

Article

Inclusive and Safe Mobility Needs of Senior Citizens: Implications for Age-Friendly Cities and Communities

Anthony Jnr. Bokolo ^{1,2} 

¹ Department of Applied Data Science, Institute for Energy Technology, 1777 Halden, Norway; anthony.bokolo@ife.no or anthony.j.bokolo@hiof.no

² Department of Computer Science and Communication, Østfold University College, 1757 Halden, Norway

Abstract: Municipalities are concerned with addressing social issues such as mobility inclusion and safety by increasing access to transport facilities and services for all groups in society to create equitable and equal access for all citizens. Moreover, the public transportation systems provided in cities have to be inclusive and safe, driven by emerging technologies such as Artificial Intelligence (AI)-based services that provide personalized recommendation to improve mobility inclusion and safety for all citizens in society, especially vulnerable road users such as senior citizens or older people. But at the moment, there are few studies that have investigated how municipalities can provide inclusive and safe public transportation in general and for senior citizens, particularly those aged 65 and above. Therefore, this study aimed to examine how to provide inclusive and safe mobility for senior citizens to improve out-of-home mobility services for senior citizens towards age-friendly cities and communities. Accordingly, a systematic literature review grounded on secondary data was adopted to investigate inclusive and safe mobility needs for senior citizens. The data were collected from previous research and existing documents, and a descriptive data analysis was carried out to provide insights on urban transportation policies related to senior citizens. Furthermore, case studies were adopted to present policies and strategies employed in Norway, Canada, the United States of America, the United Kingdom, Sweden, and Northern Ireland to identify measures employed to address the public transportation needs of an aging society, focusing on the provision of inclusive and safe mobility to senior citizens. Further findings from this study included the possible use of emerging technologies such as AI-based machine learning for inclusive and safe mobility.



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Keywords: safe mobility; inclusive mobility; AI-based machine learning; sustainable mobility; senior citizens; smart cities and communities

1. Introduction

Public transportation provided in cities including the first and last mile travel is a key part of urban development, which contributes to sustainable cities and communities. The mobility system in most cities has immense importance for urban dwellers, particularly for vulnerable groups, such as low-income groups, pregnant women, children, physically challenged persons, and senior citizens who have less access to a private vehicle and rely on public transportation [1,2]. Mobility is essential for accessing physical, social, and cultural activities, connecting neighborhood facilities, and engaging in social participation. Mobility also supports healthy aging and quality of life as it promotes the physical movement of humans [3]. But without mobility equality and equitability, public transportation services provided to vulnerable road users in society such as senior citizens may be inhibited from participating in social activities [2]. Most senior citizens rely on driving to accomplish their mobility needs. But as senior citizens advance in age, they are faced with functional limitations, such as vision impairment, dementia, and cognitive decline, which make driving more challenging [4,5]. The findings from Tournier et al. [6] suggested that senior citizens are faced with issues, such as attention deficits, physical frailty, and visual impairment,

which negatively impact senior citizens' safety either as pedestrians or when using public transportation.

To improve urban transportation, there is a need to propose policies that promote safe and accessible public transportation infrastructures [7]. However, there is less evidence underpinning issues related to mobility inclusion, particularly for senior citizens. Although issues related to urban transportation have been researched in several studies, there is inadequate evidence of inclusive mobility for all individuals, mostly senior citizens [8]. Sustainable mobility for senior citizens should provide support services in terms of acceptability, affordability, accessibility, availability, and adaptability for inclusion in society [1]. Furthermore, research that provides policy best practices grounded on strategies to improve the mobility of senior citizens is limited.

Most studies previously funded within European programs produced developed tools/products to be used by local authorities and municipalities in the form of pilot projects, prototypes, and guidelines, but most of the experience derived from these projects are not well transferred into practice [9]. This is because these findings are often not well included in a coherent policy framework of strategies and probably do not directly connect with the stakeholders' needs in society. Additionally, the final end-users are not involved in the co-creation and co-design processes from the beginning to the end of the project [10]. Also, it is challenging to address the real needs and requirements of a very heterogeneous target group in society such as that of senior citizens [9]. Accordingly, there is a need for approaches that can improve inclusive and safe mobility in cities to reduce urban isolation and social injustice. Therefore, this study aims to examine the following research questions:

- What is the state of the art in regard to policies related to the mobility inclusion and safety of senior citizens?
- How can the use of emerging technologies such as Artificial Intelligence (AI) promote the inclusive and safe mobility of senior citizens?
- What strategies and initiatives are to be adopted to promote the mobility inclusion and safety of senior citizens?

The current study adds to the body of knowledge by investigating how to improve the inclusive and safe mobility of senior citizens. The findings from this study contribute to improving the mobility accessibility and safety for senior citizens, particularly those aged 65 and above, when they use public transportation in urban and suburban environments. The findings will be useful for practitioners and researchers interested in understanding how to improve the abilities of senior citizens to cope with the changing transport system and further provide insight into future urban mobility needs. The remainder of this article is structured as follows: The Section 2 is the Methodology section. Next, a descriptive analysis of the literature is presented. This is followed by a content-related analysis of the literature. Then, the findings from case studies are presented, followed by the Section 6. The Section 7 is the conclusion, which highlights the significance of this study and the possible limitations, including future works.

2. Methodology

This study conducts a systematic literature review (SLR) as suggested by Webster and Watson [11] and Kitchenham and Charters [12]. An SLR offers an approach that uses data from existing document reports and previous research as secondary data. In this study, an SLR is employed to provide a more contextual, holistic, and complete understanding of inclusive and safe mobility in cities and communities. Thus, an SLR was employed in this study similar to prior studies [10,13,14], as it is suitable for exploring research works that are at an early stage, thereby providing preliminary information to help identify the gap in knowledge that needs to be addressed. As shown in Figure 1, an SLR typically comprises six main phases as defined in the literature [11,12]: (1) specifying the research question(s), (2) defining the required characteristics of main studies, (3) retrieving potentially pertinent works in the literature, (4) selecting the relevant works in the literature, (5) synthesizing and extracting works in the literature, and (6) reporting the findings and future direction.

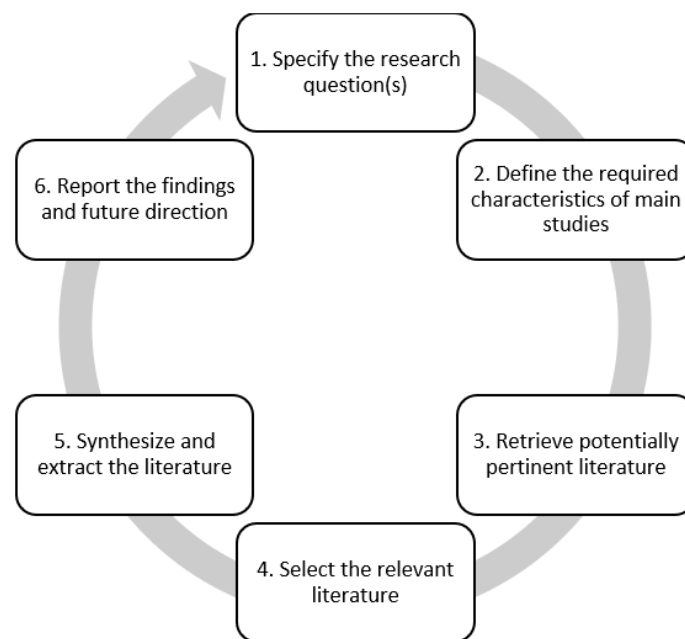


Figure 1. Review method employed in this study.

