Near Miss								
Vehicle Turning Head-On	1 (50)	1 (50)	4 (57.1)	1 (25)	1 (25)		8 (40)	124 (37.1)
Vehicle Turning Left			2 (28.6)	1 (25)	2 (50)		5 (25)	73 (21.9)
Vehicle Turning Right	1 (50)	1 (50)	1 (14.3)	1 (25)	1 (25)		5 (25)	67 (20.1)
Total Responses within Groups	**2 (100)**	**2 (100)**	**7 (100)**	**4 (100)**	**4 (100)**	**1 (100)**	**20 (100)**	**334 (100)**

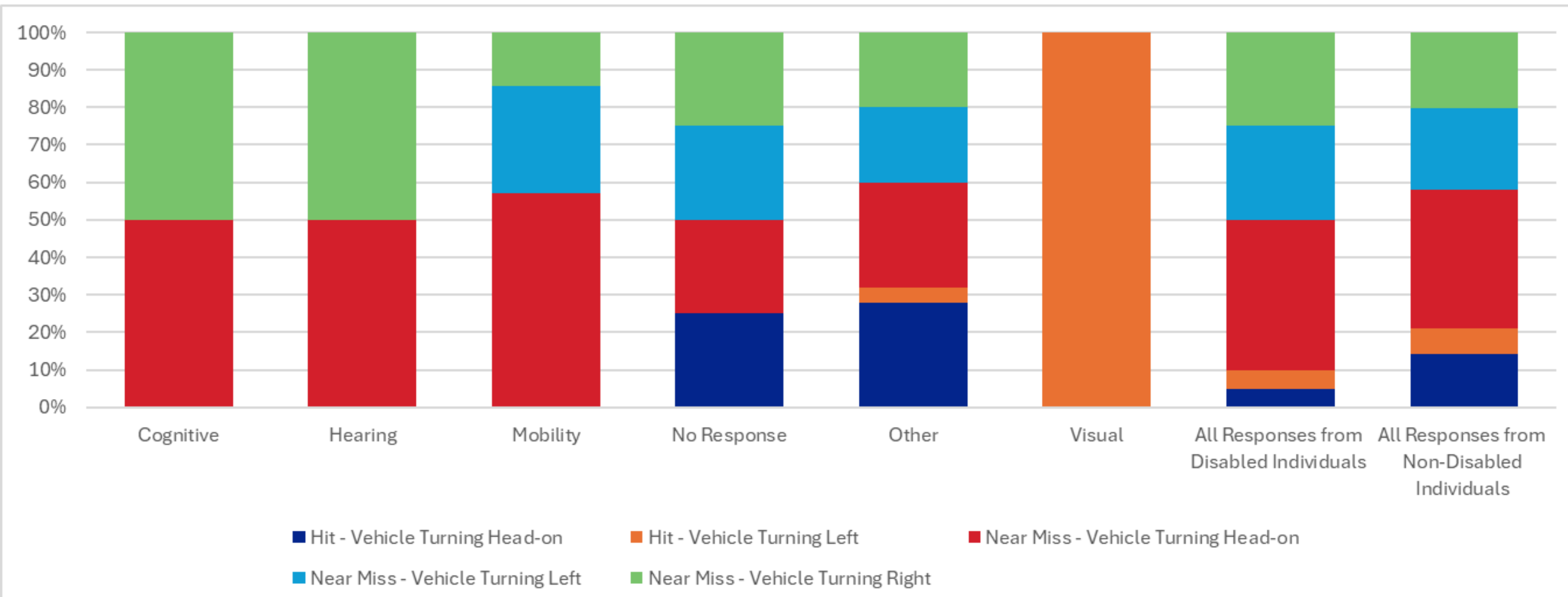


Figure 13. A visual summary of the top five incidents reported by disabled and non-disabled individuals.

4.2.3 Hazard and Concern Reports

Table 14. Summary of all hazard and concern reports submitted during the study period.

Hazard and Concern Type	n (%)
Crossing Issue	
Conflict With Vehicles Turning Left	37 (2.1)
Conflict With Vehicles Turning Right	33 (1.9)
Conflict With Vehicles Turning Right - On Red	14 (0.8)
Crosswalk Markings No Longer Visible	13 (0.7)
Crosswalk Needed	113 (6.5)
Drivers Don't Stop or Yield	304 (17.5)
Other	75 (4.3)
Poor Visibility of Pedestrians	69 (4)
Signal - Button Difficult to Access	8 (0.5)
Signal - Needs an Audible	5 (0.3)
Signal - Pedestrian Interval Too Short	45 (2.6)
Signal - Wait Time to Cross Too Long	35 (2)
Safety/Comfort Concern	
Animal - Dog	8 (0.5)
Other	131 (7.5)
Other Users - Bicycle	28 (1.6)
Other Users - E-Scooters	1 (0.1)
Other Users - Mobility Scooters/Electric Wheelchairs	5 (0.3)
Personal Safety - Gathering of Unknown People	8 (0.5)
Personal Safety - Harassment or Unwanted Attention	7 (0.4)
Personal Safety - Inadequate Lighting	23 (1.3)
Personal Safety - Isolated	3 (0.2)
Vehicles - Number	59 (3.4)
Vehicles - Speed	256 (14.7)
Sidewalk Infrastructure Issue	
Missing Curb Cut	18 (1)
Obstruction - Bike Rack (Including Bikeshare)	1 (0.1)
Obstruction - Bollard	2 (0.1)
Obstruction - Bus Shelter	2 (0.1)
Obstruction - Garbage or Recycling Bins	5 (0.3)
Obstruction - Inadequate or Lack of Safe Detour for Pedestrians	30 (1.7)
Obstruction - Parked E-Scooters/Bicycles	2 (0.1)
Obstruction - Parked Vehicles or Delivery Vans	15 (0.9)
Obstruction - Pole (Hydro, Telephone)	17 (1)
Obstruction - Sign Blocking Path	4 (0.2)
Obstruction - Uneven Sidewalk Roots, Holes, Cracks)	110 (6.3)
Obstruction - Vegetation Narrows Pathway	25 (1.4)
Other	72 (4.1)
Slope Issues (Driveways)	12 (0.7)
Too Narrow	45 (2.6)
Uncomfortable Service (For Wheelchairs, Etc.)	21 (1.2)
Weather-related or Seasonal	
Ice	14 (0.8)
Leaves	2 (0.1)
Other	7 (0.4)
Puddles, Flooding, Splash Zone	6 (0.3)
Snow	51 (2.9)
All Responses	**1741 (100)**

Table 14 shows a summary of hazard and concern reports (n = 1741) submitted by respondents during the study period. The "Hazards and Concerns Type" is organized into four categories, including crossing issues, safety and/or comfort concerns, sidewalk infrastructure issues, and weather-related or seasonal concerns. The corresponding sub-type denotes specific environmental conditions that present and/or create barriers.

Crossing issues account for approximately 43% (n = 751) of the hazard and concerns dataset, with 17.5% (n = 304) of all respondents identifying issues with drivers who failed to stop or yield to pedestrian rights-of-way. Additionally, 6.5% (n = 113) of respondents identified concerns with missing crosswalks. Roughly 30% (n = 529) of respondents reported concerns relating to their sense of personal safety and/or comfort, with 14.7% (n = 256) stating vehicle speeds significantly detracted from their ability to feel welcome or prioritized in space. "Other" concerns reported by 7.5% (n = 131) of respondents included poor visibility (due to vegetation, intersection design, etc.), litter or broken glass, and vehicles not adhering to traffic regulations (red light violations, failure to stop at signs, etc.). Lastly, hazards presented by sidewalk infrastructure were identified by over 21% (n = 381) of respondents, with 6.3% (n = 110) of respondents reporting obstructions due to uneven sidewalks (roots, holes, or cracks creating discontinuous, unlevel, or split surfaces in a sidewalk). The concerns discussed here represent the top five identified within the dataset. How each demographic segmentation responded to them is discussed in the following sections**.**

Hazards and Concerns Reported by Gender

Table 15 and Figure 14 show a breakdown of the top five hazards and concerns reported by gender. Men and women identified concerns at similar rates. For example, 36% (n = 112) of men and 34.1% (n = 139) of women reported issues with drivers failing to yield. In contrast, respondents who chose not to identify their gender (27.2%, n = 50) or identified as non-binary (27.3%, n = 3) reported fewer problems with drivers failing to yield but significantly more problems with vehicle speeds (39.7%, n = 73 and 45.5%, n = 5, respectively) compared to men (25.7%, n = 80) and women (24%, n = 98).

Table 15. Summary of the top five hazards and concerns reported by gender.

Gender	Men n (%)	No Response n (%)	Non-Binary n (%)	Women n (%)	All Responses n (%)
Hazard and Concern Type					
Crossing Issue					
Crosswalk Needed	50 (16.1)	18 (9.8)		45 (11)	113 (12.4)
Drivers Don't Stop or Yield	112 (36)	50 (27.2)	3 (27.3)	139 (34.1)	304 (33.3)
Safety/Comfort Concern					
Other	37 (11.9)	32 (17.4)	1 (9.1)	61 (15)	131 (14.3)
Vehicles - Speed	80 (25.7)	73 (39.7)	5 (45.5)	98 (24)	256 (28)
Sidewalk Infrastructure Issue					
Obstruction - Uneven Sidewalk	32 (10.3)	11 (6)	2 (18.2)	65 (15.9)	110 (12)
Total Responses within Groups	**311 (100)**	**184 (100)**	**11 (100)**	**408 (100)**	**914 (100)**

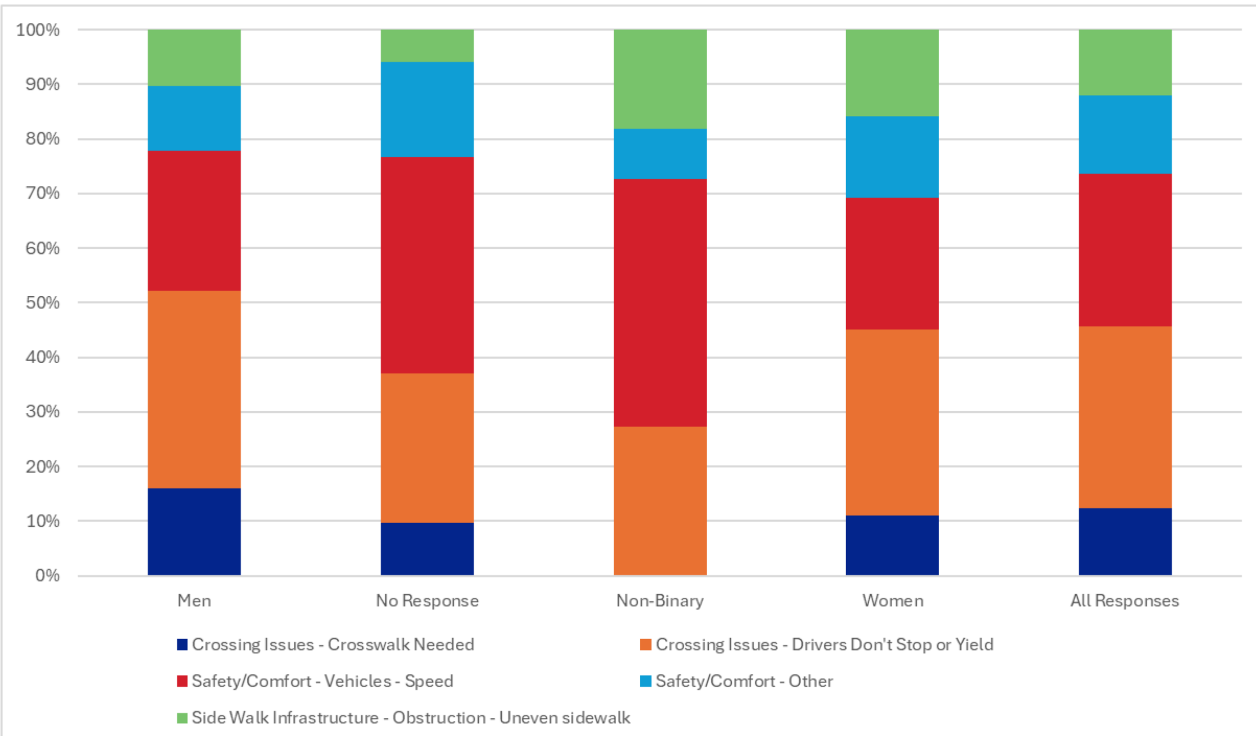


Figure 14. A visual summary of the top five hazards and concerns reported by gender.

Hazards and Concerns Reported by Age

Table 16 and Figure 15 show a breakdown of the top five hazards and concerns reported by age. There is significant variability in the reported barriers within each age group compared to the whole dataset. Situations where drivers fail to stop or yield for pedestrians are generally agreed to be a top concern. However, vehicle speeds were the top concern for respondents aged 12 years and younger (46.2%, n = 6) and 75 years and older (58.8%, n = 30), whereas uneven sidewalks were the top concern for respondents aged 18-24 years (42.4, n = 39).

Hazards and Concerns by Disabled and Non-Disabled Individuals

Hazard and concern reports from disabled individuals provide the most complete information and the largest sample size compared to other datasets in this segment. Table 17 and Figure 16 show how this demographic segment responded to the top five hazards and concerns compared with responses from non-disabled respondents.

