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School of Transportation Sciences

Master of Transportation Sciences

Master's thesis

Older adults' mobility: travel behaviour, mobility experiences and measures to improve their safety in Flanders

Emmanuel Hitimana

Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences, specialization Traffic Safety

SUPERVISOR :
Prof. dr. An NEVEN

CO-SUPERVISOR :
dr. Ariane CUENEN

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PREFACE

This dissertation discusses older adults' mobility, travel behavior, mobility experiences, and safety measures in Flanders, Belgium. Master's student Emmanuel Hitimana conducted the research under the supervision of Prof. dr. An Neven and Dr. Ariane Cuenen.

The study evaluated objective and subjective factors that affect older adults' mobility and travel behavior, identified mobility experiences and safety barriers, and proposed specific measures to improve their mobility and safety. Mobility allows older adults to access goods, services, and facilities and engage in social and cultural activities. Current generations of older adults are more physically fit and active than previous generations, and their increase coincides with a rise in the number of older road users, posing a significant health risk to older adults with the likelihood of more accident fatalities than other groups. To ensure their safe mobility, you must first understand their mobility needs, perceptions, experiences, and safety barriers. Perceived barriers to older people's mobility explain the activities they want or need to do more of but cannot.

Without the following people, I could not have completed my research or earned my master's degree. First, I would like to thank my promoters, Prof. dr. An Neven and Dr. Ariane Cuenen, for their time, input, consistent support, and guidance. I also appreciate my classmates' ideas and moral support. Thanks to UHasselt and Lund University’s faculty who impacted and inspired me.

Finally, I am grateful to my wife, Eugenie, and our children, Aldric and Arden, for their love, patience, and encouragement during the past two years of study.

ABSTRACT

The percentage of seniors (>60 years) worldwide will nearly double between 2015 and 2050. Countries face challenges preparing their health and social systems for this demographic shift. Mobility is a key factor in later life independence and quality of life because it allows people to access goods, services, and facilities and engage in social and cultural activities. As developing and developed countries experience a demographic shift toward an aging population, it is important to provide transportation for older adults. Several studies show that older adults are more physically fit and active than previous generations, and their increase coincides with a rise in the number of older road users, posing a significant health risk to older adults with the likelihood of more fatalities in accidents than other population groups. Ensuring their safe mobility requires understanding the needs and developing specific measures to improve mobility and safety.

This thesis examines how socio-demographic factors, health factors, transport-related factors, activities, and built environment affect older adults' mobility and travel behavior in Flanders, Belgium. The study also evaluates subjective mobility factors (in addition to objective factors), identifies mobility experiences, perceptions of safety, and barriers older adults face when using different modes of transport, and proposes specific measures to improve their mobility and safety. In this study, subjective mobility indicators were used to better understand older people's mobility needs, perceptions, and experiences instead of objective measures, which often neglect the multiple dimensions of individual experiences.

Using a mixed approach, this study applied the conceptual framework of Luiu and colleagues (2018) to investigate older adults' mobility and travel behavior based on five interconnected domains: 1) demographic characteristics, 2) health and well-being, 3) transportation, 4) built environment, and 5) activities. 164 seniors (60-92 year) took part in the online survey and 51 seniors (60-88 year) took part in focus groups. Survey and focus group data were collected in May and December 2019, respectively. Survey and focus groups were conducted through older adult organizations in Flanders. Using IBM SPSS Statistics 28, two ordinal logistic regressions were performed to identify the most influential factors on older people's travel decisions in terms of mode choices and carrying out activities. Two Spearman's correlations were performed to investigate the effect of subjective measures in addition to the objective indicators used in the two analysis models above. Additionally, a framework analysis was performed on focus group data using NVivo 12 software.

Social demographics influence seniors' travel decisions. Women are more likely to use cars as passengers than men, while more men participate in daily life activities. 75-year-olds and older are less likely to cycle, drive a car, and use public transport than younger adults. Living with a partner negatively affects walking and cycling, but positively affects public transport (PT) use. Living alone negatively affects cycling and car driving. Living with a partner positively affects almost all activities or locations studied, while living alone only affects social activities. Lower-educated older people drive more than higher-educated people and travel less for daily activities.

Access to transportation resources influenced older travelers. Bicycle ownership benefits older cyclists but hurts driving and PT, while car ownership reduces cycling and PT use while boosting driving. A bus train card improves PT. Driver's license and bus/train card possession is positively

associated with most activities in general, while older adults are less likely to use a car for trips to the city center, grocery stores, parks, and sporting events. Subjective factors were effective predictors of older adults' travel decisions in terms of mode choices and trip frequencies during activities, allowing full understanding of their mobility needs (realized/not realized) and related perceived barriers.

This study examined how older people's needs, desires, and importance of travel modes affect their travel decisions. This, along with subjective measures related to the built environment and transportation, and focus group results, made it possible to identify a wide range of perceived mobility barriers, which explain the activities older people want or need to do more of (desired mobility) but can't (unfulfilled mobility needs). Out of these many barriers, those directly related to older adults' safety, such as drivers' behavior, speeding traffic, road users not following rules and traffic signs, and other road users, were user behaviors; and poor quality pavements or surfaces, sharing the pavements with others, unsafe crossings, insufficient lighting, and the presence of obstacles along the pathways, and difficulty boarding PT vehicles were infrastructure/facilities. The proposed measures included training/educational and behavioral measures such as training of bus drivers (all PT users) targeting awareness of issues that affect older people and other educational and awareness campaigns for road user behavior change combined with strict enforcement of traffic rules. Infrastructure/facilities and road design improvements included improving pavements, increasing the width of pedestrian/cycle paths, separating cycling routes/sidewalks from car lanes, use of technology aids to make street crossing easier, installing LED-lights in pavements, and using raised platforms or low-floor buses.

This study is unique because many previous studies did not investigate the effect of people's perceived importance of needs and desires and travel modes on their travel decisions. This approach helped understand the connection between objective/subjective mobility measures and older adults' travel behavior and needs, including realized and unrealized needs. The methods complement each other and reveal concerns and connections that would have been hidden with just one form of data collection and analysis. The study has some potential limitations, including (1) only some selected aspects of the model by Luiu and colleagues (2018) were examined, leaving some issues unexplained; (2) the sample population may reflect older adults' lives in general on some variables/aspects studied; and (3) measures to improve mobility and safety of older people did not address vehicle design improvements. Despite these limitations, the current research will stimulate further investigation of older adults' mobility behavior and needs, especially their safety barriers associated with various modes of transportation from the perspectives of health, personal/traffic safety, and the built environment.

Key words:
Older road users; Mobility; Travel behaviour; Mobility needs; Subjective measures; Mobility barriers; Safety; Safety measures

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1. INTRODUCTION

1.1 Older Adults Growth

Between 2015 and 2050, the **proportion of older adults aged 60 and up** worldwide nearly doubles, rising from 12% to 22%. (Figure 1). In Europe, older adults are expected to account for 35 percent of the total population in 2050, up from 24.9 percent in 2015. In the same year, Belgium had over 2.5 million people aged 60 and up, accounting for 23.9 percent of the country's population (Eurostat, 2019). The Flanders region, the northern, Dutch-speaking part of Belgium, has the highest rate of older adults aged 60 or over, accounting for 27 percent of the total region population (Statistics Flanders, 2021).

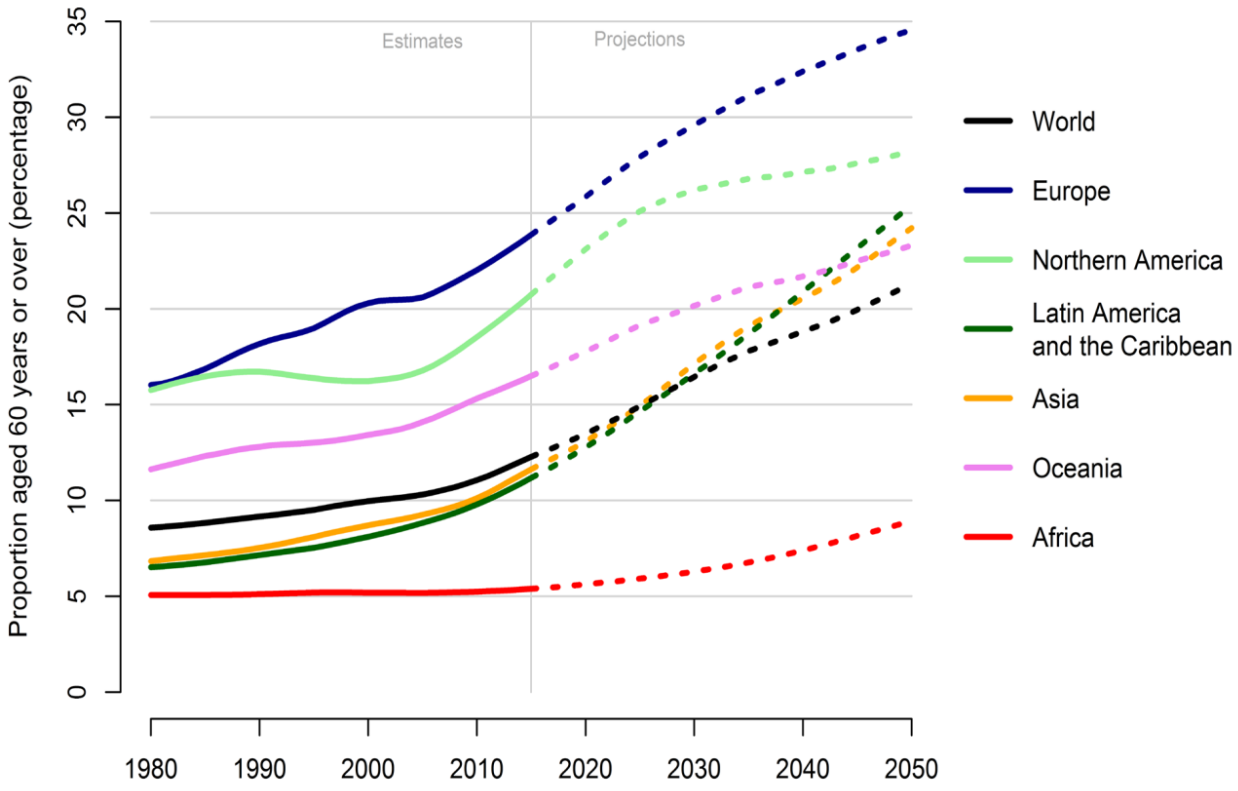


FIGURE 1 Percentage of World population aged 60 or over by region, from 1980 to 2050 (United Nations, 2017)

The majority of the world's nations have faced significant obstacles in preparing their health and social systems for this **demographic shift** (WHO, 2018). According to the World Health Organization (2015), mobility is essential for healthy aging because it enables individuals to access goods, services, and facilities as well as engage in social and cultural activities. Mobility is widely recognized as one of the key factors associated with later-life independence and quality of life (Bowling et al., 2002; Bricocoli et al., 2018). As a result of the demographic shift toward an aging population that both developing and developed countries are experiencing, it is becoming increasingly important to provide transportation that is suitable for older adults (Luiu and Tight 2021). According to Kim et al., 2013, as cited in Luiu et al., 2017, when older people do not

participate in out-of-home activities, it may be due to a lack of transportation options or an unfriendly environment, rather than a lack of need. Multiple studies have found that mobility outside the home tends to decline with age (Haustein et al. 2013, as cited in Luiu and Tight, 2021). Reduced mobility has been associated with worsening health conditions (Haustein et al. 2013; Siren and Hakamies-Blomqvist 2004; Hjorthol 2013, as cited in Luiu and Tight, 2021), but inadequate travel resources and mobility environment also play a role (World Health Organization 2015, as cited in Luiu and Tight, 2021). Luiu and Tight (2021) proposed future policies, planning, and interventions targeting age-friendly and inclusive transport and environments to help older people remain active and engaged in society. Such measures and interventions should include providing mobility beyond the car for those who cannot access, use, or afford it, improving attitudes toward alternatives to the car, and implementing public transport training programs.

According to Polders et al. (2015), as the population ages, more older adults participate in road traffic. Recent European statistics show that the **risk of death in an accident** is many times higher for older cyclists and pedestrians than for older car drivers. In Flanders, older people account for 33.5% of traffic deaths (Statistics Flanders, 2021). According to a recent Belgian study, over half of **older people killed** were pedestrians or cyclists. Walking and cycling are the most dangerous modes of transportation for older people. Older drivers have a low death rate, according to the study. Safe mobility for older road users has become a major social concern (Marin-Lamellet and Haustein, 2015).

Managing the safe mobility of older adults, however, necessitates policies and programs that strike a balance between safety and access to essential services and amenities. There is evidence, for example, that providing safe travel options that allow easy access to essential services and amenities is an important factor in preserving the mobility of older road users (Ottoni et al., 2021). As a result, identifying the mobility needs and travel behaviors of older adults is critical in order to fully understand their mobility needs and develop measures to improve their mobility and traffic safety (Shen et al., 2017). Such measures should have a positive impact on traffic participation, safety, mobility, and quality of life. The creation of an urban environment that accommodates the travel patterns and needs of older road users can help meet their demand for quick travel (O'Hern and Oxley, 2015).

1.2 Research context

Mobility and transportation needs for older adults have been analyzed and classified in a variety of ways in the literature. Metz (2000) proposed five key elements to describe mobility in relation to quality of life and personal needs: having access to desired people and places; psychological benefits of movement; health benefits of movement (e.g., physical exercise), benefits from social and local community involvement, and benefits from potential travels. Musselwhite and Haddad (2010) proposed a three-level pyramid of self-awareness-based transportation needs. "Practical needs" are seen as primary in their hierarchy, and are essentially those related to day-to-day, functional, and utilitarian travel, such as meeting appointments (e.g., medical) or visiting shops, services, and other people (e.g. friends or family). "Social needs" are regarded as secondary and are linked to psychological feelings of independence, control over one's life, and "keeping in tune with society." Finally, "aesthetic needs" are regarded as tertiary, and are associated with leisure and recreational travel, including travel for relaxation or to visit natural environment (Figure 2).

According to the literature review conducted by Luiu and colleagues (2017) on **factors influencing the fulfillment of travel needs** in later life, at least one-third of older people have unmet travel needs. Leisure and social activities, especially visiting family or other people, were the most affected out-of-home activities, especially for women and those over the age of 75.

Common **mobility indicators** include travel behavior, demand, preferences, choices, satisfaction, activity patterns, and access to transportation options. While these methods are generally valid for general population studies, they are unlikely to provide sufficient insight into the specific needs of older adults (Luiu et al., 2017). Mobility has traditionally been evaluated as a demand derived from travel behavior and preferences based on actual trips and activities undertaken by individuals (Hjorthol, 2013, as cited in Luiu et al., 2018). According to Luiu and colleagues (2018), these approaches are frequently insufficient to explain aging mobility. Luiu and colleagues (2017) argued that when investigating the travel patterns and behaviors of older individuals, it is important to consider not only actual mobility, but also unmet travel needs and desires. Unmet travel needs were defined as trips and activities that people want or need to do more of, but are unable to do so for various reasons. In their research on the relationship between mobility and well-being, Nordbakke and Schwanen (2014) suggest that, given the significance of subjective experiences of well-being, understanding the relationships between well-being and mobility in later life requires additional research that combines subjective and objective approaches to well-being.

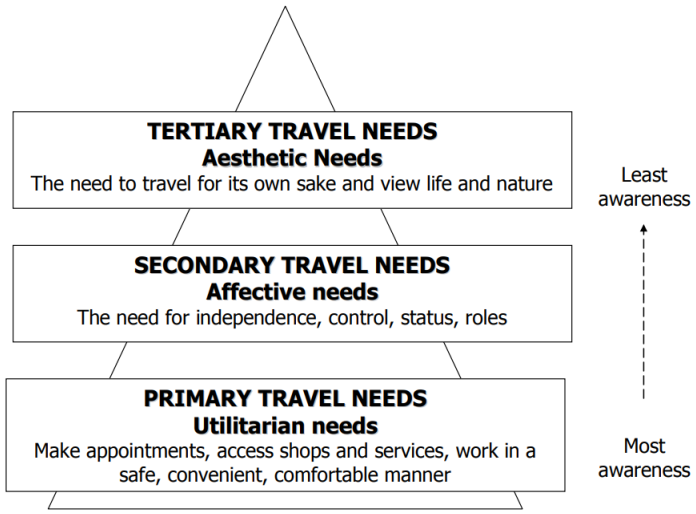


FIGURE 2 The three-level pyramid of self-awareness-based transportation needs (Musselwhite and Haddad, 2010)

Due to the limitations of previous research methods and the heterogeneity of older adults, Luiu and colleagues (2018) developed a **conceptual framework** that expands the factors that must be considered when assessing their mobility needs. They proposed five interconnected qualitative and quantitative domains that shape and influence the mobility of older adults (Figure 3). The **"Transportation"** domain examines travel patterns and access to transportation modes, attitudes toward transportation, coping strategies for those who do not drive, and trip planning to evaluate an individual's transportation mobility resources and abilities. The **"Health and wellbeing"** domain evaluates subjective and objective health conditions and life satisfaction, as well as the

relationship between the type of impairment and difficulties in performing activities and using transportation modes. The **"Built environment"** domain evaluates spatial characteristics in relation to the contextual conditions of the place of residence, not only from a broad perspective, such as urban, suburban, or rural, but also from a narrower range of settlement spatial characteristics. In addition, this domain examines the accessibility of the built environment in terms of access to transportation resources, service facilities, and goods, as well as the quality of infrastructure features provided. The **"Activity"** domain evaluates the type of activity, the level of engagement with activities, and the perceived importance of these for older adults. Lastly, the **"Demographics"** domain assesses the demographic characteristics of individuals in terms of their individual characteristics, socioeconomic factors, living form and environment, and social network.

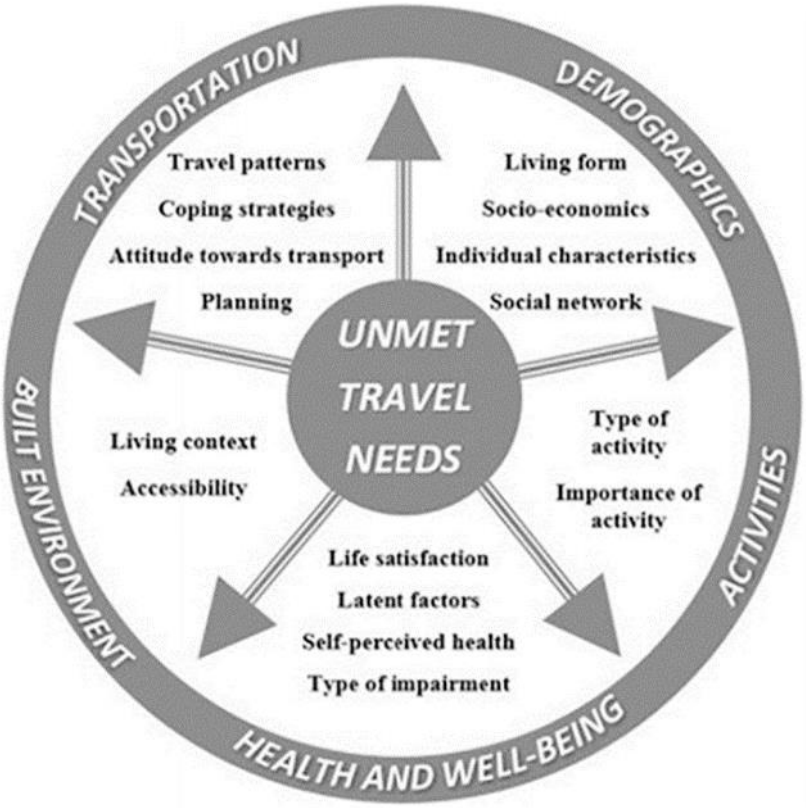


FIGURE 3 Conceptual framework to assess mobility needs of older adults (Luiu et al., 2018).

According to Nordbakke and Schwanen (2014), many previous studies focused on objective mobility factors to understand **older adults' travel behavior and needs**, such as car availability and use, self-perceived health, socio-demographics (gender, age, living situation), socio-economic status (income), residential location, and social network support. Mollenkopf et al. (2011) argue that subjective mobility evaluation could be a better predictor of well-being (than objective) and that objective measures often neglect the multiple dimensions of individual experiences. Unlike studies on older drivers' safety, relatively little research has been done on walking and cycling in later age, especially on barriers. The built environment, health, and safety are priorities (Luiu et al., 2018a).

Based on Nordbakke and Schwanen's (2014) recommendation for future research that more explanatory factors be given greater attention and qualitative methods be used for deeper insights and understanding of older adults' perceptions, mobility experiences, and safety barriers, this study draws on reported gaps in prior research and applies Luiu and colleagues' (2018) conceptual framework through a mixed use method (quantitative-qualitative approach).

1.3 Aim of the study and Research Questions

On the basis of conceptual framework by Luiu and colleagues (2018), this thesis examines the effects of socio-demographics, health factors, built environment, activities of interest, multiple transport-related factors, and perceptions of safety on the mobility and travel behavior of older adults. In addition, the most significant mobility- and safety-related issues affecting older adults' frequency of travel while engaging in their daily life activities using the various modes of transport will be identified as the basis for measures to improve the mobility and traffic safety of older adults. In pursuit of this objective, the study is organized around the five research questions listed below:

1) Which personal characteristics and transport resources influence the mode selections of older adults?
2) How do socio-demographic factors, health characteristics, and mobility resources influence the actual travel behavior of older adults?
3) How do subjective mobility factors in terms of health, transport, built environment, and activities influence older adults' mobility and travel behavior?
4) What mobility experiences and perceived safety barriers do older adults encounter when using various modes of transportation?
5) Which potential measures can improve the mobility and traffic safety of older adults?

2. LITERATURE REVIEW

2.1 Ageing, Mobility and Health

Not only will the older population increase (as discussed in section 1.1), but their **health and well-being** will also change. Musselwhite et al. (2015) found that older individuals are more physically fit and physically active than previous generations. They have greater aspirations, may continue to work, have caregiving responsibilities (for other older people, for example, or for their children or grandchildren), and have extensive social and recreational networks. People's engagement with a hypermobile society that desires and requires frequent long-distance travel does not change as they age. In addition, they noted that **mobility has intrinsic benefits**, such as promoting independence and physical activity and reducing social isolation. Its contribution to society will continue, if not increase in the future, so long as older people's mobility options are maximized, such as by increasing the number of buses, improving public transportation concessionary tickets, and introducing driverless cars. The Japanese study by Tsunoda et al. (2015), for example, suggests that using motor vehicles and cycling allows people to travel further, which is associated with increased physical activity, expanded social networks, and better mental health. In addition, research by Bowling et al. (2002) and Bricocoli et al. (2018) demonstrates that **mobility (travel) is an essential component of the quality of life for older adults**. In other words, mobility and the ability for out-of-home activities are important for the quality of life of older individuals, as high frequency of mobility and participation in social and physical activities are associated with greater life satisfaction (Gagliardi et al., 2010; Schwanen et al., 2012). In contrast, the study by Hallgrimsdottir et al. (2015) emphasized how health-related issues frequently impede mobility opportunities. Nonetheless, Fristedt et al. (2014) concluded that mobility plays a crucial role in preserving the health of older adults.

However, Luiu and colleagues (2018a) reported **sensory, cognitive, and physical health barriers for older pedestrians**. Sensory impairments increase the risk of falling, reduce perception of fixed and moving objects, and make it difficult to detect approaching vehicles. Cognitive impairments affect multitasking and information, causing problems with spatial navigation and orientation (especially in new environments), learning new routes, taking longer to cross the street, walking more slowly, and falling more often. Muscle and joint changes cause impairments. Muscle weakness slows walking and increases the risk of falling, while joint pain hinders walking and stair climbing.

WHO (2018) defines an age-friendly environment as the absence of physical and social barriers supported by policies and other instruments that primarily focus on (i) promoting health; (ii) building and maintaining physical and mental capacity across the life course; and (iii) enabling people, even when experiencing capacity loss, to continue to do the things they value. Mobility is one of the most important aspects of an age-friendly environment, involving travel and access to desired locations; safe transportation enables older adults to engage in independent out-of-home activities, allowing them to remain socially active and physically healthy.

2.2 Age-friendly environment

WHO created the Global Strategy and Action Plan on Aging and Health, which focuses on "creating environments that are age-friendly." Two of the eight key areas covered by the concept

of an age-friendly environment that are more relevant to current research are outdoor spaces and transport and mobility (Plouffe and Kalache, 2010 and WHO, 2007). According to WHO (2018), the concept of mobility encompasses travel and access to desired locations, which is the central component of an age-friendly environment. In Belgium, cities such as Brussels and Gent are already part of the WHO Global Network of Age-friendly Cities and Communities Initiative (GNAFCC).

Multiple studies indicate that older adults use a variety of modes of transportation, including cars, walking, public and private transportation, and specialized transport services (Rosenbloom, 2009 and WHO 2017). However, the walkability of neighborhoods and the accessibility of public transportation are two important factors that influence the transportation choices of older adults and should be the primary focus of age-friendly environment interventions (WHO, 2017). In the sections that follow, the mobility and traffic safety-related aspects of older adults are discussed in detail, along with the various modes of transportation.

2.2.1 Public areas pavements

The pavement condition, such as pavements that are narrow, uneven, cracked, with high curbs, congested, or with obstructions, presents potential hazards and thus affects older adults' ability to walk around (Van Hoof et al., 2021 as cited in WHO, 2007). Pavements can be age-friendly by improving design and maintenance to ensure the following key features: a smooth, level, and non-slip surface; sufficient width to accommodate wheelchairs; dropped curbs to the level with the road; clearance from obstructions such as street vendors, on-street parking and trees; and priority of access for pedestrians (Łabędowicz, 2018 and WHO, 2007).

2.2.2 Safe pedestrian crossings

Several studies from both the US and the UK showed that the majority of healthy people aged 60 and plus present difficulties to cross the road in the normal green-man walk time (at 1.2 m/s), which tends to discourage walking or putting older adults at high risk of injury (Asher et al., 2012 and Webb et al., 2017). According to Webb et al. (2017) and WHO (2007), the ability to cross the road safely has always been a concern for older pedestrians. The two studies provide some key interventions that include increasing the crossing time to allow for slower walking speeds, use of timed lights that count down the seconds remaining to cross, and adopting the recent Singaporean innovative technology known as the "Green Man+" scheme, which grants older and disabled people extra crossing time. Other possibilities to improve the conditions for people crossing the road include the installation of traffic lights at pedestrian crossings, traffic islands, pedestrian crossings, and non-slip strips on pedestrian crossings as well as appropriate bridges and tunnels (Łabędowicz, 2018 and Webb et al., 2017).

2.2.3 Public transportation and other specialized modes

Aksoy and Korkmaz-Yaylagul (2019) argue that improving **accessibility and availability of facilities** for older adults in cities is crucial to ensure that they are able to meet their own needs as well as prevent their exclusion from society. These physical facilities include transportation networks, public transport facilities, consumption facilities, health care centers, recreational facilities, and areas for social networking as important components for an independent life in old age without social exclusion. WHO (2007) emphasizes that accessible and affordable public

transport is a key factor influencing active aging. On the other hand, a study by Rosenbloom (2009) in the USA revealed that older passengers have a variety of safety, personal security, flexibility, reliability, and comfort concerns about public transport, even if it is physically accessible.

According to Luiu and colleagues (2018a), it is commonly assumed that as people age, they are more likely to experience mobility issues, stop driving, and thus switch to using public transportation or special demand-responsive transport services. This perception may be based on patterns that show older people rely more on public transportation than younger people. However, the same authors discovered that older people perceive public transportation to be unresponsive to their travel needs. They have also identified and classified the **transportation barriers affecting public transportation usage** among older adults into six major categories: (1) reliability and availability of service provision; (2) health and mobility issues; (3) comfort; (4) personal safety; (5) information and awareness; and (6) affordability.

Service reliability and availability affect modal choice. Unsuitable routes, timetables, and scheduling are a problem for older adults using public transportation. Utilitarian transport needs, like medical appointments, are usually well-served by public transport, but they may be problematic in rural areas due to inconvenient schedules and infrequent services. Older adults are uncomfortable with public transport for discretionary trips. Spontaneous leisure, social, and shopping travel is difficult. Several studies show that older people have more time and can adjust their schedules around public transportation. However, off-peak public transport is unreliable (e.g., weekend or holidays). Older people are unhappy with stop locations, punctuality, waiting times, and connectivity with other buses and/or transport modes (Luiu et al., 2018a).

Public transport usage is influenced by the **health and mobility problems** older people face (Buys et al., 2012; Luiu et al., 2018a). Older people have problems with boarding and exiting vehicles. Getting on and off and having to stand are seen as key reasons for low public transport use. Overcrowding and personal space/privacy, lack of information about public transport services (ticketing options, timetables, maps, and directions), difficulty carrying heavy groceries, limited toilet access, and affordability were also issues (Buys et al., 2012).

Older adults are sensitive to **safety and security**; they feel unsafe when traveling at night or at peak times when buses and trains are less full, when traveling alone, or due to other passengers' presence or behavior. Driver behavior is often underrated in transport research. Unfriendly and unhelpful drivers who do not stop close to the curb, wait until passengers are seated before pulling away, drive erratically, and do not lower the bus during entry and exit operations are a safety concern for the older adults (Luiu et al., 2018a).

O'Hern and Oxley (2015) said that older people using public transportation care more about **stop density** than service frequency. They suggested that walking infrastructure could boost senior active transportation. Improving public transportation spatial distribution to meet a 500-m walking distance could increase public transportation mode share among all, including older adults, while improving active transportation mode share. Levin et al. (2012) noted that there is much to be improved in promoting older people's use of public transportation. For example, more than 200–300 meters is too far to walk for many older people, and many interchanges are uncomfortable

and stressful. Luiu and colleagues (2018a) noted that inappropriate locations and the distance of stops from home and destination could discourage older people from using public transportation.