The SLR process employed in this study to examine “the inclusive and safe mobility needs of senior citizens” is summarized in Figure 1 and described as follows:

- (1) Specify the research question(s). This phase helps to guide the SLR by stating the defined research question(s). This helps to identify useful literature surveys. Presently, scientific contributions dealing with “inclusive” and “safe” mobility needs of senior citizens are still at an early stage, where thorough research has not yet been well carried out. As such, this current study aims to provide a systematic discussion of the research in order to identify the state of the art and define the main challenges to be addressed to position future research.
- (2) Define the required characteristics of main studies. In this study, scientific articles published in refereed journals, conference proceedings, book chapters, and books (indexed in Scopus and/or Web of Science), and technical reports and thesis reports written in the English language, which contributed to understanding inclusive and safe mobility needs of senior citizens in society, were retrieved.
- (3) Retrieve potentially pertinent works in the literature. The search was carried out by retrieving important sources from the Scopus and/or Web of Science databases. The choice of the search terms was based on the paper title, keywords, and the research questions. The search terms were not too generic so as to exclude studies that are immediate in content but were not directly associated with inclusive and safe mobility needs of senior citizens.

To confirm the quality of the selected sources, search terms were formulated by using Boolean and/or operators to combine the search terms to improve the relevance of the search procedure. The main search terms comprise “mobility of older adults”, “mobility of senior citizens”, “mobility of older people”, “mobility inclusion”, “safe mobility”, “age friendly city”, “mobility needs for seniors”, “emerging technologies”, “artificial intelligence”, “machine learning”, “mobility policies”, “mobility measures”, “mobility strategies for elderly”, and “mobility initiatives for elderly”.

Figure 2 illustrates the study selection process carried out based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) as employed by prior review studies [10,14].

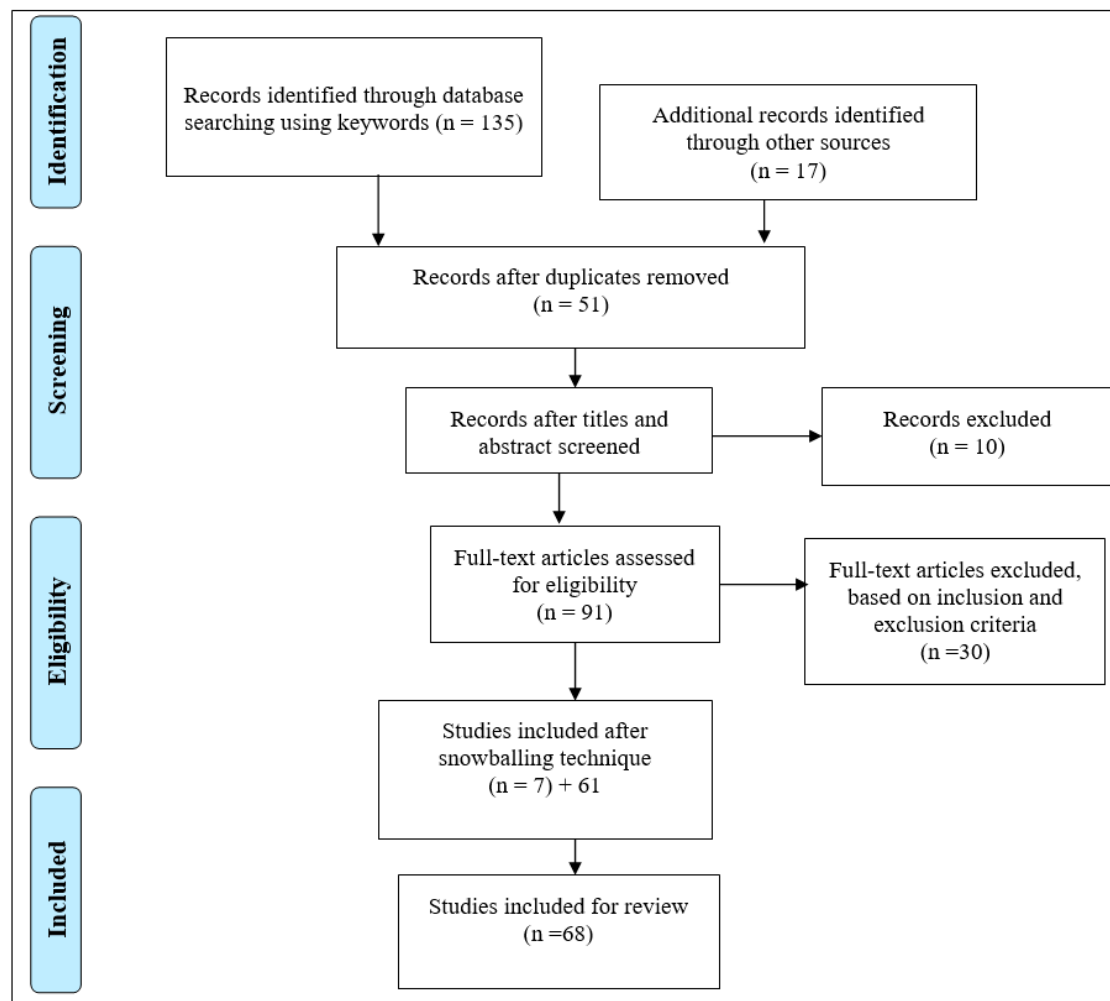


Figure 2. Study selection process for the SLR.

In the early stage of the search process, 152 potential sources were retrieved from online databases and from other sources such as policy websites (World Health Organization (WHO), European Union (EU) commission, and other websites), as seen in Figure 2, using the above-mentioned keywords. A total of 51 sources were found as duplicates and were removed. Hence, the total number of the remaining sources resulted in 101 sources, and their titles and abstracts were screened to be in line with the study area of inclusive and safe mobility needs of senior citizens. Next, 10 sources were removed, as the titles and abstracts were not fully aligned with the study area, resulting in 91 sources, which proceeded to the full-text assessment. In this phase, the author read all the sources and checked that their contents were related to the research questions in the first phase. At that point, no sources were removed. Then, the remaining 91 sources were assessed against the inclusion and exclusion criteria. Therefore, 30 sources were excluded, as these sources did not meet the inclusion criteria. This resulted in 61 sources, after which 7 sources were added based on snowballing, resulting in a total of 68 sources, as seen in Figure 2 and the References section of this article.

- (4) Select the relevant works in the literature. The next step was to identify sources that are mainly related to inclusive and safe mobility needs of senior citizens. This was accomplished in a two-step process: first, by manually screening the titles, keywords, and abstracts and selecting only the relevant articles, and then by checking the inclusion and exclusion criteria. Studies published in the English language, journal articles, conference proceedings, books/book chapters, technical reports, and thesis reports published from 2000 to date were included. Also, sources that provided possible dis-

cussions and implications of the examined research questions and employed review, quantitative, qualitative, modeling, and experimental studies were included. Studies that did not meet these inclusion criteria were excluded, as seen in Figure 2.

- (5) Synthesize and extract the literature. In this phase, descriptive analysis and content-related analysis of the literature was carried out. To carry out the descriptive analysis aspect, this study synthesized and extracted secondary data regarding the selected literature, as seen in Sections 3 and 4 of this paper. A descriptive analysis of the selected sources comprised the type of publication, years of publication, adopted methodology, geographic area, and study context. The result of this stage involved the clustering of terms that occurred with the highest frequencies.
- (6) Report the results and discussion of future research directions. This phase involved the reporting of the content-related analysis of the literature as well as findings from the case studies on existing polices employed in different countries (Norway, Canada, the United States of America (USA), the United Kingdom (UK), Sweden, and Northern Ireland) to promote inclusive and safe mobility needs for senior citizens. In this phase, data obtained from the previous phases were used to critically define the state of the art and main issues to be addressed. This supported the extension from the analytical phase to the specification of future research lines that are not well addressed in the literature on age-friendly cities and communities.