All disabled respondents reported relatively higher rates of concerns with vehicle speeds compared to non-disabled respondents. Additionally, 34.1% (n = 14) of respondents with mobility impairments reported issues with uneven sidewalks, in contrast to 28.8% (n = 93) of non-disabled individuals.

Table 16. Summary of the top five hazards and concerns reported by age.

Age Group	≤ 12 n (%)	13-17 n (%)	18-24 n (%)	25-34 n (%)	35-44 n (%)	45-54 n (%)	55-64 n (%)	65-74 n (%)	75+ n (%)	All Responses n (%)
Hazard and Concern Type										
Crossing Issue										
Crosswalk Needed	3 (23.1)	1 (2.6)	9 (9.8)	26 (16)	32 (11.3)	22 (20.6)	12 (13.3)	7 (9.1)	1 (2)	113 (12.4)
Drivers Don't Stop or Yield	3 (23.1)	16 (41)	16 (17.4)	60 (37)	116 (41)	39 (36.4)	21 (23.3)	27 (35.1)	6 (11.8)	304 (33.3)
Safety/Comfort Concern										
Other	1 (7.7)	8 (20.5)	13 (14.1)	14 (8.6)	40 (14.1)	9 (8.4)	23 (25.6)	16 (20.8)	7 (13.7)	131 (14.3)
Vehicles - Speed	6 (46.2)	12 (30.8)	15 (16.3)	42 (25.9)	87 (30.7)	26 (24.3)	21 (23.3)	17 (22.1)	30 (58.8)	256 (28)
Sidewalk Infrastructure Issue										
Obstruction - Uneven Sidewalk		2 (5.1)	39 (42.4)	20 (12.3)	8 (2.8)	11 (10.3)	13 (14.4)	10 (13)	7 (13.7)	110 (12)
Total Responses within Groups	**13 (100)**	**39 (100)**	**92 (100)**	**162 (100)**	**283 (100)**	**107 (100)**	**90 (100)**	**77 (100)**	**51 (100)**	**914 (100)**

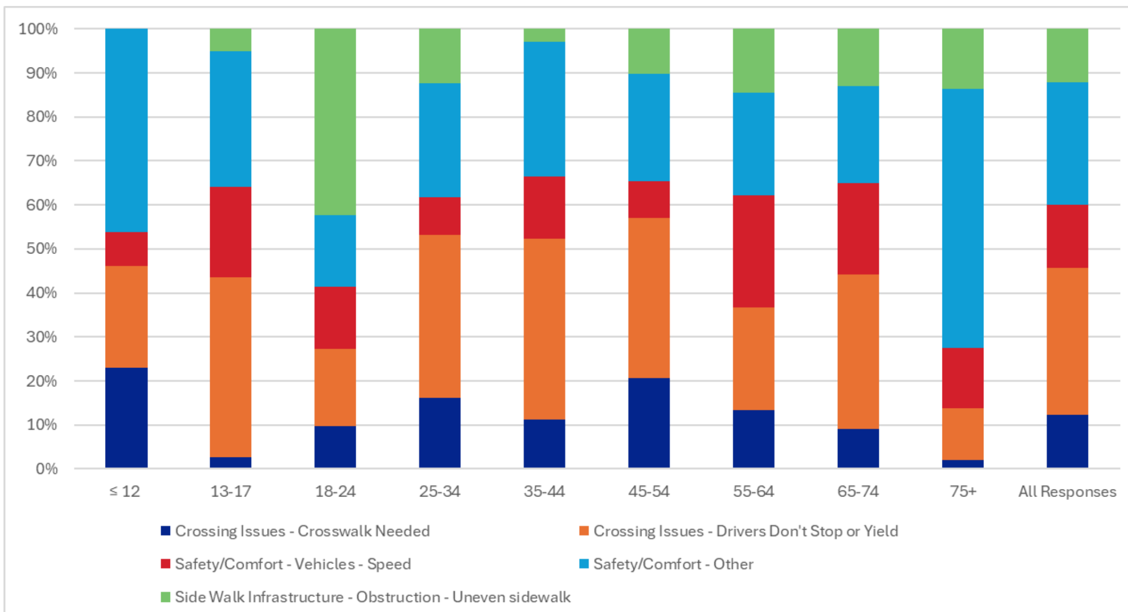


Figure 15. A visual summary of the top five hazards and concerns reported by age.

Table 17. Summary of the top five hazards and concerns reported by disabled and non-disabled individuals.

Disability Type	Cognitive n (%)	Hearing n (%)	Mobility n (%)	Other n (%)	All Responses from Disabled Individuals n (%)	All Responses from Non-Disabled Individuals n (%)
Hazard and Concern Type						
Crossing Issue						
Crosswalk Needed	2 (28.6)	1 (16.7)	5 (12.2)	1 (20)	9 (10.7)	104 (15.3)
Drivers Don't Stop or Yield	1 (14.3)	2 (33.3)	9 (22)	1 (20)	13 (20.8)	291 (22)
Safety/Comfort Concern						
Other	1 (14.3)	1 (16.7)	3 (7.3)	1 (20)	6 (16.9)	125 (23.7)
Vehicles - Speed	1 (14.3)	2 (33.3)	10 (24.4)	1 (20)	14 (36)	242 (10.2)
Sidewalk Infrastructure Issue						
Obstruction - Uneven Sidewalk	2 (28.6)		14 (34.1)	1 (20)	17 (15.7)	93 (28.8)
Total Responses within Groups	**7 (100)**	**6 (100)**	**41 (100)**	**5 (100)**	**59 (100)**	**855 (100)**

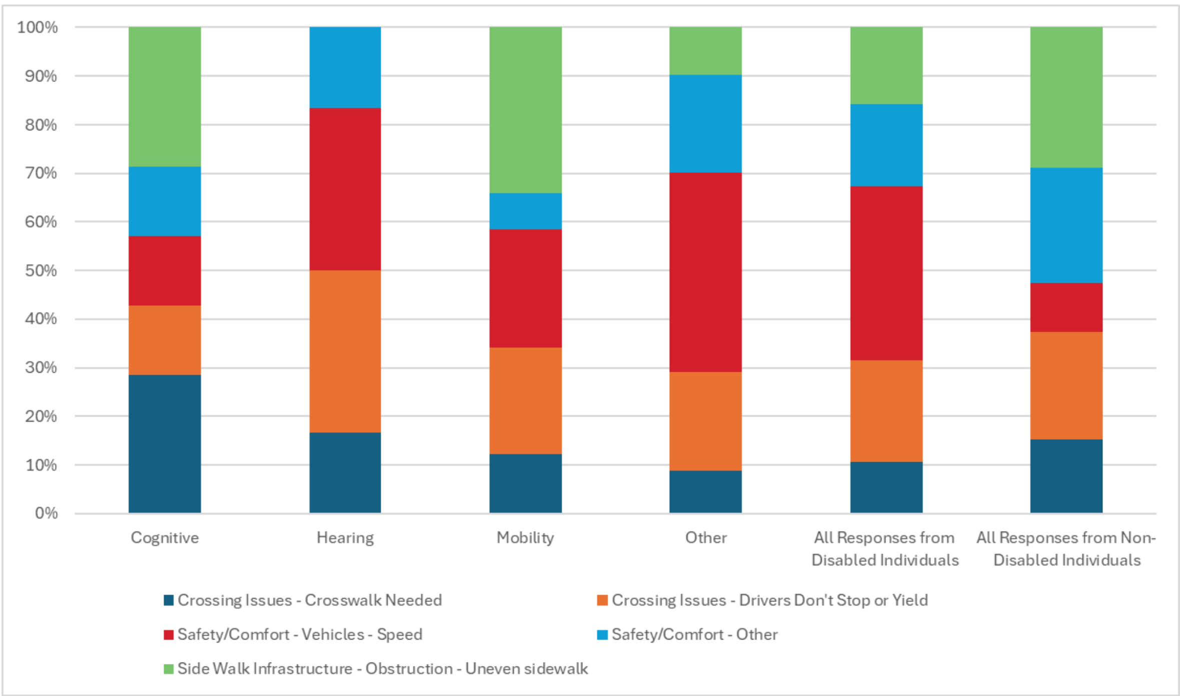


Figure 16. A visual summary of the top five hazards and concerns reported by disabled and non-disabled individuals.

4.3 Themes

The results of the thematic analysis are discussed in this section. Two common categorical themes emerged: behaviours exhibited by respondents or other street users, and specific barriers commonly discussed in the same demographic segment. These themes are organized and discussed in the following sections.

4.3.1 Behaviours

Aggressive and/or inconsiderate street users

These behavioural themes apply to multiple categories of street users. By reviewing trends within the segmented reports, I found respondents identifying as women or non-binary almost exclusively reported problems with inconsiderate dog owners. Respondents expressed similar sentiments about off-leash dogs jumping up and hitting their torso without receiving an apology from dog owners. Another experience with dogs included a complaint about animal excrement left on pathways. This "*make[d] it hard to walk"* or led to unpleasant public spaces, such as when a *"[g]arbage pail at bus stop [was] overflowing with dog poo bags. Yuck!"*

Inconsiderate behaviours also appeared when examining data from Segment 2 – Age, Youth. The phrase "Parents who" frequently appeared in the data. It was often associated with instances of parents picking up or dropping off children at school and was linked with words like "danger," "obstruct," and "stop" on sidewalks. One respondent expressed discomfort in school drop-off areas because *"[m]any parents…stop and obstruct the sidewalk…in front of the school"* and perform *"dangerous maneuvers blocking the reserved lane."*

There was another pattern with time, which was used to describe motorists' as "impatient" or "hasty" in school zones. In this report, for example, *"many students from the [School Name] flow through [Intersection Name]. Impatient motorists turn very close to pedestrians so as not to miss their light".* Notably, issues around schools were described most often in the Segment 2 – Age, Youth – data.

Vehicle Speed

Respondents stated that the speeds of vehicles and/or cyclists were concerning. When describing the speed, older adults most often referenced concerns with cyclists' volumes. In this report, for example, bike traffic is identified as "*intermittent so the lane is often empty"* yet "*when they come, they come fast. It is easy to forget to check by looking in the correct direction."* In another report from an older adult, bike volumes again were flagged as an ongoing challenge and described to have *"increased significantly. As the last few km [of Road Name] are done, many more cyclists will flood this narrow corridor".* In reports from respondents identifying as women or non-binary, cyclists *"racing through parking lot[s]"* were described as having *"little awareness of pedestrians"* and again exhibited aggressive behaviours. For example, a cyclist in this report came *"riding at a high speed on the sidewalk…up behind me and swooped around me on my left just as I started veering left to turn into a building, missing me by a couple of inches".*

Vehicle Proximity

Proximity to vehicles was referenced often by respondents using the phrase "close to". This phrase was often associated or linked with "traffic", "cars", "turning", and "speeding". These words (tags) were used by respondents to describe how environmental conditions exposed them to risks, either by forcing pedestrians onto the street or into situations where narrow roads, pathways, or sidewalks led to vehicle encroachment on pedestrian infrastructure. A report by a woman or non-binary identifying respondent, describes such a space without sufficient area to "*wait for the bus…. Either you must stand on the shoulder*, *close to automobile traffic, or on uneven grass. I imagine most of the transit facilities along…here are similar conditions. Not very comfortable for vulnerable road users, [especially] with wheelchairs/strollers/etc."*

Many respondents from the youth segment described these "close" encounters as "scary", for example, by stating encroaching vehicles caused *"many scary encounters with fast cars coming dangerously close to us".* This sentiment was again used to describe interactions with vehicles while crossing. For example, when *"signal favour vehicles"* this creates a *"scary intersection for pedestrians crossing"* who "*have to scramble quickly across the roads dodging turning cars."*

4.3.2 Barriers

Caution Required with Barriers and/or Traffic

When reviewing reports for different sentiments, the tag "extreme" was used to describe various environmental conditions that created barriers for pedestrians. "Extreme" was found in all segments, often used to describe the intensity of a situation, barrier, or navigation approach. Disabled respondents were the only segment to use "extreme" when describing the "caution" they used to circumnavigate barriers. In this report, for example, *"extreme caution"* was required to avoid *"various large potholes in [an] alley. Wheelchairs and walkers have extreme difficulty passing"* in such situations.