Taxis, as one of the specialized modes of transportation (also known as paratransit), are essential for older people who do not have cars or who are unable to use public transportation due to health issues. Previous research discovered that the majority of older adults who took taxis were low-income, carless, and disabled women. Taxis, even at night, are a quick, direct, and safe way for seniors to travel. Taxis are underutilized by seniors. Cost and availability are critical. Taxis are avoided by older adults in the United Kingdom and Australia due to their high cost. There are issues with dependability and availability. Older people complain about taxi delays, a lack of cost information, and the inability to see the taxi meter. Taxi drivers' rudeness, dishonesty in route selection, and refusal to take short trips or assist disabled people all discouraged people from using taxis (Luiu et al., 2018a).

Minder Mobielen Centrales (MMC), or "Less Mobile Central" as it is translated, is another type of specialized transport relevant to this thesis that is operated by municipalities or other organizations in Belgium where volunteers provide transportation services to older people. This transportation service is intended to provide low-income and mobility-impaired individuals with transportation options. This service assists people in overcoming social isolation. These are typically older adults, disabled, or low-income individuals who do not own a car and cannot afford a taxi. Minder Mobielen Centrales members typically request rides for family visits, grocery shopping, doctor's appointments, or administrative matters at the town hall. Members must request rides at least 48 hours in advance. This allows the central manager to locate a suitable driver. The driver arrives at the member's home at the agreed-upon time and takes the requested route. At the end of the trip, the member pays the expense allowance based on the number of kilometers driven (MMC website, May 2022).

2.2.4 Walking and cycling

Walking and cycling contribute to "healthy aging" in two ways: first, as transportation that improves mobility and access to services, and second, as physical activity that improves physical and mental health (Satariano et al., 2012). Walking and cycling are cost-effective ways for older adults to stay mobile and active. Walkways and cycle paths are also considered healthy and age-friendly. Concerns or problems may limit their use by older adults. Concerns include cyclists and pedestrians sharing a path, uneven walkways and cycle paths, and insufficient wheelchair access. Cities need to develop a system of walkways to move through the area, install walkways in car parks to ensure pedestrian safety, and add public toilets near walkways (Łabędowicz, 2018 and WHO, 2007).

Walking is the most accessible and popular mode of transport for older adults for local trips, while cycling remains popular in the same age group. It allows greater distances to be covered, which may benefit older adults' mobility and physical activity space (Van Cauwenberg et al., 2018 and WHO, 2017). **Active transportation** (cycling and walking) increases health, fitness, and longevity, according to O'Hern and Oxley (2015). **Physical activity** in older adults reduces the risk of chronic diseases like heart disease and diabetes, lowers mortality, and improves cognitive functioning.

Walking and cycling are often promoted as a solution to modern car-oriented society's problems (Luiu et al., 2018a). Both are green (no air or noise pollution), affordable, reliable, and reduce traffic and parking problems. Walking and cycling are more feasible and faster travel options for older people than the car or public transport. This was discovered to be especially true for short trips in densely populated or congested urban centers. Both modes serve as a mode of transportation as well as a recreational activity and provide physical exercise, which has positive health and well-being effects. However, they are not always simple for older adults to perform. WHO (2017) recommends safe infrastructure to encourage older adults to use active transportation. Several safety issues about older adults' mobility have been identified, including difficulties negotiating street crossings due to intersections without traffic lights and with relatively large crossing distances (Section 2.1.2), poorly maintained and inadequately designed pavements, walkways, and cycle paths, and low enforcement of motor traffic measures such as calming motorized traffic, speed limits, and road safety campaigns (Koepsell et al., 2002; Moran et al., 2014; Nyman et al., 2013; Van Cauwenberg et al., 2018; and WHO, 2017).

Koepsell et al. (2002), Rosenbloom (2009), and WHO (2017) suggest **measures that improve walking** as a travel mode and to access public transportation. Suggested interventions include well-connected and wide enough streets with walkable destinations, raised pavement markings, refuge islands, improved user-activated signal crossing devices, enhanced intersection signals, lighting along pedestrian streets, and well-separated motorized and bicycle traffic. Traffic calming devices, lowering speed limits, active enforcement of traffic rules, and maintaining pedestrian facilities are also options. Older adults need **safe conditions to cycle**, including segregated safe and wide cycling lanes (that allow riding at different speeds) from pedestrians and cars, a well-connected network of cycling lanes with easy access from older adults' homes and reaching locations of interest, and sufficient green phases at traffic signals (WHO, 2017). Levin et al. (2012) emphasized wide bicycle paths or cycle streets separated from main streets, plus avoiding high kerbstones and steep gradients. Similarly, there is potential for more technical support systems addressing older bikers' comfort and safety; for example, detectors well in advance of signal-regulated intersections to give cyclists the green light without slowing down or dismounting, signals or lights warning cyclists of approaching motor vehicles or vice versa at intersections, and better guidance at night, e.g. leading lights in pavements or stronger street lighting at times when cycle traffic is present.

2.2.5 Unsafety feelings

Feeling secure in people's living environment strongly affects the willingness to move around in their local communities, which in turn affects their independence, physical health, social integration, and emotional well-being (WHO, 2007). Lamellet and Haustein (2015) and Ottoni et al. (2021) argue that **security or perceived safety** from crime determines the areas where older adults may choose to walk. Usually, high-density areas with a mix of residential buildings and amenities and the possibility of social interactions may attract older adults for walking, and hence more trips. However, any perceived lack of security (e.g. vandalism) contributes to avoidance and/or decreases the likelihood that older adults will walk in these areas. Another example can be the lack of street lighting on the local community roads and in the city's public places, which is one of many concerns that discourage many older adults from going out at night (WHO, 2007).

According to Golovchanova et al. (2021), older adults fear of crime, health issues, infrastructure problems, and social climate were found to be the **perceived reasons of unsafety**. Perceived physical danger can result from a threat of victimization. Aging-related bodily changes and illnesses can cause a perception of health risk. Health limitations have been linked to fear of crime and are especially important for older adults. Decreased health in older adults increases environmental risk. In old age, impaired vision, instability, involuntary falls, or reduced mobility may make the environment seem less safe. Inconvenient infrastructure, like a dark neighborhood, can make people feel unsafe. After a fall, older adults felt unsafe. When the physical environment is perceived as inconvenient, unsafety may result. When the social climate in a neighborhood is perceived as unattractive due to unfriendliness, social exclusion, or lack of belonging, social context may be compromised, resulting in experienced safety.

2.2.6 Safe driving behavior

According to Luiu and colleagues (2018a), transportation gerontology studies place a premium on having access to a car in later life. Metz (2000) defines mobility as "access to desired places; psychological benefits of travel; benefits of physical exercise as part of everyday mobility (exercise benefits); maintaining social networks and potential travel." It gives you autonomy, flexibility, independence, access at any time, and convenience (O'Hern and Oxley, 2015). It can also compensate for health issues, allowing older people to be more independent.

However, decreases in functional abilities (such as visual, cognitive, and psychomotor function) among older drivers are associated with poorer driving performance and increased crash risk (Eby et al., 2019). Anstey et al. (2005) found that older adults alter their **driving behavior** based on how physical illness, medication, and cognitive and sensory decline might affect their ability to drive safely. Lack of awareness of cognitive, sensory, or physical limitations may contribute to poor driving performance and crash rates. These authors created a model that combines safe driving factors for older adults (Figure 4). Driving capacity is determined by cognition, sensory, and physical function, but self-monitoring driving beliefs and driving capacity itself affect driving behavior, such as avoiding night driving due to poor vision.

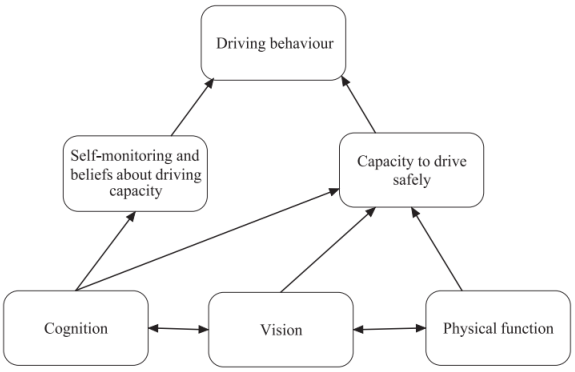


FIGURE 4 Schematic model of factors enabling safe driving behavior (Anstey et al., 2005).

Self-monitoring and beliefs about driving capacity involve evaluating one's physical and cognitive abilities and deficits, adapting driving habits accordingly, and interacting with three enabling factors to produce safe driving: Cognition, Vision, and Physical Function. Reaction time,

processing speed, visual attention, short-term memory, and executive function are linked to driving safety. Visual abilities consist of visual acuity and sensitivity to contrast. Physical measures include neck rotation and potential risk factors for falls, arthritis, and cardiovascular disease.

Reaction time identifies response and movement speed as essential for responding adequately to on-road situations. **Attention** reflects the need to accurately direct attention to relevant traffic information and the capacity to ignore irrelevant stimuli. **Executive function** is necessary to plan and coordinate sensorimotor and cognitive responses to complex driving situations, and requires adequate working memory resources. **Short-term memory** may be needed for information integration, and deficits may indicate neurological disorders. **Visual abilities** provide basic sensory information about the driving scene, including the road ahead, other vehicles, pedestrians, and potential hazards. The **physical Function** factor in the model includes functional mobility and medical conditions that may affect driving behavior. Self-monitoring and driving beliefs may influence safe driving behavior and crash risk. Any or all of these factors may increase crash risk.

Older drivers generally know their **limitations** and limit their driving (Molnar et al., 2015). Drivers 65 and older with memory, vision, mobility, or medical conditions like arthritis or diabetes were more likely to self-limit their driving by making fewer trips, traveling shorter distances, or avoiding night, interstate, or ice/snow driving (Braitman & McCartt, 2008). Martensen (2015) found that the normal age-related decline in driving fitness can be compensated by changes in driving behavior: older adults drive more carefully at less busy times and avoid complex and/or unknown situations. Several medical conditions, due to their effects on physiological and cognitive function, have been identified as crash risk factors and predictors of driving cessation (Anstey et al., 2005).

2.3 Travel behavior of older adults

Goulias et al. (2020) define **travel behavior** as the combination of doing things in different places at different times and how people move from one place to another. It also refers to the complicated decision-making process of travelers during a trip, regarding travel mode choice, route choice, departure time choice, destination choice, and so on (Li et al., 2019). The transportation requirements of older people are diverse. Their requirements vary and are influenced by a wide range of factors (Cui et al., 2017). Lifestyle (such as whether people work or are retired, and housing styles) and socio-demographic characteristics (such as age, gender, income, possession of a driver's license, and household size and structure) can have a significant impact on older people's transportation needs (Lin and Cui, 2021). When studying the travel behavior of older people, it is important to distinguish between younger seniors (65–75) and older adults (75+), as people's health often begins to deteriorate at the age of 75 (Berg et al., 2011). With retirement, older people's lifestyles and, as a result, mobility patterns change significantly (Siren & Haustein, 2015, as cited in Luiu et al. 2017). Retirement implies that older people have more free time to spend on desired leisure activities, but they also have fewer financial resources and, in some cases, poorer health conditions (Siren & Hakamies-Blomqvist, 2004, as cited in Luiu et al. 2017).

Lättman et al. (2019) discovered that the oldest age group (aged 85+) stands out from the rest when studying the travel behavior of older adults. They travel less than the other age groups and,

presumably, are more reliant on the quality and overall experience of their travel due to issues of aging and health. Despite traveling by car and bicycle significantly less than older adults aged up to 74, they manage to walk and use public transportation to a similar extent as other older people. Interestingly, the findings show that frequent walking and car use are positively associated with perceived accessibility across all age groups.

O'Hern and Oxley (2015) indicate that the **travel patterns** and mobility needs of older adults differ for males and females. For example, older females have been shown to drive less and have higher levels of car usage as passengers. In addition, they are also likely to give up driving earlier and rely more on walking and public transport than older males.

2.3.1 Determinants of mode choice

Previous studies show that older adults use various modes of travel, including car, walking, public transport, and private, and specialized transport services (Rosenbloom, 2009; WHO 2017). Šimeček et al. (2018) describe the **transport mode choice** as an important aspect of travel behavior of older adults and stress that passenger cars remain their favorite travel mode choice in Western European Countries. Among other reasons, this situation may be due to the increasing distance between a residence and the nearest bus stop and the accessibility of public transport reflecting physical and cognitive impairments of the older adults.

De Witte et al. (2013) conclude that modal choice is determined by a whole range of factors that are interrelated to a larger or smaller extent. Their study identified:

- Sociodemographic factors (age, gender, education, employment, income, household size and composition, and car availability);
- Socio-psychological factors (attitudes and experiences, familiarity, habits, lifestyle);
- Trip characteristic indicators (purpose, distance, time, cost, departure time, trip chaining, weather, information, interchanges on public transport); and
- Spatial indicators (density, diversity, proximity to infrastructure, public transit frequency, and parking).

Several studies show that socio-demographic variables affect older adults' activity patterns, trip frequencies, transport mode choices, and physical activity (Böcker et al., 2017 and Haustein, 2012). Older adults have different **mobility and travel behavior** based on stages of life, personal characteristics, health conditions, and transport resources (Luiu et al., 2018a); however, there is a lack of knowledge of the similarities and differences in travel behavior across their different age segments (Haustein, 2011; Lättman et al., 2019; and Marin-Lamellet and Haustein, 2015). Age alone cannot predict older adults' mobility, as De Witte et al. found (2013). Transport-related (travel frequency, trip purpose, travel mode choice), personal (age, gender, education), household (income, number of cars/bicycles, train/bus subscription card), and health-related factors influence older adults' mobility (Böcker et al., 2017). Availability of a car, a driver's license, and fitness to drive are also important factors (Kubitzki and Janitzek, 2009 and Rosenbloom, 2009). Xing et al. (2010) found that perceived safety of cycling infrastructure and short distances to destinations increase bicycling. Having more destinations within 400 meters of one's home increases walking and biking (Hoehner et al., 2005).

Böcker and colleagues (2017) in their study conducted in the Netherlands examined the influence of the demographics, access to mobility resources, and found out that women are more dependent on walking, cycling, and using public transport in comparison to the car. The same study concluded that car ownership has an important negative effect and public transport card ownership has an important positive effect on the use of all transport modes other than the car. Furthermore, they also found that older adults living in larger households walk, cycle, and use public transport significantly more than those living in smaller households. On the other hand, Dumbaugh (2008) reported the evidence that older adults living in higher-density areas use public transport at much higher rates than those living in less dense environments. Another study by Li et al. (2005) found a positive correlation between walking behavior and older adults' perceptions of walking safety. While public transport was found to be an important alternative to the use of private cars, Dumbaugh (2008) reported major barriers that may prevent older adults from using public transport. These included the perception of crime, followed by the lack of accessible destinations, and increased travel times linked to public transport use.

2.3.2 Travel behavior survey data and facts

2.3.2.1 Older adults' trip-making

Lättman et al. (2019) argue that older adults' ability to participate in **daily activities** affects their overall life satisfaction, that subjective evaluations of travel are important, and that the possibility and ability to use public transportation is related to cognitive and emotional experiences while doing so. As people age, they do more at home and less outside. For the oldest (85+), more activities may seem too far away or difficult to access, reducing perceived accessibility.

Seniors typically travel during the midday peak and during daylight hours. Between 9.30 a.m. and 3 p.m., the majority of them travel (Fatima et al., 2020; O'Hern and Oxley, 2015). This is most likely attributable to the decline in work- and school-related travel among adults over the age of 65 and the increase in leisure and shopping travel. This decline in the number of trips taken by older adults over the age of 65 may also be attributable to changes in lifestyle, health, and physical activity associated with aging (O'Hern and Oxley, 2015). Consequently, older adults travel shorter distances and take fewer trips than adults aged 25 to 59 (Bocker et al., 2017; Fatima et al., 2020).

According to one of the most recent studies on the mobility and safety of older road users in Belgium, conducted by Martensen (2015), mobility decreases with age, particularly for women. The proportion of older adults who drive a car decreases, while the proportion who walk increases. For women, the number of trips taken as drivers is rapidly declining, while the majority of their trips are taken as passengers. In the past decade, the proportion of older people who still drive a car on a regular basis has increased, particularly among drivers aged 85 and older. Moreover, they travel primarily for shopping, medical care, and recreation. 21 percent of older adults in Melbourne, Australia travel for shopping purposes, according to a survey of their travel motivations (VISTA, 2016). Janssens et al. (2020), who conducted a recent travel behavior survey in Flanders, found that shopping accounts for 35 percent of older adults' total average daily trips, followed by relaxation/sport/culture (16.9 percent) and others (Figure 5).

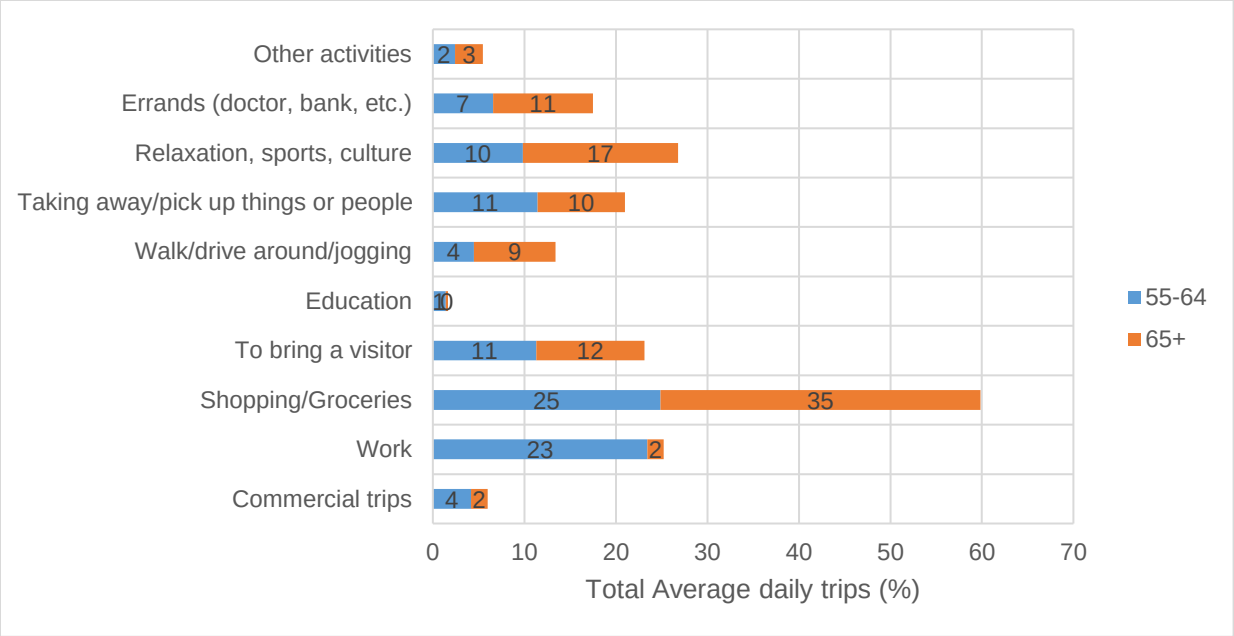


FIGURE 5 Distribution of total average daily trips (%) by age and trip purposes (Source: Janssens et al., 2020)

2.3.2.2 Travel mode preferences

Because it is easily accessible and convenient, the **car** is the most popular mode of transportation among older adults (O'Hern and Oxley, 2015). Many older adults prefer driving as a mode of transportation, and today's older adults have a higher percentage of valid driver licenses than their predecessors (Fatima et al., 2020). According to Janssens et al. (2020), a recent study on travel behavior in Flanders, the proportion of older adults with a valid driver's license is relatively high, with men outnumbering women (Figure 6).

This trend lends credence to the claim that the aging population in developed countries is becoming more **car-dependent and less likely to use alternative modes** of transportation. Furthermore, a lack of viable alternatives to the car is frequently cited as one of the primary reasons for older adults' car dependence (Luiu et al., 2018). Nonetheless, the growing reliance on automobiles has serious consequences for traffic congestion, road safety, and the environment. It is also worth noting that older adults' reliance on the car allows them to meet their needs for longer trips; however, experienced health problems may lead to **driving cessation** with no ability to drive the car anymore, which has serious consequences of limited mobility and social exclusion.

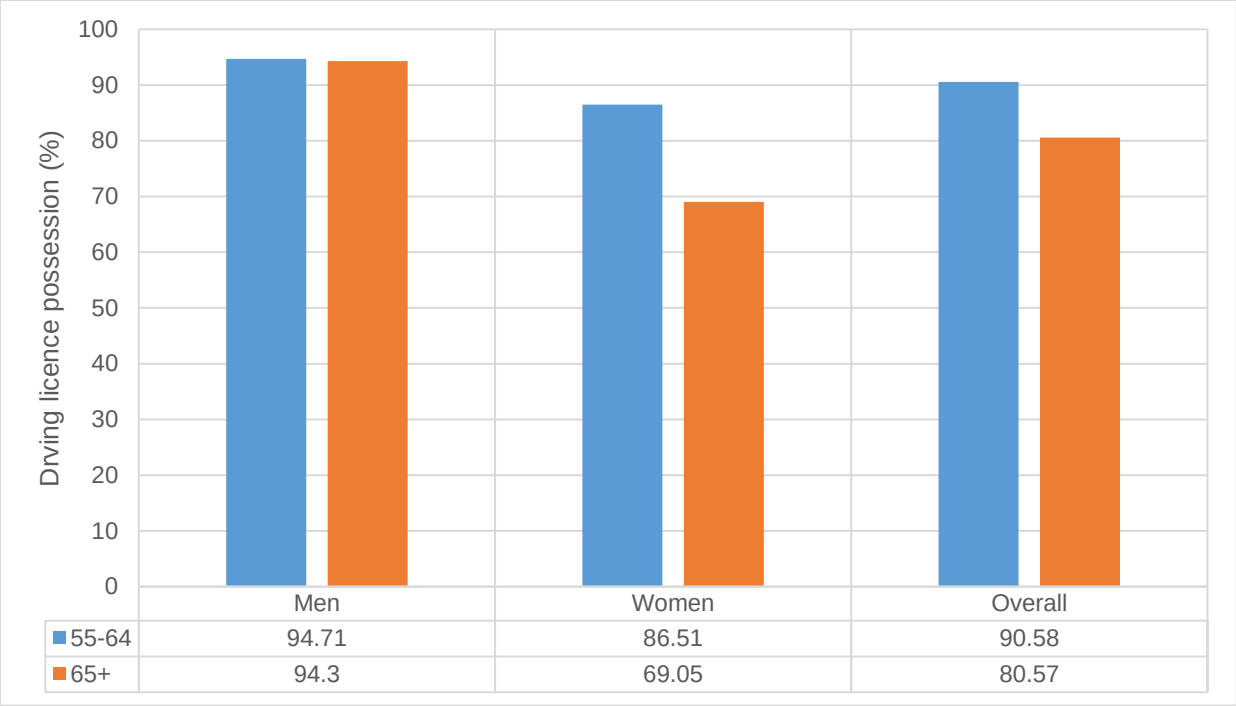
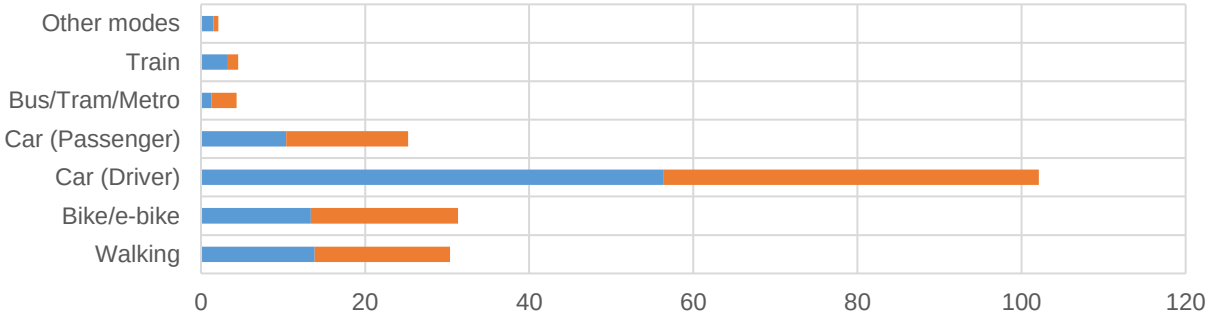


FIGURE 6 Driving license possession (%) by age and gender (Source: Janssens et al., 2020).

Ryan (2020) found that the two most important **reasons for modal choice** for everyday travel among older people were suitability and comfort. The car was more likely to be chosen among those who had a variety of modal options, with poor health being one of the main reasons given for choosing the car over public transportation. Cycling, on the other hand, appeared to be the most sensitive in terms of selection, being the first option to drop out of all the modal options. This is primarily because cycling has been discovered to be quite difficult for older people, with reports of issues with traffic safety, concerns with cycling environments, and the behavior of other road users. There was, however, a sense of 'positive' and ‘active' selection of the more active modes, with more positive reasons such as the environment, health, exercise, and enjoyment linked to the selection of active or more sustainable modes such as walking and cycling.

The recent survey data about the **travel behavior in Flanders** (Janssens et al., 2020) show that older adults perform 45.6% of their daily trips as car drivers (and 14.8% as car passengers), 17.9% cycle, 16.5% walk, and only 4.4% use public transport (bus, train, tram or metro). Similarly, the results indicate a significant share of car dependence among the age group of 55-64, which amounts to 56.4% (Figure 7). Decker et al. (2013) argue that the car dependence by older adults in Flanders may be linked among other factors to the spatial layout of the region (dominated by urban sprawl) that keep many families away from some important basic services such as groceries, bakeries, and butchers. This situation forces many older adults to use mostly private cars to access essential services.



	Walking	Bike/e-bike	Car (Driver)	Car (Passenger)	Bus/Tram/Metro	Train	Other modes
55-64	13.86	13.38	56.41	10.38	1.29	3.17	1.52
65+	16.5	17.95	45.69	14.85	3.04	1.37	0.61

FIGURE 7 Modes of transport use (%) by age (Source: Janssens et al., 2020).

Another recent study conducted in some Northern European countries by Lättman et al. (2019) revealed that the majority of older adults in all the age groups are still reliant on their private cars for daily travel with 60%–70% using their cars as drivers or passengers either daily or a few times a week. Similarly, a study carried out in Germany by Kubitzki and Janitzek (2009) found that older adults tend to drive their private cars on roads than using other modes of transport. The results indicate approximately two-thirds of all trips by car, followed by walking 24%, bicycles 8%, and public transport 2.1%. However, private cars were found less important for destinations in natural areas/parks or the countryside, where walking still dominates. This high-frequency use of private cars could be more linked with the limited availability of acceptable alternatives to maintaining their mobility, and to a lesser extent, older adults may be enjoying driving. Nevertheless, O'Hern and Oxley (2015) argue that though car use is still the most popular mode of travel among older adults, other alternative travel modes are offered and promoted, and their use is increasing in developed countries. Van Cauwenberg et al. (2018) also establish the evidence that many of the trips that older adults undertake by private car are within the distances feasible for cyclists.

On the other hand, Hjorthol and colleagues (2010) study in three European countries predicted an increase in aging generations accustomed to car use, high mobility, and travel-intensive lifestyles. At the same time, Haustein's (2012) study results predict the increase in order adults' (especially women) ownership of driving license and access to a private car, which would result in a higher share of older drivers and a decrease in public transport users. As a result, this expected growth rate of older adults relying on private cars poses both safety-related and environmental consequences. Moreover, Ryan (2020) mentioned that having only one or a few options may put one at risk later in life if those modal options are no longer viable. As a result, studying and mapping out the process of modal choice, the reasons for choosing specific modal options, and the links between these and other aspects of life provides a better foundation for understanding and planning for older people's mobility. Measures to promote and encourage sustainable mobility can thus be shaped and implemented in a way that supports the well-being of older people.

2.3.3 Safety of older road users

The **safety and mobility of older road users** remains a topic of importance as the population ages (OECD, 2001). The safety of older adults is described by Lamellet and Haustein (2015) and Ottoni et al. (2021) as a combination of three domains: personal safety, traffic safety, and personal security. **Personal safety** includes incidents such as harmful falls, and outdoor falls are the leading cause of serious injuries among older adults. This perceived risk of falling can be reduced by incorporating lighting, smooth pavement, and benches into all accessible public spaces. Dealing with the actual and perceived risk of collisions with other road users – both motorized and non-motorized – is part of **traffic safety**. Due to slow reaction time, low confidence, and frailty, older adults sustain severe injuries in collisions with other road users, and their risk of being involved in a traffic collision increases with age. **Security or the perception of safety** from crime determines where older adults choose to walk. High-density areas with a variety of residential buildings and amenities, as well as the opportunity for social interactions, may encourage older adults to walk, resulting in more trips. However, any perceived lack of security (such as vandalism) contributes to avoidance and/or reduces the likelihood of older adults walking in these areas. On the other hand, older individuals feel less secure in traffic than those of middle age. This is especially true for those between the ages of 65 and 74 who continue to travel frequently but may experience their first traffic difficulties. Those over 75 who are still mobile feel safer than their younger counterparts aged 65 to 74. This is likely due to the fact that older people who feel unsafe eventually stop using the mode of transportation in question (Martensen, 2015).

Moreover, according to Tournier et al. (2016), the most significant **safety concern for older road users** (and pedestrians in particular) is their visual impairment, increased physical frailty, and attention deficits, which have a significant negative impact on their safety and mobility and make them more susceptible to serious injury. For instance, older adults pedestrians exhibit deteriorating walking skills compared to their younger counterparts, including a decrease in walking speed, less stable balance, less effective wayfinding strategies, and an increase in unsafe road crossing behaviors. Recent evidence suggests that these difficulties are associated with changes in sensorial, cognitive, physical, and self-perception abilities associated with aging. In addition, Burlando et al. (2021) report that the majority of older drivers (primarily those over 75) experience navigational or traffic difficulties, causing them to drive less frequently in favor of walking or public transportation.