A case study was employed to collect existing data and information that are accessible via online libraries, websites, etc., on polices employed to improve inclusive and safe mobility needs of senior citizens. The data were retrieved, extracted, and synthesized to support the investigation by providing preliminary evidence on the study area. A case study approach is the most suitable preferred method when researchers want to know the “why” or “how” questions related to the contemporary phenomenon being investigated. Qualitative data have been less employed in studies related to the mobility of senior citizens, as such case studies are adopted to confirm the internal validity of the findings [15].

Qualitative data offer a good understanding of the dynamic aspects underlying the relationship among different variables [16]. In this study, data for case studies on “TT-kort (Tilrettelagt Transport) facilitated transport”, “paratransit or specialized transit”, and “community mobility service route” were collected via a series of document reviews involving qualitative data from technical reports, websites, and the literature on mobility of senior citizens from 2000 to 2023. The literature recommends employing multiple sources of evidence in case studies to triangulate data between different points of view and reduce the amount of subjectivity in the study [15,16]. To this end, multiple secondary sources were used essentially to gather qualitative data on mobility of senior citizens. This approach was employed to arrive at conclusions that are mostly in conformity and as reproducible as possible [17].

3. Descriptive Analysis of the Literature

Based on the selected sources included in this study, a descriptive analysis was conducted, focusing on the distribution of source types, year of publication, country of the publishing research institution, methodology employed, and context of the study in relation to the mobility of senior citizens. The findings in Figure 3 present the distribution of the selected 68 sources, where 55% (N = 37) are journal articles, 13% (N = 9) are conference proceedings, 25% (N = 17) are technical policy reports, 4% (N = 3) are books/book chapters, and lastly, 3% (N = 2) are thesis reports. The complete list of the selected sources included can be found in the References section of this paper. This finding reveals that most of the published work related to the mobility needs of senior citizens are mostly journal articles, which is followed by publications linked to policy and technical reports. This is because municipalities across the world are becoming more concerned with issues related to older people in society.

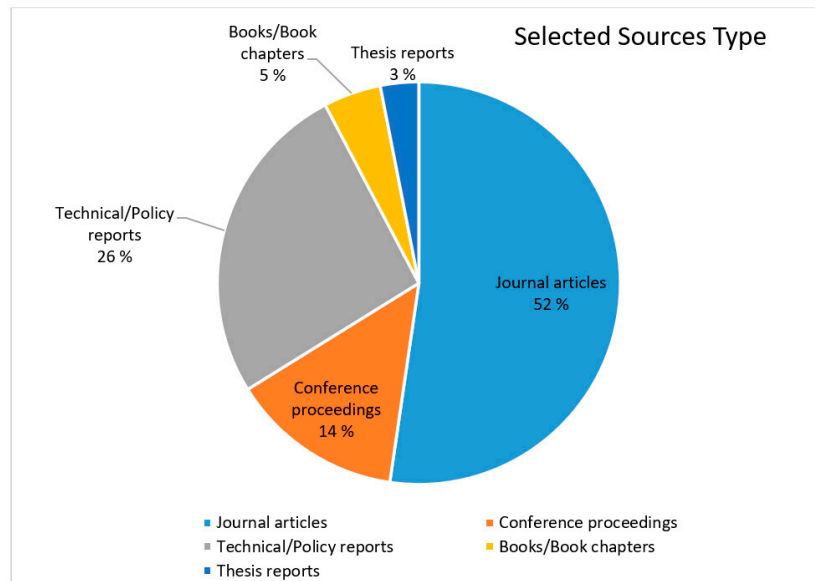


Figure 3. Distribution of selected sources based on source type.

The findings in Figure 4 suggest that the majority of the included sources was published in 2019 with N = 9, followed by 2020 and 2021 with N = 8 individually. In 2022, N = 6 sources related to the mobility of senior citizens were published. The years of 2017 and 2018 both had N = 5, and 2013 had N = 4. The years of 2007, 2010, and 2011 recorded N = 3. The years of 2002, 2008, 2016, and 2023 recorded N = 2 sources, which is logical for 2023, as this paper was written within this year. Finally, 2000, 2001, 2005, 2006, 2014, and 2015 only had N = 1 source included. This finding suggests that only a few studies have been published in this important area, and this necessitates more research related to the mobility inclusion and safety of senior citizens.

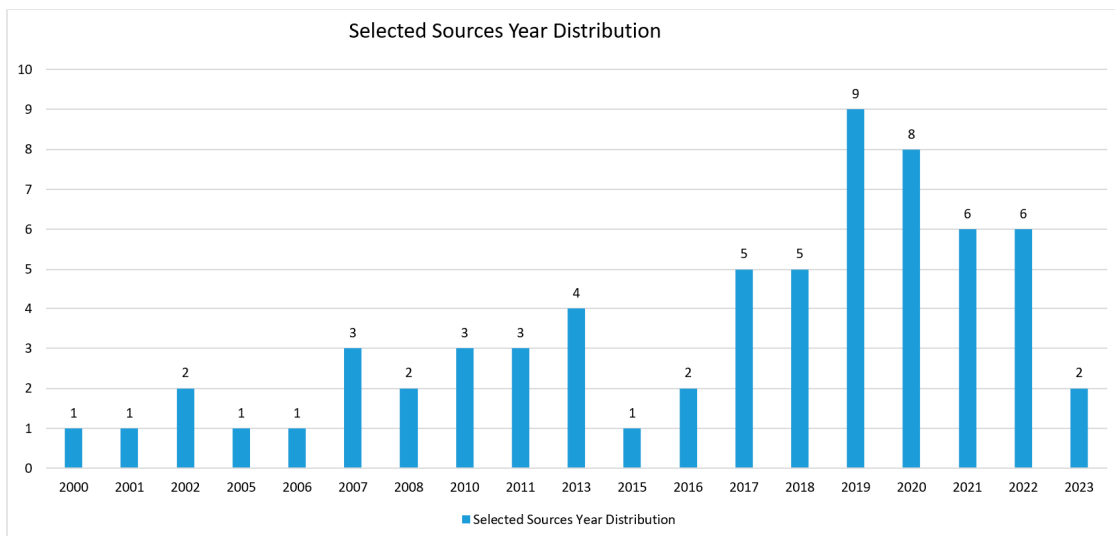


Figure 4. Distribution of selected sources' years.

Figure 5 indicates that when analyzing the 68 sources, it was found that most of the sources included in this article adopted a literature review as the research method, with 39 sources using this method, followed by interviews, which were used in 11 sources, and focus groups, which were used in 4 sources. The findings in Figure 5 also depict other methods that were employed such as modeling and experimentation, which was used in three sources, and mixed mode and surveys, which were used in two sources. The

remaining sources employed other research methods to collect data. This finding indicates that there are fewer studies on senior citizens’ mobility that provide evidence based on qualitative data via case studies, as seen in Figure 5. This current study will provide evidence based on an SLR as well as case studies from Norway, Canada, the USA, the UK, Sweden, and Northern Ireland.