Women or non-binary identifying respondents used “extreme” in reference to the observed needs of other pedestrians. When describing a situation with no sidewalk or alternate crossing area, this respondent suggests, *“[i]t is extremely treacherous for anyone with mobility issues that needs to cross.”* Another respondent stated, *“[t]he intersection is extremely wide[,] but the crossing time is ridiculous. Despite the presence of many children and elderly people, pedestrians are forced to run to reach the other side.”*

Inclement Weather

“Snow removal” and “storage” were commonly used phrases to indicate barriers due to inclement weather. Issues with “snow” was found in all segments; however, older adults expressed unique concerns about the increasing accumulation of snow. For example, a respondent stated, *“[s]now piled up, walkways not cleared”;* therefore, they “*had to walk far too close to speeding traffic”.* Another older adult reported, *“snow from the park constantly ends up on the sidewalk in winter. People are forced to walk in the street.”*

Similarly, disabled respondents reported concerns with visibility, where snow created *“poor visibility [on] street corners for drivers because”* with “*piles of snow, we cannot see and ensure the safety of the street before moving forward because the high piles of snow”* are in *“all corners.”*

Inaccessibility due to Steep Grades and/or Slopes

Phrases referencing “steep grades” or “slopes” were also common in the data. When referenced, these phrases were linked with descriptions referring to issues with sidewalks and/or ramps, inaccessibility for wheelchairs, or difficulties crossing intersections. Two older adult respondents stated ramps were not available to facilitate crossing or did not offer safe entry/exit points. In this report, for example, the respondent stated, *“Sight lines are limited due to width and elevation profile[s]. [The] ADA ramp on [Road Name] heading toward [Road Name] appears to empty into the middle of intersection”.* Similarly, another older adult stated the *“curb is too steep for a motorized wheelchair. We tried it a few times and the wheels just kept spinning.”*

The “steep” tag was also used in combination with sentiments describing the “dangerous” or “stressful” sidewalk conditions. Where again, a disabled respondent expressed the slope was *“Way too steep! It’s dangerous it’s so steep”,* to describe the recurrent risks. Another stated that *the “sidewalk has a very, very steep grade”* and recognized the infrastructure was not aligned with the land-use composition, where there “*is a community agency with many individuals using walkers/wheelchairs/ who have other mobility issues. We often go on community walks together[;] however, the steep grade of the sidewalk is a real safety risk and causes some stress to the clients.”* This sentiment was also shared by a woman or non-binary respondent to describe the challenges steep slopes presented for both disabled and non-disabled individuals. In their report, *"people on wheeled devices descending [the] ramp"* were described to "*frequently have near misses with pedestrians."*

Similarly, inaccessibility was a common theme for disabled respondents where "ramps" were either required or created barriers due to ineffective installations. Where required, one respondent stated a connection to a street *"has three steps at the [Road Name] end of the footpath, where a ramp might be preferable for mobility-impaired people."* When ineffectively installed, one disabled respondent stated that a *"temporary ramp constructed of wooden boards sits across the ditch for pedestrians to enter/exit [the] bank. At each end of the ramp, two large pylons stand so close together, they block average-width wheelchair from safely entering/exiting the ramp."* Where in another situation, an accessibility "*ramp* [*was] blocked by parking [a] spot."*

5.0 Discussion

The findings from this study add to previous research on pedestrian safety and accessibility in several ways. First, this research utilizes pedestrian-centric inputs typically omitted in accident analysis research to identify barriers to pedestrian mobility (Section 5.1). Second, demographic segmentation establishes a baseline for understanding where there is agreement or disagreement on the types of barriers pedestrians experience (Section 5.2). These findings can inform the development and implementation of pedestrian and active mobility policies, as well as future research.

5.1 Barriers to Mobility as Identified by Pedestrians

In official datasets, pedestrian safety is measured with information often derived from recorded accidents (Branion-Calles et al., 2017). In other words, the data is often provided after tragic collisions between motorists and pedestrians occur, suggesting other dangerous and/or isolating pedestrian conditions are likely underreported or omitted from official databases.

However, pedestrian-vehicle collisions are only reported in 3% of all WRM reports. This indicates WRM adds a rich source of crowdsourced data before accidents occur. For example, WRM respondents also described situations where they were unable to rest due to the absence of benches, felt unsafe without adequate streetlighting, and encountered obstacles due to uneven sidewalks. These pedestrian-centric metrics are not often measured in accident analysis research or collected in official datasets. Therefore, the exploration of WRM data is shown to provide an objective means to measure, understand, and support the response to problems within pedestrian environments before tragedies occur.

Figure 17. A slip lane is a road feature designed to avoid vehicle stoppages at right turns.

The data crowdsourced with WRM clearly show that pedestrians are neither prioritized nor respected in shared spaces. WRM data contextualizes these experiences by primarily categorizing data omissions as problems pedestrians encountered with crossing (drivers failing to yield), missing or inaccessible pedestrian infrastructure (marked crosswalks, sidewalks), and dangerous driving behavior (excessive speeds). Threats to pedestrian safety due to vehicle proximity, speed, or occupation of crosswalks were highlighted consistently throughout the data. This aligns with past accident analysis research, demonstrating that prolonged pedestrian exposure in intersections increases collision risks (Ma et al., 2022; Shirazi & Morris, 2017).

Further contextualizing these findings, respondents described situations where motorists disrespected pedestrian rights-of-way by failing to stop or yield and encroaching on pedestrian infrastructure. Both situations imply a sense of motorist entitlement, where the design and function of streets establish a clear movement hierarchy favoring vehicles over pedestrians. Such as with slip lanes (Figure 17), designed to maintain vehicle speed and prevent stoppages during right turns. Whereas these intersections increase the risk for pedestrians, as they require pedestrians cross in front of moving vehicles at multiple points. This movement hierarchy and design priority demonstrate forms of normalized violence or vehicle-based harm towards pedestrians (Miner et al., 2024), often perpetuated by design standards that prioritize high levels of service for vehicles over pedestrian safety. Reports of missing marked crosswalks or narrow sidewalks further highlight situations where the pedestrian right to access space is entirely overlooked.

These findings indicate that pedestrians experience danger from vehicles in multiple ways, providing further evidence of severe data omissions in official databases. They also demonstrate how WRM can supplement these gaps with powerful and citizen-informed descriptions of the dangers and personal impact of restricted pedestrian mobility. Achieving this pathway, however, will require more systematic forms of data collection. The WRM platform may be limited by its web-based nature, which can create barriers to access since it relies on respondents to remember and report their challenges after they have occurred. In contrast, a mobile-based application, such as Google Maps, allows for more immediate reporting of issues as they occur, making it a more expedient solution for data collection.

Additionally, detailed reports of issues in pedestrian spaces can be enriched with photographic evidence of the barriers that pedestrians encounter. This visual documentation can assist researchers, policy practitioners, urban designers, and planners in identifying recurring design problems and potentially expanding towards more spatially focused analysis and intervention methods. Therefore, WRM can enhance its data collection and usability by integrating a user interface that supports both a mobile-based application and photo-supported reporting.

5.2 A Diversity of Responses to Adverse Environmental Conditions

Demographic segmentation helps us understand how different groups respond to adverse environmental conditions. However, when interpreting the results, it's important to note that due to the relatively small sample sizes (n < 30) for some report types, relative percentages can be misleading or fail to provide an accurate scale of the reported barriers. Additionally, given the large size of the overall WRM dataset, I strategically applied a non-comparative approach to this study. This presents a limitation because general themes about barriers encountered by underrepresented populations are discussed, instead of providing direct comparisons on how barriers are experienced across different populations. Consequently, not all perspectives are fully depicted. Future studies can mitigate both limitations with targeted data collection to bridge data gaps. Regardless of these limitations, I share the trends observed across gender, age, and disabled segments in the following sections.

5.2.1 Gender

Gender-based differences were apparent in the WRM data. Responses from men represent roughly 35% of reports. This is a surprising finding as evidence from previous studies show contributions from men dominates the data make-up in other digital map spaces (Stephens, 2013). Whereas responses from women account for almost half of all reports with the WRM dataset. Higher reporting rates from women respondents may imply different commuting patterns or inequitable vehicle access (Palm, Allen, et al., 2021; Preston & McLafferty, 2016), further implying women may encounter different pedestrian exposure rates than men on average.

Women and LGBTQ2S+ people often experience higher rates of harassment, crime, or assault in public spaces (Laberee et al., 2023). The thematic analysis in this study loosely supports past research, as respondents identifying as women or non-binary reported problems with inconsiderate dog owners, suggesting higher likelihoods of experiencing unpleasant interactions compared to other genders. Additionally, Stoker et al. (2015) find women spend more time as pedestrians compared to men, as household income decreases. Palm, Allen, et al. (2021) find a similar trend, where women's car access was directly associated with different familial roles and car priority was given to males within the household, suggesting women have a higher degree of transport disadvantage than men (Lucas, 2004; Lucas et al., 2018; Zhao & Gustafson, 2013). While income and role-based analysis is outside the scope of this study, these findings support the need for future gender-based studies to explore gaps in pedestrian experiences.

However, themes of care and empathy were also emphasized in the thematic analysis. Women and/or non-binary identifying respondents expressed concern for how barriers impacted vulnerable populations. This finding may imply different levels of gender-based observations due to higher rates of care-based activities (non-paid labour such as household labour, childcare, or volunteer work) among women. In Sánchez de Madariaga (2013) study on gender-based transportation exclusions, she found "men spend significantly more time than women [in] paid employment and leisure activities" (p. 35), whereas women were more likely to escort and/or accompany others, compared to men. Higher rates of care-based activities among women may indicate more practice observing others, also carrying into their pedestrian perspective.

5.2.2 Age

Youth

Some discernable trends were pulled from the youth segment; however, due to limited data availability, it is difficult to measure the scale of identified issues. Youth respondents reported higher rates of concerns with vehicles speeds and traffic/pedestrian signals, compared to other age groups. However, emergent patterns of youth-based pedestrian safety and accessibility, suggest the greatest risks occur within school zones.

Johnston (2008) provides evidence to contextualize school zone-based risks. The author observes that the percentage of American youth walking to school drastically decreased from 70% in the 1960s to 15% in 2008, based on tracking commuting trends. In Canada, only 28% of youth walked to school as of 2014 (Parks Canada, 2014). These declining patterns suggest that youth increasingly rely on bus transportation or parental drop-offs, limiting their independent mobility.

Despite regulatory controls aimed at limiting vehicle speeds in school zones, increased traffic volumes from vehicle drop-offs, combined with reported motorist aggression and entitlement, heightens overall pedestrian risk. Vehicle-related trauma accounts for 25% of child deaths outside of infant mortality (Johnston, 2008). Similarly, youth face higher collision risks due to their smaller size, which makes them less visible to drivers and, therefore, more susceptible to danger.

In brief, limited insights from the youth segment may also suggest increased sedentary behavior or that fewer children are independently using public spaces. Evidence of this latter assessment is consistent with measurements of play-based behaviours. For example, Canadian researchers discovered only 7% of children were achieving their daily physical activity needs (Active Healthy Kids Canada, 2012). Taken together with limited data availability, higher risk in school zones, and commuting changes can be indicative of wide scale technological, social, and transportation changes leading to less public lifestyles for youth.

Older Adults

Reports from older adults describing concerns with cyclists were linked with concerns about narrow pathways, and cyclist volumes. The connection suggests older adults may experience discomfort when sharing space with high volumes of fast-moving cyclists due to declining reaction speeds. Evidence from past research suggests older adults have difficulty moving out of harm’s way due to slower walking speeds

(Dumbaugh, 2008), existing mobility impairments, or declining cognitive awareness (Stoker et al., 2015). Similarly, a high percentage of respondents in the 75 years and older group expressed a need for marked crosswalks, which may suggest they prefer to cross at intersections which afford high visibility.

Like the disability segment, older adults expressed concern with increasing accumulations of snow and uneven sidewalks. This may suggest that, alongside fall risks, older adults are increasingly susceptible to poor sidewalk conditions. This finding is consistent with evidence from Rantanen (2013), who observed associations between barriers on sidewalks and a significant risk of older adults developing new walking impairments. Conversely, Frehlich et al. (2022) found associations between obstacles in the built environment and improved motor fitness in older adults. The authors argue moving around obstacles mimics balance-based activities commonly found in structured exercise, which can improve health outcomes for otherwise sedentary older adults. While having opportunities to stimulate balance-based exercises can support individual motor fitness, it's still important to promote social inclusion and active aging by minimizing barriers that create fall risks, fully immobilize, or otherwise, subject older adults to increased vehicular exposure.

Active aging promotes the development of infrastructure and transportation systems that support positive health outcomes for people during all stages of life. For example, access to adequate rest stops and bathroom facilities is cited as a standard for developing age-friendly cities (World Health Organization, 2007). Within this study, older adults expressed a need for benches. This finding is aligned with past community-based research I conducted with older adults, where they indicated they chose routes based on the availability of benches, allowing for frequent rest stops. Additionally, benches facilitate social integration and stimulation, which is especially beneficial for those at risk of dementia or Alzheimer's disease. Observation of busy street environments is known to "stimulate social features" and "minimize unwanted behaviors and feelings" in dementia patients (Lawton & Zarit, 2001, p. S56-7).

What's not indicated by the WRM results, however, is a strong desire for public washrooms. Where in my past engagements, older adults emphasized a need for these facilities due to health conditions that required planning routes to mitigate bowel stress.

Despite the prevalence of age-based disabilities, frailty, or health decline among older adults in past research, these were not strong themes in the WRM results. Changes in an individual's physio-cognitive capabilities, for example, were previously shown to impact how individuals perceive and assess risks (Lachapelle & Cloutier, 2017), or alter their decision-making processes (Lord et al., 2018). For example, Stoker et al. (2015) find older adults with vision impairments “look less at traffic and accept significantly smaller” traffic gaps when crossing streets (p. 380). In Lachapelle and Cloutier’s (2017) review of crossing behaviours among older adults, they suggest diminishing cognition can result in lower concentration and/or attention levels, where they may overestimate their walking speeds, gaps in traffic, or vehicle speeds.