Other studies conducted in Belgium and the United Kingdom revealed that **older drivers** are most concerned about traffic safety (Van Cauwenberg et al., 2018). According to a study by Polders et al. (2015), older drivers were responsible for 25 percent of all traffic fatalities in the EU in 2013. According to the most recent report on road safety in Belgium, published by IRTAD, there were 5.6 deaths per 100,000 inhabitants, while the rate for older adults increased to 9.6 deaths per 100,000 between 2010 and 2019. (IRTAD, 2020). Among older adults, car occupants accounted for the majority of road fatalities in 2019, followed by cyclists and pedestrians. In addition, the report highlights the leading causes of accidents in general, such as excessive speed, driving under the influence of alcohol, mobile phone distraction, and fatigue. However, it does not differentiate road user behaviors based on user category and age, for example.

Using data from 2008 to 2012, the same study by Martensen (2015) on the mobility and safety of older road users in Belgium determined the number of **accident victims and the risk of being fatally injured** by type of road user. The results demonstrated that the absolute number of fatalities among older drivers is still relatively low. Cycling and walking are the most problematic modes of transportation for older adults. Over half of the older killed were either pedestrians or cyclists. In contrast, the proportion of car drivers among older adults fatalities is lower than among middle-aged victims (Figure 8).

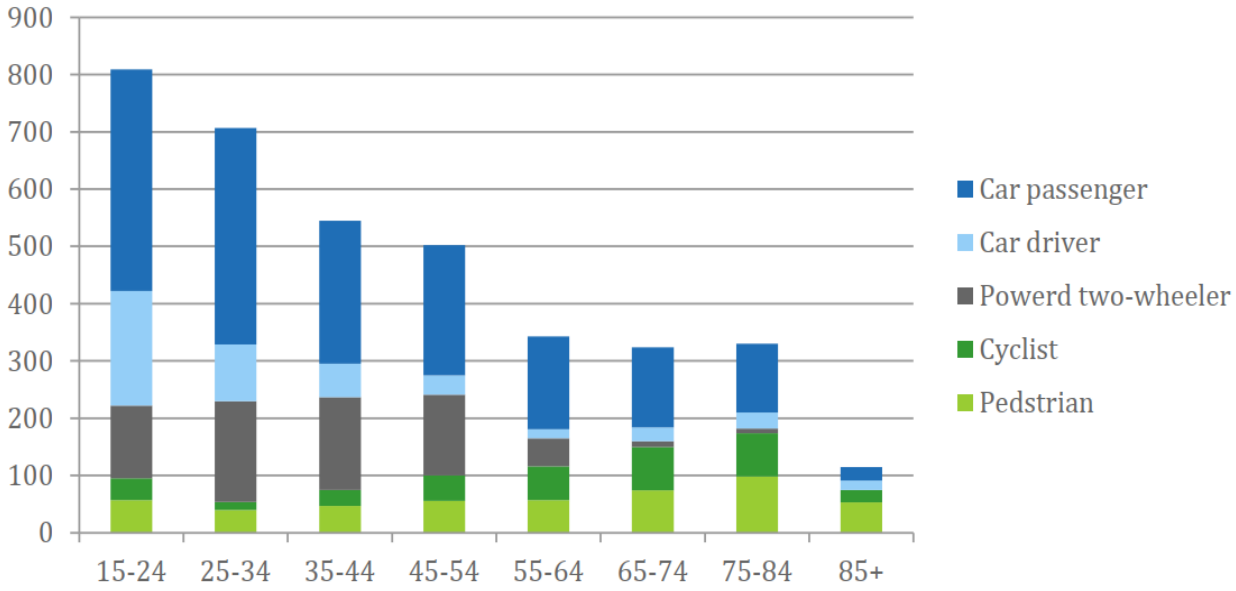


FIGURE 8 Number of killed drivers by age-group and type of road user (Martensen, 2015).

As depicted in Figure 9, the risk of fatal injury is increased for people aged 75 and older in all modes of transportation compared to the calculated average risk across all age groups. The risk is doubled for older car passengers, four times as high for older pedestrians, and six times as high for older cyclists compared to the average risk.

Those between the ages of 65 and 74 also face an elevated risk, though the increase is considerably smaller. Only as cyclists, the "younger" older adults are significantly more vulnerable (4 times as high as the average across all ages).

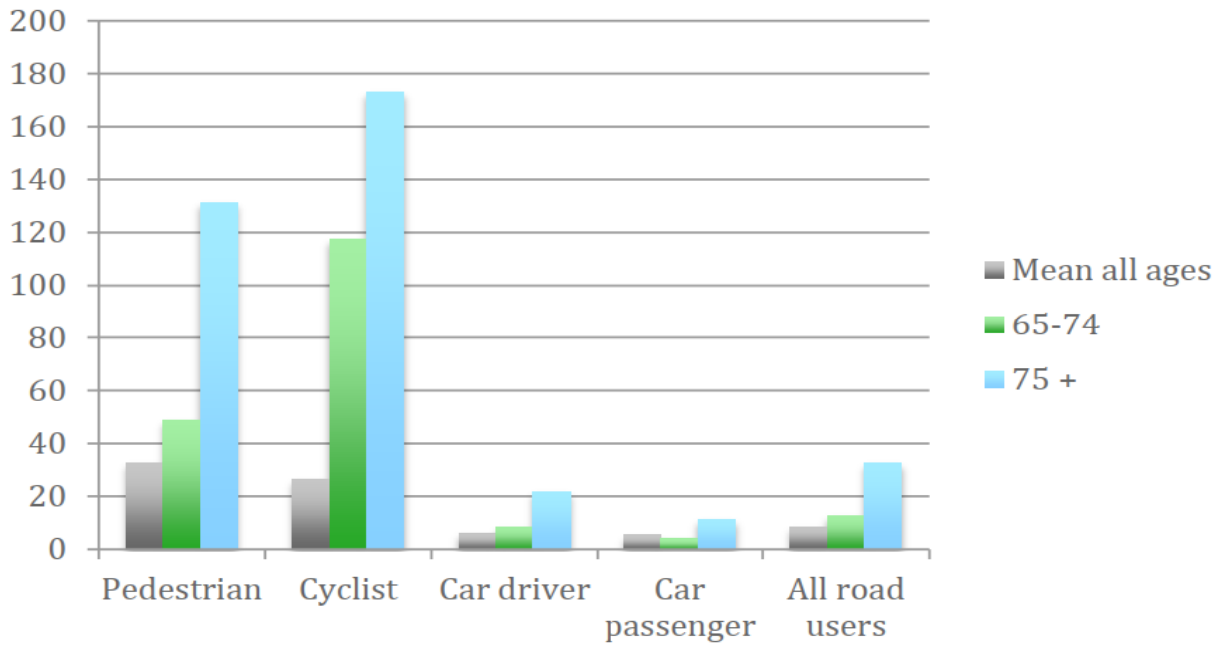


FIGURE 9 Number killed per billion km travelled by type of road user and age-group (Martensen, 2015)

Three factors contribute to an increase in risk for older drivers. **(1) Frailty**: Older adults break things more easily and quickly, injuries heal more slowly, and can lead to complications that far outweigh the severity of the original injury when combined with prior health conditions. In Belgium, at least half of the increase in the risk of severe accidents is due to the frailty of older drivers. **(2) Less travel**: older drivers travel less than middle-aged drivers. Drivers who travel fewer kilometers have a higher risk per kilometer driven, regardless of age. This is due, in part, to the type of road one mostly travels on (few kilometers on highways), but also to being a less experienced driver. **(3) Driving fitness**: Although older drivers are generally more cautious, they are still more likely to cause accidents due to the impairments mentioned above (Martensen, 2015). Moreover, according to data from 2020, there were a total of 254 road fatalities in Flanders, of which 33.5 percent involved passenger cars, 29.5 percent involved bicycles, 13.4 percent involved motorcycles, and 11.8 percent involved pedestrians. More than 30 percent of all recorded road fatalities are attributable to drivers and passengers over 65 years old (Statistics Flanders, 2021). Anstey et al. (2016), who conducted a study of older cyclists in Sweden, determined that falls when mounting or dismounting the bicycle or uneven road surfaces are the most common causes of injury, accounting for 94 percent, compared to only 6 percent due to vehicle collisions. Nevertheless, the layout of crossings and intersections also contributes to the elevated risk faced by older pedestrians. For example, older pedestrians face a greater risk at unmarked crossings than at marked crossings with traffic signals or signage. Martensen (2015) briefly described the main factors contributing to accidents involving older adults in Belgium, including the fact that older road users have a harder time maintaining their peripheral vision, that crossings are the most difficult situations for them, and that the most dangerous maneuvers include pedestrians crossing and left turns for cyclists/drivers.

BoeleVos et al. (2017) did a similar study in the Netherlands on crashes (primarily single-bicycle and bicycle-bicycle crashes) involving cyclists aged 50 and older, documenting the factors and circumstances that influence the occurrence and outcomes of these crashes. The findings revealed that cyclists aged 75 and older are more likely than younger cyclists to be involved in bicycle falls. The most common contributors to a large number of collisions were the actions of another road user, distraction, and inadequate cycling facilities or traffic lanes. However, the factors that influence the occurrence of a collision vary based on the type of collision.

2.3.4 Maintaining safe mobility for older adults

According to Hu et al. (2013) and Oxley and Whelan (2008), for older road users to maintain safe mobility, governments, policymakers, and the community must take precautions. They must fully understand the characteristics of older people, their travel habits, and their demand for transportation services. In addition, knowledge of the advantages of safe transportation options must be combined with crash risk and susceptibility to severe injury in order to develop appropriate policies and initiatives to ensure older adults' safe mobility. As a guide for the development of **measures and initiatives to enhance the safe mobility** of older road users, O'Hern and Oxley (2015) identified four major categories: (i) behavioral and educational measures, (ii) infrastructure and road design improvements, (iii) vehicle design improvements, and (iv) improvements to alternative transport options. Each of the four groups of measures can have a positive impact on traffic participation, safety, mobility, and the quality of life associated with them. According to Levin et al. (2012), older people's safety and mobility are closely related. Therefore, safety measures are most promising when they result in increased physical activity, such as by providing practical assistance and making pedestrian infrastructure simpler, less demanding, and more appealing. Important to seniors are prepared pedestrian crossings and signal-controlled intersections, as well as pavements.

Similarly, Hu et al. (2013) and Oxley et al. (2010) argue that, in order to improve the travel mobility and safety of older adults, road designers should pay more attention to **design elements** that reduce the rates of serious injury and fatality among older adults, as highlighted previously (section 2.3). The proposed improvements may include a sidewalk, cycle paths, and the conversion of one-way streets to two-way streets. In addition, Loukaitou-Sideris et al. (2018) suggested that enhancing the safety of older adults should take into account driver-friendly, pedestrian-friendly, and transport-friendly urban design alternatives, such as an increase in the number and quality of signs and traffic controls, as well as parking facilities that are easier to navigate. In addition to enhanced street lighting, elevated pavement markings for pedestrians, enhanced pedestrian crossings, and the addition of median islands, additional measures for improvement include improved street lighting. Moreover, Koepsell et al. (2002) add that urban planners should consider how aging affects the ability to safely negotiate traffic and implement increased traffic control, separation of vehicles and pedestrians, and pedestrian visibility.

O'Hern and Oxley (2015) observed that older individuals walk more slowly than younger adults due to **age-related physical alterations**. Age-related differences in walking speed can impact the design of infrastructure for senior walkers. In Australia, **pedestrian crossings** are designed to accommodate a walking speed of 1.2 meters per second, while standards dictate slower

speeds for facilities utilized by children, older adults, and the disabled. These authors recommend implementing intelligent crossing facilities, such as PUFFIN, that monitor pedestrians as they cross the street and adjust the pedestrian clearance phase according to their walking speed. In addition, senior pedestrians benefit from measures to slow traffic, promote mode separation, and improve crossing design. In high pedestrian activity zones, it is possible to implement speed reduction measures, such as lower variable speed limits and supporting infrastructure, and to reallocate signal time at crossings to better accommodate the walking speeds of older pedestrians. Kerb outstands and median refuges can shorten crossing distances and facilitate crossing movements, resulting in a safer environment at crossings. Enhanced urban planning will increase the frequency with which senior citizens walk. Personal errands and shopping are the most prevalent motives for older individuals to utilize active transportation. (O'Hern and Oxley, 2015) These activities take place in areas with high pedestrian and vehicle traffic, which increases the risk of pedestrian injury from vehicle collisions.

Moreover, the introduction of **measures to improve public transportation** raises questions about the entire transport environment and conceptualizes the journey from beginning to end (i.e. the whole journey concept). Previous research has shown that measures promoting the mobility of older people on public transportation cannot be implemented without considering the entire journey. For example, public transportation always involves some walking or bicycling (Levin et al., 2012), and addressing issues associated with these two modes of transportation could significantly increase the use of public transportation among older adults.

Older drivers require visual, muscular, and cognitive abilities for safe driving, according to Dickerson et al (2017). Despite the fact that some older drivers experience declines in these abilities (typically as a result of health problems or medications), **safety measures** should focus on functional abilities, not age or medical diagnosis. Cuenen et al. (2019) investigated whether driving simulator-based training can improve driving competence in older drivers, thereby keeping them as safe as possible for as long as possible and reducing the likelihood of crashes resulting in serious injuries/deaths. After undergoing driving simulator-based training, drivers' lateral control improved and participants were involved in fewer accidents. Other specific measures of driving ability, such as giving right-of-way to traffic on the right side, require driving-specific feedback. Haan et al. (2022) found that changes in physical and cognitive abilities not only impair the driving ability of older adults, but in some situations age-related changes in driving behavior necessitate that other road users adapt their behavior to maintain a safe traffic situation. While evaluating the driving performance of older adults in a driving simulator in challenging situations (such as merging onto a freeway), older drivers exhibited compensatory behavior in the form of slower driving speed and longer waiting times, thereby creating more time for lower task requirements. In a time-sensitive situation, however, this compensatory behavior had negative effects because other road users had to slow down to maintain a safe distance. In addition, the importance of anticipation and adaptation by other road users for the success of older drivers' strategies and traffic safety is emphasized.

In their research on older drivers' experiences with automated vehicle (AV) technology, Classen et al. (2021) noted that Stakeholders in the field of AVs—from industry to the general public, and specifically older drivers—seek confidence in the safety of these systems in order to adopt them

as an acceptable mode of transportation. Using automated vehicles (AVs) may provide health and safety benefits to senior drivers, assuming they accept and adopt these technologies. Despite the potential safety benefits of in-vehicle safety technologies (e.g., collision warning/mitigation, parking assist, navigation assistance), older individuals may find it challenging to adapt to a new mode of transportation that relies heavily on technology (Luiu et al., 2018a). Nonetheless, the study by Classen et al. (2021) found that older drivers' perceptions of safety, trust, and perceived usefulness of AV technology increased after exposure to AV technology.

Furian et al. (n.d.) evaluated a variety of mobility options for the older adults and discovered that cars and public transportation are the safest, whereas cycling and walking are the least safe. In addition, they conclude that feeling unsafe in a mode of transportation is a deterrent to using it. Hanson and Hildebrand (2011) propose the development of mobility alternatives and public transportation systems to ensure road safety and facilitate the transition from drivers to non-drivers. Environmental factors such as travel distances and the absence of pedestrian facilities may be barriers to walking among older adults. However, implementing programs to promote walking as a viable travel mode to nearby destinations and providing safe and comfortable walking facilities may increase walking among older adults (Dumbaugh, 2008).

O'Hern and Oxley (2015) concluded that driving provides the greatest mobility to older adults and that sustained mobility requires access to a car for as long as it is safe to drive or ride as a passenger. Not being able to drive necessitates that those who rely on public transportation have quick access to services and amenities via safe, reliable options. They concluded that strategies that address key components of the transport system (safer road users, vehicles, roads, and speeds), the creation of a safer and more forgiving environment that matches the characteristics and travel needs of road users, and the provision of viable, affordable, accessible, safe, coordinated, and individualized alternative transport options can provide effective mobility solutions.

3. METHODOLOGY

3.1 Mixed-Method Study

This thesis uses both quantitative and qualitative data collection and analysis methods, such as survey data with statistical analysis and focus group data with framework analysis. A framework analysis is a qualitative method for analyzing and interpreting qualitative data, such as focus group or interview data. Data is sifted, charted, and sorted in the analysis using five steps: familiarization; identifying a thematic framework; indexing; charting; and mapping and interpretation. Methodological triangulation is also used to connect the two datasets, allowing the analysis model to use both survey data and focus group data (Noble and Heale, 2019). In this research study, the use of the triangulation method or mixed-method contributes to a more comprehensive and unbiased set of findings. In other words, survey data are used to describe the main demographics, travel patterns, and travel needs of the sample population, whereas focus groups are used to illuminate older adults' mobility and perceived safety experiences (Ottoni et al., 2021). Because quantitative and qualitative data were collected at the same time, the analysis is done separately, and the results are compared to draw overall conclusions. This design method is known as convergent parallel design.

3.2 Sample and study area description

The study focused on 60-year-old and older Flanders residents. Flanders is located in northern Belgium and shares borders with parts of the Netherlands and France. The region has a population of 6.65 million people (57.6 percent of the total population of Belgium excluding Brussels), with 27 percent of the population aged 60 and older (STATBEL, 2021). In comparison, this age group accounts for 25.5 percent of the Belgian population. Flanders is the most flat and densely populated of Belgium's three regions, with the second-highest population density (487 inhabitants per square kilometer). Table 1 contains important information about the study area, sample population, and total Belgian population. The sample was divided into three distinct age groups to investigate variations in travel behavior among older adults: pre-retirees (60-64), young older adults (65-74), and older adults (75+) (Burlando et al., 2021).

TABLE 1 Key characteristics of the study area (Source: STATBEL, 2021).

Variable	Flanders	Belgium
Population	6,629,143	11,492,641
Area (km²)	13,626	30,689
Density (population/km²)	488	375
% aged 60 or over	27.0%	25.5%

The socio-demographic characteristics of the survey participants are detailed in Table 2. The survey inquired about the sociodemographic characteristics (age and gender), income, education, living arrangements/household composition, health condition, and mobility/transport characteristics of the participants (resources).

The descriptive statistics reveal that the age range of the sample population is 60 to 92 years, with a mean age of 71.5 years. There is a small disparity between the representation of gender

and, to a lesser extent, age groups in this survey and the actual older population (60 and older) in Flanders. Men are overrepresented, while those between the ages of 65 and 74 are more prevalent in the sample population than in reality, whereas those aged 75 and older are underrepresented.

The age range of the participants in the focus groups is 60 to 88, with a mean age of 68.4 years. The proportion of men is extremely low (15.7%) compared to the proportion of women (84.3%).

TABLE 2 Key descriptive statistics of the survey participants.

Variables	**Statistics**				
	Mean	Range			
Age (years)	71.46 (S.D=7.1)	60-92			
	Count (N=164)	%		Count (N=164)	%
Age Groups			**Self-reported hearing**		
60-64	30	17.1% [24.3%]	Hear well	123	75.0%
65-74	77	48.2% [28.7%]	Don't hear well without hearing aid	16	9.8%
75+	57	34.8% [47%]	Poor hearing with hearing aid	25	15.2%
Gender			**Self-reported sight**		
Female	63	38.4% [53.6%]	See well	74	45.1%
Male	101	61.6% [46.3%]	See poorly without glasses	6	3.7%
Monthly Household Income			See poorly with glasses	84	51.2%
€500 - €999	4	2.4%	**Use of Mobility aids**	9	5.5%
€1000 - €1499	37	22.6%	**Has fallen in the past year (at least once)**	40	24.4%
€1500 - €1999	60	36.6%	**Self-reported walking limitations**	41	25.0%
€2000 - €2499	34	20.7%	Not possible to walk > 1000 m	21	12.8%
€2500 - €3000	8	4.9%	Not possible to walk > 500 m	2	1.2%
> €3000	10	6.1%	Not possible to walk > 400 m	3	1.8%
No answer/do not know	11	6.7%	Not possible to walk > 100 m	1	0.6%
Highest level of Education			Not possible to walk > 20 m	0	0.0%
No completed Education	5	3.0%	Not possible to use stairs	4	2.4%
Primary Education	10	6.1%	Not possible to walk on high gradients	17	10.4%
Secondary Education	79	48.2%	**Access to mobility/transport resources**		
Higher Education	70	42.7%	Has access to a car (at least one)	148	90.2%
Household Composition			Has access to a bicycle (at least one)	142	86.6%
Living with a partner	123	75.0%	Bus/train Card ownership	66	40.2%
Living with children	6	3.7%	Driving license possession	151	92.1%
Living with grand children	0	0.0%	**Distance to nearest bus stop**		
Living alone	39	23.8%	< 500 m	93	56.7%

Living with parents	1	0.6%	500-1000 m	40	24.4%
Other	2	1.2%	> 1000 m	31	18.9%
Self-reported health rating					
Excellent	15	9.1%			
Very good	54	32.9%			
Good	84	51.2%			
Honest	6	3.7%			
Bad	0	0.0%			
No idea/don't want to share	5	3.0%			

[+]the figures in square brackets are data of the 2021 population statistics in the Flemish Region

3.3 Data collection and analysis

3.3.1 Data collection

Quantitative and qualitative data were collected in May 2019 and December 2019 prior to the COVID 19 pandemic, respectively. During the course of data collection, 164 participants aged 60 or older responded to an online survey distributed by various organizations serving older adults in Flanders (contacted via email), including CD&V Senioren, OKRA, senioren.net, etc. This survey was composed of three sections:

1) The participants' socio-demographic and health conditions
2) The mobility and travel behavior, including transport system accessibility
3) The evaluation of mobility perceptions and safety barriers regarding the use of various modes of transportation and other traffic aspects.

Through older adults organizations in Flanders (Doppahuis Hasselt), six face-to-face focus groups with a total of 51 participants aged 60 and older (average session length: 90 minutes) were conducted to gain a deeper understanding of the mobility and perceived safety experiences of older adults (Ottoni et al., 2021). Participants in the focus group were invited and given the option to indicate their interest in participating in a discussion regarding "experiences and opinions regarding mobility and safety issues." These participants were not necessarily the same as those in the survey (though it is possible that some also participated in the survey, no identification link exists between the two). The discussions centered on the experiences and perspectives of older people regarding the probable mobility and safety issues for various modes of transportation under varying traffic conditions. Transport and traffic topics included walking, cycling, public transportation, parking facilities, street infrastructure, and mobility in general. A variety of problematic situations were presented, and participants were asked to identify those that apply to their neighborhood, rank them in order of importance (most important=1 to least important=4), and provide explanations for the mobility issues identified.

3.3.2 Data Analysis

3.3.2.1 Setting up the study variables

From survey questions regarding the frequency with which older adults traveled for various daily activities, two dependent variables of interest were derived. "How often do you visit these destinations?) and transportation modes" "How often do you use each of the following modes of transportation? e.g. Walk, Bike/e-bike, Car (as a driver), etc., "which were responses to 5-point Likert-type questions. On the basis of research questions (see section 1.3), the entire survey dataset was analyzed to determine the most influential factors affecting the mobility of older adults in Flanders. On the basis of previous research (Sulikova and Brand, 2021; O'Hern and Oxley, 2015; Bocker et al., 2017; Lattman et al., 2019; Nordbakke, 2019), greater emphasis was placed on the variables that indicated particular significance for older adults' transport mode use and frequency of out-of-home activities. In addition to the objective indicators associated with the five domains of the model by Luiu and colleagues (2018) (as discussed in section 1.2), this study included subjective factors to provide a better understanding of older adults' travel behavior and mobility barriers while performing daily life activities using the various modes of transport (Table 3). A portion of independent variables were omitted because they were associated with other independent variables in the model (multicollinearity test). The variables included in the final model as well as the analysis techniques are detailed in the table below.

TABLE 3 Outline of the analysis models with the targeted independent variables

Type of analysis	Key aspects	Research question	Description of analysis
Quantitative analysis I	Travel mode choice	Which personal characteristics and transport resources are associated with older adults' transport mode choices?	Ordinal logistic regression (OLR) Dependent variable: • Frequency of use for the different travel modes: Walking, Cycling, Car as a driver, car as a passenger, Bus/Tram/Metro, Train, Taxi, and MMC. Independent variables: • Age Group • Gender • Living status (alone or with a partner) • Monthly income • Education level • Self-reported health condition • Self-reported hearing condition • Self-reported sight condition • Self-rated walking limitations • Access to a bicycle • Access to a car • Possession of a bus/train card • Ownership of a driving license • Distance of the nearest bus stop

			• Activity type/frequency/participation
Quantitative analysis II	Out-of-home mobility	How do the socio-demographic factors, health attributes, mobility resources, and built environment related features affect older adults' actual travel behavior?	Ordinal logistic regression (OLR) Dependent variable: • Frequency of travel for different out-of-home activities, such as visiting health care center, shopping/grocery store, going to a restaurant/café, and visiting family or friends. Independent variables: • Age Group • Gender • Living status (alone or with a partner) • Monthly income • Education level • Self-reported health condition • Self-reported hearing condition • Self-reported sight condition • Self-rated walking limitations • Access to a bicycle • Access to a car • Possession of a bus/train card • Ownership of a driving license • Distance of the nearest bus stop
Quantitative analysis III	Effect of subjective measures	How do the subjective mobility factors influence mobility and travel behaviour of older adults?	Spearman's correlation Dependent variables: • Frequency of use for the different travel modes: Walking, Cycling, Car as a driver, car as a passenger, Bus/Tram/Metro, Train, Taxi, and MMC. • Frequency of travel for different out-of-home activities, such as visiting health care center, shopping/grocery store, going to a restaurant/café, and visiting family or friends. Independent variables: • Subjective factors such as importance of different travel modes, importance of different places or out-of-home activities, availability of the different transport mode facilities, and various traffic related aspects.
Qualitative analysis	Safety barriers	What are the mobility experiences and perceived	Framework analysis for the focus groups data with NVivo 12 software.

	preventing adults to perform more trips with different travel modes	safety barriers affecting older adults while using the different modes of transport?	The analysis shall consist of different steps incl. data coding, identification of themes, patterns, and relationships, and linking findings to research questions and objectives.
n/a	Development of actions	Which potential measures can improve older adults' mobility and traffic safety?	Developing the specific measures to improve mobility and safety

3.3.2.2 Description of measures

In accordance with the five domains of the framework proposed by Luiu and colleagues (2018), the measures for this study were derived from the survey and focus groups. Transportation measures included access to transport resources, barriers to using various modes of transportation, and older adults' experiences with and perceptions of the safety of modes of transportation. The former included travel frequencies with walking, cycling, the car (as both driver and passenger), bus/metro/tram, train, taxi, and MMC (daily, several times a week, once a week, once a month, rarely/never), as well as the importance of each of these modes of transportation; access to a car; bus/train subscription card; driver's license ownership; and barriers related to different transport mode facilities and other traffic aspects.

The respondents' health status was determined by their own self-ratings of health. Health and well-being variables included whether participants had mobility limitations during specific activities (e.g., self-reported walking limitations) and how they perceived their health condition (Self-reported health rating, self-rated hearing, self-rated sight, etc.). Given that previous research has found a strong correlation between self-reported health and objective health measures, it is assumed that the subjective health reported by participants in this study is related to their actual health (Nordbakke, 2019).

The distance to the nearest bus stop was used to measure the built environment. Under activities, the frequency of travel for a variety of out-of-home activities, type of activities, importance of activities, as well as the perceived problems associated with various modes of transportation and traffic aspects, were measured (barriers that could prevent them from doing so). The following pursuits were examined: 1) visiting a health center; 2) visiting a community center; 3) visiting a city center; 4) visiting a grocery store; 5) visiting a shopping center; 6) visiting a restaurant; 7) visiting a library; 8) visiting an educational institution; 9) visiting a park; 10) visiting a sports facility; 11) attending a sporting event; 12) visiting a place of employment; and 13) visiting family or friends. Lastly, demographic factors were measured in terms of the standard participant profile characteristics. Age group (1=60-64, 2=65-74, 3=75+), gender (0=female, 1=male), household composition (living with a partner, living with children, living alone), education (1 = no education, 2 = primary education, 3 = secondary education, and 4 = higher education), and income levels were among the variables analyzed.

3.3.2.3 Quantitative Analysis

The survey data were analyzed to determine the socio-demographic characteristics of the sample population, their travel patterns in terms of frequency of trips for different out-of-home activities

and their preferred mode of travel, as well as the determinants of their daily mobility and potential mobility perceptions and safety barriers. The survey data were statistically analyzed using IBM SPSS 26 software, and a p-value of less than 0.05 was regarded as statistically significant. The analysis will focus on the travel/mobility behavior of older adults (primarily travel frequency to different activity locations and transport mode choice) as a function of socio-demographic characteristics, health factors, frequency/types and importance of activities, availability of mobility resources, importance of each of the various modes of transportation, and various mobility barriers for the various modes of transport. As shown in Table 3, two ordinal logistic regression (OLR) analyses were conducted to evaluate the factors associated with transport mode selection and the frequency of travel while engaging in various daily activities, respectively. Two Spearman's correlations were performed to gain a deeper understanding of the effect of subjective measures on older adults' travel behavior (both actual and desired). These analyses were chosen to correspond with the survey data types, in which both dependent variables were measured at the ordinal level and all independent variables were categorical (ordinal or nominal). In addition, all necessary assumptions were validated before running the analysis models, including the multicollinearity test, the normal distribution test, etc.

The following scores were assigned to the responses to the two dependent variable questions: "Daily" equals 5, "several times a week" equals 4, "once a week" equals 3, "once a month" equals 2, and "rarely/never" equals 1. The responses were arranged on a scale that was transformed into a combined index of the mean scores for each respondent using a similar approach used by Nordbakke (2019) in order to analyze the factors related to the overall frequency of travel for out-of-home activities and the frequency of various modes of transportation use. A score of 5 indicates that the respondent participates in the activities or uses the various modes of transportation on a nearly daily basis, whereas a score of 1 indicates that the respondent never participates in any of the fifteen activities or uses any of the modes of transportation and/or that they are irrelevant to this respondent. The daily activity index has a mean score of 2.0163 (standard deviation = 0.4173), indicating that each of the fifteen activities is visited at least once a month on average. The transport use index has a mean score of 2.3880 (standard deviation = 0.3995), indicating that each of the eight modes of transportation is used at least once per month. Each of the two indices received responses from 164 people.