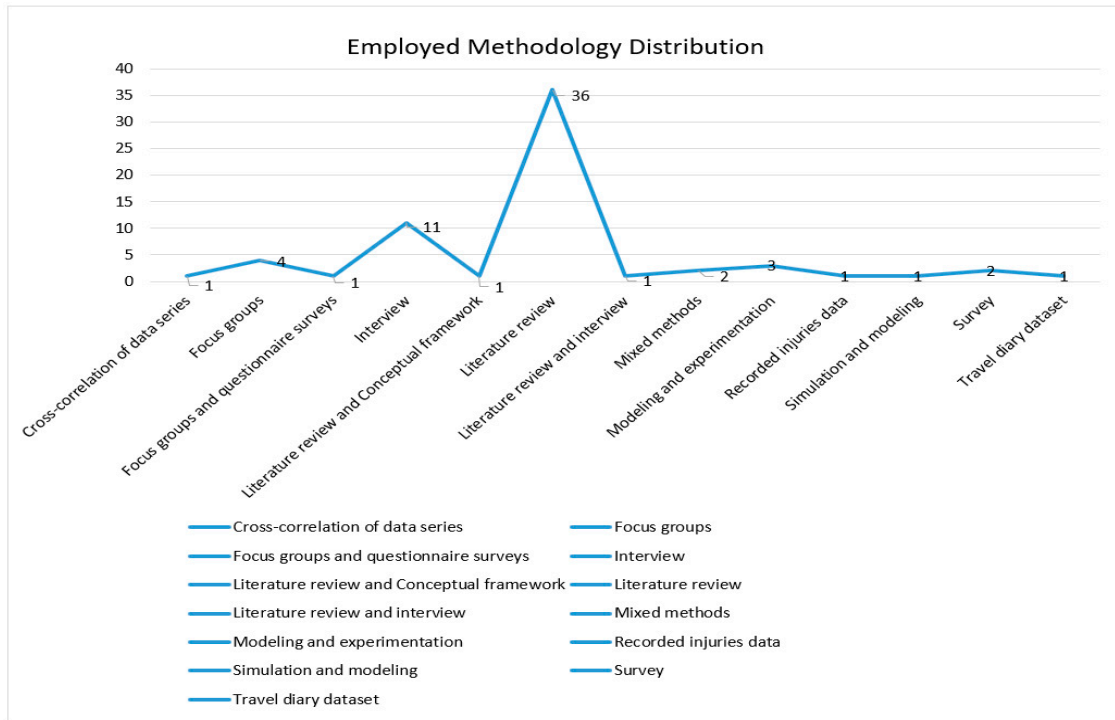


Figure 5. Distribution of methodology employed in selected sources.

Figure 6 shows that there is a total of 24 countries of the “countries of published authors” in the selected sources. This finding suggests that most contributors to the study area related to mobility needs for senior citizens are mostly in the USA and Norway, with 16 sources, respectively. Four sources were published from Japan, Australia, and the UK. This is followed by Portugal, Poland, and the Netherlands, each with three studies included compared to the other regions, as seen in Figure 6.

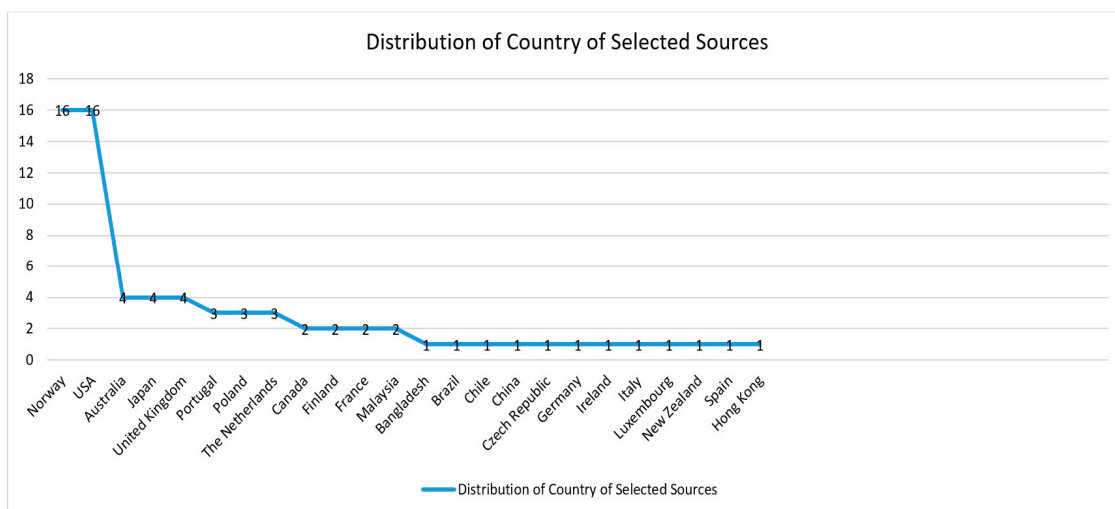


Figure 6. Distribution of countries of published authors in selected sources.

In addition, out of the 68 sources included in this study, Figure 7 summarizes the study contexts examined in the selected studies. The result suggests that most of the studies explored older people's mobility and transport, age-friendly transport, and sustainable transport. Also, the finding shows that additional areas related to the mobility of senior citizens were researched such as transportation services for older adults, accessibility and safety for elderly people, and safety and mobility issues among older pedestrians. The result in Figure 7 also presents other areas or research domains examined. However, there are fewer studies [5,18] that present policy recommendations on how to improve the mobility of senior citizens. Similarly, there are limited studies that explore both the "inclusive" and "safe" mobility of senior citizens towards achieving age-friendly cities and communities.

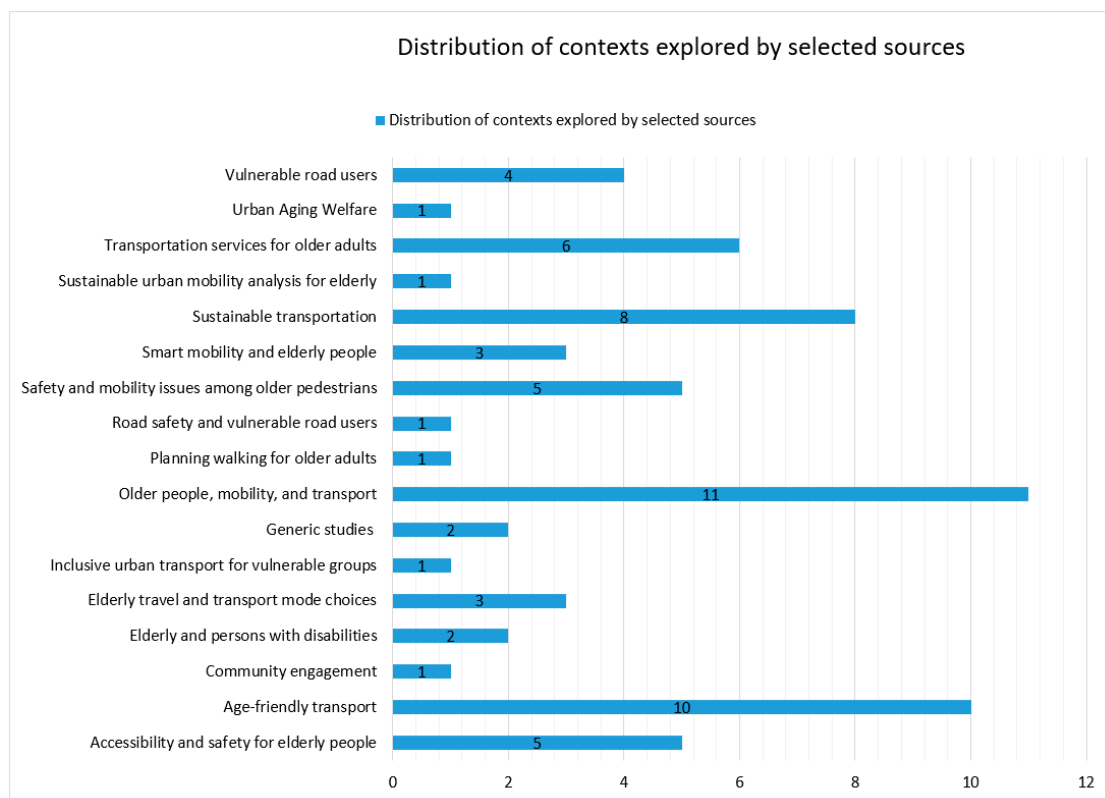


Figure 7. Distribution of explored contexts in selected sources.