However, such themes were not found in the WRM data from older adults. This may imply older adults do not identify with or reject representations that depict them as frail or ailing. The absence of these themes within the data serves as a reminder that, despite professional representations, attitudes, judgements, and bias, older adults are not accurately portrayed by the literature. As a growing population, older adults exhibit a diversity of needs, behaviours, and attitudes. Therefore, policy advocates, along with planning and engineering professionals, need to directly engage with older adults to redefine assumptions about their pedestrian experience.

5.2.3 Disability

Disabled respondents approached barriers with an increased sense of caution, otherwise not apparent in descriptions of barriers from other demographic segments. An abundance of caution suggests that barriers can increase fall risks or immobilizations, as individuals with different types of disabilities require different navigation approaches to access public spaces effectively. For example, snow piles were described to decrease safety because neither motorists nor disabled pedestrians had clear visibility of each other.

Additionally, wet and snowy weather conditions were described to amplify fall risks for disabled individuals. This finding is consistent with previous literature, where fear of fall risks during inclement weather is related to short-term travel avoidance (Vergouwen et al., 2021), and longer-term declines in social participation (Plaut et al., 2021). Mao and Chen (2021) found that regardless of the disability type and severity, physical barriers cause disabled individuals to feel confined “within very limited spaces, such as their homes, neighborhoods, and workplaces” (p. 7). This indicates disabled individuals may be more sensitive to physical barriers than other demographics.

For example, the segment and thematic analyses showed disabled individuals were more sensitive, compared to non-disabled respondents, to impedances caused by obstructions (uneven surfaces), vehicle speeds, and structural barriers (stairs, slopes, curb cuts to nowhere). This evidence is consistent with previous research, which indicates accessible infrastructure can be superficially built and therefore, unusable due to facilities being blocked, broken, or otherwise occupied (Gan et al., 2022; Mao and Chen, 2021). Additionally, the frequency at which structural barriers occur suggests user experience and infrastructure functionality are considered late in the design process. However, more data is required to comprehensively compare how disability impacts the pedestrian experience.

Overall, the findings from this study suggest, despite shifts toward universally designed spaces, walking is still a default behaviour designed into pedestrian spaces. Therefore, to mitigate the creation of disabling environments its important to ensure accessible infrastructure is functionally design, well-maintained, and adequately connected.

6.0 Conclusion

This research aimed to address problems of underreporting and understanding the barriers to pedestrian safety and accessibility. The primary goal was to identify common barriers to pedestrian mobility using crowdsource data, and to determine demographic variability in reporting trends. The purpose of deriving this information is to support the equitable development of urban and transportation planning policies with use of pedestrian-centric metrics to measure and mitigate risk for pedestrians. Achieving this aim requires a comprehensive data strategy to ensure data inputs are more representative of the population, include quantitative and qualitative metrics, and work to study risks occurring in pedestrian spaces.

By conducting a segment analysis, commonly identified barriers emerged from the WRM data. Those identified in missing amenity reports suggest pedestrians – regardless of demographic segmentation – require adequate pedestrian infrastructure to support their journeys and feel safe. This finding is further supported by the vehicle-centric barriers identified in incident reports. Pedestrians indicated the most concern with vehicles turning, suggesting street design that prioritizes vehicle mobility creates conditions where pedestrians are not visible to moving vehicles. Whereas those identified in hazard and concern reports imply that issues arise from a lack of adequate crosswalks and sidewalk conditions, as well as motorist entitlement leading to unfavourable pedestrian environments.

These findings were further built on with the thematic analysis, where demographic variability was clearer. Women and non-binary respondents identified safety concerns due to aggressive and inconsiderate street users. Youth reported unsafe conditions also arising from aggressive and inconsiderate motorist behaviours faced in school zones. Older adults emphasized they had difficulty navigating pedestrian spaces due to unpredictable cyclist speeds and volumes. Lastly, disabled individuals associated fearful and cautious sentiments to describe steep or obstructed sidewalk conditions.

Based on the findings presented within this study, several recommendations for future research are proposed:

1. Employ spatial methods to evaluate the implications of land use, street design, and identified barriers on specific populations. Respondents highlighted barriers that impeded safety around schools and seniors' centers or prevented access due to steep slopes. By applying spatial methods and using these findings as a baseline, user-centric approaches can measure the severity of identified barriers to pedestrian mobility.
2. My research reveals demographic variability in how barriers are experienced, such as how missing or inaccessible sidewalks can socially isolate older adults. Future research can build on this by focusing on fewer and more specific population subsets within the WRM data to evaluate demographic sensitivity to barriers and risk. This approach can help identify which groups are most affected by certain barriers and why to support targeted interventions to improve pedestrian conditions.
3. The largest limitation of the study is the underrepresented perspective of various population sub-segments representing the most vulnerable pedestrians. A more concerted effort is required to build a representative dataset. While WRM data currently contains useful user data, there is still persistent overrepresentation of adults aged 25-44 years. This indicates older adults may have difficulty accessing, understanding, or gaining knowledge of the WRM platform. Devoting resources to directly engaging with invisible populations, whether through focus groups, participatory mapping events, or other means, can support targeted data collection.
4. Within the WRM platform, seek to simplify the reporting options to improve data quality and representation of pedestrian barriers. Despite the removal of the most common barriers, these reappeared in the thematic analysis. This suggests respondents may not fully comprehend their options, have limited time to read through and select answers of best fit, or are selecting "other" due to survey fatigue. Therefore, learning from user-centered design and accessibility best practices (data input options with audio and visual prompts for those with disabilities) can enhance the reporting process.
5. Expand the WRM platform to a mobile-based application which also allows respondents to upload images. Respondents described specific crossing concerns where they felt extremely unsafe or disrespected asserting their pedestrian right-of-way. Updating WRM to accept image-based reports can expand our understanding and evidence of design-based impacts on pedestrian safety and accessibility.

6. Cities are ever-evolving landscapes that must adapt to the needs of their residents. Demographic segmentation reveals that current policy mechanisms to regulate motorist behavior, such as those in school zones, are ineffective. Moreover, road designs that prioritize vehicle movement foster motorist entitlement and disrespect for pedestrians, undermining their right to access shared or accessible spaces. Therefore, to create safer and inclusive cities, it's imperative to revise mobility policies in ways that elevate pedestrian rights. This requires acknowledgement of and support for the complex social, safety, and physical needs of pedestrians to promote active lifestyles.

In summary, this research sheds light on the multifaceted barriers that pedestrians, particularly vulnerable populations, encounter in urban environments. By leveraging crowdsourced data, we have unveiled critical insights into the demographic-specific challenges faced by pedestrians, providing a foundation for more inclusive and equitable pedestrian planning. The implications of these findings extend beyond academic inquiry, offering actionable guidance for policymakers and urban designers to prioritize pedestrian safety and accessibility. Ultimately, this study underscores that transforming our cities into more inclusive, safe, and pedestrian-friendly environments requires actively listening to all pedestrians, continually engaging with the community, and acknowledging professional bias.

This conversation is ongoing, and more participation is needed to improve pedestrian experiences and safety. Join us in this effort by contributing to the WalkRollMap.org dataset. Your input will make a significant difference in how we plan, design, and build our cities.

Appendix A: Report Questions

The sections below present a wireframe example of the three report types available on the WalkRollMap.org platform. Data is crowdsourced from pedestrians who are reporting a missing pedestrian amenity, an incident (fall, hit, near-miss), or a hazard or concern. Demographic information is also collected and anonymized for each report (age, gender, disability type).

Suggest a Missing Amenity

What type of amenity is missing?

a) Sidewalk
b) Marked crosswalk
c) Curb cut
d) Traffic or pedestrian signal
e) Audible
f) Stop sign
g) Benches
h) Washroom
i) Lighting or additional lighting
j) Access to transit stop
k) Wayfinding signs
l) Connections (cut-through needed)
m) Shade in summer
n) Other

Describe your concerns in more detail. [Mandatory open-ended section]

Describe the ideal solution to the issue you identified. [Open-ended. Optional]

When did you last notice the hazard or concern (or missing amenity)? [Date/Time]

Report an Incident

What type of incident are you reporting?

a) Hit by:

What were you (or the person you are reporting for) hit by?

a. A vehicle:
    i. Turning right
    ii. Turning right on red
    iii. Turning left
    iv. Heading straight at me
    v. From behind
b. A cyclist
c. An animal
d. Other

What was your involvement in this incident?

a. This happened to me
b. This happened to someone in my care
c. I witnessed the incident

Were you (or the person you are reporting for) injured?

a. Not injured
b. Injured; self-treatment
c. Injured; Saw Family Doctor
d. Went to ER by myself
e. Was transported by ambulance to ER
f. Hospitalized

When did this occur? [Date; Time]

b) Near-miss with:

What did you (or the person you are reporting for) have a near-miss with?

a. A vehicle:
    i. Turning right
    ii. Turning right on red
    iii. Turning left
    iv. Heading straight at me
    v. From behind
b. A cyclist
c. An animal
d. Other

What was your involvement in this incident?

a. This happened to me
b. This happened to someone in my care
c. I witnessed the incident

Were you (or the person you are reporting for) injured?

a. Not injured
b. Injured; self-treatment
c. Injured; Saw Family Doctor
d. Went to ER by myself
e. Was transported by ambulance to ER
f. Hospitalized

When did this occur? [Date; Time]

c) Fall

What type of fall did you (or the person you are reporting for) have?

a. Slipped
b. Tripped
c. Other

What was your involvement in this incident?

a. This happened to me
b. This happened to someone in my care
c. I witnessed the incident

Were you (or the person you are reporting for) injured?

a. Not injured
b. Injured; self-treatment
c. Injured; Saw Family Doctor
d. Went to ER by myself
e. Was transported by ambulance to ER
f. Hospitalized

When did this occur? [Date; Time]

Report a Hazard or Concern

1. Sidewalk Issue

What is the issue with the sidewalk?

a) Obstruction
    a. Bollard
    b. Pole (hydro, telephone)
    c. Uneven sidewalk (roots, holes, cracks)
    d. Mailbox
    e. Bike rack (including bike share)
    f. Bus shelter
    g. Vegetation that narrows pathway
    h. Sign blocking path (construction, sandwich board)
    i. Parked e-scooters/bicycles
    j. Garbage or recycling bins
    k. Parked vehicles or delivery vans
    l. Construction – inadequate or lack of safe detour for pedestrians
b) Missing curb cut

c) Too narrow

d) Uncomfortable surface (for wheelchairs etc.)

e) Slope issues (driveways)

f) Other

2. Crossing Issues

What type of crossing issue?

a) Crosswalk needed

b) Conflicts with vehicles turning

    a. Right

    b. Right on red

    c. Left

c) Drivers don’t stop or yield to pedestrians

d) Traffic/pedestrian signal issues:

    a. Pedestrian interval is too short

    b. Needs an audible signal

    c. Push button is difficult to access

    d. Waiting time to cross is too long

e) Poor visibility of pedestrians (in a blind corner, vegetation/fences blocking sightlines)

f) Marking for crosswalk no longer visible

g) Other

3. Weather-related or seasonal issues

What type of weather-related or seasonal issue?

a) Snow

b) Ice

c) Puddles, flooding, splash zone

d) Leaves

e) Other

4. Safety/Comfort Concerns

What type of weather-related or seasonal issue?

a) Number of vehicles makes it uncomfortable
b) Speed of vehicles makes them uncomfortable
c) Bicycles
d) E-scooters
e) Roller blades, skateboards, kick scooters
f) Mobility scooters/electric wheelchairs
g) Dogs
h) Inadequate lighting
i) Isolated (dead-ends)
j) Harassment or unwanted attention
k) Gathering of unknown people
l) Other

Demographics

[Mandatory]

[Pop-up needed] Why are we asking for demographics?

Please share your gender or the gender of the person you are reporting for (Force One response only)

a) Male
b) Female
c) Or please describe [Open Text]
d) Prefer not to say

How do you identify yourself or the person you are reporting for? (Multiple response option)

a) Black
b) East Asian
c) Southeast Asian
d) Indigenous
e) Latino

f) Middle Eastern

g) South Asian

h) White

i) Other [Open-ended] Please describe your identity (optional)

j) Prefer not to say

What year were you or the person you are reporting for born in?

Do you currently have a disability or are you a caregiver for someone with a disability?

a. Yes

    i. If Yes:

    What type of disability do you (or the person in your care) have?

    1. Visual impairment
    2. Hearing Impairment
    3. Mobility impairment
    4. Cognitive impairment
    5. Other [Open-ended text field but not mandatory]
    6. Prefer not to say

    ii. If Yes: Do you (or does the person in your care) use a mobility aid?

    1. If Yes:

    What type of mobility aid?

    a. Wheelchair
    b. Electric wheelchair/Mobility scooter
    c. Walker
    d. Cane
    e. Crutches
    f. Service dog
    g. Other [Open ended text field but not mandatory]

    2. No
    3. Prefer not to say

e) No

f) Prefer not to say

Appendix B: Data Inputs

The table below defines all the inputs available within the WRM data. Those used for data analysis in this study are report type, feature type and subtype, event description, gender class, age class, and disability type.

Table 18. Summary of data inputs used in this study.