The combined index mean score for travel frequency while performing essential activities represents the balance between the most frequently performed activities, such as shopping/grocery store, visiting family/friends, and going to the city center (at least several times a week or once a week), and the least performed activities, such as visiting a health care center, an educational institution, and going to work (rarely/never). The combined index mean score for travel mode use is determined by balancing the most frequently used modes, such as walking and car use as a driver (at least several times per week), and the least frequently used modes, such as Train, Taxi, and MMC (once a month or rarely/never).

3.3.2.4 Qualitative analysis

First, the responses from each focus group were transcribed and reorganized for each interview protocol question according to their respective major themes. Thematic coding was performed using NVivo 12 software for the analysis. The process of data analysis consisted of data coding,

the identification of themes, patterns, and relationships, and the linking of findings to research questions and objectives (Table 3). This analysis model will provide key perceptions of safety and experiences of older adults regarding different modes of transportation and traffic in general, which will ultimately be analyzed to identify their potential mobility issues and propose suitable countermeasures.

Finally, the results of both quantitative and qualitative data analysis models were compared and findings will be tied together in order to draw conclusions and develop strategies to improve the mobility and traffic safety of older adults. The qualitative findings are used to supplement the quantitative survey findings regarding the key mobility patterns and issues faced by older adults, as well as their experiences and perceptions of safety, which are elaborated upon through the study of meaning.

4. RESULTS

4.1 Quantitative part

4.1.1 Travel mode choice

A frequency analysis was used to assess the frequency of the various travel modes used by the participants, and the results were summarized in a chart (Figure 10).

The graph depicts how frequently various modes of transportation are used. Walking is the most popular mode of transportation, followed by driving a car, cycling, and driving a car as a passenger (also based on the calculated index mean scores for individual modes of transport). Older adults use public transportation and other forms of specialized transportation the least. The findings are consistent with Janssens' (2020) previous findings, which discovered that the car is the most common mode of transportation used by Flemish older adults, followed by cycling, walking, and car as a passenger. Public transportation and other specialized modes of transportation were also discovered to be the least used modes of transportation by older adults.

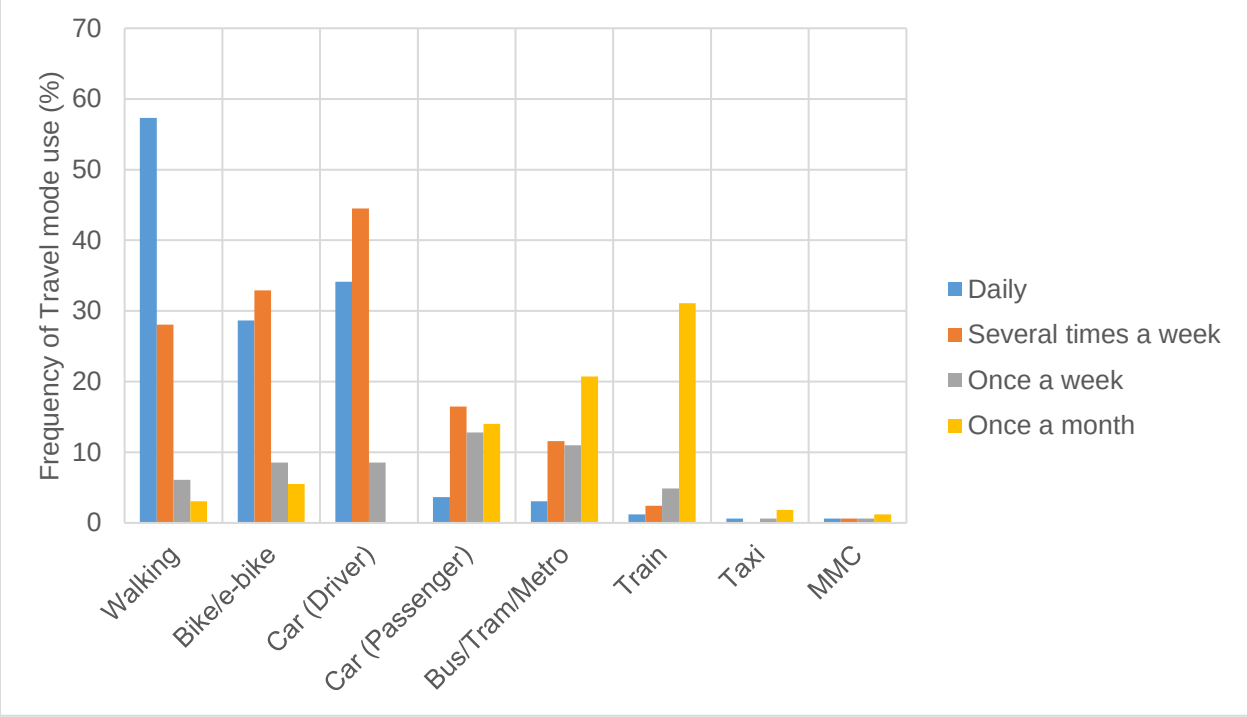


FIGURE 10 Frequency of using different modes of transport by respondents.

The analysis of frequency allowed assessing travel mode use in general by using the combined index mean score for the different modes of transport, as shown in the figure below. Walking (95 percent) was the most commonly used mode of transportation in general at least once a month, followed by driving a car (87 percent) and cycling (76 percent).

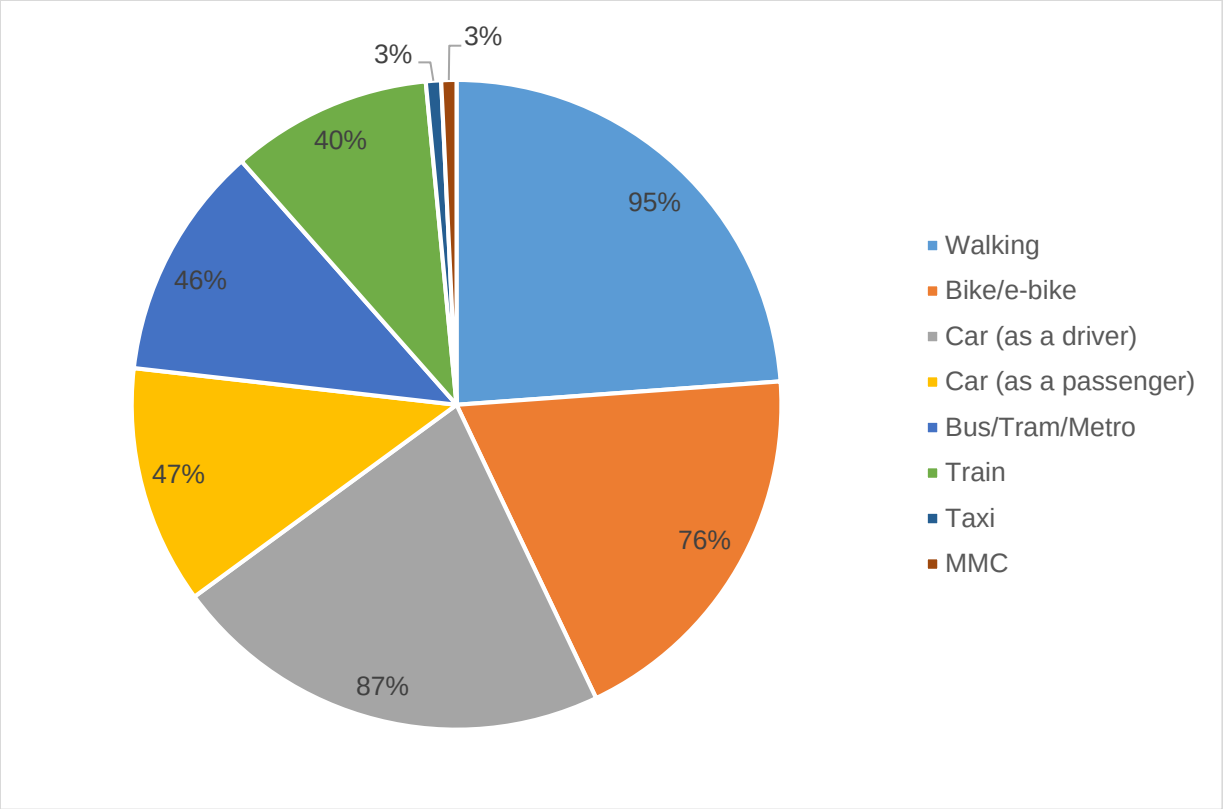
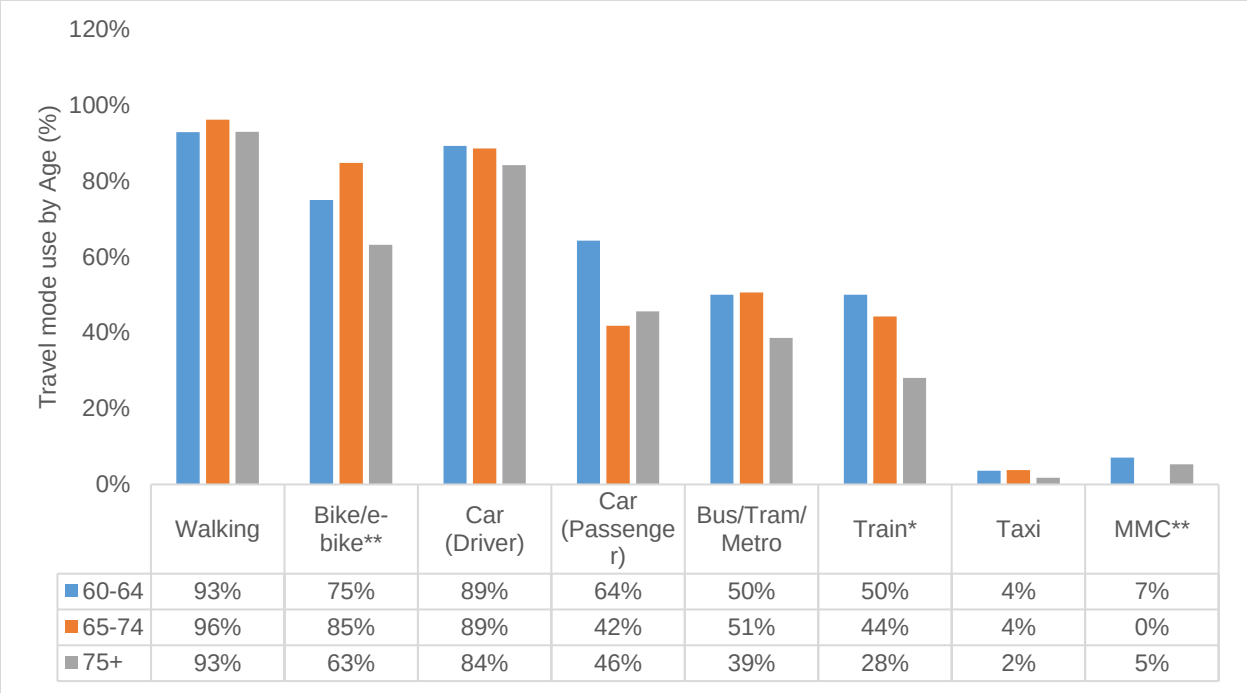


FIGURE 11 Transport Modes use (once a month or more often, in %) in general.

Following that, a bivariate analysis/cross-tabulation was performed to determine how different modes of transportation are used by gender and age. To determine whether or not there was a significant relationship between gender/age groups and travel mode use, the Fisher's exact test was used.

Travel mode use (as measured by the combined mean score index) differs significantly across age groups for those who cycle, as shown in Figure 11, with those aged 65-74 (young older adults) having the highest mode use share, while those aged 75 and above (old and old older adults) reporting significantly more use of Less Mobile Centers (MMC). The use of the remaining modes of transportation showed no statistically significant differences. Young older adults (65-74) appear to travel more than other age groups, as can be seen.

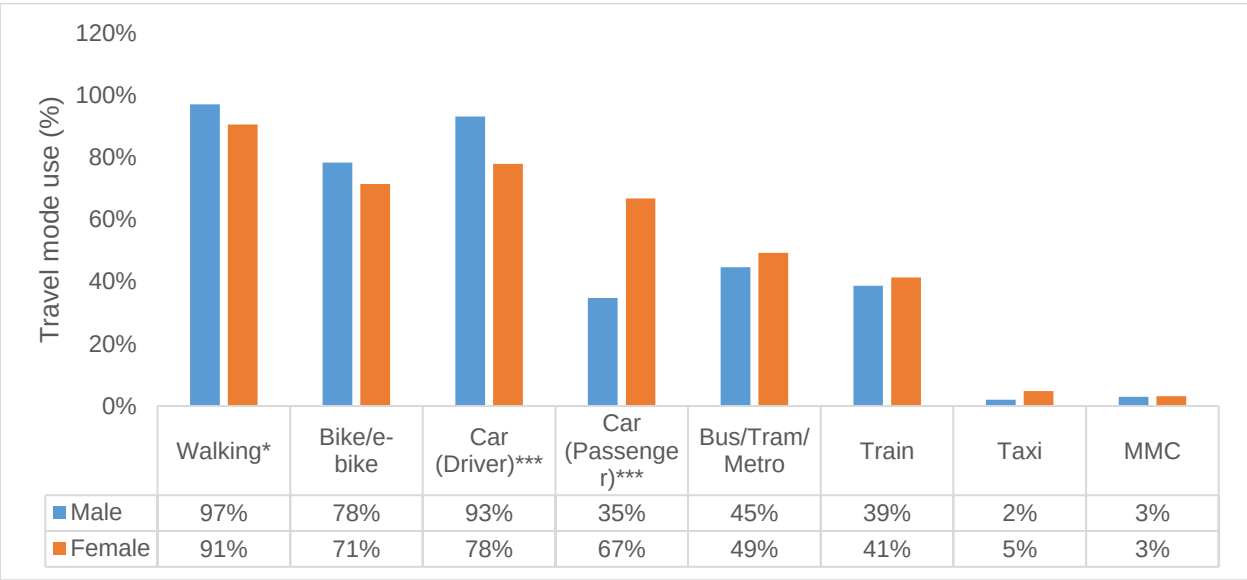


	Walking	Bike/e-bike**	Car (Driver)	Car (Passenger)	Bus/Tram/ Metro	Train*	Taxi	MMC**
60-64	93%	75%	89%	64%	50%	50%	4%	7%
65-74	96%	85%	89%	42%	51%	44%	4%	0%
75+	93%	63%	84%	46%	39%	28%	2%	5%

[+]Significance levels: *<0.10, **<0.05, ***<0.01

FIGURE 12 Travel Modes use (at least once a month, in %) by Age group.

The gender test of transportation mode use yielded significant results for those who use cars as both drivers and passengers, with more males (93 percent) driving than females (78 percent). Females, on the other hand, outnumber males as car passengers. Other modes of transportation yielded no significant results (Figure 13).



	Walking*	Bike/e-bike	Car (Driver)***	Car (Passenger)***	Bus/Tram/ Metro	Train	Taxi	MMC
Male	97%	78%	93%	35%	45%	39%	2%	3%
Female	91%	71%	78%	67%	49%	41%	5%	3%

[+]Significance levels: *<0.10, **<0.05, ***<0.01

FIGURE 13 Travel modes use by Gender

Table 4 displays the results of the first ordinal regression model. They show that **people who live with their partner** are less likely to use active transportation modes (walking and cycling) and are more likely to use public transportation (bus/metro/train). Similarly, living alone has a significant impact on how older people choose to travel. **Living alone** has a negative impact on both cycling and driving. Looking at the **trip purpose or types of out-of-home activities**, older adults are less likely to walk or use a car as a passenger or driver while performing social activities and visiting the City center. Cycling, car use as a driver, car as a passenger, Bus/Metro/Tram, and Train have a positive effect on other activities or locations such as cafe/park, grocery store/educational institution/workplace, health care center/cafe, restaurant/park, and health care center/park/trip to another city or country, respectively.

The findings also show that **access to transportation resources** can have an impact on both negative and positive travel mode choices among older people. For example, not having bicycles in their household is negatively associated with non-use of cycling, whereas it is positively associated with both car use as a driver and public transportation (Bus/Metro/Tram). On the other hand, not having a car benefits both cycling and public transportation (train), while obviously having a negative impact on driving. Possession of a bus/train card has a positive effect on public transportation use, as expected; however, ownership of a driver's license was unexpectedly positively associated with train use.

Other **socio-demographic factors**, such as age, gender, education, and income, were discovered to be predictors of transportation mode choices among older adults. The findings show that age has a significant impact on mode choice for both car drivers and Bus/Metro/Tram users. Younger older adults aged 65-74 are more likely than those over 75 to use both modes of transportation. Gender, in addition to age, has a significant impact, with more females than males using cars as passengers. Lower educated older people are found to drive more than higher educated people; however, lower income older adults are less likely to use cars as passengers than higher income older adults.

When it comes to **health and well-being measures**, self-reported health rating and other impairments have a significant impact on modal choice. However, these results look a bit strange as they don’t provide a good indication of the impacts of health issues on using the different transport modes. Poor hearing, for example, is associated with both car use as a driver and public transportation (Bus/Metro/Tram), whereas poor sight is associated with both car use as a passenger and public transportation (Bus/Metro/Tram). Those who self-report excellent health are less likely to use public transportation (Bus/Metro/Tram) than those who self-report poor health. Furthermore, those who reported walking limitations are less likely to use the train while going about their daily lives.

Finally, some aspects of the **built environment** may have a significant impact on the mode of transportation chosen by older adults. For example, if bus stops are located within a short distance, older people are more likely to use public transportation (Bus/Metro/Tram).

TABLE 4 Factors associated with travel modes choice, significant results of Ordinal regression model (N=140)

Variables	Estimate	p-value	CI Lower (95%)	CI Upper (95%)
Walking[1]				
Living with a partner (ref=yes). No	15.30	0.00**	13.96	16.64
Purpose: Social activities	-0.54	0.03*	-1.02	-0.06
[1]Model fitting information: X^2 (45) = 56.143, p-value = 0.123. Cox & Snell R square = 0.330 and Nagelkerke R square = 0.368				
Cycling[2]				
Living with a partner (ref=yes). No	3.67	0.03*	0.39	6.95
Living alone (ref=yes). No	4.02	0.03*	0.46	7.59
Purpose: Café	0.44	0.04*	0.02	0.87
Purpose: Park	0.56	0.03*	0.05	1.07
Number of bicycles (ref=one or more bicycles). No bicycle	-6.64	0.00**	-9.51	-3.77
Number of cars (ref=one or more cars). No car	20.18	0.00**	17.47	22.88
[2]Model fitting information: X^2 (45) = 109.637, p-value < 0.001. Cox & Snell R square = 0.543 and Nagelkerke R square = 0.578				
Car as a driver[3]				
Age group/Life stages (ref=75+). 65-74	2.17	0.00**	0.86	3.49
Education (ref=higher). Secondary	1.23	0.03*	0.13	2.32
Living alone (ref=yes). No	4.73	0.04*	0.23	9.23
Self-reported hearing condition (ref=poor hearing). Fair	-3.23	0.00**	-5.36	-1.11
Number of cars (ref=one or more cars). No car	-28.69	0.00**	-36.05	-21.34
Number of bicycles (ref=one or more bicycles). No bicycle	2.80	0.01**	0.58	5.02
Purpose: City center	-0.94	0.00**	-1.52	-0.36
Purpose: Grocery store	1.40	0.00**	0.63	2.18
Purpose: Educational institution	0.87	0.03*	0.11	1.64
Purpose: Workplace	0.70	0.01**	0.14	1.26
[3]Model fitting information: X^2 (45) = 242.906, p-value < 0.001. Cox & Snell R square = 0.824 and Nagelkerke R square = 0.908				
Car as a passenger[4]				
Male (ref=female)	-3.84	0.00**	-5.32	-2.37
Monthly household income (ref≥€2500-3000). €1500 - 1999	-2.29	0.04*	-4.49	-0.09
Self-reported sight condition (ref=poor sight). See well	1.27	0.02*	0.24	2.30
Purpose: Health care center	2.22	0.00**	1.35	3.09
Purpose: City center	0.65	0.01**	0.15	1.16
Purpose: Café	0.56	0.01**	0.11	1.01
Purpose: Social activities	-0.61	0.02*	-1.13	-0.09
[4]Model fitting information: X^2 (45) = 113.701, p-value < 0.001. Cox & Snell R square = 0.556 and Nagelkerke R square = 0.601				
Bus/Metro/Tram[5]				
Age group/Life stages (ref=75+). 60-64	1.97	0.04*	0.12	3.83
Age group/Life stages (ref=75+). 65-74	2.11	0.01**	0.61	3.60
Living with a partner (ref=yes). No	-17.09	0.00**	-18.64	-15.55
Self-reported health rating (ref=Honest). Excellent	-4.89	0.01**	-8.48	-1.29
Self-reported hearing condition (ref=poor hearing). Hearing well	-2.07	0.01**	-3.71	-0.43
Self-reported sight condition (ref=poor sight). Fair	5.10	0.00**	1.87	8.33
Number of bicycles (ref=3 or more bicycles). two bicycle	1.69	0.03*	0.17	3.21
Bus/train card owner (ref=no). Yes	3.28	0.00**	2.09	4.47
Distance of the nearest bus stop (ref>1000m). 500-1000m	1.80	0.03*	0.15	3.44
Purpose: Restaurant	1.46	0.00**	0.61	2.31
Purpose: Park	0.89	0.00**	0.33	1.45
[5]Model fitting information: X^2 (45) = 288.855, p-value < 0.001. Cox & Snell R square = 0.873 and Nagelkerke R square = 0.956				
Train[6]				
Self-reported walking limitations (ref=no). Yes	-1.83	0.03*	-3.53	-0.13
Number of cars (ref=one or more cars). No car	18.88	0.00**	15.83	21.92

Variables	Estimate	p-value	CI Lower (95%)	CI Upper (95%)
Bus/train card owner (ref=no). Yes	2.09	0.00**	0.95	3.23
Ownership of a driving license (ref=no). Yes	2.45	0.04*	0.13	4.77
Purpose: Health care center	1.18	0.00**	0.36	2.00
Purpose: Park	0.66	0.02*	0.09	1.23
Purpose: Trip to another city/country	1.64	0.00**	0.73	2.55
[6]Model fitting information: X^2 (45) = 86.831, p-value < 0.001. Cox & Snell R square = 0.462 and Nagelkerke R square = 0.551				
Taxi[7]				
[7]Model fitting information: X^2 (45) = 44.645, p-value = 0.487. Cox & Snell R square = 0.273 and Nagelkerke R square = 1.000				
MMC[8]				
[8]Model fitting information: X^2 (45) = 56.463, p-value = 0.117. Cox & Snell R square = 0.332 and Nagelkerke R square = 1.000				

The reference category is the group "Daily User" of different travel modes.
Significance codes: * <0.05, ** <0.01

4.1.2 Out-of-home Mobility

The frequency of performing daily life essential activities at various locations was measured using frequency analysis, and the results are displayed in the form of a chart (see Figure 14). According to the computed individual index mean scores (as described in section 3.3.2.3), older adults make the most trips to the grocery store (3.59), social activities (3.08), city center (3.07), café (2.13), park (2.09), shopping center (1.99), and restaurant/trip to another city or country (1.95).

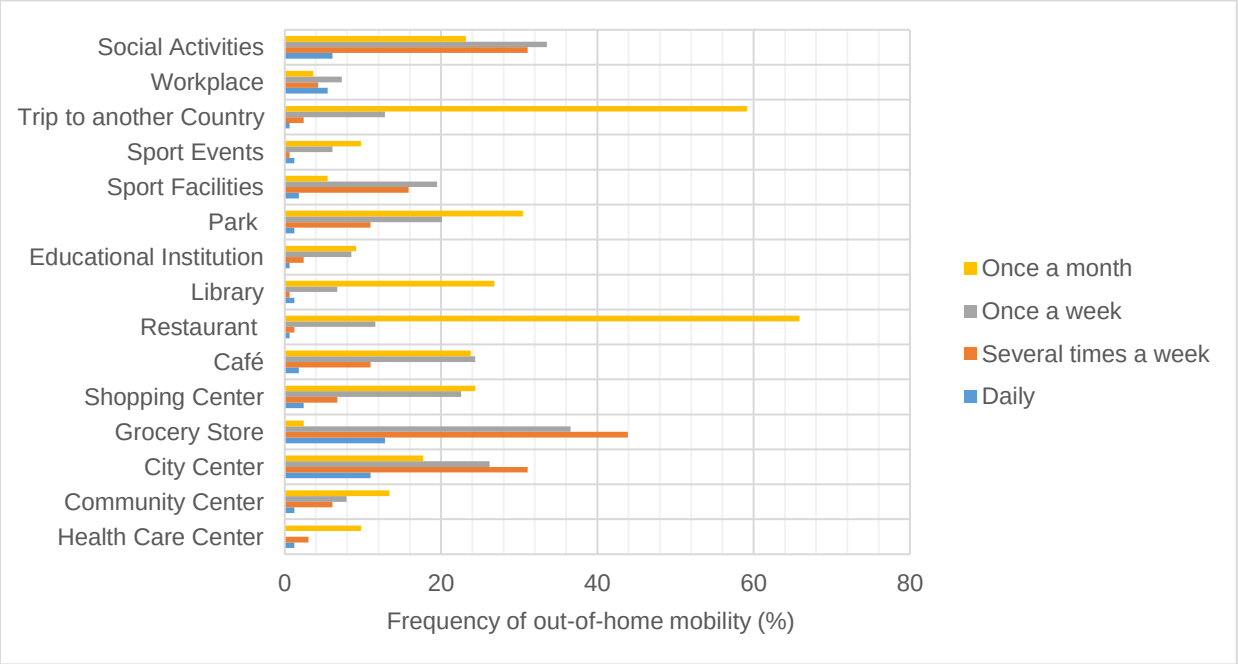


FIGURE 14 Older adults' travel frequency while undertaking daily life activities (%).

Table 5 displays the results of the second ordinal regression model. The findings show that the **household status** of older adults has a significant impact on their travel decisions. Living with a partner predicts making more trips while performing daily life activities for almost all types of activities or locations studied, whereas living alone has a positive effect only on social activities.

Health and well-being measures, like travel mode selection, have a significant impact on older people's trips while out and about. Poor vision has a positive impact on visiting the community center and café, but a negative impact on visiting the shopping center and traveling to work. Having a good self-reported health condition has a negative effect on going to the grocery store and going to work, whereas hearing well or fairly has a negative effect on going to sports facilities and a positive effect on going to sporting events. Furthermore, self-reported limitations have a positive impact on trips to the health care center but a negative impact on trips to the city center and grocery store.

When measuring the **availability of transportation resources**, the results show both positive and negative effects on older adults' trip-making. For example, owning a car has a negative effect on trips to the city center, grocery store, parks, and sporting events, but a positive effect on trips to the workplace. Having a driving license, on the other hand, has a positive effect on trips to the city center, grocery store, shopping center, and library; whereas having a bus/train card has a positive effect on trips to educational institutions and a negative effect on trips related to social activities.

Age, gender, education, and income had significant results in predicting older people's trip-making while performing certain activities for **socio-demographic characteristics**. In terms of gender, males are more likely than females to make trips to the city center, grocery store, sporting events, and workplace, while females make fewer trips to educational institutions. Lower educated people are found to make fewer trips to the city center, shopping center, restaurant, educational institutions, and another city/country and more trips to the cafe than higher educated older adults. Lower-income older people are more likely to visit the city center, shopping malls, and restaurants, while they travel less to educational institutions than their higher-income counterparts. Looking at the effect of the **built environment**, the findings show that older adults who live close to the nearest bus stops are more likely to visit the café and workplace, while they are less likely to visit the shopping center.

TABLE 5 Factors associated with travel frequency for trips to different locations, significant results of Ordinal regression model (N=140).