4. Content-Related Analysis of the Literature

4.1. Age-Friendly Mobility for Wellbeing and Welfare of Senior Citizens

As postulated by the World Health Organization (WHO) [19], eight strategic areas need to be considered by municipalities to achieve age-friendly cities. These eight key areas, in no order, comprise social participation; respect and social inclusion, transportation, communication and information, housing, civic participation and employment, outdoor spaces and buildings, and lastly, community support and health services. Among these strategic areas, "transportation" is predominantly noteworthy because it allows for senior citizens to utilize urban mobility services to interact with other citizens and thus promotes active aging, improving opportunities for participation, health, and inclusion in order to improve senior citizens' quality of life [9,20]. Mobility is important to senior citizens' daily activities as it helps to maintain independence, a healthy lifestyle, psychological wellbeing, access to support services and community networks [21], and overall life satisfaction for senior citizens either as drivers or passengers in vehicles [18,22,23].

Undoubtedly, there should be equality and equitability in public transportation services for social inclusion. In this regard, existing transportation services should be adapted

to fit senior citizens with physical, cognitive, or sensory impairments, and new mobility services should be developed in order to guarantee independent community living [24]. According to the literature [14], special consideration should be devoted to individuals with special needs such as senior citizens with high or specific needs, those needing protection against violence, senior citizens needing support in making decisions, senior citizens in early phases of old age, senior citizens at risk of isolation due to their residence being in rural areas and marginal locations, and finally, senior citizens at risk of financial exclusion due to debts or low income. Mobility is an important aspect of the wellbeing and welfare of individuals, especially senior citizens. The findings from the literature highlighted that senior citizens within the ages of 65–85 years require access to public transportation for improved quality of life, i.e., a good mobility service is essential if they are to have an active social life [25,26]. The findings from the literature also reveal that irrespective of their age, senior citizens agreed that the availability of some sort of public transportation is essential for having a functioning social life and a good quality of life [25].

4.2. Inclusive and Safe Mobility Needs for Senior Citizens

It is estimated that the number of elderly people above 60 years old in the world will increase to more than 22% by 2050 [8,13,14]. As such, various regional, national, and international initiatives aim to promote continued mobility via access to a vehicle, either as a passenger or as a driver [27], towards improving the independence, wellbeing, health, and quality of life of senior citizens [14]. But in order to ensure a future of inclusive and safe mobility, there is a need to provide accessible transport systems for every group in society to achieve truly sustainable mobility [28]. However, as senior citizens, especially those who are disabled, tend to encounter several forms of social exclusion, these individuals are disproportionately affected by mobility-related exclusion. This type of exclusion is not intrinsically initiated by a lack of social opportunities but is due to inadequate access to services, opportunities, and networks [29]. Additionally, senior citizens within the age range of 65–85 are faced with challenges in using some of the existing mobility solutions, as at times, they experience some form of travel impairment, which hinders their access to public transportation. Moreover, as the global population is aging, the percentage of residents experiencing mobility-related impairments is estimated to increase at the same time as the demand for accessible transport services. It is thus deemed necessary that services and products are re-designed to suit senior citizens [8,29,30].

Also, this user group includes senior citizens who are visually disabled, have impaired hearing, and senior citizens who use wheelchairs [28]. The mobility needs and preferences of senior citizens should be considered by city administrators during the design of pedestrians' roads, as this will contribute to greater accessibility for senior citizens and might increase their participation in outdoor and social activities [9]. This also has important implications for senior citizens aged over 65 who may experience multiple disadvantages as they become older, as they may decide to give up their driving license because they mostly feel pressured by health practitioners, family members, or an inability to deal with daily traffic conditions [3]. Thus, senior citizens need other alternate transportation modes. This is in line with the findings from a prior study, which suggested that the ability of senior citizens to drive or have access to a car may significantly impact their quality of life, particularly for those residing in rural areas [28]. As suggested by Salmela et al. [28], the mobility needs of senior citizens comprise primary, secondary, and tertiary needs, as seen in Figure 8.

Accordingly, Figure 8 depicts the mobility needs of senior citizens based on the literature. Although to support senior citizens in achieving these mobility needs, "service lines", which are voluntary transport services or demand-responsive transport services, should be provided when public transportation is inadequate or limited. Demand-responsive transport can take senior citizens to a bus stop or location where public transportation is accessible [28,31]. However, these special mobility services are only available within

some pre-defined routes of existing bus routes and are only made available during certain hours [1].

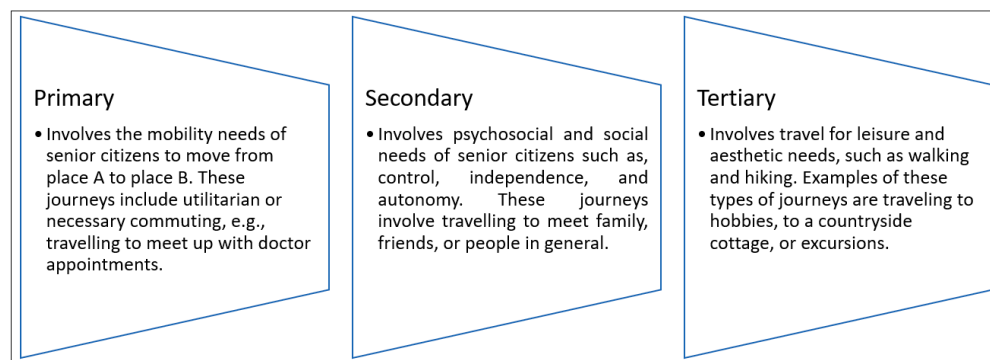


Figure 8. Mobility needs of senior citizens.

Additionally, an age-friendly city and community, including safe transportation, has been identified as an important factor for enhancing the quality of life of senior citizens [32,33]. This is because senior citizens face considerable risks when they walk around urban environments, which often makes it unsafe for them when they are walking on the street [34]. Adequate safety is not only important to senior citizens alone, but also to those with whom senior citizens interact with daily [32,35]. Safe mobility plays a significant role in cities and communities and is one of the challenges faced in society. For instance, the safe mobility of senior citizens, mostly those with disabilities, is hindered due to the dynamic, intermodal, and multimodal systems in urban environments [36]. Safe mobility is a prominent issue in cities and communities when there are inadequate connections across different modes of public transportation such as city buses, primarily in the first and last mile travels for older people [8].

Overall, some studies have examined issues related to the mobility of senior citizens. A few of these studies related to the current study area being researched are shown in Table 1.

Table 1. Existing studies on mobility of senior citizens.

Author(s), Year, and Contributions	Explored Mobility Areas	Methodology Employed	Context	Countries
Rocha et al. [12] reviewed smart cities’ applications to support the mobility of older adults.	<ul style="list-style-type: none"> • Smart city apps • Sensors and city data • Age-friendly initiatives 	Literature review	Employed Information Technology (IT) to facilitate the mobility of older people in urban spaces.	Portugal
Fatima et al. [32] carried out a review on sustainable mobility for the elderly.	<ul style="list-style-type: none"> • Travel patterns • Mode preferences • Infrastructure solutions • Accessibility indices 	Literature review	Identified indices that have been proposed to measure walking and accessibility among elderly populations.	Australia
Schmeidler [37] researched the area of safe cities for senior citizens and pedestrians.	<ul style="list-style-type: none"> • Urban and public spaces • Environmental pollution • Car traffic and traffic accidents 	Literature review	Aimed to develop newer attitude towards the mobility of senior citizens.	Czech Republic
Cirella et al. [13] investigated transport innovations for elderly individuals.	<ul style="list-style-type: none"> • Technical infrastructural • Recommendations • Governmental support • Financial limitations 	Literature review	Focused on raising awareness on the importance of mobility innovations for older people.	Poland

Table 1. Cont.