Field	Variable Types
ID	Numeric-Discrete
Date	Numeric – Discrete
Date_Reported	Numeric - Discrete
Report_Type	Categorical - Nominal
Birth_Year	Numeric - Discrete
Gender	Categorical - Nominal
Race	Categorical - Nominal
Disability	Categorical - Nominal
Disability_Type	Categorical - Nominal
Mobility_Aid	Categorical - Nominal
Mobility_Aid_Type	Categorical - Nominal
Feature_Type	Categorical - Nominal
Feature_Subtype	Categorical - Nominal
Event_Description	Text - Descriptive
Longitude	Numeric - Spatial
Latitude	Numeric - Spatial
Gender_Class	Categorical - Nominal
Age	Numeric - Discrete
Age_Class	Numeric - Discrete
Geometry	Numeric - Spatial
Mobility_Aid_Type_Class	Categorical - Nominal
Disability_Type_Class	Categorical - Nominal

Appendix C: Summary of Reports

Summary of all Missing Amenity Reports

Table 19. Summary of all missing amenities reported by gender.

Gender	Men n (%)	No Response n (%)	Non-Binary n (%)	Women n (%)	All Responses n (%)
Amenity Type					
Access To Transit Stop	4 (1.2)	1 (0.6)		1 (0.3)	6 (0.7)
Audible	1 (0.3)			1 (0.3)	2 (0.2)
Benches	12 (3.6)	6 (3.6)	2 (12.5)	13 (3.3)	33 (3.6)
Connections (Cut-Through Needed)	13 (3.9)	7 (4.2)	1 (6.3)	11 (2.8)	32 (3.5)
Curb Cut	14 (4.2)	3 (1.8)		10 (2.5)	27 (3)
Lighting or Additional Lighting	9 (2.7)	23 (13.8)		16 (4.1)	48 (5.3)
Marked Crosswalk	85 (25.4)	32 (19.2)	5 (31.3)	79 (20.1)	201 (22.1)
Other	23 (6.9)	13 (7.8)	1 (6.3)	24 (6.1)	61 (6.7)
Shade In Summer	2 (0.6)	2 (1.2)		10 (2.5)	14 (1.5)
Sidewalk	133 (39.8)	51 (30.5)	5 (31.3)	182 (46.2)	371 (40.7)
Stop Sign	9 (2.7)	9 (5.4)		7 (1.8)	25 (2.7)
Traffic or Pedestrian Signal	19 (5.7)	14 (8.4)	1 (6.3)	23 (5.8)	57 (6.3)
Transit				1 (0.3)	1 (0.1)
Washroom	6 (1.8)	2 (1.2)		4 (1)	12 (1.3)
Water Fountain				2 (0.5)	2 (0.2)
Wayfinding Signs	4 (1.2)	4 (2.4)	1 (6.3)	10 (2.5)	19 (2.1)
Total Responses within Group	**334 (100)**	**167 (100)**	**16 (100)**	**394 (100)**	**911 (100)**

Table 20. Summary of all missing amenities reported by age.

Age Group	≤ 12 n (%)	13-17 n (%)	18-24 n (%)	25-34 n (%)	35-44 n (%)	45-54 n (%)	55-64 n (%)	65-74 n (%)	75+ n (%)	All Responses n (%)
Amenity Type										
Access to Transit Stop				2 (0.9)	3 (1)		1 (1.4)			6 (0.7)
Audible					1 (0.3)	1 (1.1)				2 (0.2)
Benches	2 (11.8)		10 (8.7)	8 (3.8)	2 (0.7)	2 (2.1)	2 (2.7)	4 (7.4)	3 (14.3)	33 (3.6)
Connections (Cut-Through Needed)	1 (5.9)		8 (7)	4 (1.9)	14 (4.8)	3 (3.2)	1 (1.4)	1 (1.9)		32 (3.5)
Curb Cut	2 (11.8)	1 (2.9)	3 (2.6)	4 (1.9)	8 (2.8)	2 (2.1)	4 (5.4)	3 (5.6)		27 (3)
Lighting or Additional Lighting		1 (2.9)	18 (15.7)	13 (6.2)	5 (1.7)	5 (5.3)	5 (6.8)	1 (1.9)		48 (5.3)
Marked Crosswalk	4 (23.5)	10 (28.6)	13 (11.3)	49 (23.2)	77 (26.6)	14 (14.7)	13 (17.6)	12 (22.2)	9 (42.9)	201 (22.1)
Other	1 (5.9)	3 (8.6)	9 (7.8)	10 (4.7)	18 (6.2)	7 (7.4)	5 (6.8)	5 (9.3)	3 (14.3)	61 (6.7)
Shade In Summer			2 (1.7)	4 (1.9)	6 (2.1)		2 (2.7)			14 (1.5)
Sidewalk	4 (23.5)	11 (31.4)	34 (29.6)	90 (42.7)	122 (42.2)	50 (52.6)	33 (44.6)	22 (40.7)	5 (23.8)	371 (40.7)
Stop Sign		1 (2.9)	5 (4.3)	4 (1.9)	6 (2.1)	1 (1.1)	3 (4.1)	4 (7.4)	1 (4.8)	25 (2.7)
Traffic or Pedestrian Signal	1 (5.9)	6 (17.1)	7 (6.1)	15 (7.1)	19 (6.6)	6 (6.3)	1 (1.4)	2 (3.7)		57 (6.3)
Transit				1 (0.5)						1 (0.1)
Washroom	2 (11.8)		3 (2.6)		2 (0.7)	3 (3.2)	2 (2.7)			12 (1.3)
Water Fountain			1 (0.9)	1 (0.5)						2 (0.2)
Wayfinding Signs		2 (5.7)	2 (1.7)	6 (2.8)	6 (2.1)	1 (1.1)	2 (2.7)			19 (2.1)
Total Responses within Group	**17 (100)**	**35 (100)**	**115 (100)**	**211 (100)**	**289 (100)**	**95 (100)**	**74 (100)**	**54 (100)**	**21 (100)**	**911 (100)**

Table 21. Summary of all missing amenities reported by disabled and non-disabled individuals.

Disability Type	Cognitive	Mobility	No Response	Other	Visual	All Responses from Disabled Individuals	All Responses from Non-Disabled Individuals
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Amenity Type							
Access to Transit Stop	1 (5.9)					1 (1.6)	5 (0.5)
Audible							2 (0.2)
Benches							33 (3.6)
Connections (Cut-Through Needed)	1 (5.9)					1 (1.6)	31 (3.4)
Curb Cut		4 (11.1)			1 (50)	5 (8.2)	22 (2.4)
Lighting or Additional Lighting		2 (5.6)				2 (3.3)	46 (5)
Marked Crosswalk	5 (29.4)	7 (19.4)	1 (25)		1 (50)	14 (23)	187 (20.5)
Other	3 (17.6)	4 (11.1)				7 (11.5)	54 (5.9)
Shade In Summer				1 (50)		1 (1.6)	13 (1.4)
Sidewalk	6 (35.3)	12 (33.3)	2 (50)	1 (50)		21 (34.4)	350 (38.4)
Stop Sign		1 (2.8)				1 (1.6)	24 (2.6)
Traffic or Pedestrian Signal		6 (16.7)				6 (9.8)	51 (5.6)
Transit							1 (0.1)
Washroom							12 (1.3)
Water Fountain							2 (0.2)
Wayfinding Signs	1 (5.9)		1 (25)			2 (3.3)	17 (1.9)
Total Responses within Groups	**17 (100)**	**36 (100)**	**4 (100)**	**2 (100)**	**2 (100)**	**61 (100)**	**850 (93.3)**

Summary of all Incident Reports

Table 22. Summary of all incidents reported by gender.

Gender	Men n (%)	No Response n (%)	Non-Binary n (%)	Women n (%)	All Responses n (%)
Incident Type					
Fall					
Other	1 (0.6)			1 (0.5)	2 (0.5)
Slipped	3 (1.7)	1 (2.9)		3 (1.4)	7 (1.6)
Tripped	2 (1.1)			1 (0.5)	3 (0.7)
Hit By	43 (24.6)	7 (20.6)	1 (16.7)	43 (19.6)	94 (21.7)
Animal - Dog				2 (0.9)	2 (0.5)
Cyclist	1 (0.6)			1 (0.5)	2 (0.5)
Other	2 (1.1)			2 (0.9)	4 (0.9)
Vehicle From Behind	4 (2.3)			1 (0.5)	5 (1.2)
Vehicle Turning Head-on	22 (12.6)	6 (17.6)	1 (16.7)	19 (8.7)	48 (11.1)
Vehicle Turning Left	11 (6.3)	1 (2.9)		12 (5.5)	24 (5.5)
Vehicle Turning Right	3 (1.7)			5 (2.3)	8 (1.8)
Vehicle Turning Right on Red				1 (0.5)	1 (0.2)
Near Miss	126 (72)	26 (76.5)	5 (83.3)	171 (78.1)	328 (75.6)
Animal – Dog				1 (0.5)	1 (0.2)
Cyclist	3 (1.7)			3 (1.4)	6 (1.4)
Other	5 (2.9)	4 (11.8)		1 (0.5)	10 (2.3)
Vehicle From Behind	9 (5.1)	2 (5.9)	1 (16.7)	4 (1.8)	16 (3.7)
Vehicle Turning Head-on	45 (25.7)	8 (23.5)	2 (33.3)	77 (35.2)	132 (30.4)
Vehicle Turning Left	33 (18.9)	3 (8.8)		42 (19.2)	78 (18)
Vehicle Turning Right	29 (16.6)	6 (17.6)	2 (33.3)	35 (16)	72 (16.6)
Vehicle Turning Right on Red	2 (1.1)	3 (8.8)		8 (3.7)	13 (3)
Total Responses within Group	**175 (100)**	**34 (100)**	**6 (100)**	**219 (100)**	**434 (100)**

Table 23. Summary of all incidents reported by age.

Age Group	≤ 12 n (%)	13-17 n (%)	18-24 n (%)	25-34 n (%)	35-44 n (%)	45-54 n (%)	55-64 n (%)	65-74 n (%)	75+ n (%)	All Responses n (%)
Incident Type										
Fall										
Other						1 (1.6)	1 (2)			2 (0.5)
Slipped			1 (3.8)	2 (2.1)	2 (1.6)	1 (1.6)			1 (7.1)	7 (1.6)
Tripped	1 (12.5)						1 (2)		1 (7.1)	3 (0.7)
Hit By										
Animal - Dog					1 (0.8)	1 (1.6)				2 (0.5)
Cyclist			1 (3.8)			1 (1.6)				2 (0.5)
Other	1 (12.5)			1 (1.1)		2 (3.1)				4 (0.9)
Vehicle From Behind			1 (3.8)	1 (1.1)		1 (1.6)		2 (6.1)		5 (1.2)
Vehicle Turning Head-on	4 (50)	5 (27.8)	4 (15.4)	8 (8.4)	7 (5.6)	10 (15.6)	6 (12)	2 (6.1)	2 (14.3)	48 (11.1)
Vehicle Turning Left			3 (11.5)	4 (4.2)	4 (3.2)	3 (4.7)	3 (6)	4 (12.1)	3 (21.4)	24 (5.5)
Vehicle Turning Right		1 (5.6)		3 (3.2)	1 (0.8)		2 (4)		1 (7.1)	8 (1.8)
Vehicle Turning Right on Red					1 (0.8)					1 (0.2)
Near Miss										
Animal – Dog						1 (1.6)				1 (0.2)
Cyclist			1 (3.8)		1 (0.8)	1 (1.6)	2 (4)	1 (3)		6 (1.4)
Other			1 (3.8)	2 (2.1)	4 (3.2)		1 (2)	2 (6.1)		10 (2.3)
Vehicle From Behind	1 (12.5)		1 (3.8)	3 (3.2)	5 (4)	2 (3.1)	2 (4)	2 (6.1)		16 (3.7)
Vehicle Turning Head-on	1 (12.5)	5 (27.8)	9 (34.6)	25 (26.3)	51 (40.5)	21 (32.8)	10 (20)	10 (30.3)		132 (30.4)
Vehicle Turning Left		3 (16.7)	1 (3.8)	23 (24.2)	20 (15.9)	9 (14.1)	12 (24)	5 (15.2)	5 (35.7)	78 (18)
Vehicle Turning Right		4 (22.2)	2 (7.7)	18 (18.9)	26 (20.6)	8 (12.5)	8 (16)	5 (15.2)	1 (7.1)	72 (16.6)
Vehicle Turning Right on Red			1 (3.8)	5 (5.3)	3 (2.4)	2 (3.1)	2 (4)			13 (3)
Total Responses within Group	**8 (100)**	**18 (100)**	**26 (100)**	**95 (100)**	**126 (100)**	**64 (100)**	**50 (100)**	**33 (100)**	**14 (100)**	**434 (100)**

Table 24. Summary of all incidents reported by disabled and non-disabled individuals.