Variables	Estimate	p-value	CI Lower (95%)	CI Upper (95%)
Visiting Health Center[1]				
Living with a partner (ref=yes). No	-15.45	0.00**	-17.48	-13.43
Self-reported walking limitations (ref=no). Yes	3.65	0.00**	1.53	5.77
[1]Model fitting information: X^2 (30) = 44.656, p-value = 0.042. Cox & Snell R square = 0.273 and Nagelkerke R square = 0.428				
Visiting Community center[2]				
Living with a partner (ref=yes). No	-16.85	0.00**	-18.22	-15.49
Self-reported sight condition (ref=poor sight). See well	-1.03	0.04*	-2.03	-0.03
Number of bicycles (ref=3 or more bicycles). One bicycle	1.46	0.03*	0.12	2.79
[2]Model fitting information: X^2 (30) = 28.436, p-value = 0.547. Cox & Snell R square = 0.184 and Nagelkerke R square = 0.216				
Visiting City center[3]				
Gender (ref=female). Male	1.14	0.01**	0.23	2.04
Education (ref=higher). Primary education	-3.09	0.00**	-4.64	-1.53
Self-reported walking limitations (ref=no). Yes	-0.98	0.03*	-1.84	-0.12
Monthly household income (ref≥€2500-3000). €500 - 999	3.19	0.03*	0.39	5.99
Number of cars (ref=one or more cars). No car	4.22	0.05*	-0.06	8.50

Variables	Estimate	p-value	CI Lower (95%)	CI Upper (95%)
Ownership of a driving license (ref=no). Yes	1.84	0.03*	0.16	3.52
[3]Model fitting information: X^2 (30) = 61.769, p-value < 0.001. Cox & Snell R square = 0.357 and Nagelkerke R square = 0.374				
Visiting Grocery Store[4]				
Gender (ref=female). Male	1.07	0.03*	0.10	2.03
Self-reported health rating (ref=Honest). Good	-2.51	0.01**	-4.47	-0.54
Self-reported walking limitations (ref=no). Yes	-0.99	0.03*	-1.90	-0.07
Number of cars (ref=one or more cars). No car	6.40	0.01**	1.68	11.12
Ownership of a driving license (ref=no). Yes	2.35	0.01**	0.59	4.11
[4]Model fitting information: X^2 (30) = 47.103, p-value =0.024. Cox & Snell R square = 0.286 and Nagelkerke R square = 0.314				
Visiting Shopping center[5]				
Education (ref=higher). Primary education	-3.63	0.00**	-6.02	-1.23
Living with a partner (ref=yes). No	-15.53	0.00**	-16.67	-14.39
Self-reported sight condition (ref=poor sight). Fair	2.76	0.01**	0.69	4.84
Monthly household income (ref≥€2500-3000). €500 - 999	3.93	0.02*	0.74	7.13
Ownership of a driving license (ref=no). Yes	1.81	0.04*	0.05	3.56
Distance of the nearest bus stop (ref>1000m). <500m	-1.47	0.00**	-2.47	-0.46
[5]Model fitting information: X^2 (30) = 64.542, p-value < 0.001. Cox & Snell R square = 0.369 and Nagelkerke R square = 0.398				
Visiting Cafe[6]				
Education (ref=higher). No completed education	3.96	0.00**	1.85	6.07
Self-reported sight condition (ref=poor sight). See well	-0.97	0.01**	-1.74	-0.20
Distance of the nearest bus stop (ref>1000m). <500m	0.96	0.05*	0.01	1.92
[6]Model fitting information: X^2 (30) = 45.898, p-value = 0.032. Cox & Snell R square = 0.280 and Nagelkerke R square = 0.299				
Visiting Restaurant[7]				
Education (ref=higher). Primary education	-2.69	0.00**	-4.53	-0.85
Monthly household income (ref≥€2500-3000). €500 - 999	3.09	0.05*	-0.05	6.24
[7]Model fitting information: X^2 (30) = 39.973, p-value = 0.105. Cox & Snell R square = 0.248 and Nagelkerke R square = 0.295				
Visiting Library[8]				
Ownership of a driving license (ref=no). Yes	4.40	0.00**	1.92	6.88
[8]Model fitting information: X^2 (30) = 49.191, p-value = 0.015. Cox & Snell R square = 0.296 and Nagelkerke R square = 0.355				
Visiting Educational Institutions[9]				
Gender (ref=female). Male	-1.98	0.02*	-3.59	-0.37
Education (ref=higher). Secondary education	-1.24	0.04*	-2.44	-0.04
Monthly household income (ref≥€2500-3000). €1000 - 1499	-3.29	0.05*	-6.53	-0.06
Number of bicycles (ref=3 or more bicycles). One bicycle	2.46	0.01**	0.55	4.38
Bus/train card owner (ref=no). Yes	1.44	0.03*	0.15	2.74
[9]Model fitting information: X^2 (30) = 69.037, p-value < 0.001. Cox & Snell R square = 0.389 and Nagelkerke R square = 0.495				
Visiting Park[10]				
Age group/Life stages (ref=75+). 60-64	1.28	0.03*	0.13	2.43
Number of cars (ref=one or more cars). No car	21.18	0.00**	19.16	23.21
[10]Model fitting information: X^2 (30) = 42.409, p-value = 0.066. Cox & Snell R square = 0.261 and Nagelkerke R square = 0.280				
Visiting Sport facilities[11]				
Living with a partner (ref=yes). No	-14.76	0.00**	-15.87	-13.65
Self-reported hearing condition (ref=poor hearing). Hearing well	-1.33	0.02*	-2.46	-0.20
[11]Model fitting information: X^2 (30) = 29.290, p-value = 0.502. Cox & Snell R square = 0.189 and Nagelkerke R square = 0.208				
Visiting Sport events[12]				
Gender (ref=female). Male	1.89	0.03*	0.23	3.54
Living with a partner (ref=yes). No	-15.93	0.00**	-17.55	-14.30
Self-reported hearing condition (ref=poor hearing). Fair	2.43	0.04*	0.14	4.72
Number of cars (ref=one or more cars). No car	17.18	0.00**	13.72	20.63
[12]Model fitting information: X^2 (30) = 39.006, p-value = 0.126. Cox & Snell R square = 0.243 and Nagelkerke R square = 0.325				
Visiting Trip to another City/Country[13]				
Education (ref=higher). Primary education	-1.89	0.03*	-3.55	-0.24
[13]Model fitting information: X^2 (30) = 28.193, p-value = 0.560. Cox & Snell R square = 0.182 and Nagelkerke R square = 0.209				

Variables	Estimate	p-value	CI Lower (95%)	CI Upper (95%)
Visiting Workplace[14]				
Age group/Life stages (ref=75+). 60-64	2.25	0.01**	0.63	3.86
Gender (ref=female). Male	2.03	0.02*	0.33	3.73
Living with a partner (ref=yes). No	-18.64	0.00**	-20.50	-16.77
Self-reported health rating (ref=Honest). Good	-2.56	0.04*	-5.05	-0.06
Self-reported sight condition (ref=poor sight). See fairly	2.56	0.05*	-0.02	5.15
Number of cars (ref=one or more cars). No car	-20.31	0.00**	-23.18	-17.45
Distance of the nearest bus stop (ref>1000m). 500-1000m	1.95	0.04*	0.12	3.78
[14]Model fitting information: X^2 (30) = 56.164, p-value = 0.003. Cox & Snell R square = 0.330 and Nagelkerke R square = 0.412				
Participating in social activities[15]				
Living with a partner (ref=yes). No	-4.09	0.02*	-7.38	-0.79
Living alone (ref=yes). No	-5.45	0.00**	-8.94	-1.95
Bus/train card owner (ref=no). Yes	-0.85	0.03*	-1.60	-0.10
[15]Model fitting information: X^2 (30) = 36.619, p-value = 0.189. Cox & Snell R square = 0.230 and Nagelkerke R square = 0.245				

The reference category is the group "Daily Visitor" of different locations/out-of-home activities.
Significance codes: * <0.05, ** <0.01

4.1.3 Effect of subjective measures on mobility and travel behavior

In addition to the objective measures associated with the five domains of the conceptual framework by Luiu and colleagues (2018), subjective factors were considered in this study to provide a better understanding of older people's mobility needs, experiences, and barriers encountered while carrying out daily life activities using the various modes of transportation studied. These subjective measures include, for example, the importance of various modes of transportation, the importance of various places or out-of-home activities, the availability of various modes of transportation facilities (in terms of quality infrastructure or services), and various traffic safety aspects. In the following sections, the results of two Spearman's correlations are presented and interpreted.

4.1.3.1 Transport modes use

The results from the first Spearman's correlation are shown on Table 6. In general, older adults who value **specific activities** are more likely to use specific modes of transportation, with weak to moderate correlations. Those who value a health care center, for example, are more likely to use MMC, Bus/Tram/Metro, Taxi, and Car as a passenger. Trips to the city center are positively associated with using the bus/train/metro; trips to restaurants are associated with driving as a passenger; and those whose needs are related to using the library and going to the park are more likely to use public transportation. Consideration of a **specific mode** as important to older adults was found to be positively associated with using that particular mode of transport (with weak to very strong correlations), and in some cases, consideration of specific modes of transport was found to be negatively associated with using other modes of transport. For example, the importance of walking as a mode of transportation is associated with frequent walking and using a car as a passenger, while it is negatively associated with driving a car. Cycling is associated with more cycling use; those who consider car as a driver an important mode to them are more likely to use it and less likely to use car as a passenger and public transportation; car as a passenger is very strongly associated with more use of this mode and negatively associated with cycling and car as a driver; while the importance of public transportation has a very strong positive

relationship with using this mode. The importance of taxis and MMCs is related to each of their respective modes of transportation.

Looking at other subjective measures related to different **modes of transportation, facilities, and other traffic aspects**, some are negatively associated with using specific modes of transport while others are positively associated. Weather conditions have a negative relationship with both cycling and public transportation (train), whereas cycling was found to be negatively associated with inadequate lighting, a lack of benches along routes, and insufficient parking. Feeling safe while using pedestrian paths, on the other hand, has a negative relationship with cycling, whereas good condition cycle paths have a positive relationship with walking. The difficulties in boarding while using public transportation were positively associated with car use as a passenger; however, the availability/respect of priority parking and drop off spots for people with special needs, as well as taxis' accessibility, affordability, and helpful taxi drivers, were negatively associated with car use as a driver and car as a passenger, respectively.

On the other hand, adequate lighting along roadways and sidewalks, as well as the affordability of parking costs, were both positively associated with public transportation use; whereas unclean and poorly maintained public transportation vehicles, inconsistent/high public transportation costs, a lack of discounts to public transportation services, inconvenient payment methods for tickets, a lack of specialized transportation for people with limited mobility/disability, and more restrictions on car use were all positively associated with public transportation use. In terms of specialized modes of transportation, convenient/accessible and well-lit transport stops, inconvenient fare payment methods, inadequate lighting at parking places, and availability of MMC are all negatively associated with taxi use; whereas parallel parking as a hindrance to mobility is positively associated with taxi use.

TABLE 6 Spearman's correlations between transport mode use and problems related to different modes of transport & traffic aspects.

Subjective measure	Walking	Bike/e-bike	Car (Driver)	Car (Passenger)	Bus/Tram/ Metro	Train	Taxi	MMC
Importance of Health Care Center				.154*	.182*		.159*	.348**
Importance of City Center					.172*			
Importance of Restaurant				.222**				
Importance of Library					.245**			
Importance of Park					.163*			
Importance of Walk	.460**		-.197*	.168*				
Importance of Bike / e-bike		.745**						
Importance of Car (as driver)			.558**	-.201**	-.259**			
Importance of Car (as passenger)		-.163*	-.299**	.914**				
Importance of Bus/tram/metro			-.225**		.927**	.482**		
Importance of Train			-.188*		.489**	.957**		
Importance of Taxi							.176*	
Importance of Minder Mobielen Centrale								.175*
Pedestrian paths feels safe		-.166*						
Cycle path surface is in good condition	.192*							

Subjective measure	Walking	Bike/e-bike	Car (Driver)	Car (Passenger)	Bus/Tram/ Metro	Train	Taxi	MMC
Weather conditions are normally suitable for cycling		-.297**				-.165*		
Adequate lighting along roadways and sidewalks		-.205**			.241**			
Appropriate provision of benches are provided along routes and important places		-.159*						
Public Transport - Transport stops and stations are conveniently located and are accessible							-.184*	
Public Transport - Transport stops and stations are well-lit and well-marked							-.205**	
Public Transport - Vehicles are clean and usually well maintained					-.259**			
Public Transport - Difficulties in boarding				.159*				
Public Transport - Costs are consistent, clearly displayed and affordable					-.365**	-.295**		
Public Transport - Public transport service provides discount					-.298**	-.176*		
Public Transport - Payment methods for tickets/fare are good					-.228**	-.173*	-.185*	
Public Transport - Specialized transportation is available for people who have a mobility disability					-.197*			
There are sufficient parking places in numbers		-.176*						
Priority parking and drop-off spots for people with special needs are available and is respected			-.172*					
Parking costs are affordable					.169*			
Payment method for parking is convenient						.172*		
Parallel parking creates hindrances in mobility							.197*	
Parking places are well-lit							-.173*	
More restrictions on the use of a car (e.g. speed control, car-free zones, increase in parking cost)		-.184*			-.198*	-.197*		
MMC is available							-.169*	
Taxis are accessible, affordable and drivers are courteous and helpful				-.155*				

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 7 displays the results of the second Spearman's correlation. The findings show that the importance/desire attached to a **specific activity or place of interest** was positively associated

with the frequency of travel while undertaking similar activities for all daily life activities, except going to work and performing social activities (family/friends). However, valuing certain activities was linked to some other activities. Trips to the city center, shopping center, café, library, educational institution, park, and sporting events, for example, were positively associated with visits to the grocery store, trip to another city/country, community center/restaurant/social activities, city center, restaurant, city center, and trip to another city/country, respectively. The importance of trips to the city center, grocery stores, and sporting events, on the other hand, has a negative relationship with the frequency of trips to sporting facilities, sporting facilities, and restaurants, respectively.

Looking at the relationship between the importance of different **modes of transportation** and the frequency with which older adults perform their daily life activities, the findings show that all modes of transportation are positively associated with the frequency of travel while performing specific activities, with the exception of driving, which has a negative relationship with trips to the city center. Walking, for example, was positively associated with trips to both the city center and the grocery store, while cycling was found to have a similar relationship with visits to both educational institutions and sports facilities. The importance of car as a passenger and public transportation (bus/tram/metro) was positively associated with visits to both the health care center and the restaurant; whereas the importance of train was positively associated with trips to the city center and library, as well as trips to another city/country. When it comes to **specialized modes of transportation**, taxi was found to be positively associated with trips to both restaurants and social activities by older people, while MMC was found to be similarly associated with trips to the health care center.

In general, all subjective measures related to **different modes of transportation, facilities, and other traffic aspects** were found to be associated with the actual frequency of travel while carrying out daily life activities. For example, trips to the shopping center, park, park, health care center, and grocery stores/park were negatively associated with quality of pedestrian facilities such as good condition paths surface, proper lane markings, availability of pedestrian paths, and easy pedestrian crossings, as well as unsuitable weather conditions. Lack of quality cycling facilities, such as wide cycle paths and well-maintained path surfaces, as well as unsuitable weather conditions for cycling, had a negative relationship with trips to the health care center, health care center/educational institution/social activities, and city center/grocery store, respectively.

When it comes to **public transportation user facilities**, a negative relationship was discovered between older adults' most important activities (such as trips to a health care center, community center, café/restaurant, educational institutions, park, trip to another city or country, workplace, and family/friends) and insufficient public transportation services due to issues such as public transport inaccessibility, inconsistent timetables that do not match needs to access desired locations, unclean and poorly maintained vehicles, overcrowded vehicles, lack of priority seating/not respected by other passengers, difficulties boarding, driver behavior, inconsistent/high public transportation costs, lack of discounts to public transportation services, inconvenient ticket payment methods, lack of specialized transportation for people with limited mobility/disability, and so on.

When it comes to **driving and other specialized modes of transportation**, the quality of parking facilities has a significant impact on older people's out-of-home mobility. The negative coefficients were discovered for the link between several parking issues such as insufficient parking spaces, high parking space costs, narrow parking spaces, not feeling safe in parking areas, and a lack of proper parking space maintenance and actual older adults' trips while carrying out their activities. Other mobility aspects with a similar relationship include the lack of restrictions on driving in their neighborhood and the lack of specialized transportation modes (Taxi and MMC).

TABLE 7 Spearman's correlations results between several subjective measures and out-of-home mobility.

Subjective measure	Health Center	Community Center	City Center	Grocery Store	Shopping Center	Café	Restaurant	Library	Educational Institution	Park	Sport Facilities	Sport Events	Trip to another City Country	Workplace	Social Activities
Importance of Health Care Center	.501**								.165*						
Importance of Community Center		.615**													
Importance of City Center			.332**	.228**							-.195*		.165*		
Importance of Grocery Store				.167*							-.156*				
Importance of Shopping Center					.238**								.194*		
Importance of Cafe		.154*				.472**	.196*						.155*		.187*
Importance of Restaurant							.333**								
Importance of Library			.225**					.606**							
Importance of Educational institution to follow a course or courses							.191*		.620**						
Importance of Park			.160*							.450**					
Importance of Sport facilities to participate in sport activities											.558**				
Importance of Sport events as a spectator							-.198*					.657**	.175*		
Importance of Trip to another city or country					.154*								.400**		
Importance of Walk			.282**	.168*											
Importance of Bike / e-bike									.165*		.157*				
Importance of Car (as driver)			-.157*												
Importance of Car (as passenger)	.278**						.222**								
Importance of Bus/tram/metro	.156*						.164*								
Importance of Train			.211**					.179*					.195*		
Importance of Taxi							.216**								.163*
Importance of Minder Mobielen Centrale	.156*														
Pedestrian path widths are appropriate								.163*							
Pedestrian path surface is good					-.176*										
Lane marking on pedestrian paths are properly made										-.184*					
Pedestrian paths are available in all streets										-.248**					
Pedestrian crossings are easy	-.172*														

Subjective measure	Health Center	Community Center	City Center	Grocery Store	Shopping Center	Café	Restaurant	Library	Educational Institution	Park	Sport Facilities	Sport Events	Trip to another City Country	Workplace	Social Activities
Weather conditions are normally suitable for walking				-.175*						-.174*					
Cycle path widths are appropriate	-.166*														
Cycle path surface is in good condition	-.242**								-.238**						-.200*
Weather conditions are normally suitable for cycling			-.161*	-.159*											
Public Transport accessibility (with good connections and well-marked routes and vehicles)	-.161*														
Public Transport - The timetables are consistent with your routine to access the desired locations	-.212**														
Public Transport - Vehicles are clean and usually well maintained	-.178*													-.165*	
Public Transport - Vehicles are not overcrowded usually													-.230**		-.237**
Public Transport - Priority seating’s are respected										-.163*					
Public Transport - Difficulties in boarding						.176*									
Public Transport - Drivers stop at designated stops and beside the curb to facilitate boarding and wait for passengers to be seated before driving offboarding		-.198*													
Public Transport - Costs are consistent, clearly displayed and affordable	-.204**								-.181*						
Public Transport - Public transport service provides discount						-.180*	-.173*								
Public Transport - Payment methods for tickets/fare are good									-.176*						

Subjective measure	Health Center	Community Center	City Center	Grocery Store	Shopping Center	Café	Restaurant	Library	Educational Institution	Park	Sport Facilities	Sport Events	Trip to another City Country	Workplace	Social Activities
Public Transport - Specialized transportation is available for people who have a mobility disability									-.181*	-.170*					
Parking - Areas designated for parking and drop-offs are safe												-.159*			
Parking - There are sufficient parking places in numbers										-.159*			-.252**		
Parking - Parking places are conveniently located (not far from destinations)													-.175*		
Parking - Priority parking and drop-off spots for people with special needs are available and is respected													-.157*		
Parking - Parking costs are affordable						-.160*			.160*	-.212**					
Parking - Parking spaces are not too narrow			.162*									.223**			
Parking - Parking areas feels safe								-.153*						-.228**	
Parking - Parking spaces are properly maintained								-.163*						-.195*	
More restrictions on the use of a car in your area (e.g. speed control, car-free zones, increase in parking cost	-.160*														
Specialized transport & Taxi - Minder Mobielen Centrale is available															-.164*

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.2 Qualitative part

4.2.1 Older adults' perceptions/experiences of mobility and safety

4.2.1.1 Highly ranked mobility problems

Focus groups were held as part of this study to gain a better understanding of older adults' experiences and perspectives on potential mobility issues related to various modes of transportation and different aspects of traffic in general; these focus groups were structured according to the six topics listed below. Participants were asked to identify existing mobility problems in their neighborhood and rank them from "most important" to "least important" under the six studied topics, which included walking, cycling, street infrastructure, public transportation (Bus/Train/Metro/Train), parking (car driver or passenger), and traffic in general. Table 8 lists the most significant mobility issues that older adults face, with a focus on those that are relevant to their safety.

TABLE 8 Identified mobility barriers while using different modes of transport.

Potential barriers	% ranked as the most important
Walking	
Pedestrian path surface is good	40%
Pedestrian paths are available in all streets	32%
Pedestrians are sharing road space with fast moving vehicles	32%
Pedestrian path widths are appropriate	27%
Cyclists uses pedestrian paths	23%
Pedestrian paths feels safe	22%
Time for crossings at junctions are appropriate	17%
Pedestrian crossings are easy	14%
Cycling	
Cycle path widths are appropriate	56%
Cycle path surface is good	52%
Lane marking on cycle paths are properly made	22%
Street Infrastructure	
Adequate lighting along roadways and sidewalks	53%
Proper traffic calming measures e.g. traffic signs, speed bumps etc. are installed in your neighborhood	43%
Roads and streets are well maintained	35%
Traffic signs and intersections are visible and well placed	33%
Appropriate provision of public toilets along routes and important places	29%
Drains along roads are covered	18%
Appropriate provision of benches are provided along routes and important places	14%
Public Transport (Bus / Tram / Metro / Train)	
Inaccessibility of public transport (with poor connections)	48%
Difficulties in boarding	36%
Poor provision of Public transport services (not reliable and infrequent)	35%

Potential barriers	% ranked as the most important
Vehicles are usually overcrowded	25%
Long distance to stops	20%
Lack of seating and shelters	15%
Priority seating's not respected	14%
Problems entering and leaving a vehicle (drivers' behaviour)	8%
Parking (Car driver or passenger)	
There are sufficient parking places in numbers	63%
Areas designated for parking and drop offs are safe	33%
Parking places are conveniently located (not far from destinations)	30%
Parking costs are affordable	29%
Priority parking and drop-off spots for people with special needs are available and is respected	17%
Parallel parking creates hindrances in mobility	13%
Parking spaces are not too narrow	8%
Mobility (general)	
Road users follow traffic signs	58%
There should be more restrictions on the use of car in your area (e.g. speed control, car free zones, increase in parking cost etc.)	50%
Roadways are free of obstructions and do not block drivers vision	44%
Minder Mobielen Centrale is available	33%
Taxis are accessible, affordable and drivers are courteous and helpful	25%

4.2.1.2 Older adults' experiences and perceptions of safety

After all focus group participants were asked to identify and rank **potential mobility issues**, the second question required them to explain why one issue was more important than the others. Figure 14 depicts the analysis's thematic coding, which revealed that infrastructure problems (29.4 percent) and perceived safety (25.9 percent) were the two most frequently mentioned themes in terms of total mentions. While infrastructure issues were the most common, both were discovered to be more prevalent across modes of transportation than others. Parking issues for cars (11.5%), Public Transportation and specialized transport issues (9.4%), Pedestrian facilities (9.4%), and cyclist facilities (6.4%) were more closely associated with their respective modes of transportation. Walking, cycling, and traffic in general were associated with the theme Education, awareness, and enforcement (2.4 percent), while weather conditions were associated with both walking and cycling (1.6 percent), and 'More restrictions on car use' (2.4 percent). The final theme concerned health issues or personal disabilities, which were more closely associated with walking and public transportation use (1.4 percent).

Given these findings about the mobility experiences and perceptions of older adults while using various modes of transportation, walking appears to be the most affected mode of transportation, with the most perceived mobility related barriers (28.6 percent), followed by cycling (17.6 percent), car use (14.1 percent), and public transportation (11.1 percent). The following sections go over each of the ten identified themes (referred to as potential mobility barriers).

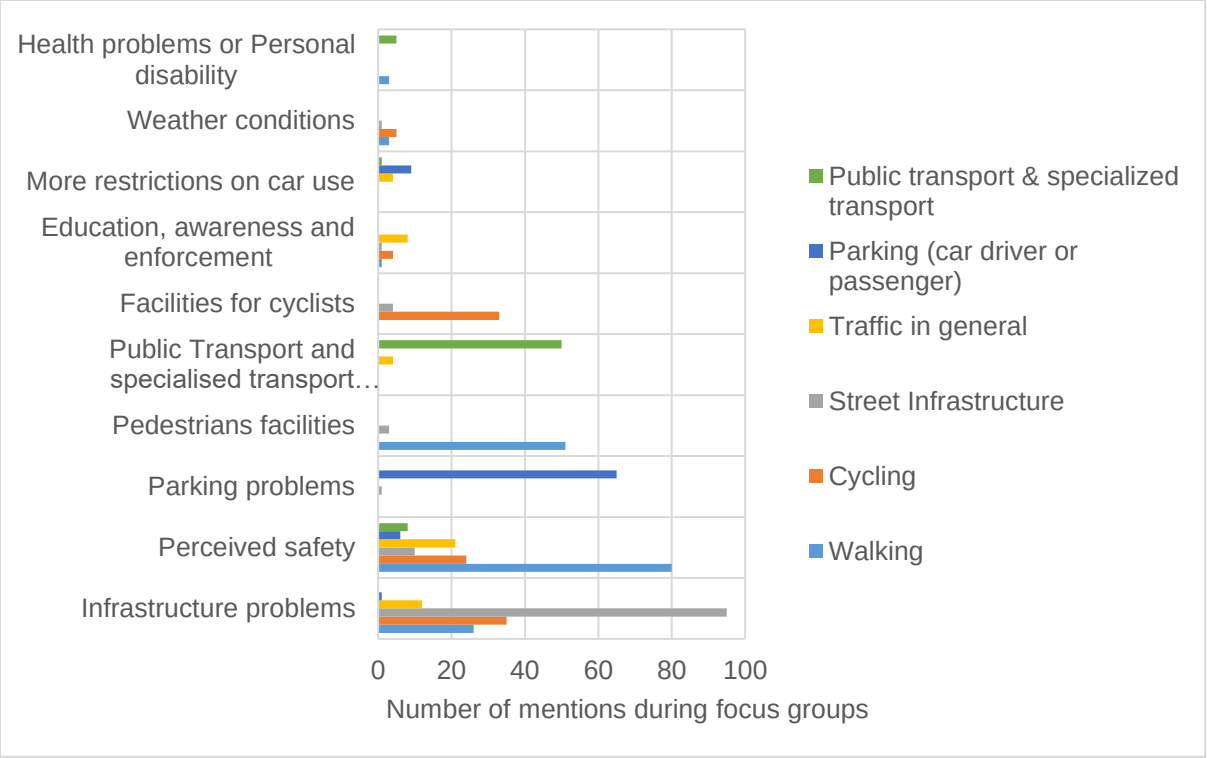


FIGURE 15 Resulting themes in this study by focus groups' topics.

1) Infrastructure problems

Within the infrastructure lens, participants identified a number of barriers or mobility issues faced by older people across various modes of transportation, which are ranked in order of importance in the figure below.

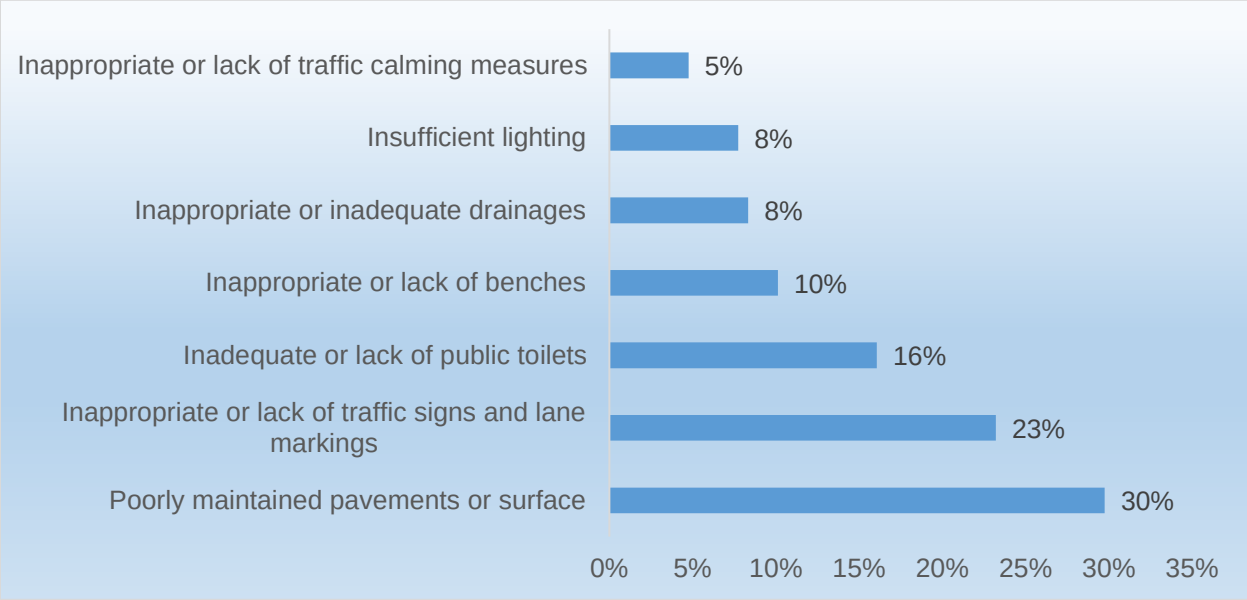


FIGURE 16 Key identified infrastructure related barriers to mobility of older adults

- Poorly maintained pavements/surfaces

The poor maintenance of pavements and surface was the most dominant reported problem as it is one of the most contributing factors to older adults' fall risk while both walking and cycling. Several concerns related to **quality of pavements** or surfaces were raised, such as, uneven surface, cracked pavements with holes, grown roots of trees, etc. For instance, participants mentioned, "Cycle path surface is not good, uneven surface, holes, roots of trees." "There are cobble stones and a lot of holes / uneven in the cobblestone. That's not very good." "Loose stones, they are not properly laid, dangerous." Other participants trying to describe the pedestrian paths condition, cited "Pedestrian path surface is not good, because it is not unequal [unleveled], uneven."

On the other hand, participants reported concerns with **lack of regular pavement maintenance** following unfavorable weather conditions or seasonal effects They said, "In Autumn they have leaves; you have to be careful when you have to take turn. In winter, they put ice on streets but not in pedestrian path. They don't always clean it." "I think the roads are not maintained, I live on the other side of the Railways, and I have to pass the tunnels. And in heavy rains, there is water, and you have to bike in the water, it could be much better."

- Inappropriate or lack of traffic signs and lane markings

Most of the participants were concerned about **unsuitable or inadequate traffic signs and lane markings** mostly along walking and cycling routes. The issues raised included lack of visibility or obstructed traffic signs, poor design of signs and road markings, insufficient signs along the routes, non-functional traffic light, etc. For example some participants said, "A lot of traffic signs around the bushes, you cannot see them." Other participants complained about poorly designed or lack of harmonization of traffic signs: "Traffic signs are not clear; different signs which one to follow? Both on stations and on roads." Regarding the road markings, one participants noted, "I only have the markings on the country road, the markings are not clear."

While participants emphasized on the insufficiency of traffic signs, two participants remarked that, "Not enough traffic signs for cyclists, but too much for cars", and "Where there is a pedestrian crossing, they must stop the cyclists." For lane markings, other participants reported, "No marking between pedestrian paths and cycle paths". "One should make a clear distinction between pedestrian paths and cycle paths." Moreover, some participants complained about **non-functional or inappropriate traffic signals** and one participant revealed, "Traffic signals both side green and don't know for what traffic, cars and bicycles, it creates confusion."