Author(s), Year, and Contributions	Explored Mobility Areas	Methodology Employed	Context	Countries
Gorman et al. [33] conducted a review of older residents, transport, and mobility.	<ul style="list-style-type: none"> • Aging and transport • Evidence and policy • Aging, health, and mobility • Social isolation and support 	Literature review	Aimed to improve mobility policy for the increasing number of older people.	UK
Battarra et al. [9] explored how information and communication technologies (ICT) can make cities more accessible for elderly people.	<ul style="list-style-type: none"> • Smart mobility safety, accessibility, and ICT • Smart mobility measures and initiatives 	Literature review	Provided strategies to improve safety and accessibility for elderly people.	Italy
Tanaka [38] researched the use of technologies to improve mobility for elderly people and those with disabilities.	<ul style="list-style-type: none"> • The features of the elderly • Current mobility and robotic technology 	Literature review	Motivated to examine the use of innovative technology that could support the mobility of elderly and disabled people.	Japan
Somenahalli et al. [34] investigated accessible mobility issues faced by elderly populations.	<ul style="list-style-type: none"> • Universal design concerns • Mobility scooter challenges 	Survey	The study provided new approaches to address challenges based on policies.	Australia and Japan
Tournier et al. [6] conducted a review of safety and mobility challenges in older pedestrians.	<ul style="list-style-type: none"> • Walking • Wayfinding • Road crossing 	Literature review	Examined elements in developing safety measures for older pedestrians.	Luxembourg and France
Schlieder et al. [39] investigated the application of assistive technology to facilitate senior citizens' mobility.	<ul style="list-style-type: none"> • Geo-Wiki • Matchmaking service for connecting elderly people 	Literature review/ conceptual framework	Aimed to address mobility barriers and create mobility connections via social collaboration.	Germany
Oxley et al. [18] explored safe mobility of senior citizens who are drivers based on the urban road designer's perspective.	<ul style="list-style-type: none"> • Safe system context • Urban road design and operation • Countermeasures 	Literature review	The study provided some possible solutions to resolve the safe mobility of older people with an emphasis on crash.	Australia
Arai et al. [40] explored the deployment of urban mobility support for older residents.	<ul style="list-style-type: none"> • Healthy older people • Older people with dementia 	Survey	Aimed to investigate the provision of mobility assistance measures in communities.	Japan
Cortés et al. [41] developed an intelligent i-Walker tool to aid in the mobility of elderly people.	<ul style="list-style-type: none"> • Autonomy and disability • Agent-based service 	Modeling and experimentation	Focused on decreasing the risk of fall convenience and on enjoyment.	Spain
Ståhl et al. [42] researched on the classification and prioritization of safety and accessibility measures for elderly people.	<ul style="list-style-type: none"> • Reduced speed limits and improved maintenance • Specific initiatives in pedestrian walkways 	Mixed method (questionnaire and observations)	Aimed at improving safety and accessibility in an outdoor pedestrian environment.	Sweden
Eberhard et al. [27] researched tools and strategies to promote safe mobility for older adults.	<ul style="list-style-type: none"> • Driver assessment • Community awareness • Driver self-assessment tools • Safe mobility guides 	Literature review	Provided a thorough listing of information, programs, and websites to support safe mobility of older people.	USA

Several studies have previously examined the mobility of senior citizens based on different perspectives, as reviewed in Table 1. A few studies focused on the travel patterns and living area preferences of senior citizens, while others examined policies and structural

improvements to resolve the transport accessibility issues faced by senior citizens. More recently, mode choice and mobility accessibility studies for senior citizens are receiving increased attention [32]. The evidence from the literature highlighted the need for proactive and thorough urban transport planning in cities and communities to reduce exclusion and improve the safety of senior citizens' lifelong mobility [13,37]. However, research focusing on the mobility inclusion and safety for senior citizens is lacking. Senior citizens are not homogeneous since they differ in terms of preference for mode of travel, state of health, and travel needs, and most have some form of disability [13]. There is a need for a study that considers the aforementioned issue. Therefore, the current study investigates how to foster inclusive and safe mobility that could improve out-of-home mobility services for senior citizens aged 65 and above towards age-friendly cities and communities. Therefore, this article provides implications towards addressing policy challenges to reduce social exclusion from the transportation sector by addressing mobility inequities and inequity in relation to senior citizens' inclusion and safety.

4.3. Safe Walkability and Wayfinding for Senior Citizens

Walking is a healthy and sustainable mobility option and is a common mode for senior citizens who cannot or opt not to drive. However, for senior citizens, the road environment is often perceived as highly risky and unsafe. This often leads to avoidance behavior for senior citizens [3,8,43]. As such, there is a need to ensure the safe mobility of pedestrians. But at the moment, walking within and across cities is not completely safe, especially for senior citizens. In the USA, among certain age grades (13–17, 18–24, 25–34, 35–44, 45–54, 55–64, 65–74, and 75 and older), individuals aged 65 years and older have the highest pedestrian injuries and fatality rate compared to other age groups, with about 803 fatalities and 9000 injuries recorded in 2008 [44]. Research is needed to identify the most effective ways to manage the mobility of senior citizens; it is important to gain a good understanding of the safe mobility needs of senior citizens, risk factors, and countermeasures, and identify the best practice approaches to reduce falls, injuries, and accidents faced by senior citizens [18].

Similarly, falls are one of the main causes of injury or death for senior citizens, and it is estimated that in 2007, over 18,000 senior citizens died from falls, as reported by the Centers for Disease Control and Prevention (CDC) in the USA. To improve walkability for senior citizens, the pedestrian environment can be improved to help mitigate and reduce pedestrian-related falls, fatalities, and injuries from unmaintained/inadequate pedestrian facilities, especially in different seasons of the year (winter, rainy conditions, windy conditions, etc.). In the USA, a few walkability initiatives were proposed such as the "California WALKS" initiative, which aimed to engage communities in the California area to directly involve senior citizens as a proactive approach to promote walking [44]. Also, in Norway, senior citizens within the age range of 65–85 are mostly faced with injuries [45], and the fatality rates in relation to the distance traveled is higher than those for middle-aged drivers within the age range of 35–54. Also, injury and crash rates are likely to increase in the coming years due to the aging population, increased mobility, and travel amongst senior citizens [40,46]. The findings from the literature suggest that contributory factors include frailty and reduced fitness due to medical conditions.

Additionally, in an urban environment, "wayfinding" refers to the formal and informal signs and symbols that people use to navigate a city or community. These symbols can be textual in the form of signs or pictorial in the form of symbols. Overall, wayfinding infrastructures comprise landmarks, street signage, and building numbers. Wayfinding is important as it can help senior citizens of all abilities and possibly all ages feel safe, and provides a sense of mobility orientation so that they can see where they are. This can be specifically important for senior citizens with cognitive impairments. This information provided for wayfinding can also be included in handled devices and other emerging technologies to support walkability within and across cities and communities [24].