Disability Type	Cognitive		Mobility	No Response	Other	Visual	All Responses from Disabled Individuals	All Responses from Non-Disabled Individuals
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Fall								
Other				1 (20)	1 (16.7)		2 (7.4)	
Slipped			2 (20)				2 (7.4)	5 (1.2)
Tripped								3 (0.7)
Hit By								
Animal - Dog								2 (0.5)
Cyclist								2 (0.5)
Other					1 (16.7)			3 (0.7)
Vehicle From Behind								5 (1.2)
Vehicle Turning Head-on				1 (20)			1 (3.7)	47 (11.5)
Vehicle Turning Left						1 (100)	1 (3.7)	23 (5.7)
Vehicle Turning Right								8 (2)
Vehicle Turning Right on Red								1 (0.2)
Near Miss								
Animal – Dog								1 (0.2)
Cyclist								6 (1.5)
Other								10 (2.5)
Vehicle From Behind								16 (3.9)
Vehicle Turning Head-on	1 (33.3)	1 (50)	4 (40)	1 (20)	1 (16.7)		8 (29.6)	124 (30.5)
Vehicle Turning Left			2 (20)	1 (20)	2 (33.3)		5 (18.5)	73 (17.9)
Vehicle Turning Right	1 (33.3)	1 (50)	1 (10)	1 (20)	1 (16.7)		5 (18.5)	67 (16.5)
Vehicle Turning Right on Red	1 (33.3)		1 (10)				2 (7.4)	11 (2.7)
Total Responses within Groups	**3 (100)**	**2 (100)**	**10 (100)**	**5 (100)**	**6 (100)**	**1 (100)**	**27 (100)**	**407 (100)**

Summary of all Hazard and Concern Reports

Table 25. Summary of all hazards and concerns reported by gender.

Gender	Men n (%)	No Response n (%)	Non-Binary n (%)	Women n (%)	All Responses n (%)
Hazard and Concern Type					
Crossing Issue					
Conflict With Vehicles Turning Left	14 (2.4)	5 (1.5)	1 (5)	17 (2.2)	37 (2.1)
Conflict With Vehicles Turning Right	14 (2.4)	3 (0.9)		16 (2)	33 (1.9)
Conflict With Vehicles Turning Right - On Red	5 (0.8)	1 (0.3)	1 (5)	7 (0.9)	14 (0.8)
Crosswalk Markings No Longer Visible	5 (0.8)	5 (1.5)		3 (0.4)	13 (0.7)
Crosswalk Needed	50 (8.4)	18 (5.3)		45 (5.7)	113 (6.5)
Drivers Don’t Stop or Yield to Pedestrians	112 (18.9)	50 (14.7)	3 (15)	139 (17.7)	304 (17.5)
Other	26 (4.4)	19 (5.6)		30 (3.8)	75 (4.3)
Poor Visibility of Pedestrians	28 (4.7)	16 (4.7)	1 (5)	24 (3.1)	69 (4)
Signal - Button Difficult to Access	3 (0.5)	1 (0.3)		4 (0.5)	8 (0.5)
Signal - Needs an Audible	2 (0.3)	3 (0.9)			5 (0.3)
Signal - Pedestrian Interval Too Short	12 (2)	6 (1.8)	1 (5)	26 (3.3)	45 (2.6)
Signal - Wait Time to Cross Too Long	10 (1.7)	6 (1.8)		19 (2.4)	35 (2)
Safety/Comfort Concern					
Animal - Dog		1 (0.3)		7 (0.9)	8 (0.5)
Other	37 (6.2)	32 (9.4)	1 (5)	61 (7.8)	131 (7.5)
Other Users - Bicycle	14 (2.4)	3 (0.9)		11 (1.4)	28 (1.6)
Other Users - E-Scooters		1 (0.3)			1 (0.1)
Other Users - Mobility Scooters/Electric Wheelchairs	2 (0.3)	1 (0.3)		2 (0.3)	5 (0.3)
Personal Safety - Gathering of Unknown People	4 (0.7)	3 (0.9)		1 (0.1)	8 (0.5)
Personal Safety - Harassment or Unwanted Attention	1 (0.2)	1 (0.3)	1 (5)	4 (0.5)	7 (0.4)
Personal Safety - Inadequate Lighting	1 (0.2)	4 (1.2)	1 (5)	17 (2.2)	23 (1.3)
Personal Safety - Isolated	1 (0.2)			2 (0.3)	3 (0.2)
Vehicles - Number Makes Uncomfortable	29 (4.9)	14 (4.1)	1 (5)	15 (1.9)	59 (3.4)

Vehicles - Speed Makes Uncomfortable	80 (13.5)	73 (21.4)	5 (25)	98 (12.5)	256 (14.7)
Sidewalk Infrastructure Issue					
Missing Curb Cut	12 (2)	1 (0.3)		5 (0.6)	18 (1)
Obstruction - Bike Rack (Including Bikeshare)	1 (0.2)				1 (0.1)
Obstruction - Bollard	2 (0.3)				2 (0.1)
Obstruction - Bus Shelter	1 (0.2)			1 (0.1)	2 (0.1)
Obstruction - Garbage or Recycling Bins	3 (0.5)			2 (0.3)	5 (0.3)
Obstruction - Inadequate or Lack of Safe Detour	13 (2.2)	2 (0.6)		15 (1.9)	30 (1.7)
Obstruction - Parked E-Scooters/Bicycles		2 (0.6)			2 (0.1)
Obstruction - Parked Vehicles or Delivery Vans	7 (1.2)	2 (0.6)		6 (0.8)	15 (0.9)
Obstruction - Pole (Hydro, Telephone)	4 (0.7)	1 (0.3)		12 (1.5)	17 (1)
Obstruction - Sign Blocking Path	3 (0.5)			1 (0.1)	4 (0.2)
Obstruction - Uneven (Sidewalk Roots, Holes, Cracks)	32 (5.4)	11 (3.2)	2 (10)	65 (8.3)	110 (6.3)
Obstruction - Vegetation That Narrows Pathway	10 (1.7)	1 (0.3)	1 (5)	13 (1.7)	25 (1.4)
Other	21 (3.5)	13 (3.8)		38 (4.8)	72 (4.1)
Slope (Issues Driveways)		2 (0.6)		10 (1.3)	12 (0.7)
Too Narrow	15 (2.5)	6 (1.8)	1 (5)	23 (2.9)	45 (2.6)
Uncomfortable Service (For Wheelchairs, Etc.)	7 (1.2)	4 (1.2)		10 (1.3)	21 (1.2)
Weather-related or Seasonal					
Ice	3 (0.5)	4 (1.2)		7 (0.9)	14 (0.8)
Leaves				2 (0.3)	2 (0.1)
Other		4 (1.2)		3 (0.4)	7 (0.4)
Puddles, Flooding, Splash Zone	1 (0.2)	3 (0.9)		2 (0.3)	6 (0.3)
Snow	9 (1.5)	19 (5.6)		23 (2.9)	51 (2.9)
Total Responses within Groups	**594 (100)**	**341 (100)**	**20 (100)**	**786 (100)**	**1741 (100)**

Table 26. Summary of all hazards and concerns reported by age.

Age Group	≤ 12 n (%)	13-17 n (%)	18-24 n (%)	25-34 n (%)	35-44 n (%)	45-54 n (%)	55-64 n (%)	65-74 n (%)	75+ n (%)	All Responses n (%)
Hazard and Concern Type										
Crossing Issue										
Conflict With Vehicles Turning Left	2 (10)	2 (3)		6 (1.8)	16 (3.2)	6 (2.7)	2 (1.1)	1 (0.7)	2 (2.1)	37 (2.1)
Conflict With Vehicles Turning Right	1 (5)		2 (1.2)	4 (1.2)	10 (2)	3 (1.3)	8 (4.3)	3 (2.1)	2 (2.1)	33 (1.9)
Conflict With Vehicles Turning Right - On Red		1 (1.5)	1 (0.6)	1 (0.3)	3 (0.6)	2 (0.9)	2 (1.1)	4 (2.8)		14 (0.8)
Crosswalk Markings No Longer Visible			1 (0.6)	3 (0.9)	3 (0.6)		2 (1.1)	3 (2.1)	1 (1.1)	13 (0.7)
Crosswalk Needed	3 (15)	1 (1.5)	9 (5.2)	26 (7.8)	32 (6.4)	22 (9.7)	12 (6.5)	7 (4.8)	1 (1.1)	113 (6.5)
Drivers Don’t Stop or Yield to Pedestrians	3 (15)	16 (24.2)	16 (9.2)	60 (17.9)	116 (23.3)	39 (17.3)	21 (11.4)	27 (18.6)	6 (6.4)	304 (17.5)
Other		4 (6.1)	8 (4.6)	14 (4.2)	14 (2.8)	15 (6.6)	5 (2.7)	9 (6.2)	6 (6.4)	75 (4.3)
Poor Visibility of Pedestrians		6 (9.1)	7 (4)	20 (6)	20 (4)	8 (3.5)	3 (1.6)	4 (2.8)	1 (1.1)	69 (4)
Signal - Button Difficult to Access				2 (0.6)	2 (0.4)		1 (0.5)	1 (0.7)	2 (2.1)	8 (0.5)
Signal - Needs an Audible			2 (1.2)	2 (0.6)					1 (1.1)	5 (0.3)
Signal - Pedestrian Interval Too Short		2 (3)	6 (3.5)	9 (2.7)	14 (2.8)	4 (1.8)	5 (2.7)	4 (2.8)	1 (1.1)	45 (2.6)
Signal - Wait Time to Cross Too Long		1 (1.5)	5 (2.9)	8 (2.4)	15 (3)	1 (0.4)	3 (1.6)	1 (0.7)	1 (1.1)	35 (2)
Safety/Comfort Concern										
Animal - Dog				1 (0.3)	4 (0.8)	2 (0.9)		1 (0.7)		8 (0.5)
Other	1 (5)	8 (12.1)	13 (7.5)	14 (4.2)	40 (8)	9 (4)	23 (12.4)	16 (11)	7 (7.4)	131 (7.5)
Other Users - Bicycle	1 (5)			2 (0.6)	9 (1.8)	6 (2.7)	5 (2.7)	5 (3.4)		28 (1.6)
Other Users - E-Scooters								1 (0.7)		1 (0.1)
Other Users - Mobility Scooters/Electric Wheelchairs				1 (0.3)	2 (0.4)	1 (0.4)			1 (1.1)	5 (0.3)
Personal Safety - Gathering of Unknown People			2 (1.2)	2 (0.6)	1 (0.2)		2 (1.1)		1 (1.1)	8 (0.5)
Personal Safety - Harassment or Unwanted Attention			3 (1.7)	1 (0.3)			1 (0.5)	1 (0.7)	1 (1.1)	7 (0.4)
Personal Safety - Inadequate Lighting	1 (5)	1 (1.5)		9 (2.7)	3 (0.6)	5 (2.2)	2 (1.1)	1 (0.7)	1 (1.1)	23 (1.3)
Personal Safety - Isolated			1 (0.6)	1 (0.3)		1 (0.4)				3 (0.2)
Vehicles - Number Makes Uncomfortable		5 (7.6)	5 (2.9)	13 (3.9)	21 (4.2)	4 (1.8)	6 (3.2)	2 (1.4)	3 (3.2)	59 (3.4)
Vehicles - Speed Makes Uncomfortable	6 (30)	12 (18.2)	15 (8.7)	42 (12.5)	87 (17.5)	26 (11.5)	21 (11.4)	17 (11.7)	30 (31.9)	256 (14.7)

Sidewalk Infrastructure Issue										
Missing Curb Cut			2 (1.2)	6 (1.8)	3 (0.6)	1 (0.4)	3 (1.6)	2 (1.4)	1 (1.1)	18 (1)
Obstruction - Bike Rack (Including Bikeshare)					1 (0.2)					1 (0.1)
Obstruction - Bollard			2 (1.2)							2 (0.1)
Obstruction - Bus Shelter					1 (0.2)		1 (0.5)			2 (0.1)
Obstruction - Garbage or Recycling Bins			2 (1.2)		2 (0.4)		1 (0.5)			5 (0.3)
Obstruction - Inadequate or Lack of Safe Detour			4 (2.3)	6 (1.8)	5 (1)	3 (1.3)	7 (3.8)	5 (3.4)		30 (1.7)
Obstruction - Parked E-Scooters/Bicycles									2 (2.1)	2 (0.1)
Obstruction - Parked Vehicles or Delivery Vans			1 (0.6)	2 (0.6)	6 (1.2)	3 (1.3)	3 (1.6)			15 (0.9)
Obstruction - Pole (Hydro, Telephone)				2 (0.6)	2 (0.4)	6 (2.7)	4 (2.2)	3 (2.1)		17 (1)
Obstruction - Sign Blocking Path			1 (0.6)			2 (0.9)	1 (0.5)			4 (0.2)
Obstruction - Uneven (Sidewalk, Roots, Holes, Cracks)		2 (3)	39 (22.5)	20 (6)	8 (1.6)	11 (4.9)	13 (7)	10 (6.9)	7 (7.4)	110 (6.3)
Obstruction - Vegetation That Narrows Pathway			5 (2.9)	8 (2.4)	3 (0.6)	6 (2.7)	3 (1.6)			25 (1.4)
Other		1 (1.5)	4 (2.3)	11 (3.3)	17 (3.4)	17 (7.5)	5 (2.7)	10 (6.9)	7 (7.4)	72 (4.1)
Slope (Issues, Driveways)			1 (0.6)	4 (1.2)	1 (0.2)	4 (1.8)		2 (1.4)		12 (0.7)
Too Narrow		2 (3)	5 (2.9)	13 (3.9)	13 (2.6)	4 (1.8)	6 (3.2)	1 (0.7)	1 (1.1)	45 (2.6)
Uncomfortable Service (For Wheelchairs, Etc.)			4 (2.3)	5 (1.5)	5 (1)	2 (0.9)	3 (1.6)		2 (2.1)	21 (1.2)
Weather-related or Seasonal										
Ice			3 (1.7)	2 (0.6)	1 (0.2)	3 (1.3)	3 (1.6)	2 (1.4)		14 (0.8)
Leaves				1 (0.3)		1 (0.4)				2 (0.1)
Other			1 (0.6)	1 (0.3)	1 (0.2)		4 (2.2)			7 (0.4)
Puddles, Flooding, Splash Zone				1 (0.3)	1 (0.2)	1 (0.4)	1 (0.5)		2 (2.1)	6 (0.3)
Snow	2 (10)	2 (3)	3 (1.7)	12 (3.6)	15 (3)	8 (3.5)	3 (1.6)	2 (1.4)	4 (4.3)	51 (2.9)
Total Responses within Groups	**20 (100)**	**66 (100)**	**173 (100)**	**335 (100)**	**497 (100)**	**226 (100)**	**185 (100)**	**145 (100)**	**94 (100)**	**1741 (100)**

Table 27. Summary of all hazards and concerns reported by disabled and non-disabled individuals.