- Lack of adequate lighting

Participants mentioned concerns about **insufficient lighting along roads/streets and in tunnels**. For instance, one participant stated, "You still have to be careful; I don't feel safe all the time. There are not enough lights so you don't always run everywhere." Another participant said, "More lights would be easier when you go out and in the evening more lights would be better to feel safer." One participant also shared a similar complaint: "In the evening we don't go the city we feel it is dangerous, you don't feel safe. Most of the woman don't take the tunnels, and it is a problem when you have to go to the city, you can only use the tunnels. Not alone." Another one

echoed, “Not enough lights especially in Tunnels and they are not very big, and I doubt I will fall, not safe.”

- ❖ Inappropriate or lack of traffic calming measures

Lack of proper traffic calming measures (speed signs, speed bumps, etc.) was mentioned in the discussions. For example, one participant said, “Speed bumps are too high. Problem in back while riding fast.” Another participant remarked, “They aren’t any traffic calming measures.” Another one echoed, “Speed of vehicles are too fast.”

- ❖ Insufficient or lack of Public toilets

Participants reported that public restrooms were either unavailable or dirty. For example, one respondent stated, "And the city center, and then there are only two toilets in Hasselt." [locations], people go to the shops to use the restroom." "Not necessary because they are dirty," one participant said.

- ❖ Inappropriate or lack of road drainages

During the focus group discussions, the issue of road drainages was mostly raised in relation to a lack of or insufficient drains, as well as those that are not covered. For example, one participant stated, "We do not have sewage, and the streets are small, so you have to cycle, and there is a lot of water [ditch] [drainage] nowadays." Another voiced a similar complaint: "Drains are the most important." Walking and cycling near water is inconvenient." One participant, on the other hand, stated, "Drains are open, very dangerous."

- ❖ Insufficient or lack of benches

The availability of benches was regarded as a facilitator, improving the walking behaviors of older adults. The lack of benches along the walking routes or in public spaces was reported as an issue by several participants. "When you walk, you need to sit in between; there should be more benches; there are not enough benches," one participant observed. Another female participant stated, "as a woman, you need to be careful.... benches, if you go on vacation, you need a bench, you can not sit and get that feeling in your own town."

2) Perceived safety

During a focus group discussion, participants perceived themselves to be unsafe while using various modes of transportation, particularly walking. Sharing routes with other road users, encroachments on pedestrian or cyclist paths, visibility obstructions, other road users risky behavior, fast-moving vehicles, road users who do not follow rules and traffic signs, unsafe pedestrian crossings, high volume of users, and so on (see Figure 17).

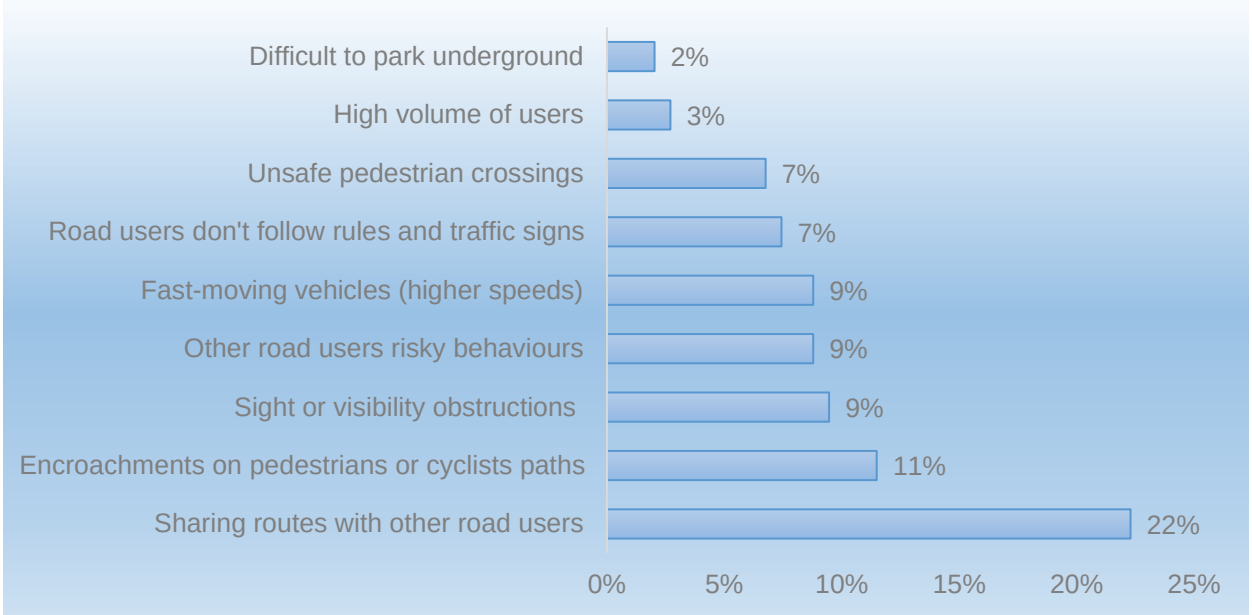


FIGURE 17 Key identified perceived safety among older adults across the different modes

- ❖ Sharing routes with other road users

Participants reported risks associated with sharing routes with other road users, which apply to situations in which cycle paths are shared with other vehicles, pedestrian paths are shared with cars, and streets are shared by pedestrians, bicycles, and cars. "Because of the lack of a cycle path, cyclists use the pedestrian path," said one participant. "Sometimes it is a problem that the cyclists use the path [it comes later] and we also have to share it with fast moving vehicles," said another participant. "When cyclists use the pedestrian path, it becomes dangerous because you do not always hear what is going on behind you," said another. You do not hear as well as you used to when you are older." Participants also emphasized the significance of the absence of safety features (e.g. separation of people from vehicles). "You have to walk in the streets with cars and bicycles," one participant said. "They do not always feel safe because they are net to the car, next to the traffic," said another participant.

- ❖ Encroachments on pedestrians or cyclists paths

Encroachments into pedestrian or cycle paths were also identified as a barrier to older adults' mobility, and it was discovered to be linked to misplacement of other infrastructure (such as traffic signs, electric poles, and so on) and bad practices by other road users. One participant, for example, stated, "The walking path is used for anything and everything." So I believe that is a major issue." "Then they have to put up road signs." What are they going to do with it? "On that walking trail." "And our sidewalks are all at least three meters wide," another participant added. Nonetheless, the problem on those wide sidewalks is that we have different things, cafes with terraces, and police regulations require a meter and a half of free passage on those sidewalks. However, there is usually a lighting pole in that meter and a half. (Laughter) Then we are lost. We reapplied for it. We will have a bottleneck walk in three months." One participant, on the other hand, stated, "Widths are too small, cars are standing next to it." Another participant stated, "We

almost never see cyclists on the footpath because the municipality has bicycle paths." They are not always safe because there is a sidewalk, a bicycle path, and a parking lot." "Sometimes you have parking cars so close to the pedestrian path, when they open the doors, 25/h, it is dangerous," said another.

- ❖ Sight or visibility obstructions

A lack of visibility was reported while walking, cycling, and driving. This was primarily due to grown trees alongside streets and on-street parking, which impeded road users' visibility. "Trucks block visions," one participant said. High trees have been blown into garden corners, and construction work is obstructing vision." One of the major sight obstructions identified by participants was on-street parking. "Sometimes they park half on the street and half on the pedestrian path," one participant observed. [People with medical care have only 15 or 20 minutes to work, and they do not have a place to park, so they park in front of the house, causing problems for pedestrians and cyclists.] "I had that parallel parking creates hindrances, it is so annoying," said another participant. They park in the middle of the road, sometimes standing next to it and unloading. [I am not sure what it means] [They do the same in the town center]."

- ❖ Other road users risky behaviors

This issue was primarily related to walking, cycling, and taking public transportation. "Cyclists go very fast and do not consider pedestrians because work places do not have enough space," one participant said. Electric bikes are faster." Another participant who had a similar experience with e-bike users agreed, saying, "with e-bikes it is difficult and they do not bell [speed peddlers, they are horrible]." Participants emphasized the dangers of cyclists riding in the wrong direction, with one remarking, "more people riding in the wrong direction coming to the city from Kiewet." They go in the wrong direction; cycling is easier than driving." "Cyclists do not respect pedestrian paths," said another participant. Participants also reported risky behavior by some public transportation drivers. One participant, for example, stated, "When I take the bus, the drivers do not wait until I sit down." "Not all drivers wait for passengers to seat up," another participant said. On the other hand, some drivers do not consider lowering the bus to accommodate older adults, resulting in boarding difficulties. "Drivers are not thinking," one participant revealed. The bus driver has the ability to lower the buses." One participant admitted to using his phone while driving. "Use phone in car," they said. Cars stop and talk to each other, and you can not say anything to them."

- ❖ Fast-moving vehicles

This was primarily a concern for pedestrians and cyclists, and to a lesser extent for car drivers. "Sometimes it is a problem that the cyclists use the path [it comes later] and we also have to share it with fast moving vehicles," one participant explained. "Cyclists are fast, you have to jump," one participant said. The dangers of fast-moving bikers (mostly e-bikers) on cycling were reported by participants. "Some bikers are fast (electric bike) 40 km/hr," one participant said. "And they drive too fast," another participant added. On a bicycle path, no faster than ten miles per hour." Drivers also reported dangers associated with driving at higher speeds. "Too fast (70-80) and sharp turns feel very dangerous," one participant said. "Buses are too fast, it is very dangerous for cars and everyone," said another participant.

- ❖ Road users don't follow rules and traffic signs

This issue was primarily associated with cycling and car use. "But now the road code says that the carrier must wait if a cyclist is cycling in the lane and may not pass if there is no oncoming car," one participant said. However, this does not always occur." Another participant had a similar experience: "In Hasselt, there are cycle streets, but cars are not allowed to cross [but they do not care, there is no control]." One participant stated, "biking street, speed limit 30 km/h and the cars may not cross them but they always do][they do not follow the proper traffic measures]." "Not everyone obeys traffic signs," another participant said.

- ❖ Unsafe pedestrian crossings

The majority of participants cited time for crossings as a significant factor in their walking. One participant, for example, stated, "At junctions, when you are in the middle, it turns red [you could have the best infrastructure, but if people do not use it]." "Time is short for babies, wheelchairs, and disabled people," another participant said. Another remarked, "Sometimes crossings are not appropriate, more time is required."

- ❖ High volume of users/high neighborhood density

Congested buses/trains and busy streets were identified as critical subthemes by some participants. One participant, for example, stated, "Buses are overcrowded during school periods (morning and evening)." "There are overcrowded buses and trains," another participant complained. On the other hand, one participant stated, "There are a lot of people in the center, and I think it is dangerous."

3) Parking problems for cars

The most common complaints from participants were that parking lots are too expensive, too narrow, too far from destinations, or do not feel safe. Other participants complained about a lack of parking information and overly complicated payment methods (Figure 18). For example, one participant commented, "Expensive parking cost." There is not much free parking. A day costs 12 Euros. Occasionally, more than 12 Euros are spent. Normally, the hourly rate is 2 euros. If you stay longer than 10 minutes, you must pay 4 Euro per hour." Another participant stated, "sometimes it is very expensive[most of the time, it is a lack of information, where to park cheaply][when you come into the city you have some places left][there are some areas with one euro, some places it is seven euros, even the Dusart plan is cheap at the back, underground parking is expensive." "We want free parking stations," one participant said.

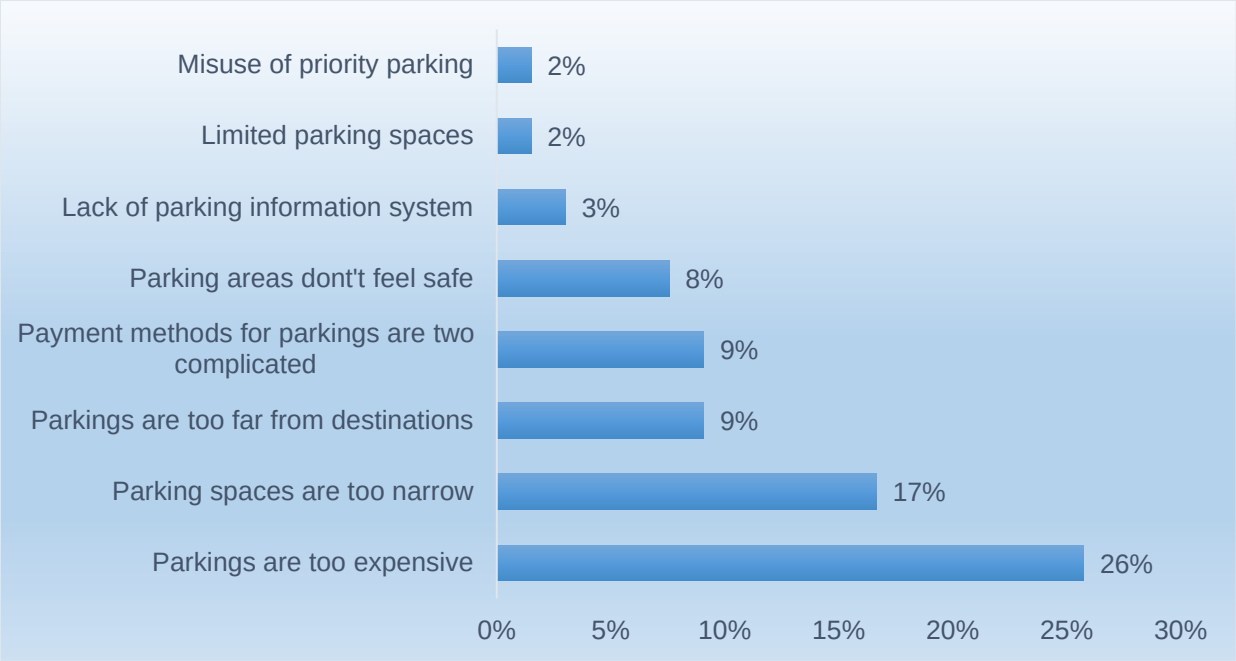


FIGURE 18 Summary of the main parking problems

In terms of parking space quality, several participants complained about parking spaces being too narrow. "The parking places are not big enough for cars[you find it difficult to go around the parking place] most of the time [the cars are getting bigger] [do you feel the parking spaces are appropriate in the parking places] not for me, I am not the best driver," one participant said. [he refers to women] [chat in nederland][ok if you have small cars]." Participants also complained about the inconvenient location of parking spaces, which, in most cities, are far from their destinations. One participant, for example, stated, "Mostly they are too expensive, and sometimes the parking places are too far away from your locations and destinations." "Not always convenient," said another participant.

There were concerns that payment methods for parking spaces would be too difficult for older adults. One participant, for example, stated, "Sometimes there are Obligations to come by car and it is not easy payment methods." "Young people pay with their phones." Another participant expressed a similar sentiment: "Payment method is complicated." You must remember your license plate number." Participants also reported that the parking lots did not feel safe and that other users did not respect the priority parking for older adults. "Parking lots are not safe, and there are not enough lights," one participant said. "Kiss and rides at stations- they have to cross the square," another participant complained. It is extremely dangerous." On the other hand, one participant stated, "Priority parking is mostly occupied - many times especially at Clinics, hospitals [other participants disagreed]." Disable does not go to the movies or the swimming pool because he is disabled. Once, a young woman parked in first place with her car. At the time, I was riding with my mother. I approached her and said. We called the cops, who do not respect priority parking."

4) Public Transport and specialized transport problems

The shortcomings in public transportation and specialized transportation services were primarily related to the transportation system's reliability, convenience, accessibility, availability, and affordability (Figure 19). The responses mostly focused on public transportation being unreliable and infrequent, inconveniences when using public transportation, and difficulties boarding. Participants also mentioned a lack of seating and shelters, as well as high prices for taxis and other specialized transportation for people with limited mobility. For example, one participant stated, "On weekends, I can not go to any family or friend because I start my travel in the morning and arrive in the afternoon." There is no direct train, and they are not on time." "There is a city bus outside of school hours," said another participant. Buses are frequently late and unreliable."

Participants emphasized the inconvenient nature of taking public transportation. "Last train at 21:30, and sometimes no connections," one participant said. "Long queues in the evening are inconvenient," another participant added. Other two participants expressed dissatisfaction with the lack of a public transportation station and specialized transportation for people with limited mobility. "There are no public transportation stations," one participant observed. "Ask for the cost, no specialized transport, especially for wheelchairs," said another participant. Participants also reported boarding difficulties, particularly when using trains. "Difficulty in train, steps are too high/ there is a gap then you can enter the train," one participant said. Another person complained about the bus, saying, "I do not take bus Too high for boarding for Hasselt."

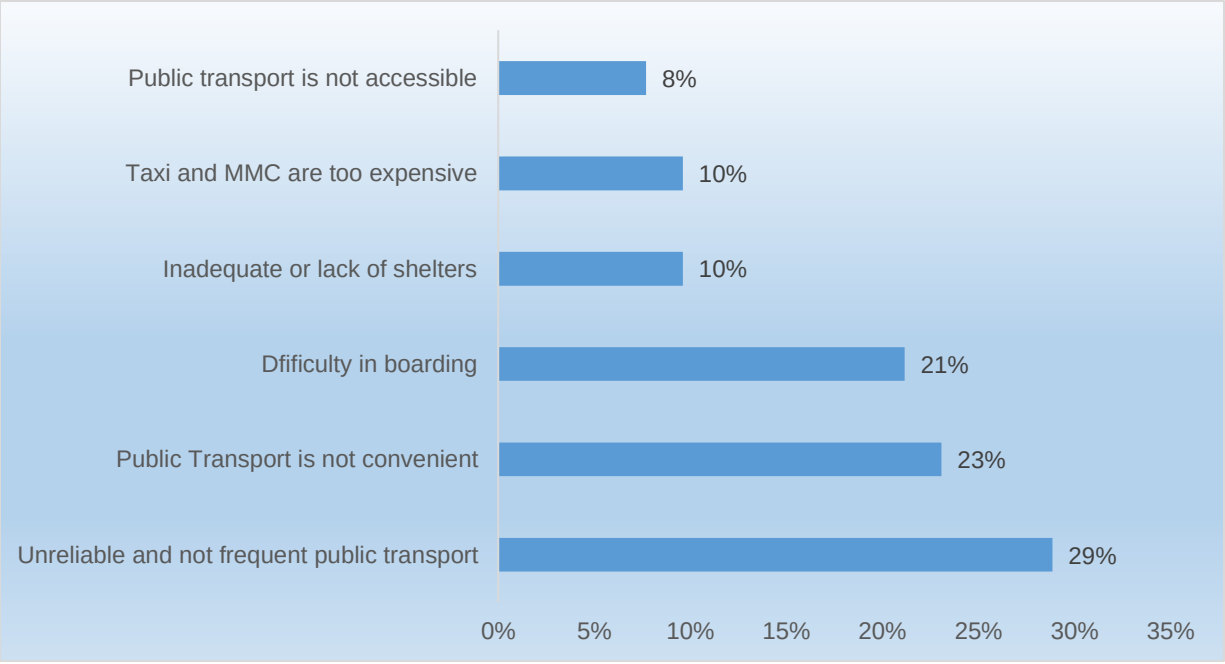


FIGURE 19 Key identified public transport services related barriers.

Other participants expressed dissatisfaction with the inaccessibility of public transportation. "No buses or trains," one participant stated. We used to have some, but now we don't." Participants also stated that public transportation (particularly trains), taxis, and less mobile Centers (MMC) are prohibitively expensive. One participant, for example, stated that "the train is very expensive."

It is better (before) not good if you are 65 or older. The Rail Pass is evolving. Everyone says to use public transportation, but it is expensive." "Taxi and Minder Mobielien Centrale (translated as 'less mobile') are expensive," said another participant. Participants also complained about a lack of seating and shelters at bus stops and train stations. "There are no shelters," one participant stated. Difficult in the rain [people damage it]."

5) Pedestrian facilities

The importance of appropriate walking paths or sidewalks was mentioned by participants. When they walked, most participants were concerned about the inadequacy and poor quality of walking paths or sidewalks. According to one participant, "one thinks of the car first, then the cyclist, and if there is still a meter of space, a walking path will be created." "We do not have a pedestrian path and the cycle path has speed bumps, which is dangerous because the streets are small," said another participant. Participants, on the other hand, emphasized the narrowness and steepness of walking paths. One participant, for example, stated, "Where the maximum width is between one meter and one and a half meters." So it is dangerous when you go from the Kuringersteenweg to the Vaart, for example, because the intersection is very bad."

6) Facilities for cyclists

The majority of participants raised concerns about insufficient cycle path widths and the impact of two-way bicycle paths. "I think more and more people cycle in the city, so they need to make it larger, they are too small," one participant said. "The only problem is that people now frequently make double cycle paths," said another participant. So you look to the side where you expect to see a cyclist rather than the side where you don't. That is a problem for me." Participants also stressed the importance of keeping cycle paths separate from motorized traffic. "In the Netherlands, the cycle path is separated from the roads," one participant said. [This is a cycling country.]

7) Education, awareness and enforcement

Participants in the focus group discussions also mentioned the importance of public awareness and education about traffic rules, as well as effective enforcement (control) of these rules. One participant, for example, stated that "[this year nobody knows what the signs mean][drivers license these days they know][they should be more aware][misuse of cycle 5km/h][you have to stay behind][we have to see why this particular street, it should make sense][the rules are not clear to everybody]." "Not everyone understands the signs meaning of cycle path (cars & cycles)," said another participant. Some participants expressed concern about the lack of enforcement of traffic rules (control). "In Hasselt, you have cycle streets, but cars are not allowed to cross [but they do not care, there is no control]," one participant observed. Another participant stated, "Most speed controls for cars and bikes are not sound."

8) More restrictions to car use

Some participants expressed concerns about car use and suggested that cities provide more space for pedestrians and cyclists. "I found the transportation to be loud," one participant said. Cars and buses make a lot of noise." "I have no problem, I do not have a car. [It is very good for the environment]," said another participant. Another participant expressed a similar sentiment: "I

do not drive because it is too expensive to drive to the city, so I ride my bike." One participant, on the other hand, stated, "Few times need car, more bikes and walk." "In the city center, more space for pedestrians and cyclists," said another participant.

9) Weather conditions

Participants (those who walk and cycle) expressed concern about the inclement weather. "Weather conditions are not normally suitable for cycling," several participants commented. Another walker stated, "It is very difficult when it rains."

10) Health problems or Personal disability

Despite the fact that the survey data did not produce significant results in predicting travel mode choice, health was one of the topics discussed by participants in focus groups. Participants cited their health issues as a major deterrent to walking. "You do not feel safe," one participant observed. I am cautious because I wear two pairs of glasses. With my glasses on, I can not see the surface properly." Another participant had a similar experience: "Most footpaths are slopey, with loose stones and holes, and when cyclists use pedestrian paths, it becomes dangerous, because you do not always hear what is going on behind you." You do not hear as well as you used to when you are older." "The pedestrian path surface is not that good," a third participant said, "because I do not feel safe because I have to watch where I walk, and my back is not good, and the combination of those two." Another participant expressed a similar sentiment: "I do not take the bus." Too high for Hasselt boarding. Connections to the coast from Hasselt are difficult. It is a problem for people over the age of 70. Disability requires you to request wheelchair steps in Hasselt ahead of time." This video shows how age-related declines in vision, cognition, and physical abilities have a significant impact on how older road users walk and use other modes of transportation.

5. DISCUSSION AND STUDY LIMITATIONS

This study aimed to: (1) examine the effects of socio-demographics, health factors, access to mobility resources, and subjective feelings of safety on the mobility of older adults; (2) identify the subjective mobility factors/barriers associated with the mobility of older adults; and (3) propose future intervention measures to improve the safety of older adults for the various travel modes. Overall, this study established a relationship between objective/subjective mobility measures studied using the model by Luiu and colleagues (2018) and mobility behavior, in light of the study objectives of understanding older people's mobility behavior, needs, experiences, and perceived barriers (in terms of their travel mode choices and trip frequencies while undertaking activities). This allows for a complete understanding of older people's mobility needs (both actual and unfulfilled), experiences, and barriers encountered during their out-of-home mobility for daily life activities. The findings' implications are discussed under three main headings: travel modes, out-of-home mobility, and recommendations for improving mobility and safety.

5.1 Transport mode use

5.1.1 Factors associated with travel mode choices

The findings of this study on the factors influencing older adults' travel mode choices confirm a number of previous findings, including the impact of **socio-demographic characteristics**, activities of interest, access to transportation resources, and built environment. **Gender** influences car usage as both a driver and a passenger, with women more likely to rely on car usage as a passenger while men rely more on car usage as a driver. This backs up the findings of O'Hern and Oxley (2015) and Lattman et al. (2019), who discovered that males were more likely than females to drive and were less likely to be passengers. Unlike Bocker and colleagues (2017) and Luiu and Tight (2021), who discovered that women rely on walking, cycling, and public transportation more than men, the effect of gender on these other modes of transportation was not established. In terms of **age**, the results show that older adults aged 75 and over are less likely to cycle, drive a car, or use public transportation (bus/metro/tram) than the other age groups. This could be attributed to the fact that older people's health deteriorates and more health impairments become more prevalent as they get older, as opposed to young old adults. There were no other significant age effects discovered. These findings are consistent with the findings of Lattman et al. (2019), who discovered that people aged 75 and up use their cars (both as drivers and passengers) and bikes significantly less.

Other demographic factors that influence travel mode selection include **household status, monthly income, and educational level**. Living with a partner has a negative impact on walking and cycling while having a positive impact on public transportation use; however, living alone has a negative impact on both cycling and driving. This trend can be attributed to a variety of factors, including health-related issues or disability, which may limit the use of active travel modes on the one hand, and the nature of the main activities performed by older adults, such as trips to the city center, shopping centers, social activities, and so on, which require socializing with others and traveling together, as well as their personal safety and security concerns. Lower educated older people are found to drive more than higher educated people; however, lower income older adults are less likely than higher income older adults to use cars as passengers. This is consistent with

the findings of Lättman et al. (2019), who discovered that car ownership increases the likelihood of choosing to travel as a car passenger rather than driving.

When the impact of access to various modes of transportation was examined, it was discovered that the **availability of transportation resources** was a strong predictor of travel mode choices by older adults. Bicycle ownership benefits older people cycling while having a negative impact on driving and public transportation. Car ownership has a significant negative impact on cycling and public transportation while having a significant positive impact on driving. Furthermore, having a bus train card has a significant positive effect on using public transportation, while having a driver's license was unexpectedly found to be positively associated with train use. Overall, these findings are consistent with those reported by Böcker and colleagues (2017) and Sulikova and Brand (2021). The unexpected result could be attributed to the fact that people who live in rural areas far from train stations and lack access to public transportation would have to drive to the stations before their journeys began.

When it comes to **activities**, older adults have been observed to use cycling and public transportation for personal business and recreational activities, but they are less likely to use walking and driving as a passenger for social trips. This finding is consistent with O'Hern and Oxley's (2015) findings on active transportation use. Other significant findings include a negative effect on driving trips to the city center and a positive effect on driving for grocery shopping. This would be attributed on the one hand to difficulties encountered when attempting to enter the city center, such as a lack/inconvenient location of parking spaces, traffic jams, and so on (as highlighted in this study's focus group discussions), and on the other hand to difficulties in carrying heavy groceries while using modes of transportation other than the car.

Unlike previous studies by Luiu and Tight (2021) and Sulikova and Brand (2021), which found that good health is associated with a higher likelihood of walking, cycling, and taking public transportation, a similar effect of **self-reported health condition** was not established in this study, most likely because more than 90% of the participants rated their health condition as good or above, and thus the impact of health issues on travel mode choices could not be observed. However, according to Luiu and Tight (2021) and many other previous studies, health deteriorates with age, and thus older people are more likely to experience difficulties due to declining health functions. Finally, the built environment had a significant impact on the use of public transportation in terms of the distance to the nearest transport stops. This finding is consistent with the findings of Luiu et al. (2018a), who discovered that the distance between stops from both home and destination may necessitate some walking, which may discourage older people from using public transportation.

5.1.2 Subjective measures' effect and perceived mobility barriers

In addition to the objective factors discussed above, subjective measures were very helpful in understanding older adults' mobility needs, experiences, and perceived barriers in relation to their travel mode choices. **The importance of specific activities** was found to be associated with frequent use of specific modes of transportation; however, **valuing specific modes of transportation** was associated with higher frequency of using a particular mode; and in some cases, the importance of a specific mode has a negative effect on the use of other travel modes, e.g. walking vs car use. This study is somewhat unique in that many previous studies did not

investigate the effect of people's perceived feelings in terms of the importance of both activities of interest and available modes of travel in their travel mode choices.

Several subjective measures related to the **built environment and other transportation aspects**, such as access to transportation facilities/services and quality infrastructure, were found to be associated with the use of specific modes of transportation. Unsuitable weather conditions, poor design and quality of walking-cycling infrastructure/environment, insufficient lighting, and a lack of benches along routes are the main perceived barriers/issues with regard to walking and cycling. The lack of priority parking and drop-off zones for people with special needs is perceived to limit older car driving. Furthermore, the findings revealed several perceived barriers to public transportation use, including unclean and poorly maintained public transportation vehicles, inconsistent/high public transportation costs, a lack of discounts to public transportation services, inconvenient ticket payment methods, a lack of specialized transportation for people with limited mobility/disability, and a lack of restrictions on car use. Finally, perceived barriers to using Taxi/MMC included inconvenient/inaccessible and poorly-lit transportation stops or inadequate lighting at parking places, inconvenient fare payment methods, and a lack of specialized transportation modes.