4.4. Use of Emerging Technologies for Inclusive and Safe Mobility

Designing mobility services for senior citizens requires knowledge of older people's living conditions from many perspectives [28]. In improving mobility inclusion and safety, emerging technology can be adopted. This is because technology plays an important role in how senior citizens live, including the way they travel. Recent studies [26,29,47] highlighted the significance and potential of transport innovations for senior citizens, such as personalized travel support services that help to improve mobility accessibility. Thus, novel technologies and systems are presently being adopted to offer smart mobility infrastructures in cities [9]. The use of technology by senior citizens can help to prevent mobility-related risks such as accidents, falls, injuries, etc., which occur when using public transportation and in soft mobility either on foot or when cycling [9].

Thus, emerging technologies such as Artificial Intelligence (AI)-based machine learning, data mining, etc., can contribute to improve mobility inclusion and safety. However, these emerging technologies need to be incorporated with the current mobility habits of senior citizens to guarantee usage. Moreover, the use of AI-based machine learning and data mining can help to make cities and communities more "age-friendly" by improving walkability, wayfinding, and access to information [9]. Flexible public transport arrangements, supported by emerging technologies, may help senior citizens efficiently cope with associated physical limitations [47]. While existing research has mainly focused on the use of technologies in urban transportation systems, little research has been conducted on the societal implications of adopting emerging technologies to improve mobility inclusion and safety [29]. *Therefore, there is little research that investigated how emerging technologies can offer personalized, safe, and inclusive mobility services to vulnerable users in society such as senior citizens.*

AI-Based Machine Learning for Inclusive and Safe Mobility

Over the years, only little research has been conducted specifically on senior citizens employment of emerging technologies to foster inclusive and safe mobility. Hence, there is a need for research aimed at exploring how AI-based machine learning can be employed to address mobility inclusion and safety among senior citizens of all ages represented (65–74 years and 75 years and older). Although several projects have been carried out to improve senior citizens' mobility [48], there are fewer studies that have employed AI or machine learning to improve the inclusive and safe mobility of senior citizens. These proposed solutions do not always consider the real needs and requirements of senior citizens, as the technologies are developed for senior citizens and not with senior citizens, and consequently, they are not suitable to address the real mobility needs of senior citizens [9,49]. Additionally, emerging technologies such as AI-based interactive voice technology can be employed to facilitate safe mobility if adapted to the needs of senior citizens [26]. Interactive voice technology can be developed as an easily affordable and accessible platform facilitating intuitive, consistent, and personalized mobility services, such as for outdoor monitoring, safe walkability, and wayfinding.

AI-based interactive voice technology can foster safe mobility by utilizing crowd-sourced data (for unexpected events such as road closure due to construction, available facilities, and rest opportunities), as well as publicly available historical data and real-time data on maps (OpenStreetMap), traffic, weather, broken sidewalks, curbs without cuts, multimodal transit, busy roads with no sidewalks, elevation changes, and route nodes. The data can be used to provide personalized mobility route guidance to senior citizens based on the user capabilities, current weather, transit information, accessibility, elevation status, and road slope for safe and secure walkability [2,4]. Moreover, AI-based interactive voice technology can support senior citizens with physical disabilities to navigate or travel on accessible routes. They can help senior citizens with visual impairments by offering audio navigational assistance.

The findings from the literature suggested that wayfinding applications have previously been developed for individuals with cognitive disabilities to offer navigational

guidance through digital navigational aids and Global Positioning System (GPS) signals via Bluetooth technology to provide aid for users utilizing public transportation facilities [24]. In addition, digital platforms using AI-based machine learning can be provided to senior citizens to provide personalization based on the current characteristics of the individual profiling data, e.g., preferences, routes, start location, frequent destinations, motivation, physical condition, health condition, and surroundings (neighborhood, living accommodation, preferred public transportation, etc.) [9]. Likewise, visual recognition using machine learning algorithms can be used to help senior citizens to automatically recognize the edges of the sidewalks and traffic warning signs for safe walkability and wayfinding. Image recognition can be employed to provide recommendations as senior citizens walk in the city when the algorithms and models recognize signboards, such as detour signs, traffic cones, construction signs, and the yield sign, which are likely obstacles for senior citizens, which can be detected in real time when they go walking [2].

On the other hand, the findings from the literature suggested that the adoption of technological inventions can be difficult, especially for senior citizens, as they experience changes that normally occur with aging such as vision loss and physical impairments; they may also face difficulties in learning how to access tools with a touch screen or screen readers [50]. Similarly, Rynning et al. [26] argued that emerging technology may constitute barriers for senior citizens who are not familiar with the use of technology. This can be due to accessibility and ease of use problems, which contribute to senior citizens' resistance to technology adoption, although this argument is not consistent with the findings of Cirella et al. [13], where the authors stated that senior citizens are not as hesitant to adopt modern technologies as opposed to popular belief. Also, senior citizens' use of internet-based devices depends on their cognitive abilities such as perceptual speed, working memory, and reasoning, which lead to reduced performance. The findings from Rynning et al. [26] advocated for carrying out testing and training (for senior citizens) as one of the most important approaches for increasing the uptake of technological innovation provided to facilitate the mobility of senior citizens.

5. Findings from Case Studies

As discussed in Section 2, qualitative data were analyzed in this study to provide evidence on the existing practices employed to improve the mobility of senior citizens based on three case studies, as discussed below. The case studies from Norway, Canada, the USA, the UK, Sweden, and Northern Ireland retrieved from the SLR on the mobility of senior citizens were included, as seen in Figure 6.

5.1. Case Study 1—TT-Kort (Tilrettelagt Transport) Facilitated Transport

"The active ageing agenda" in Norway stated that senior citizens should have active and independent aging, which encourages older people to take part in society for a long time [51]. Presently, the "health, care, and coping department" (Kommunalavdeling Helse og mestring) in municipalities across Norway such as Halden municipalities aims for the city to be a safe place for inhabitants to reside throughout their life by offering various initiatives aimed at addressing issues such as social exclusion by providing access to facilities and services for all groups in society [25,52]. At times, the distance to the train station or bus stop is often too far to walk, and senior citizens may not want to use public transportation if they are not sure if they will obtain an available seat. The existing conventional public transport schemes provided are often unable to meet the needs of special groups, such as older people, as they are inadequate, infrequent, and offer poor accessibility.

The Norwegian Labour and Welfare Administration (NAV), patient transport (helsenorge), the Municipal Department for Health and Coping (Kommunalavdeling Helse og mestring), and other volunteering associations such as Red Cross (Røde Kors), the Norwegian Association of Disabled (NAD), etc. [53], in Norway provide different community transport services to older people as good alternatives to conventional public transport. Similarly,

the “arranged transport” TT-card (TT-kort- tilrettelagt transport) is provided for those who are unable to travel via public transport due to a permanent disability [54]. The TT scheme is proposed for leisure trips via taxis, it is managed by local public transportation, and the municipality is responsible for arranging public transportation for senior citizens, who may not be able to commute with public transportation due to their disability. The personal doctor or guardian of a senior citizen can apply for the TT card on behalf of the individual, and the municipality determines how much is granted based on their annual budget [54].

5.2. Case Study 2—Paratransit or Specialized Transit

In Norway, Sparelab [55] and Ruter [56] (a public transport company) offer on-demand door-to-door “paratransit” mobility services, which aim to connect senior citizens to their communities within Oslo [55]. Senior-citizen-focused mobility is becoming progressively important in Oslo’s transit infrastructure. In September 2017, Ruter launched the “Age-friendly transport” (Ruter Aldersvennlig Transport (RAT)) [56], a shared door-to-door mobility service for older people aged 67+. Ruter previously adopted a Trapeze paratransit software, but later opted to utilize Spare Platform [55], to modernize how RAT was provided to citizens. This shift has created a medium for Oslo to become a primary actor in the “WHO Global Network of Age-friendly Cities and Communities”. The RAT mobility service has changed the way senior citizens travel in their communities. The findings suggested that 20% of senior citizens (aged 80+) who used the RAT mobility service resided in the Nordre Aker area in Norway and were satisfied with the mobility service, while 88% of commuters were “very satisfied”.