Disability Type	Cognitive n (%)	Hearing n (%)	Mobility n (%)	No Response n (%)	Other n (%)	Visual n (%)	All Responses from Disabled Individuals n (%)	All Responses from Non-Disabled Individuals n (%)
Hazard and Concern Type								
Crossing Issue								
Conflict With Vehicles Turning Left	1 (7.7)						1 (0.7)	36 (2.3)
Conflict With Vehicles Turning Right								33 (2.1)
Conflict With Vehicles Turning Right - On Red								14 (0.9)
Crosswalk Markings No Longer Visible								13 (0.8)
Crosswalk Needed	2 (15.4)	1 (16.7)	5 (5.1)		1 (6.3)		9 (6.4)	104 (6.5)
Drivers Don’t Stop or Yield to Pedestrians	1 (7.7)	2 (33.3)	9 (9.1)		1 (6.3)		13 (9.2)	291 (18.2)
Other			2 (2)		1 (6.3)		3 (2.1)	72 (4.5)
Poor Visibility of Pedestrians	2 (15.4)		3 (3)				5 (3.5)	64 (4)
Signal - Button Difficult to Access								8 (0.5)
Signal - Needs an Audible				1 (25)			1 (0.7)	4 (0.3)
Signal - Pedestrian Interval Too Short			5 (5.1)		1 (6.3)		6 (4.3)	39 (2.4)
Signal - Wait Time to Cross Too Long			5 (5.1)				5 (3.5)	30 (1.9)
Safety/Comfort Concern	4 (30.8)	3 (50)	20 (20.2)		3 (18.8)	2 (66.7)	32	497 (31.1)
Animal - Dog								8 (0.5)
Other			3 (3)			1 (33.3)	6 (2.8)	24 (1.5)
Other Users - Bicycle							4	1 (0.1)
Other Users - E-Scooters			1 (1)		1 (6.3)		(1.4)	3 (0.2)
Other Users - Mobility Scooters/Electric Wheelchairs							2	8 (0.5)
Personal Safety - Gathering of Unknown People								7 (0.4)
Personal Safety - Harassment or Unwanted Attention	1 (7.7)		1 (1)				(1.4)	21 (1.3)
Personal Safety - Inadequate Lighting	1 (7.7)						2 (0.7)	2 (0.1)
Personal Safety - Isolated			2 (2)			1 (33.3)	1 (2.1)	56 (3.5)

Vehicles - Number Makes Uncomfortable	1 (7.7)	2 (33.3)	10 (10.1)		1 (6.3)		3 (9.9)	242 (15.1)
Vehicles - Speed Makes Uncomfortable	1 (7.7)	1 (16.7)	3 (3)		1 (6.3)		14 (4.3)	125 (7.8)
Sidewalk Infrastructure Issue	3 (23.1)		46 (46.5)	1 (25)	7 (43.8)		57	324 (20.3)
Missing Curb Cut			4 (4)				4 (2.8)	14 (0.9)
Obstruction - Bike Rack (Including Bikeshare)								1 (0.1)
Obstruction - Bollard								2 (0.1)
Obstruction - Bus Shelter			1 (1)				1 (0.7)	1 (0.1)
Obstruction - Garbage or Recycling Bins								5 (0.3)
Obstruction - Inadequate or Lack of Safe Detour	1 (7.7)		3 (3)		1 (6.3)		5 (3.5)	25 (1.6)
Obstruction - Parked E-Scooters/Bicycles								2 (0.1)
Obstruction - Parked Vehicles or Delivery Vans			3 (3)		1 (6.3)		4 (2.8)	11 (0.7)
Obstruction - Pole (Hydro, Telephone)			4 (4)		2 (12.5)		6 (4.3)	11 (0.7)
Obstruction - Sign Blocking Path								4 (0.3)
Obstruction - Uneven (Sidewalk Roots, Holes, Cracks)	2 (15.4)		14 (14.1)		1 (6.3)		17 (12.1)	93 (5.8)
Obstruction - Vegetation that Narrows Pathway				1 (25)	1 (6.3)		2 (1.4)	23 (1.4)
Other			8 (8.1)		1 (6.3)		9 (6.4)	63 (3.9)
Slope (Issues, Driveways)			4 (4)				4 (2.8)	8 (0.5)
Too Narrow			4 (4)				4 (2.8)	41 (2.6)
Uncomfortable Service (For Wheelchairs, Etc.)			1 (1)				1 (0.7)	20 (1.3)
Weather-related or Seasonal			4 (4)	2 (50)	2 (12.5)	1 (33.3)	9	71 (4.4)
Ice			3 (3)	2 (50)			5 (3.5)	9 (0.6)
Leaves								2 (0.1)
Other			1 (1)			1 (33.3)	2 (1.4)	5 (0.3)
Puddles, Flooding, Splash Zone					2 (12.5)		2 (1.4)	4 (0.3)
Snow								51 (3.2)
Total Responses within Groups	**13 (100)**	**6 (100)**	**99 (100)**	**4 (100)**	**16 (100)**	**3 (100)**	**141 (100)**	**1600 (100)**

Bibliography

Abdel-Aty, M., Lee, J., Siddiqui, C., & Choi, K. (2013). Geographical unit based analysis in the context of transportation safety planning. *Transportation Research Part A: Policy and Practice*, *49*, 62–75. https://doi.org/10.1016/j.tra.2013.01.030

Active Healthy Kids Canada. (2012). *Is Active Play Extinct? The active healthy kids Canada 2012 report card on physical activity for children and youth.* https://www.participaction.com/wp-content/uploads/2022/09/2012-Children-and-Youth-Report-Card.pdf

Amabile, M., Clark, G., Hargrave, J., & Simunich, J. (2019). *Cities alive: Designing for ageing communities*.

Berchicci, M., Lucci, G., & Di Russo, F. (2013). Benefits of physical exercise on the aging brain: The role of the prefrontal cortex. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*, *68*(11), 1337–1341. https://doi.org/10.1093/gerona/glt094

Boss, D., Nelson, T., Winters, M., & Ferster, C. J. (2018). Using crowdsourced data to monitor change in spatial patterns of bicycle ridership. *Journal of Transport and Health*, *9*(March), 226–233. https://doi.org/10.1016/j.jth.2018.02.008

Bourke, J. (2017). Children's experiences of their everyday walks through a complex urban landscape of belonging. *Children's Geographies*, *15*(1), 93–106. https://doi.org/10.1080/14733285.2016.1192582

Branion-Calles, M., Nelson, T., & Winters, M. (2017). Comparing crowdsourced near-miss and collision cycling data and official bike safety reporting. *Transportation Research Record*, *2662*(1), 1–11. https://doi.org/10.3141/2662-01

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Charlton, S. G., & Starkey, N. J. (2017). Drivers' mental representations of familiar rural roads. *Journal of Environmental Psychology*, *50*, 1–8. https://doi.org/10.1016/j.jenvp.2017.01.003

Chen, L., Tang, T. Q., Huang, H. J., Wu, J. J., & Song, Z. (2018). Modeling pedestrian flow accounting for collision avoidance during evacuation. *Simulation Modelling Practice and Theory*, *82*, 1–11. https://doi.org/10.1016/j.simpat.2017.12.011

Chu, C. H., Nyrup, R., Leslie, K., Shi, J., Bianchi, A., Lyn, A., McNicholl, M., Khan, S., Rahimi, S., & Grenier, A. (2022). Digital ageism: Challenges and opportunities in artificial intelligence for older adults. In *Gerontologist* (Vol. 62, Issue 7, pp. 947–955). Gerontological Society of America. https://doi.org/10.1093/geront/gnab167

Cloutier, M. S., Lachapelle, U., d'Amours-Ouellet, A. A., Bergeron, J., Lord, S., & Torres, J. (2017). "Outta my way!" Individual and environmental correlates of interactions between pedestrians and vehicles during street crossings. *Accident Analysis and Prevention*, *104*(April), 36–45. https://doi.org/10.1016/j.aap.2017.04.015

Creswell, J. W. (2018). *Qualitative inquiry and research design: Choosing among five approaches*. Sage Publications, Inc.

DEKRA. (2023). *Road safety report 2023: Technology and people*. DEKRA. https://dekraprod-media.e-spirit.cloud/59f0c4f3-818a-42a7-b329-bc991b5a1ce6/media/dekra-vsr-2023-en-online.pdf

Delgado-Ortiz, L., Polhemus, A., Keogh, A., Sutton, N., Remmele, W., Hansen, C., Kluge, F., Sharrack, B., Becker, C., Troosters, T., Maetzler, W., Rochester, L., Frei, A., Puhan, M. A., & Garcia-Aymerich, J. (2023). Listening to the patients' voice: a conceptual framework of the walking experience. *Age and Ageing*, *52*(1). https://doi.org/10.1093/ageing/afac233

Dolnicar, S., Grün, B., & Leisch, F. (2018). *Market segmentation analysis understanding it, doing it, and making it useful*. Springer Nature. https://doi.org/10.1007/978-981-10-8818-6

Dommes, A., Granié, M. A., Cloutier, M. S., Coquelet, C., & Huguenin-Richard, F. (2015). Red light violations by adult pedestrians and other safety-related behaviors at signalized crosswalks. *Accident Analysis and Prevention*, *80*, 67–75. https://doi.org/10.1016/j.aap.2015.04.002

Dumbaugh, E. (2008). Designing Communities to Enhance the Safety and Mobility of Older Adults. *Journal of Planning Literature*, *23*(1), 17–36. https://doi.org/10.1177/0885412208318559

Falahatkar, H., & Fast, V. (2023). A feminist-driven computational urban design framework for mapping gender-inclusive urban places. *The 18th International Conference on Computational Urban Planning and Urban Management (CUPUM).* https://doi.org/10.17605/OSF.IO/6YR5V

Fast, V., & Rinner, C. (2014). A systems perspective on volunteered geographic information. *ISPRS International Journal of Geo-Information*, *3*, 1278–1292. https://doi.org/10.3390/ijgi3041278

Forsyth, A. (2015). What is a walkable place? The walkability debate in urban design. *Urban Design International*, *20*(4), 274–292. https://doi.org/10.1057/udi.2015.22

Frehlich, L., Christie, C. D., Ronksley, P. E., Turin, T. C., Doyle-Baker, P., & McCormack, G. R. (2022). The neighbourhood built environment and health-related fitness: a narrative systematic review. In *International Journal of Behavioral Nutrition and Physical Activity* (Vol. 19, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s12966-022-01359-0

Gan, D. R. Y., Mahmood, A., Routhier, F., & Mortenson, W. Ben. (2022). Walk/wheelability: An inclusive instrument pair for participatory age-friendly research and practice. *Gerontologist*, *62*(1), E39–E47. https://doi.org/10.1093/geront/gnab079

Golub, A., Marcantonio, R. A., & Sanchez, T. W. (2013). Race, space, and struggles for mobility: Transportation impacts on African Americans in Oakland and the East Bay. *Urban Geography*, *34*(5), 699–728. https://doi.org/10.1080/02723638.2013.778598

Golub, A., & Martens, K. (2014). Using principles of justice to assess the modal equity of regional transportation plans. *Journal of Transport Geography*, *41*, 10–20. https://doi.org/10.1016/j.jtrangeo.2014.07.014

Grise, E., Boisjoly, G., Babbar, P., Peace, J., & Cooper, D. (2022). *Understanding and responding to the transit needs of women in Canada. Leading Mobility. https://www.leadingmobility.com/transit-needs-of-women*.

Grisé, E., Boisjoly, G., Maguire, M., & El-Geneidy, A. (2019). Elevating access: Comparing accessibility to jobs by public transport for individuals with and without a physical disability. *Transportation Research Part A: Policy and Practice*, *125*, 280–293. https://doi.org/10.1016/j.tra.2018.02.017

Hauer, E. (1999). *Safety in* Geometric Design Standards*.* University of Toronto.