Furthermore, in addition to the previously discussed survey results, this study identified other **perceived barriers through focus groups**. Other barriers to walking and cycling included the presence of obstacles along the pathways, sharing pedestrian/cyclist spaces with others, fast-moving vehicles (cars and e-bikes), difficult crossing street operations, inappropriate/lack of traffic signs and lane markings, as well as inappropriate traffic calming measures, and the behavior of other road users. All of these barriers are related to older adults' perceived safety, as they were concerned about falling due to poor pavement/surface quality, being knocked over by passing cyclists and cars, crossing the street, and colliding with vehicles. Other important barriers mentioned by participants in focus group discussions that could limit their use of public transportation include inaccessibility of public transportation (with poor connections), poor provision of public transportation services (not reliable and infrequent), overcrowded vehicles, driver behavior, inconsistent/high public transportation costs, and disregard for priority seating by other passengers. Participants cited driver behavior as the most serious safety concern, claiming that bus drivers are unfriendly and unhelpful, failing to stop close to the curb, waiting until passengers are seated before pulling away, driving erratically, failing to lower the bus during entry and exit operations, and failing to provide assistance and information to passengers. Other perceived barriers associated with older car driving included excessive parking costs, inconvenient parking location (far from destinations), parking that does not feel safe (too narrow and not enough lights), parallel parking hindrances, sight/visibility obstructions, other road users' behaviors, a lack of appropriate traffic signs/lane markings, and traffic calmness. Surprisingly, some participants in the focus groups expressed a lack of interest in/need for driving in favor of more sustainable modes of transportation, such as cycling and public transportation. Overall, the findings are consistent with previous research by Buys et al. (2012), Levin et al. (2012), Leung et al. (2021), Luiu et al. (2018a), Luiu and Tight (2021), Musselwhite's (2021), Ottoni et al. (2017), and Ryan et al. (2017).

5.2 Out-of-home mobility

5.2.1 Factors associated with carrying out-of-home activities

Similarly to travel mode selection, various variables from Luiu and colleagues (2018)'s conceptual framework were included in an ordinal logistic regression model to investigate their influence on older adults' travel decisions while carrying out their activities. Older people's travel decisions are influenced by their **living arrangement**, specifically whether they live with a partner or alone. Living with a partner increases trip-making to almost all activities or locations studied, whereas living alone stimulates only social activities. This finding is consistent with the findings of Nordbakke (2019), who discovered that older people who live with a spouse/partner participate in significantly more out-of-home activities than those who do not. Other demographic characteristics, such as **age, gender, education, and income**, had significant results in predicting older people's trip-making while performing certain activities. **Gender** differences were observed, with more males participating in daily life activities than females in general, with the exception of visits to educational institutions. There was no significant **age** effect in general, except for activities such as going to the park and commuting to work, where older adults in pre-retirement age (60-64) were found to do these activities more than other older age categories. This is consistent with the findings of the study of Böcker and colleagues (2017). In general, lower educated people travel less for daily activities (except going to a café) than their highly educated counterparts; however, lower income older people appear to travel more for many activities (except trips to educational institutions) than their higher-income counterparts. These findings are consistent with Nordbakke's (2019) findings that level of out-of-home activity participation tends to increase with income and educational level, except that the effect of **income levels** was reversed in this study. This disparity may be due to a significantly lower proportion of high-income earners (>€2500 per month) among study participants when compared to lower income categories. In terms of the impact of the **built environment**, older adults who live near bus stops are more likely to perform specific activities in general, with the exception of going to the shopping center. This exception may be due to the fact that when participants were asked which facilities were lacking in their neighborhood, shopping centers were among the fewest lacking. This finding is also consistent with Nordbakke's (2019) findings, which concluded that the level of out-of-home activity participation increases with the degree of centrality of residence and the quality of public transportation supply (in terms of both frequency and distance to the nearest stop).

In terms of **health and well-being**, carrying out-of-home activities was found to be associated with **subjective health condition**. In general, poor vision, hearing loss, and walking limitations are all associated with less travel while performing certain activities. However, some exceptions were noted, such as those in good health who would travel less while participating in activities. Though the findings were more or less consistent with Nordbakke's (2019) findings, they have little or inconsistent implication, most likely due to the sample not reflecting reality in terms of older adults' health conditions (with nearly 95 percent of the participants in this study reporting the health condition as good/very good/excellent).

Looking at the impact of **transportation resource availability**, this study produced a mixed bag of findings, some of which contradicted previous research. Possession of a driver's license and a bus/train card both have a positive effect on most activities in general. This is consistent with

Nordbakke's previous findings (2019). However, with the exception of commuting to work, car ownership has a negative impact on important activities performed by older adults, such as trips to the city center, grocery stores, parks, and sporting events. Many factors can explain this same exceptional results from the previously discussed findings, including a greater likelihood of using public transportation and walking to the city center/sporting events rather than driving because they are concerned about high density traffic and expensive parking spaces, among other things, older people are more likely to cycle and use public transportation when traveling to parks, and the majority of those who are still commuting to work frequently fall in the pre-retiree age range of 60-64. Overall, this is consistent with the findings of this study, which show a significant mode share for sustainable modes of transportation (including walking, cycling, and public transport). Furthermore, this funding is consistent with the findings of focus group discussions in which participants expressed a lack of interest in/need for driving in favor of more sustainable modes of transportation.

5.2.2 Subjective measures' effect and perceived mobility barriers

Similarly, subjective measures were used to understand mobility needs in terms of carrying out essential activities and investigate the link between desired out-of-home activity participation and actual activity frequency. The findings suggest that **the importance placed on a specific activity** has a positive effect on the frequency with which similar activities are performed in general. At the same time, it was discovered that valuing certain activities was positively or negatively associated with engaging in other activities, such as trips to the city center vs. the grocery store and trips to the city center vs. sporting facilities. This indicates the likelihood that older people will engage in multiple activities from one or more locations at the same time. In terms of the relationship between **desired modes of transportation and actual activity participation level,** older adults were observed to walk, cycle, drive as a passenger, and use public transportation for personal business/errands and leisure/recreational activities, and they are less likely to drive to the city center. When it comes to **specialized modes of transportation**, valuing taxi as their preferred mode of transportation was associated with more trips to restaurants and social activities, while MMC has a similar relationship with trips to the health care center. These findings are comparable to those of Böcker and colleagues (2017) and Nordbakke (2019). The particular reliance on taxis for trips to restaurants and social activities may be linked to a lack of dependability/frequency of public transportation, which has been found to have a particular impact on older adults' spontaneous leisure, social, and shopping trips.

Similarly, subjective measures of **access to transportation facilities/modes** in terms of both quality infrastructure and transportation services, as well as other traffic aspects, were negatively associated with older people's trips while carrying out their activities. In general, older adults' mobility barriers were found to be caused by a lack of/poor quality infrastructure and inconvenient transportation services. The various perceived barriers in this regard are similar to those previously identified as influencing older people's travel decisions regarding mode of transportation use. These perceived barriers help to justify the activities that older people want or need to do more of (desired mobility) but are unable to do so (unfulfilled mobility needs). The findings are consistent with previous findings by Luiu and colleagues (2017), and Luiu and Tight (2021) on unmet travel needs and travel difficulties and barriers faced by older people.

5.3 Recommendations for improving mobility and safety

5.3.1 Older adults' safety barriers

It is critical to remember that the expected outcome of this thesis is the identification of older adults' mobility experiences and safety barriers while using transportation modes and participating in out-of-home activities, allowing the development of appropriate measures to improve older people's mobility and safety. Within the context described above, a further analysis of the identified transport barriers was conducted while integrating both the survey and focus group findings in order to highlight those barriers that have a direct impact on the mobility of older adults in terms of both safety and personal security, as well as the most frequently identified causes of fatal accidents involving older people in Belgium (or Flanders in particular) from the literature (Table 9). In this case, two aspects of safety were considered: personal safety (e.g., fear of falling), and traffic safety (e.g., interactions with other road users).

TABLE 9 Overview of identified safety barriers per transport mode.

Potential safety barrier	Mode of transport	Main issues
Personal/traffic safety	Walking and Cycling	Sharing routes with other road users (cars/bikes) Other road users behaviors
	Public Transport/ Taxi	Drivers' behaviour Difficulties in boarding
	Car	Fast-moving vehicles (PT buses) Road users don't follow rules and traffic signs Left turns
Built environment/ Infrastructure	Walking and Cycling	Poorly designed/maintained pavements or surfaces Presence of obstacles along the pathways (esp. bikes and parked cars) Lack/unsafe pedestrian crossings (crossing times) Inappropriate or lack of traffic signs and lane markings Inadequate lighting Speeding traffic (e-bikers)
	Car	Sight or visibility obstructions (trees, trucks, on-street parking, construction works) Poor visibility or obscured road signs and markings Inappropriate or lack of traffic calming measures

5.3.2 Measures

This study provided a better understanding of the travel behaviors of older adults in Flanders enabling the development of well-tailored measures to improve their mobility and safety in consideration of the three main factors: health, safety, and the built environment. The following potential measures were identified based on the main safety barriers highlighted in the previous section, with the aim of bridging these gaps.

These measures were divided into two broad categories: behavioral and educational measures and infrastructure and road design improvements.

5.3.2.1 Training/educational and behavioral measures

One of the major concerns for the safety and security of older people using public transportation was driver behavior. To avoid bus drivers leaving before the older person has sat down or failing to stop to pick them up, public (and taxi) transportation drivers should be trained and have a greater empathy and awareness of the issues that affect older people. Similar training programs should be aimed at all public transportation users in order to produce a courteous and helpful public transportation community (particularly drivers) for the benefit of older people. In this sense, training should increase age awareness by valuing older people's needs and perspectives, as well as how to provide useful information or operational behavior while driving (e.g., stopping close to the curb to facilitate boarding/alighting; ensuring that older passengers are seated prior to departure; avoiding sudden acceleration and deceleration). Simultaneously, older people could receive special training on how to use public transportation, with a focus on preventing accidents, how to behave on-board (e.g., how to safely board or alight, stand and sit), and understanding information about the journey, both on-board and at stops/stations. Furthermore, in order to ensure sustainability, beneficiaries and other charities should be involved in the design and delivery of such training, while the end results should be standardized and evaluated on a regular basis.

Other behavior-related issues identified as important barriers to older adults' safe mobility in this study included speeding traffic (e-bikers), road users not following rules and traffic signs, and other road user behaviors. As a countermeasure to reported road user risky behavior toward older people, such as not respecting pedestrians, failing to stop at pedestrian crossings, biking in the wrong direction, and so on, well-structured educational and awareness campaigns are required. Other road users must ensure the safety of older pedestrians. Furthermore, failure to stop at pedestrian crossings or speeding on routes shared with pedestrians, like other traffic violations, should be considered serious offenses punishable by fines. However, police enforcement of traffic rules (such as enforcing lower speed limits in neighborhoods, such as 30 km/h) should be improved, as this was one of the concerns raised by older people during focus group discussions.

5.3.2.2 Improvements to infrastructure/facilities and road design

When it comes to walking and cycling, older people reported a number of priority issues that directly affect their safety while using the two modes of transportation. Poor quality pavements or surfaces, sharing the pavements with others, poor quality crossings (especially crossing timing), insufficient lighting, the presence of obstacles along the pathways (especially bikes and parked cars), speeding traffic, and so on are examples. As one might expect, the key and most visible issues are all very practical barriers related to concerns about their safety. In other words, people are concerned about having an accident due to a fall caused by poor quality surfaces, being knocked over by passing cyclists and mobility scooters, crossing the road, and colliding with vehicles. Given the considerable effort required by older adults to walk and cycle, there is a need to ensure their psychological comfort in conjunction with more secure infrastructure for these two modes of transportation. Measures to improve safety should focus on general improvements to pavements, such as keeping them clean and free of obstacles, increasing the width of pedestrian/cycle paths, separating cycling routes/sidewalks from car lanes, and installing lead-lights in pavements or increasing the intensity of street lighting.

One of the major issues confronting older pedestrians was reported to be difficulty street crossing operations. As they reported the issue of insufficient crossing time, older people would prefer crossings that allow extra time for them to complete before returning to green to allow traffic to proceed. Crosswalks that are well-designed and placed can improve street crossing safety and comfort. Solutions discussed in previous studies and already implemented in Singapore included technology aids such as having a swipe card to use at the crossing and an app that alerts the crossing to give extra time, as well as simply using infrared technology or zebra crossings to lengthen the time (Musslwhite, 2021). Car-free islands in the middle of two-way roads are recommended for crosswalks without traffic signals because they allow pedestrians to cross in two steps, reducing cognitive load.

The issue of boarding and exiting public transportation vehicles was raised in this study; it is directly related to the personal safety of older adults and should be addressed as one of the priorities. At the same time, they raised a concern about a lack of priority seating or being disrespected by other passengers. As a potential measure, public transportation authorities should ensure the availability of age-friendly vehicles that allow for smooth boarding and disembarking, such as raised platforms or low-floor buses (and other vehicles accessible with a wheelchair, walker, etc.), as well as priority or modified seating. Furthermore, the design of transportation stops and stations, as well as their location and condition, are important factors. More wind shelters, lighting, and benches at bus stops/train stations could help older people who are waiting for public transportation.

Driving barriers reported by older car drivers included speeding traffic, ineffective or absent traffic calming devices, sight obstructions (due to mature trees, on-street parking, and construction work), poor visibility or obscured road signs and markings, left turns, and other road users who did not follow rules and traffic signs. Important potential measures to improve road safety for older drivers include: (1) increasing the visibility of road signs and pavement markings through lettering, size, or color, which is especially important for older drivers who may have health issues such as visual impairments; (2) adding left-turn lanes and left-turn traffic signals, particularly at intersections, or converting conventional intersections into roundabouts with advanced warning signs and directional signs to make older drivers easier to navigate; and (3) installing appropriate traffic calming measures at specific road sections aiming at reducing speeds.

5.4 Limitations and future research

This study produced complementary results by combining quantitative and qualitative methods. This mixed-methods approach enabled a deeper understanding of older adults' perceptions and mobility experiences, allowing the development of customized strategies to improve their mobility and safety. Despite the fact that the current findings support previous research on key aspects of older people's travel behavior and mobility barriers, a number of potential limitations must be acknowledged.

The first limitation is related to the model used, which was created by Luiu and colleagues (2018) and provides a comprehensive framework for analyzing unmet needs among older adults. However, only a subset of the selected aspects in this framework are examined in this study, leaving some issues concerning the mobility of older adults unexplained. Subjective and objective measures of life satisfaction, spatial characteristics, and an individual's social network are all

excluded. A second potential limitation was that the sample population may not be representative of reality in terms of older adults' lives in general on some variables/aspects studied, such as health conditions/physical limitations (nearly 95 percent of participants reported their health condition as good/very good/excellent) and income levels (low proportions of high-income earners), which influenced the results obtained. The results were either not statistically significant or provided significant results with little or no implications in the majority of cases. A third limitation is that the recommendations for improving older adults' mobility and safety were limited to behavioral and educational measures, as well as infrastructure and road design improvements, leaving out one of the most important components of the transportation system, vehicle design improvements.

Future research could address all of the study's limitations by carefully designing data collection instruments (both survey and focus groups/interviews) that address the identified gaps. Despite these limitations, this study has improved understanding of the relationship between objective/subjective mobility measures and older adults' travel behavior and needs, including both realized and unrealized needs. It is worth noting that the current study will stimulate further research into older adults' mobility behavior and needs, particularly the safety barriers associated with various modes of transportation from the perspectives of health, personal/traffic safety, and the built environment.

Future research on the same topic, likely in the same area, could fill two knowledge gaps. (1) Taxi and MMC were not thoroughly studied to identify barriers and propose ways to improve their use by older people, despite their important role as alternatives to car dependence for those without cars or unable to use public transportation due to health issues, and despite being too expensive (as reported by focus group participants). (2) The benefits of e-bikes for older adults in terms of increased biking levels and health are receiving a lot of attention right now (the current share of older adults using e-bike in Flanders is at 5.77 percent as found out by Janssens et al., 2020). Understanding the mobility and safety barriers that may be associated with older people using this mode of transportation is necessary.

6. CONCLUSIONS

This study adds to our current understanding of older adults' mobility and travel behavior (specifically in Flanders) in three ways: (1) an examination of socio-demographic characteristics, health, and transportation resources as predictors of transport mode choices and trip-making (RS 1&2); (2) identification of the main mobility barriers/perceived safety affecting older adults' mobility and safety (RS 3&4); and (3) development of recommendations for enacting policy changes to enhance older adults' mobility and safety (RQ 5). This thesis used the conceptual framework by Luiu and colleagues (2018)to investigate factors associated with older adults' mobility and travel behavior, in terms of both travel mode choice and trip making, based on five interconnected domains: demographic characteristics, health and well-being, transportation, built environment, and activities.

Because older adults' transportation needs are dependent on a wide range of variables, two ordinal logistic regressions (OLR) were performed to determine the most influential factors on older people's travel decisions in terms of mode choice and carrying out activities. In addition to the objective indicators used in the two analysis models discussed above, the effect of subjective measures was investigated in this study using the Spearman's correlation to provide a better understanding of older people's mobility needs, experiences, and barriers encountered while carrying out activities using various modes of transportation studied, including walking, cycling, car as a driver, car as a passenger, public transportation (Bus/Metro/Tram and Train), Taxi, and MMC. The findings of this study show that demographic characteristics, health, activities of interest, and access to transportation resources all have a significant impact on the travel decisions of older people.

The socio-demographic factors of gender, age, living status, education, and income have a substantial influence on the mode of transportation and activity frequency of older adults. In terms of gender differences, women are more likely to rely on car usage as a passenger, whereas men are more likely to rely on driving. On the other hand, males were found to engage in more daily life activities than females, with the exception of activities related to visiting educational institutions. In contrast, older adults aged 75 and older are less likely to cycle, use a car as a driver, and take public transportation (bus/metro/tram) than the rest of the age categories; however, the effect on daily life activities was minimal. Living with a partner has a negative correlation with walking and cycling and a positive correlation with using public transportation, whereas living alone has a negative correlation with cycling and car driving. On the other hand, living with a partner influences trip-making to nearly all activities or locations studied positively, whereas living alone has a positive effect only on social activities. Regarding education level, older people with a lower level of education are found to drive more than those with a higher level of education, and they also travel less for daily activities (with the exception of café visits) than their counterparts. The results indicate that older adults with lower incomes are less likely to use cars as passengers than older adults with higher incomes; however, the income effect had little or no impact on older people's participation in activities.

Considering the availability of transport resources, the results of this study indicate that bicycle ownership benefits older cyclists while having a negative impact on driving and public transportation; whereas access to a car is associated with lower levels of cycling and public

transportation use while having a positive impact on driving. Having a bus or train card has a substantial positive impact on public transportation usage. Possession of a driver's license and a bus/train card, on the other hand, is positively associated with participation in most activities. With the exception of commuting to work, older adults were found to be less likely to use cars for important activities such as visits to the city center, supermarkets, parks, and sporting events. This was surprisingly consistent with the results of focus group discussions in which some participants expressed a lack of interest in or necessity for driving in favor of more environmentally friendly modes of transportation. In terms of assessing the impact of perceived health condition and health issues on the travel behavior of older adults, the results of this study have shown little or no significance due to the sample population limitations described in the previous section.

As stated previously, the subjective factors studied were found to be effective predictors of older adults' travel decisions in terms of both mode selection and trip frequency while engaging in activities, allowing for a comprehensive understanding of their mobility needs (realized/unrealized) and associated perceived barriers. Noting that many previous studies did not investigate the effect of people's perceived feelings regarding the importance of both activities of interest and available modes of travel on their travel decisions, this study is somewhat unique. This is a significant contribution of this study, as it enables a better understanding of the factors that contribute to older adults experiencing mobility barriers or difficulties. However, valuing specific modes of transportation was associated with higher frequency of using a particular mode; and in some instances, the importance of a specific mode has a negative effect on the use of other travel modes, such as walking versus car use. Conversely, the importance of a particular activity has a positive effect on the frequency with which similar activities are performed in general. Additionally, it was discovered that valuing particular activities was positively or negatively correlated with participation in other activities. Simultaneously, older individuals were observed to walk, cycle, ride as a passenger in a vehicle, and use public transportation for personal business/errands and leisure/recreational activities, and they are less likely to drive to the city center. Regarding specialized modes of transportation, valuing taxi as their preferred mode of transportation was associated with more trips to restaurants and social activities, whereas MMC had a similar relationship with trips to the health care center.

In parallel, for the subjective measures related to the built environment and other transportation aspects, access to transportation facilities/services and quality infrastructure were found to be associated with older adults' use of particular modes of transportation and their participation in activities. In general, a lack of quality infrastructure/transport services and other vital facilities was negatively associated with both the use of specific modes of transportation and the frequency with which vital activities were performed. The results of the analysis performed on survey data were supplemented by the results of focus groups, allowing for a comprehensive understanding of a variety of perceived barriers affecting the mobility of older people. All of these are perceived barriers that may limit older people's mobility, which explains the activities that older people want or need to do more of (desired mobility) but are unable to do so (mobility limitations) (unfulfilled mobility needs). On the basis of this analysis, recommendations to improve the mobility and safety of older people were formulated (section...). The identified safety barriers per transport mode were grouped into two categories: personal/traffic safety and built environment/infrastructure, and respective measures were developed to improve the safety of older adults, including

training/educational and behavioral programs for older road users, and infrastructure/facilities and road design improvements, respectively.

In addition, the results of this thesis support the notion that mixed methods can complement one another and reveal issues and relationships that would otherwise remain hidden if only one method of data collection and analysis were employed. For example, the impact of perceived health condition/physical limitations was small or insignificant in the regression analyses conducted, but some health problems or personal disability issues were raised during the focus group discussions, such as the risk of falling due to sensory/cognitive/physical impairment. Although not explicitly mentioned by participants during focus group discussions, some participants expressed a lack of interest in/need for driving in favor of more sustainable modes of transportation, complementing the significant survey results indicating a positive correlation between imposing more restrictions on the use of a car in neighborhoods and cycling/public transport use. Lastly, the survey results did not highlight older people's mobility experiences and perceived safety concerns; however, the important personal/traffic safety and mobility barriers were discussed in great detail by participants during focus groups.

The ability of older adults to get up and move around is crucial to their health and wellbeing. This study demonstrates that older Flemish people are able to carry out their daily activities without having to rely solely on the cars, as a significant proportion of them use alternative modes of transportation. Despite the fact that the impact of health problems/physical limitations was not established in this study, many previous studies have confirmed that, particularly for older drivers, they can lead to driving cessation with no longer being able to operate a motor vehicle, which has severe consequences for their mobility and social exclusion. In this view, a holistic approach is required to improve the mobility and safety of older adults by shortening trips and shifting the majority of mobility from cars to more sustainable and age-friendly modes of transportation, primarily walking, cycling, and public transportation. It is important to remember that environmentally sustainable transportation must be accessible, affordable, safe, secure, and friendly to the environment. Incorporating the needs/mobility barriers of older people identified in this study into government plans to improve their mobility and safety is therefore essential.

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APPENDICES

APPENDIX 1: SURVEY QUESTIONS (ORIGINAL IN DUTCH)

Deel-1 Demografische informatie

1. Postcode: ……

2. Deelgemeente: ……

3. Leeftijd (jaren): ……

4. Nationaliteit ……

5. In welk land bent u geboren? ……

6. Geslacht? (gelieve aan te kruisen)

 Man Vrouw Andere

7. Wat is het hoogste diploma dat u hebt behaald? (gelieve aan te kruisen)

 Geen afgeronde opleiding
 Lager onderwijs
 Lager beroepsonderwijs
 Lager technisch onderwijs
 Lagere humaniora
 Hoger beroepsonderwijs
 Hoger technisch onderwijs
 Hogere humaniora
 Hoger niet-universitair onderwijs
 Universitair onderwijs

8. Wat is uw burgerlijke staat? (gelieve aan te kruisen)

 gehuwd
 gescheiden
 samenwonend
 weduwe/weduwnaar
 kloosterling(e)
 alleenstaand

9. Gemiddeld inkomen per maand (gelieve aan te kruisen)

 500-999
 1000-1499
 1500-1999 €
 2000-2499€
 2500-3000
 > 3000 €
 Weet ik niet
 Wil ik niet meedelen

10. Met wie woon je samen onder één dak? (meerdere antwoorden mogelijk)

- Partner
- Kinderen
- Kleinkinderen
- Ouders
- Andere (graag specifiëren) …….

11. Welke verklaring betreffende uw woning is bij u van toepassing? (kruis één vak aan a.u.b.)

- Ik ben eigenaar
- Ik ben huurder (privé woning)
- Ik ben huurder (sociale woning)
- Andere (graag specifiëren)…….

11. Welke verklaring betreffende uw woning is bij u van toepassing? (kruis één vak aan a.u.b.)

- Ik ben eigenaar
- Ik ben huurder (privé woning)
- Ik ben huurder (sociale woning)
- Andere (graag specifiëren)…….

12. Wat is uw huidige woonvorm? (kruis één vak aan a.u.b.)

- Thuiswonend in een ééngezinswoning
- Thuiswonend in een appartement
- Thuiswonend in een studio
- Inwonend bij de kinderen
- Serviceflat/assistentiewoning
- Groepswonen
- Kangoeroe/intergenerationeel wonen

12. Wat is uw huidige woonvorm? (kruis één vak aan a.u.b.)

- Thuiswonend in een ééngezinswoning
- Thuiswonend in een appartement
- Thuiswonend in een studio
- Inwonend bij de kinderen
- Serviceflat/assistentiewoning
- Groepswonen
- Kangoeroe/intergenerationeel wonen

Deel 2: Gezondheid

1. Hoe is uw gezondheidstoestand in het algemeen:

- ☐ Uitstekend
- ☐ Zeer goed
- ☐ Goed
- ☐ Eerlijk
- ☐ Slecht
- ☐ Geen idee
- ☐ Wil ik liever niet zeggen

2. Hoe dikwijls beperkt uw gezondheidstoestand zich ertoe om volgende activiteiten uit te voeren? (Graag elke item aanduiden)

Activiteiten	**Dagelijks**	**Verschillende keren per week**	**Een keer per week**	**Een keer per maand**	**Zelfden of nooit**

1	Zeer inspannende activiteiten zoals het optillen van zware voorwerpen					
2	Minder inspannende activiteiten					
3	Een heuvel oplopen					
4	Enkele trappen maken					
5	Buigen, bukken					
6	Huishoudelijke taken					
7	Sociale activiteiten zoals op bezoek gaan bij familie of vrienden					

3. Hoe zou u uw gehoor omschrijven? (kruis aan a.u.b.)

- □ Ik hoor goed
- □ Ik hoor slecht, maar draag een hoorapparaat
- □ Ik hoor slecht en draag géén hoorapparaat

4. Hoe zou u uw zicht omschrijven? (kruis aan a.u.b.)

- □ Ik zie goed
- □ Ik zie slecht, maar draag een bril
- □ Ik zie slecht, maar draag géén bril

5. Bent u gevallen in de afgelopen 12 maanden? (kruis aan a.u.b.)

- □ Nee
- □ Ja, twee tot drie keren
- □ Ja, één keer
- □ Ja, meer dan drie keren

6. Heeft u enige loopbeperking? (kruis aan a.u.b.)

- □ Ja
- □ Nee

Indien ja, geef dan aan welke (meervoudige antwoorden mogelijk)

- □ Niet in staat om meer dan 1000 meter te wandelen
- □ Niet in staat om meer dan 500 meter te wandelen
- □ Niet in staat om meer dan 400 meter te wandelen
- □ Niet in staat om meer dan 100 meter te wandelen
- □ Niet in staat om meer dan 20 meter te wandelen
- □ Niet in staat om trappen te maken
- □ Niet in staat om hellingen te beklimmen

6. Gebruikt u hulpmiddelen om zich te verplaatsens? (kruis aan a.u.b.)

- □ Ja
- □ Nee

Zo ja, welke van onderstaande hulpmiddelen gebruikt u (meerdere antwoorden mogelijk)

- □ wandelstok
- □ manuele rolstoel
- □ rollator
- □ elektrische rolstoel

- elektrische scooter
- Andere……(graag specifiëren)

7. Neemt u deel aan activiteiten georganiseerd door de buurt? (kruis aan a.u.b.)

- Ja
- Nee

8. Hoe graag woont u in uw buurt?

Graag een score tussen 0 en 10 (gelieve 1 nummer te kiezen)

Helemaal niet graag 0 1 2 3 4 5 6 7 8 9 10 Heel graag

Deel 3 Mobiliteit

1. **Hoe vaak bezoekt u de volgende locaties? (gelieve elk item aan te duiden)**

Plaatsen		**Dagelijks**	**Verschillende keren per week**	**Eén keer per week**	**Eén keer per maand**	**Zelden/nooit**
1	Gezondheidscentrum					
2	Buurthuis					
3	Stadscentrum					
4	Boodschappenwinkel					
5	Shopping centrum					
6	Café					
7	Restaurant					
8	Bibliotheek					
9	Onderwijsinstelling om een cursus te volgen					
10	Park					
11	Sportfaciliteiten om deel te nemen aan sportactiviteiten					
12	Sportevenementen als toeschouwer					
13	Uitstap naar een andere stad of land					
14	Werkplaats					
15	Sociale activiteit (familie, vrienden)					
16	Andere…… (graag specifiëren)					

2. Welk tijdstip van de dag geniet uw voorkeur om volgende plaatsen te bezoeken (gelieve elk item aan te duiden)

Plaats		**'s morgens**	**namiddag**	**'s avonds**
1	Gezondheidscentrum			
2	Buurthuis			
3	Stadscentrum			
4	Boodschappenwinkel			
5	Shopping centrum			
6	Café			
7	Restaurant			
8	Bibliotheek			
9	Onderwijsinstelling om een cursus te volgen			
10	Park			
11	Sportfaciliteiten om deel te nemen aan sportactiviteiten			
12	Sportevenementen als toeschouwer			
13	Werkplaats			
14	Sociale activiteit (familie, vrienden)			
15	Andere…… (graag specifiëren)			

3. Hoe belangrijk zijn deze plaatsen voor u in het algemeen? (gelieve elke item aan te duiden)

Plaats		**Niet zo belangrijk**	**Belangrijk**	**Zeer belangrijk**
1	Gezondheidscentrum			
2	Buurthuis			
3	Stadscentrum			
4	Boodschappenwinkel			
5	Shopping centrum			
6	Café			
7	Restaurant			
8	Bibliotheek			
9	Onderwijsinstelling om een cursus te volgen			
10	Park			
11	Sportfaciliteiten om deel te nemen aan sportactiviteiten			
12	Sportevenementen als toeschouwer			
13	Uitstap naar een andere stad of land			
14	Andere…… (graag specifiëren)			

4. Welke van de volgende activiteiten mist u in uw buurt? Onder '"buurt" verstaan we de straten en gebouwen rond uw woonplaats. (meerdere antwoorden zijn mogelijk)

- ☐ Buurthuis of gemeenschapscentrum
- ☐ Apotheek
- ☐ Huisarts
- ☐ Bank
- ☐ Café
- ☐ Boodschappenwinkel
- ☐ Winkel
- ☐ Park
- ☐ Andere …… (graag specifiëren)

5. Welke faciliteiten mist u in uw ? (meerdere antwoorden zijn mogelijk)

- ☐ Bushalte
- ☐ Rustbanken
- ☐ Openbare toiletten
- ☐ Andere …… (graag specifiëren)

6. Hoe dikwijls gebruikt u onderstaande vervoersmiddelen? (gelieve elk item aan te duiden)

Vervoersmiddel		**Dagelijks**	**Verschillende keren per week**	**Eenmaal per week**	**Eenmaal per maand**	**Zelden/nooit**
1	Te voet					
2	Fiets/ elektrische fiets					
3	auto (als bestuurder)					
4	auto (als passagier)					
5	Bus/tram/metro					
6	Trein					
7	Taxi					
8	Minder Mobielen Centrale					
9	Andere …….. (graag specifiëren aub)					

7. Gelieve de belangrijkheid voor uzelf per vervoersmiddel aan te duiden (duid hiervoor een numer tussen 1 en 10 aan, waar 1 staat voor minst favoriete vervoersmiddel en 10 het meest favoriete vervoersmiddel

Vervoersmiddel		**Rate**
1	Te voet	1 2 3 4 5 6 7 8 9 10
2	Fiets/ elektrische fiets	1 2 3 4 5 6 7 8 9 10
3	auto (als bestuurder)	1 2 3 4 5 6 7 8 9 10
4	auto (als passagier)	1 2 3 4 5 6 7 8 9 10
5	Bus/tram/metro	1 2 3 4 5 6 7 8 9 10
6	Trein	1 2 3 4 5 6 7 8 9 10
7	Taxi	1 2 3 4 5 6 7 8 9 10
8	Minder Mobielen Centrale	1 2 3 4 5 6 7 8 9 10
9	Andere …….. (graag specifiëren aub)	1 2 3 4 5 6 7 8 9 10

8. Hoeveel auto’s zijn er in uw gezin? (kruis aan aub)

□ 1 □ 2 □ 3 of meer

9. Hoeveel fietsen zijn er in uw gezin? (kruis aan aub)

□ 1 □ 2 □ 3 of meer

10. Bent u in het bezit van een bus of trainabonnement?

□ Ja □ Nee

11. Bent u in het bezit van een rijbewijs?

□ Ja □ Nee

12. Bent u bereid de bus vaker te gebruiken als er een bushalte is in uw buurt?

□ Ja □ Misschien □ Nee

13. Kan u te voet naar de dichts bijzijnde bushalte ?

□ Ja □ Nee

Indien ja, hoelang wandelt u erover om tot aan de dichtsbijzijnde halte te geraken vanuit uw woonplaats? (kruis aan aub)

□ < 5 min
□ 5-10 min
□ 11-15 min
□ 16-20 min
□ 20 min
□ > 20 min

14. Wat is de afstand (bij benadering) van de dichtsbijzijnde bushalte vanuit uw woonplaats? (kruis aan aub)

□ < 500 meter
□ 500-1000 meter
□ > 1000 meter

15. Geef een beschrijving van de mobiliteitsvoorzieningen in je buurt. Onder '"buurt" verstaan we de straten en gebouwen rond uw woonplaats. (Gelieve het relevante vakje aan te kruisen per onderdeel)

Wandelen		**Sterk akkoord**	**Akkoord**	**Geen idee**	**Niet akkoord**	**Helemaal niet akkoord**
1	De breedte van de voetpaden zijn voldoende					
2	De kwaliteit van het oppervlak van het voetpad is voldoende					
3	De wegmarkeringen van het voetpad zijn duidelijk					
4	Voetpaden zijn beschikbaar in alle straten					
5	De voetpaden zijn veilig					
6	De tijd om te voet over te steken op kruispunten is voldoende					
7	De oversteekplaatsen voor voetgangers zijn gemakkelijk					
8	Voetgangers delen de weg met snelle weggebruikers					
9	Fietsers gebruiken de voetpaden					
10	De weersomstandigheden zijn meestal goed om te wandelen					
Fietsen		**Sterk akkoord**	**Akkoord**	**Geen idee**	**Niet akkoord**	**Helemaal niet akkoord**
1	Het fietspad is voldoende breed					
2	Het fietspad is in goede staat					
3	De wegmarkeringen voor fietsers zijn duidelijk					
4	De weersomstandigheden zijn meestal goed om te fietsen					
Straatmeubilair		**Sterk akkoord**	**Akkoord**	**Geen idee**	**Niet akkoord**	**Helemaal niet akkoord**
1	Er is goede verlichting langs straten en stoepen					
2	Voldoende verkeersremmende maatregelen vb. Verkeersborden, vluchtheuvels enz. zijn aanwezig in je buurt					
3	Verkeersborden en kruispunten zijn goed zichtbaar en goed gepositioneerd					
4	De wegen zijn goed onderhouden					

5	Afvoergeulen langs wegen zijn goed bedekt					
6	Voldoende zitbanken zijn voorhanden langs wegen en belangrijke plaatsen					
7	Er zijn voldoende openbare toiletten voorzien langs wegen en belangrijke plaatsen					
Openbaar vervoer (Bus/Tram/Metro/Trein)		**Sterk akkoord**	**Akkoord**	**Geen idee**	**Niet akkoord**	**Helemaal niet akkoord**
1	Bushaltes en stations zijn geplaatst op een goed bereikbare plaats					
2	Bushaltes zijn goed verlicht en goed aangeduid					
3	De bushaltes zijn voorzien van zitbanken en een schuilhok					
4	Alle delen van de stad zijn goed bereikbaar met het openbaar vervoer, met goede verbindingen en goed gemarkeerde routes					
5	Volledige en duidelijke informatie betreffende de routes, uren en speciale faciliteiten zijn beschikbaar voor de gebruikers					
6	Het openbaar vervoer is betrouwbaar en frequent, inclusief ‘s nachts, in het weekend en tijdens de vakanties					
7	De dienstregelingen komen overeen met uw routine om tot bij de gewenst plaats te geraken					
8	Bussen zijn proper en meestal goed onderhouden					
10	De bussen zitten meestal niet volledig vol					
11	Prioritaire zitplaatsen worden gerespecteerd					
12	Moeilijkheden bij het instappen					
13	De chauffeurs stoppen bij de aangewezen haltes, vlak naast de stoep om instappen te vergemakkelijken, ze wachten ook totdat de passagier neerzit vooraleer ze wegrijden					
14	De kosten zijn consistent, duidelijk weergegeven en betaalbaar					
15	Het openbaar vervoer biedt kortingen aan					

16	Betalingsmethoden voor tickets zijn goed					
17	Aangepast vervoer is voorzien voor mensen met speciale noden					
Parking (autobestuurder of passagier)		**Sterk akkoord**	**Akkoord**	**Geen idee**	**Niet akkoord**	**Helemaal niet akkoord**
1	Parkings en drop-off zones zijn veilig					
2	Er zijn voldoende parkeerplaatsen					
3	Parkeerplaatsen zijn gunstig gelegen (dichtbij de bestemming)					
4	Mindervalide parkings en drop-off zones zijn beschikbaar en worden gerespecteerd					
5	De parkeerkosten zijn betaalbaar					
6	De betaalmogelijkheden voor de parking zijn ok					
7	Het langs mekaar parkeren creëert belemmeringen in het verkeer					
8	De parkeerplaatsen zijn niet te smal					
9	De parkeerplaatsen zijn goed verlicht					
10	De parkeerplaatsen zijn veilig					
11	De parkeerplaatsen worden goed onderhouden					
Verkeer		**Sterk akkoord**	**Akkoord**	**Geen idee**	**Niet akkoord**	**Helemaal niet akkoord**
1	De weggebruikers volgen de verkeersborden					
2	De wegen zijn vrij van obstakels en blokkeren het zicht van de bestuurder niet					
3	Er moeten meer beperkingen ingevoerd worden betreffende het gebruik van de wagen in uw buurt (vb. Snelheidscontroles, autovrije zones, verhoogde parkeerkosten enz.)					
Gespecialiseerd vervoer & Taxi		**Sterk akkoord**	**Akkoord**	**Geen idee**	**Niet akkoord**	**Helemaal niet akkoord**
1	Minder Mobielen Centrale is beschikbaar					
2	Taxi’s zijn toegankelijk, betaalbaar en chauffeurs zijn hoffelijk en behulpzaam					

APPENDIX 2: FOCUS GROUPS (ORIGINAL IN DUTCH)

Ervaringen en meningen over mobiliteitsproblemen

Postcode	_____		
Leeftijd (Jaren)	_____		
Geslacht	☐ Man	☐ Vrouw	☐ Andere

Instructies

In dit gedeelte vragen we uw ervaringen en meningen over mogelijke mobiliteitsproblemen, voor verschillende vervoerswijzen en voor verschillende aspecten in het verkeer:

- Wandelen
- Fietsen
- Infrastructuur
- Openbaar vervoer
- Parkeren
- Mobiliteit (algemeen)

We vragen u eerst om in de tabel aan te duiden indien u met bepaalde mobiliteitsproblemen wordt geconfronteerd. Indien een bepaalde situatie soms problematisch is voor u, dan mag u een “X” in de kolom “Problematische situatie” zetten. Indien u deze situatie nooit problematisch vindt, dan hoeft u niets in te vullen in deze kolom.

Vervolgens vragen we u om uw aangeduide problematische situaties te rangschikken volgens belangrijkheid in de kolom “Rangschikking”. Als u bijvoorbeeld 4 problemen heeft aangeduid bij de categorie Wandelen, dan vragen we om deze te rangschikken van 1 tot 4. Hierbij is 1 het meest belangrijke probleem en 4 het minst belangrijke probleem. Bij het aanduiden van de volgorde van belangrijkheid is het zinvol om rekening te houden met de vraag “welk probleem zou het eerste moeten opgelost worden?” (dit probleem krijgt dan de score 1).

Ten slotte vragen we u om de reden van de problematische situatie, en van het belang hiervan, te noteren in de kolom “Toelichting”. Hierbij kan u extra toelichting geven over waarom u een bepaalde situatie problematisch vindt, of waarom u deze meer of minder belangrijk vindt.

Wandelen

		Problematische situatie	Rangschikking	Toelichting
1	De breedte van de voetpaden is voldoende			
2	De kwaliteit van het oppervlak van het voetpad is voldoende			
3	De wegmarkeringen van het voetpad zijn duidelijk			
4	In alle straten zijn voetpaden aanwezig			
5	De voetpaden zijn veilig			
6	De duurtijd om over te steken op kruispunten is voldoende			
7	De oversteekplaatsen voor voetgangers zijn gemakkelijk			
8	Voetgangers delen de weg met snellere weggebruikers			
9	Fietsers maken gebruik van de voetpaden			
10	De weersomstandigheden zijn meestal goed om te wandelen			

Fietsen

		Problematische situatie	Rangschikking	Toelichting
1	Het fietspad is voldoende breed			
2	Het fietspad is in goede staat			

3	De wegmarkeringen voor fietsers zijn duidelijk			
4	De weersomstandigheden zijn meestal goed om te fietsen			

Infrastructuur

		Problematische situatie	**Rangschikking**	**Toelichting**
1	Er is goede verlichting langs straten en stoepen			
2	Er zijn voldoende verkeersremmende maatregelen (zoals verkeersborden, vluchtheuvels, etc.) aanwezig in mijn buurt			
3	Verkeersborden en kruispunten zijn goed zichtbaar en goed geplaatst			
4	De wegen zijn goed onderhouden			
5	Afvoergeulen/riolen langs wegen zijn goed bedekt			
6	Er zijn voldoende zitbanken aanwezig langs wegen en belangrijke plaatsen			
7	Er zijn voldoende openbare toiletten aanwezig langs wegen en belangrijke plaatsen			

Openbaar vervoer (Bus / Tram / Metro / Trein)

		Problematische situatie	**Rangschikking**	**Toelichting**

1	Bushaltes en stations zijn geplaatst op goed bereikbare plaatsen			
2	Bushaltes zijn goed verlicht en goed aangeduid			
3	Bushaltes zijn voorzien van zitbanken en een schuilhok			
4	Alle delen van de stad zijn goed bereikbaar met het openbaar vervoer, met goede verbindingen en goed gemarkeerde routes			
5	Er is volledige en duidelijke informatie betreffende de routes, uren en speciale faciliteiten beschikbaar voor de gebruikers van openbaar vervoer			

6	Het openbaar vervoer is betrouwbaar en frequent, inclusief ‘s nachts, in het weekend en tijdens de vakanties			
7	De dienstregeling van het openbaar vervoer komt overeen met mijn verplaatsingen om naar een bepaalde plaats te gaan			
8	Bussen zijn proper en meestal goed onderhouden			
9	De bussen zitten meestal niet volledig vol			
10	Prioritaire zitplaatsen (bv. voor ouderen, voor personen met een beperking) worden gerespecteerd			
11	Moeilijkheden bij het instappen van het voertuig			

12	De chauffeurs stoppen bij de aangewezen haltes, vlak naast de stoep om het instappen te vergemakkelijken, en wachten ook totdat de passagier neerzit vooraleer ze wegrijden			
13	De tarieven voor het openbaar vervoer zijn consistent, duidelijk weergegeven en betaalbaar			
14	Het openbaar vervoer biedt kortingen aan			
15	De methoden om een ticket aan te kopen, zijn goed			
16	Er is aangepast vervoer voorzien voor mensen met speciale noden			

Parkeren (autobestuurder of passagier)

		Problematische situatie	**Rangschikking**	**Toelichting**
1	Parkings en afzetplaatsen (bv. Kiss & Ride) zijn veilig			
2	Er zijn voldoende parkeerplaatsen			
3	Parkeerplaatsen zijn gunstig gelegen (dichtbij de bestemming)			
4	Mindervalide parkings en afzetzones zijn beschikbaar en worden gerespecteerd			
5	De parkeerkosten zijn betaalbaar			

6	De methoden om een parkeerticket aan te kopen, zijn goed			
7	Het langs mekaar parkeren creëert belemmeringen in het verkeer			
8	De parkeerplaatsen zijn voldoende breed			
9	De parkeerplaatsen zijn goed verlicht			
10	De parkeerplaatsen zijn veilig			
11	De parkeerplaatsen worden goed onderhouden			

Mobiliteit (algemeen)

		Problematische situatie	**Rangschikking**	**Toelichting**
1	De weggebruikers volgen de verkeersborden en -regels			
2	De wegen zijn vrij van obstakels en blokkeren het zicht van de bestuurder niet			
3	Er moeten meer beperkingen ingevoerd worden betreffende het gebruik van de wagen in mijn buurt (zoals snelheidscontroles, autovrije zones, hogere parkeerkosten, etc.)			
4	Minder Mobielen Centrales zijn beschikbaar			
5	Taxi’s zijn toegankelijk, betaalbaar, en chauffeurs zijn hoffelijk en behulpzaam			

APPENDIX 3: Factors associated with travel modes choice, full Ordinal Regression model Results (N=140)

Variables	Estimate	p-value	CI Lower (95%)	CI Upper (95%)
Walking[1]				
Living with a partner (ref=yes). No	15.30	0.00	13.96	16.64
Male (ref=female)	1.04	0.10	-0.19	2.27
Purpose: Social activities	-0.54	0.03	-1.02	-0.06
Purpose: City Center	0.52	0.06	-0.01	1.05
[1]Model fitting information: X^2 (45) = 56.143, p-value = 0.123. Cox & Snell R square = 0.330 and Nagelkerke R square = 0.368				
Cycling[2]				
Living with a partner (ref=yes). No	3.67	0.03	0.39	6.95
Living alone (ref=yes). No	4.02	0.03	0.46	7.59
Purpose: Café	0.44	0.04	0.02	0.87
Purpose: Park	0.56	0.03	0.05	1.07
Purpose: Sport events	0.51	0.08	-0.06	1.08
Self-reported sight condition (ref=poor sight). See well	0.84	0.07	-0.06	1.73
Number of bicycles (ref=one or more bicycles). No bicycle	-6.64	0.00	-9.51	-3.77
Number of cars (ref=one or more cars). No car	20.18	0.00	17.47	22.88
[2]Model fitting information: X^2 (45) = 109.637, p-value < 0.001. Cox & Snell R square = 0.543 and Nagelkerke R square = 0.578				
Car as a driver[3]				
Age group/Life stages (ref=75+). 65-74	2.17	0.00	0.86	3.49
Education (ref=higher). Secondary	1.23	0.03	0.13	2.32
Living alone (ref=yes). No	4.73	0.04	0.23	9.23
Self-reported health rating (ref=Honest). Good	-2.89	0.07	-5.97	0.20
Self-reported hearing condition (ref=poor hearing). Fair	-3.23	0.00	-5.36	-1.11
Number of cars (ref=one or more cars). No car	-28.69	0.00	-36.05	-21.34
Number of bicycles (ref=one or more bicycles). No bicycle	2.80	0.01	0.58	5.02
Purpose: Health care center	0.87	0.08	-0.09	1.82
Purpose: City center	-0.94	0.00	-1.52	-0.36
Purpose: Grocery store	1.40	0.00	0.63	2.18
Purpose: Library	0.83	0.06	-0.04	1.69
Purpose: Educational institution	0.87	0.03	0.11	1.64
Purpose: Workplace	0.70	0.01	0.14	1.26
[3]Model fitting information: X^2 (45) = 242.906, p-value < 0.001. Cox & Snell R square = 0.824 and Nagelkerke R square = 0.908				
Car as a passenger[4]				
Age group/Life stages (ref=75+). 60-64	1.58	0.06	-0.05	3.20
Male (ref=female)	-3.84	0.00	-5.32	-2.37
Monthly household income (ref≥€2500-3000). €1500 - 1999	-2.29	0.04	-4.49	-0.09
Self-reported sight condition (ref=poor sight). See well	1.27	0.02	0.24	2.30
Purpose: Health care center	2.22	0.00	1.35	3.09
Purpose: City center	0.65	0.01	0.15	1.16
Purpose: Grocery store	-0.54	0.07	-1.12	0.04
Purpose: Shopping center	0.49	0.07	-0.05	1.03
Purpose: Café	0.56	0.01	0.11	1.01
Purpose: Park	-0.49	0.06	-1.00	0.02
Purpose: Social activities	-0.61	0.02	-1.13	-0.09
[4]Model fitting information: X^2 (45) = 113.701, p-value < 0.001. Cox & Snell R square = 0.556 and Nagelkerke R square = 0.601				
Bus/Metro/Tram[5]				
Age group/Life stages (ref=75+). 60-64	1.97	0.04	0.12	3.83
Age group/Life stages (ref=75+). 65-74	2.11	0.01	0.61	3.60
Living with a partner (ref=yes). No	-17.09	0.00	-18.64	-15.55
Self-reported health rating (ref=Honest). Excellent	-4.89	0.01	-8.48	-1.29

Self-reported hearing condition (ref=poor hearing). Hearing well	-2.07	0.01	-3.71	-0.43
Self-reported sight condition (ref=poor sight). Fair	5.10	0.00	1.87	8.33
Number of cars (ref=3 or more cars). one car	-4.76	0.06	-9.74	0.22
Number of bicycles (ref=3 or more bicycles). two bicycle	1.69	0.03	0.17	3.21
Bus/train card owner (ref=no). Yes	3.28	0.00	2.09	4.47
Distance of the nearest bus stop (ref>1000m). 500-1000m	1.80	0.03	0.15	3.44
Purpose: Restaurant	1.46	0.00	0.61	2.31
Purpose: Park	0.89	0.00	0.33	1.45
Purpose: Sport facilities	-0.36	0.09	-0.78	0.06
Purpose: Workplace	-0.47	0.07	-1.00	0.05

[5]Model fitting information: X^2 (45) = 288.855, p-value < 0.001. Cox & Snell R square = 0.873 and Nagelkerke R square = 0.956

Train[6]

Self-reported walking limitations (ref=no). Yes	-1.83	0.03	-3.53	-0.13
Number of cars (ref=one or more cars). No car	18.88	0.00	15.83	21.92
Bus/train card owner (ref=no). Yes	2.09	0.00	0.95	3.23
Ownership of a driving license (ref=no). Yes	2.45	0.04	0.13	4.77
Distance of the nearest bus stop (ref>1000m). 500-1000m	1.46	0.07	-0.12	3.04
Purpose: Health care center	1.18	0.00	0.36	2.00
Purpose: Park	0.66	0.02	0.09	1.23
Purpose: Trip to another city/country	1.64	0.00	0.73	2.55
Purpose: Social activities	-0.61	0.07	-1.28	0.05

[6]Model fitting information: X^2 (45) = 86.831, p-value < 0.001. Cox & Snell R square = 0.462 and Nagelkerke R square = 0.551

Taxi[7]

[7]Model fitting information: X^2 (45) = 44.645, p-value = 0.487. Cox & Snell R square = 0.273 and Nagelkerke R square = 1.000

MMC[8]

[8]Model fitting information: X^2 (45) = 56.463, p-value = 0.117. Cox & Snell R square = 0.332 and Nagelkerke R square = 1.000

The reference category is the group "Daily User" of different travel modes.

APPENDIX 4: Factors associated with travel frequency for trips to different locations, full results of Ordinal logistic regression model (N=140)

Variables	Estimate	p-value	CI Lower (95%)	CI Upper (95%)
Visiting Health Center[1]				
Age group/Life stages (ref=75+). 60-64	2.26	0.06	-0.11	4.63
Living with a partner (ref=yes). No	-15.45	0.00	-17.48	-13.43
Self-reported walking limitations (ref=no). Yes	3.65	0.00	1.53	5.77
[1]Model fitting information: X^2 (30) = 44.656, p-value = 0.042. Cox & Snell R square = 0.273 and Nagelkerke R square = 0.428				
Visiting Community center[2]				
Living with a partner (ref=yes). No	-16.85	0.00	-18.22	-15.49
Self-reported sight condition (ref=poor sight). See well	-1.03	0.04	-2.03	-0.03
Number of bicycles (ref=3 or more bicycles). One bicycle	1.46	0.03	0.12	2.79
[2]Model fitting information: X^2 (30) = 28.436, p-value = 0.547. Cox & Snell R square = 0.184 and Nagelkerke R square = 0.216				
Visiting City center[3]				
Gender (ref=female). Male	1.14	0.01	0.23	2.04
Education (ref=higher). Primary education	-3.09	0.00	-4.64	-1.53
Self-reported walking limitations (ref=no). Yes	-0.98	0.03	-1.84	-0.12
Monthly household income (ref≥€2500-3000). €500 - 999	3.19	0.03	0.39	5.99
Number of cars (ref=one or more cars). No car	4.22	0.05	-0.06	8.50
Ownership of a driving license (ref=no). Yes	1.84	0.03	0.16	3.52
[3]Model fitting information: X^2 (30) = 61.769, p-value < 0.001. Cox & Snell R square = 0.357 and Nagelkerke R square = 0.374				
Visiting Grocery Store[4]				
Gender (ref=female). Male	1.07	0.03	0.10	2.03
Self-reported health rating (ref=Honest). Good	-2.51	0.01	-4.47	-0.54
Self-reported walking limitations (ref=no). Yes	-0.99	0.03	-1.90	-0.07
Number of cars (ref=one or more cars). No car	6.40	0.01	1.68	11.12
Ownership of a driving license (ref=no). Yes	2.35	0.01	0.59	4.11
Distance of the nearest bus stop (ref>1000m). <500m	-0.83	0.10	-1.81	0.15
[4]Model fitting information: X^2 (30) = 47.103, p-value =0.024. Cox & Snell R square = 0.286 and Nagelkerke R square = 0.314				
Visiting Shopping center[5]				
Education (ref=higher). Primary education	-3.63	0.00	-6.02	-1.23
Living with a partner (ref=yes). No	-15.53	0.00	-16.67	-14.39
Self-reported health rating (ref=Honest). Excellent	2.20	0.06	-0.11	4.51
Self-reported sight condition (ref=poor sight). Fair	2.76	0.01	0.69	4.84
Monthly household income (ref≥€2500-3000). €500 - 999	3.93	0.02	0.74	7.13
Ownership of a driving license (ref=no). Yes	1.81	0.04	0.05	3.56
Distance of the nearest bus stop (ref>1000m). <500m	-1.47	0.00	-2.47	-0.46
[5]Model fitting information: X^2 (30) = 64.542, p-value < 0.001. Cox & Snell R square = 0.369 and Nagelkerke R square = 0.398				
Visiting Cafe[6]				
Education (ref=higher). No completed education	3.96	0.00	1.85	6.07
Self-reported sight condition (ref=poor sight). See well	-0.97	0.01	-1.74	-0.20
Monthly household income (ref≥€2500-3000). €1000 - 1499	-1.61	0.07	-3.35	0.13
Distance of the nearest bus stop (ref>1000m). <500m	0.96	0.05	0.01	1.92
[6]Model fitting information: X^2 (30) = 45.898, p-value = 0.032. Cox & Snell R square = 0.280 and Nagelkerke R square = 0.299				
Visiting Restaurant[7]				
Education (ref=higher). Primary education	-2.69	0.00	-4.53	-0.85
Self-reported hearing condition (ref=poor hearing). Fair	-1.63	0.06	-3.34	0.08
Monthly household income (ref≥€2500-3000). €500 - 999	3.09	0.05	-0.05	6.24
[7]Model fitting information: X^2 (30) = 39.973, p-value = 0.105. Cox & Snell R square = 0.248 and Nagelkerke R square = 0.295				
Visiting Library[8]				
Self-reported health rating (ref=Honest). Very good	-1.98	0.07	-4.09	0.14
Ownership of a driving license (ref=no). Yes	4.40	0.00	1.92	6.88
[8]Model fitting information: X^2 (30) = 49.191, p-value = 0.015. Cox & Snell R square = 0.296 and Nagelkerke R square = 0.355				
Visiting Educational Institutions[9]				

Gender (ref=female). Male	-1.98	0.02	-3.59	-0.37
Education (ref=higher). Secondary education	-1.24	0.04	-2.44	-0.04
Monthly household income (ref≥€2500-3000). €1000 - 1499	-3.29	0.05	-6.53	-0.06
Number of bicycles (ref=3 or more bicycles). One bicycle	2.46	0.01	0.55	4.38
Bus/train card owner (ref=no). Yes	1.44	0.03	0.15	2.74
[9]Model fitting information: X^2 (30) = 69.037, p-value < 0.001. Cox & Snell R square = 0.389 and Nagelkerke R square = 0.495				
Visiting Park[10]				
Age group/Life stages (ref=75+). 60-64	1.28	0.03	0.13	2.43
Number of cars (ref=one or more cars). No car	21.18	0.00	19.16	23.21
Ownership of a driving license (ref=no). Yes	1.44	0.09	-0.22	3.11
[10]Model fitting information: X^2 (30) = 42.409, p-value = 0.066. Cox & Snell R square = 0.261 and Nagelkerke R square = 0.280				
Visiting Sport facilities[11]				
Education (ref=higher). Primary education	1.39	0.08	-0.17	2.96
Living with a partner (ref=yes). No	-14.76	0.00	-15.87	-13.65
Self-reported hearing condition (ref=poor hearing). Hearing well	-1.33	0.02	-2.46	-0.20
[11]Model fitting information: X^2 (30) = 29.290, p-value = 0.502. Cox & Snell R square = 0.189 and Nagelkerke R square = 0.208				
Visiting Sport events[12]				
Gender (ref=female). Male	1.89	0.03	0.23	3.54
Living with a partner (ref=yes). No	-15.93	0.00	-17.55	-14.30
Self-reported hearing condition (ref=poor hearing). Fair	2.43	0.04	0.14	4.72
Number of cars (ref=one or more cars). No car	17.18	0.00	13.72	20.63
[12]Model fitting information: X^2 (30) = 39.006, p-value = 0.126. Cox & Snell R square = 0.243 and Nagelkerke R square = 0.325				
Visiting Trip to another City/Country[13]				
Education (ref=higher). Primary education	-1.89	0.03	-3.55	-0.24
[13]Model fitting information: X^2 (30) = 28.193, p-value = 0.560. Cox & Snell R square = 0.182 and Nagelkerke R square = 0.209				
Visiting Workplace[14]				
Age group/Life stages (ref=75+). 60-64	2.25	0.01	0.63	3.86
Gender (ref=female). Male	2.03	0.02	0.33	3.73
Living with a partner (ref=yes). No	-18.64	0.00	-20.50	-16.77
Self-reported health rating (ref=Honest). Good	-2.56	0.04	-5.05	-0.06
Self-reported sight condition (ref=poor sight). See fairly	2.56	0.05	-0.02	5.15
Number of cars (ref=one or more cars). No car	-20.31	0.00	-23.18	-17.45
Bus/train card owner (ref=no). Yes	1.09	0.08	-0.12	2.30
Distance of the nearest bus stop (ref>1000m). 500-1000m	1.95	0.04	0.12	3.78
[14]Model fitting information: X^2 (30) = 56.164, p-value = 0.003. Cox & Snell R square = 0.330 and Nagelkerke R square = 0.412				
Participating in social activities[15]				
Age group/Life stages (ref=75+). 65-74	0.77	0.08	-0.09	1.63
Living with a partner (ref=yes). No	-4.09	0.02	-7.38	-0.79
Living alone (ref=yes). No	-5.45	0.00	-8.94	-1.95
Self-reported hearing condition (ref=poor hearing). Hearing well	-0.91	0.09	-1.97	0.14
Bus/train card owner (ref=no). Yes	-0.85	0.03	-1.60	-0.10
[15]Model fitting information: X^2 (30) = 36.619, p-value = 0.189. Cox & Snell R square = 0.230 and Nagelkerke R square = 0.245				

The reference category is the group "Daily Visitor" of different locations/out-of-home activities.