Hendrigan, H. (2019). Mixing Digital Humanities and Applied Science Librarianship: Using Voyant tools to reveal word patterns in faculty research. *Science and Technology Librarianship*, *91*. https://doi.org/https://doi.org/10.29173/istl3

Huybers, S., Van Houten, R., & Malenfant, J. E. L. (2004). Reducing conflicts between motor vehicles and pedestrians: The separate and combined effects of pavement markings and a sign prompt. *Journal of Applied Behavior Analysis*, *37*(4), 445–456. https://doi.org/10.1901/jaba.2004.37-445

Johnston, B. D. (2008). Planning for child pedestrians: Issues of health, safety and social justice. *Journal of Urban Design*, *13*(1), 141–145. https://doi.org/10.1080/13574800701803407

Kerr, J., Rosenberg, D., & Frank, L. (2012). The role of the built environment in healthy aging: Community design, physical activity, and health among older adults. *Journal of Planning Literature. 27(1).* https://doi.org/10.1177/0885412211415283

Laberee, K., Nelson, T., Boss, D., Ferster, C., Hosford, K., Fuller, D., Cloutier, M. S., & Winters, M. (2023). WalkRollMap.org: Crowdsourcing barriers to mobility. *Frontiers in Rehabilitation Sciences*, *4*. https://doi.org/10.3389/fresc.2023.1023582

Lachapelle, U., & Cloutier, M. S. (2017). On the complexity of finishing a crossing on time: Elderly pedestrians, timing and cycling infrastructure. *Transportation Research Part A: Policy and Practice*, *96*, 54–63. https://doi.org/10.1016/j.tra.2016.12.005

Lawton, M. P., & Zarit, S. H. (2001). The physical environment of the person with Alzheimer's disease. *Aging and Mental Health*, *5*(SUPPL. 1). https://doi.org/10.1080/713650004

Lee, K., & Sener, I. N. (2017). *Emerging data mining for pedestrian and bicyclist monitoring: A literature review report*. A&M Transportation Institute. https://safed.vtti.vt.edu/wp-content/uploads/2020/07/UTC-Safe-D_Emerging-Data-Mining-for-PedBike_TTI-Report_26Sep17_final.pdf

Lerman, A. E., & Weaver, V. M. (2014). Staying out of sight? Concentrated policing and local political action. *Annals of the American Academy of Political and Social Science*, *651*(1), 202–219. https://doi.org/10.1177/0002716213503085

Lord, S., Cloutier, M. S., Garnier, B., & Christoforou, Z. (2018). Crossing road intersections in old age—With or without risks? Perceptions of risk and crossing behaviours among the elderly. *Transportation Research Part F: Traffic Psychology and Behaviour*, *55*, 282–296. https://doi.org/10.1016/j.trf.2018.03.005

Lucas, K. (2004). Transport and social exclusion. In Bristol University Press (Ed.), *Running on Empty Transport, Social Exclusion and Environmental Justice* (pp. 429–434). https://doi.org/10.1016/B978-008044910-4.01034-8

Lucas, K., Phillips, I., Mulley, C., & Ma, L. (2018). Is transport poverty socially or environmentally driven? Comparing the travel behaviours of two low-income populations living in central and peripheral locations in the same city. *Transportation Research Part A: Policy and Practice*, *116*(November 2016), 622–634. https://doi.org/10.1016/j.tra.2018.07.007

Lyu, Y., & Forsyth, A. (2022). Planning, aging, and loneliness: Reviewing evidence about built environment effects. *Journal of Planning Literature*, *37*(1), 28–48. https://doi.org/10.1177/08854122211035131

Ma, W., Kofi Alimo, P., Wang, L., & Abdel-Aty, M. (2022). Mapping pedestrian safety studies between 2010 and 2021: A scientometric analysis. *Accident Analysis and Prevention*, *174*. https://doi.org/10.1016/j.aap.2022.106744

Mao, X., & Chen, L. (2021). "To go, or not to go, that is the question": Perceived inaccessibility among individuals with disabilities in Shanghai. *Disability and Society*, *0*(0), 1–19. https://doi.org/10.1080/09687599.2021.1899897

Marohn Jr., C. L. (2021). *Confessions of a Recovering Engineer*. Wilely.

Martinson, R., & Golly, T. (2023). The safe system approach. *Transportation Talk*, 37–47. https://issuu.com/cite7/docs/45.2-summer2023?fr=sMjhkOTYyNzY2NTI

Middleton, J. (2011). Walking in the city: The geographies of everyday pedestrian practices. *Geography Compass*, *5*(2), 90–105. https://doi.org/10.1111/j.1749-8198.2010.00409.x

Miller, B., & Ponto, J. (2016). Mobility among the spatialities. *Annals of the American Association of Geographers*, *106*(2), 266–273. https://doi.org/10.1080/00045608.2015.1120150

Miner, P., Smith, B. M., Jani, A., McNeill, G., & Gathorne-Hardy, A. (2024). Car harm: A global review of automobility's harm to people and the environment. *Journal of Transport Geography*, *115*. https://doi.org/10.1016/j.jtrangeo.2024.103817

Minkoff, S. L. (2014). Political engagement in a public goods context: The effect of neighborhood conditions and schools on local election turnout. *Midwest Political Science Association Annual Conference*, *April* 13.

Montgomery, C. (2013). *Happy city: Transforming our lives through urban design*. Doubleday Canada.

Müller, L. (2023). *Bridging the Gaps Realising Human Diversity in the built environment through universal design "Maybe we should remove a piece?"* [Doctoral Dissertation]. Lund University.

Müller, L., Ericsson, S., Wojahn, D., & Hedvall, P. O. (2021). Young, mobile, and highly educated cyclists: How urban planning and policy dis/able users. *Scandinavian Journal of Disability Research*, *23*(1), 124–135. https://doi.org/10.16993/SJDR.731

Nelischer, C., & Loukaitou-Sideris, A. (2022). Intergenerational public space design and policy: A review of the literature. *Journal of Planning Literature*. https://doi.org/10.1177/08854122221092175

Nelson, T., Denouden, T., Jestico, B., Laberee, K., & Winters, M. (2015). BikeMaps.org: A global tool for collision and near miss mapping. *Frontiers in Public Health*, *3*(MAR), 1–8. https://doi.org/10.3389/fpubh.2015.00053

Novaco, R. W. (2015). Transportation, psychology of. In *International Encyclopedia of the Social & Behavioral Sciences* (Second Ed. Vol. 24). Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.22020-5

Palm, M., Allen, J., Liu, B., Zhang, Y., Widener, M., & Farber, S. (2021). Riders who avoided public transit during COVID-19: Personal burdens and implications for social equity. *Journal of the American Planning Association*, *87*(4), 455–469. https://doi.org/10.1080/01944363.2021.1886974

Palm, M., Farber, S., Shalaby, A., & Young, M. (2021). Equity analysis and new mobility technologies: Toward meaningful interventions. *Journal of Planning Literature*, *36*(1), 31–45. https://doi.org/10.1177/0885412220955197

Parks Canada. (2014). *Connecting Canadians with nature — An investment in the well-being of our citizens.* Parks Canada. *https://parks-parcs.ca/wp-content/uploads/2020/09/ConnectingCanadians-English_web.pdf*

Patton, J. W. (2007). A pedestrian world: Competing rationalities and the calculation of transportation change. *Environment and Planning A*, *39*(4), 928–944. https://doi.org/10.1068/a389

Plaut, P., Shach-Pinsly, D., Schreuer, N., & Kizony, R. (2021). The reflection of the fear of falls and risk of falling in walking activity spaces of older adults in various urban environments. *Journal of Transport Geography*, *95*. https://doi.org/10.1016/j.jtrangeo.2021.103152

Preston, V., & McLafferty, S. (2016). Revisiting gender, race, and commuting in New York. *Annals of the American Association of Geographers*, 1–11. https://doi.org/10.1080/00045608.2015.1113118

Qiao, F. (n.d.). *Least square analysis on exercise duration of recorded data from the Endomondo Fitness App*. University of California, San Diego. https://cseweb.ucsd.edu/classes/wi15/cse255-a/reports/wi15/Fang_Qiao.pdf

Rantanen, T. (2013). Promoting mobility in older people. In *Journal of Preventive Medicine and Public Health* (Vol. 46, Issue SUPPL.1). https://doi.org/10.3961/jpmph.2013.46.S.S50

Roberts, I., Norton, R., Jackson, R., Dunn, R., & Hassall, I. (1995). Effect of environmental factors on risk of injury of child pedestrians by motor vehicles: a case-control study. *British Medical Journal*, *310*(6972), 91–94. https://doi.org/10.1136/bmj.310.6972.91

Roess, R. P., & Prassas, E. S. (2014). *The highway capacity manual: A conceptual and research history* (Vol. 5). Springer International Publishing. http://www.springer.com/series/11059

Roy, A., Nelson, T. A., Fotheringham, A. S., & Winters, M. (2019). Correcting bias in crowdsourced data to map bicycle ridership of all bicyclists. *Urban Science*, *3*(2), 62. https://doi.org/10.3390/urbansci 3020062

Sallis, J. F., Cervero, R. B., Ascher, W., Henderson, K. A., Kraft, M. K., & Kerr, J. (2006). An ecological approach to creating active living communities. *Annual Review on Public Health*, *27*, 297–322. https://doi.org/10.1146/annurev.publhealth.27.021405.102100

Sánchez de Madariaga, I. (2013). Mobility of care: Introducing new concepts in urban transport. In *Fair shared cities: The impact of gender planning in Europe (*1st ed.). Routledge. https://doi.org/https://doi.org/10.4324/9781315581835

Santos, T., Nogueira Mendes, R., & Vasco, A. (2016). Recreational activities in urban parks: Spatial interactions among users. *Journal of Outdoor Recreation and Tourism*, *15*, 1–9. https://doi.org/10.1016/j.jort.2016.06.001

Sheller, M. (2018). *Mobility justice: The politics of movement in an age of extremes*. Verso.

Shirazi, M. S., & Morris, B. T. (2017). Looking at Intersections: A Survey of intersection monitoring, behavior and safety analysis of recent studies. In *IEEE Transactions on Intelligent Transportation Systems* (Vol. 18, Issue 1, pp. 4–24). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/TITS.2016.2568920

Statistics Canada. (2023, October 30). *Circumstances surrounding pedestrian fatalities, 2018 to 2020*. Statistics Canada. https://www150.statcan.gc.ca/n1/daily-quotidien/231030/dq231030a-eng.htm

Statistics Canada. (2024). *The disability rate in Canada increased in 2022*. Statistics Canada. https://www.statcan.gc.ca/o1/en/plus/5980-disability-rate-canada-increased-2022

Stephens, M. (2013). Gender and the GeoWeb: Divisions in the production of user-generated cartographic information. *GeoJournal*, *78*, 981–996. https://doi.org/10.1007/s10708-013-9492-z

Stoker, P., Garfinkel-Castro, A., Khayesi, M., Odero, W., Mwangi, M. N., Peden, M., & Ewing, R. (2015). Pedestrian safety and the built environment: A review of the risk factors. *Journal of Planning Literature*, *30*(4), 377–392. https://doi.org/10.1177/0885412215595438

Svensson, Å., & Hydén, C. (2006). Estimating the severity of safety related behaviour. *Accident Analysis and Prevention*, *38*(2), 379–385. https://doi.org/10.1016/j.aap.2005.10.009

Transport Canada. (2019). National collision database online. [Dataset]. Transport Canada. https://wwwapps2.tc.gc.ca/Saf-Sec-Sur/7/NCDB-BNDC/p.aspx?l=en&l=en

Truong, L. T., & Somenahalli, S. V. C. (2011). Using GIS to identify pedestrian-vehicle crash hot spots and unsafe bus stops. *Journal of Public Transportation*, *14*(1), 99–114. https://doi.org/http://doi.org/10.5038/2375-0901.14.1.6

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences*, *15*(3), 398–405. https://doi.org/10.1111/nhs.12048

Vergouwen, M., Samuel, T. L., Sayre, E. C., & White, N. J. (2021). FROST: Factors predicting orthopaedic trauma volumes. *Injury*, *52*(10), 2871–2878. https://doi.org/10.1016/j.injury.2021.02.076

Voyant. (2024). *Tutorial/Workshop*. Voyant-Tools.Org. [Website] https://voyant-tools.org/docs/#!/guide/tutorial

WalkRollMap. (2024). *About*. [Website] WalkRollMap.Org.

White, A., & Trump, K. S. (2018). The promises and pitfalls of 311 Data. *Urban Affairs Review*, *54*(4), 794–823. https://doi.org/10.1177/1078087416673202

Wilson, K. (2024, June 5). Why so many dangerous, car-dominated cities have “achieved” vision zero. *StreetsBlogUSA*. https://usa.streetsblog.org/2024/06/05/why-so-many-dangerous-car-dominated-cities-have-achieved-vision-zero

World Health Organization. (2007). Global age-friendly cities: A Guide. In *Global age-friendly cities: A guide*. http://www.who.int/ageing/publications/Global_age_friendly_cities_Guide_English.pdf

Yasmin, S., Bhowmick, T., Rahman, M., Eluru, N. (2016). *Enhancing non-motorized safety by simulating non-motorized exposure using a transportation planning approach*. SAFER-SIM University Transportation Center. https://rosap.ntl.bts.gov/view/dot/32653

Zhao, F., & Gustafson, T. (2013). *Transportation needs of disadvantaged populations: Where, when, and how?* (Issue 30). Federal Transit Administration. https://trid.trb.org/view/1254399