At the moment, the option for the provision and use of a “Special Transport Service” for senior citizens who are unable to travel using conventional public transportation is mostly not well known among older people. This is supported by the findings of Hjorthol et al. [25], which revealed that only 15% of senior citizens have knowledge of the availability of a Special Transport Service, and only 30% of senior citizens feel that this Special Transport Service covers their mobility needs. Overall, the RAT mobility service has reduced the demand for Oslo’s current paratransit service by enabling the municipality to serve more senior citizens who require more specialized mobility assistance. Also, the remarkable uptake and use of the RAT mobility service suggests that senior citizens are socializing and moving within and across their communities more easily than before. Since the collaboration between Ruter and Spare, about 50% of journeys have been shared between passengers who may not be familiar with each other. This establishes a sense of community unity, which reduces loneliness for the older populations in society.

Although the current RAT mobility service was well adopted since its launch, the RAT mobility service has been faced with a few issues such as manual matching between drivers and passengers, which makes it difficult to effectively scale up the platform. The RAT mobility service is solely used by senior citizens who are not too familiar with the operation of digital platforms for mobility. To address these issues, Ruter has substantially improved its operational infrastructure to enhance its service scalability. Spare now supports Ruter to autonomously assign passengers to drivers, enabling optimal matching and routing to reduce operational and administrative costs. Using an Open Application Programming Interface (API), Ruter and Spare collaborate to provide a user-friendly digital booking platform tailored to the needs of senior citizens, which includes customized user profiles with default accessibility needs and favorite locations [55].

5.3. Case Study 3—Community Mobility Service Route

The “service route” scheme started in Sweden within the 1980s aimed to provide transport alternatives as “paratransit” or “special” services for older commuters (usually door-to-door taxi-type schemes) [57]. In this paratransit mobility service, low-floor (accessible) small buses were scheduled and routed to meet up with the origins and destinations required by older passengers, though other residents were also permitted to board. The vehicles often go through locations that are inaccessible to larger buses,

such as day care centers, hospitals, health centers, and even stores. Senior citizens obtained the driver's assistance if they needed it. These community mobility services mostly ran hourly, occasionally between 9 a.m. and 3 p.m., and regularly on weekdays. Furthermore, in Sweden, a larger minivan, labeled TaxiRider, was made available, with its rear compartment enabled for a full low floor, and it provides more space for five to seven individuals who can move within the vehicle in a nearly upright position of about 1.80 m to access their seats [11]. This was corroborated from findings from the literature [3], where the authors stated that ramps or lifts are being fitted for disabled people in minibuses.

Due to the high satisfaction of the service routes from the community of older people, similar operations have been expanded all over Western Europe and Scandinavia [57]. This paratransit service concept was implemented in the USA and in a number of Canadian cities, often referred to as "community buses", and has been used to offer mobility services in areas that public transportation routes do not access. In other parts of Europe such as in the UK, there are new regulations, which compel wheelchair-accessible taxicabs to be on demand or on call, which has resulted in the overall adaptation of London's taxi service. However, in some European countries, these community buses have not been widely implemented as they must be offered in connection to existing public transportation services, and they are more expensive to operate by the municipality without financial support [57]. Paratransit services provide a vast range of private and public transportation services that use vehicles that offer demand-responsive and shared door-to-door rides often termed as dial-a-ride vehicles. The paratransit vehicles used includes taxis, small minibuses, or private cars, which are built using universal design infrastructures that facilitate senior citizens' entry and exit into and out of the public transportation service.

Moreover, senior citizens in wheelchairs are able to board and get off using the physically installed access ramp, which is controlled by the driver. Also, the positioning of seats in the rear of a minivan are located close to the door to assist disabled passengers to board the vehicle and then easily move within the vehicle compartment. Paratransit is specifically suitable for communities and regions where the availability of public transportation services is low, mostly due to low resident density (such as in rural areas) or because the public transportation service is restricted to a small minority of individuals. In Northern Europe, senior citizens, especially the oldest, frequently limit their travel when the roads are icy and slippery or when it is dark, and they prefer to use public transport when there is less traffic. Additionally, senior citizens' feelings of safety and security, the guaranteed availability of a seat on the bus or train, and easy ways to purchase a travel ticket are influential factors to be considered in public transportation [25]. To support the mobility of senior citizens in Northern Ireland, bus fleets are being modernized to provide fully accessible bus fleets with low floors. Also, there have been requests for the deployment of a taxi card scheme within Northern Ireland, which will provide dedicated mobility services to individuals with disabilities based on a subsidized taxi scheme [3].

5.4. Policy Recommendations for Inclusive and Safe Mobility

With an increasing share of senior citizens in society, it is significant that urban transport policies are adjusted accordingly [25]. As such, most cities and communities in Europe are focusing on improving urban mobility by initiating policies for traffic planning, instituting applicable public policies that specify the need for an inclusive, safe, and accessible public transportation system. A major setback is guaranteeing mobility for senior citizens, which is important to ensure independence, good health, and quality of life [8]. Urban transportation infrastructure needs to be improved, according to the United Nations (UN) 2030 agenda, towards the attainment of accessible, affordable, safe, and sustainable mobility systems [40,58]. The World Bank itself notes that sustainable transportation in cities and communities should leave no one behind [22].

Thus, the evidence from this study is in line with the Sustainable Development Goals (SDGs), especially SDG 10, which aims to “reduce inequalities” by promoting the social inclusion of people regardless of their ages, disabilities, or any other social statuses towards an equitable and equal city. Also, this study is aligned with SDG 11, which focuses on achieving “sustainable cities and communities” by supporting the creation of the most inclusive and safe cities and communities. Overall, this study reinforces SDGs 10 and 11 through inclusive urban mobility planning [8]. According to the European Strategy beyond 2020, which aims to guarantee that individuals experiencing social exclusion, poverty, and limitations are supported to take active roles in community and live in dignity, there is a prerequisite for achieving a “society for all”, where everybody can pursue a fulfilling life and realize their full potential irrespective of age and based on their freely chosen autonomy or interdependence. This necessitates that mobility policies need to be planned for addressing social exclusion, embracing senior citizens’ diversity, in relation to their mobility needs [26]. Accordingly, some European countries such as Ireland have initiated strategies to provide access to good-quality transportation services, as reported in the literature [3]. Moreover, Ahern and Hine [3] stated that the government plans to put in place environmental policies aimed at providing sustainable, smarter, efficient, and citizen-orientated transport services.

Additionally, the research suggested that a transportation system, especially for senior citizens, depends on the size of cities (density), road network, transport network, population, existing public transportation services, and economic situations, as the provision of any mobility services is expensive for the municipality to operate without financial support [3,57]. As such, the provision of uninterrupted public transportation schemes in rural areas is particularly expensive due to dispersed populations, which limit current public transportation to cope with the needs of special groups, like senior citizens. To achieve the inclusive and safe mobility of senior citizens, there is a need for a flexible public transportation strategy that acknowledges the reliance on the availability and accessibility of municipality transport service, but this strategy should also effectively serve senior citizens who do not have access to public transportation [3]. The strategy should also specify the need to improve mobility availability, affordability, adaptability, and adoption to link all public transportation, enabling intermodal and multimodal mobility services towards providing the better integration of cities’ and communities’ public transportation services. There is a need to remove barriers that senior citizens with disabilities experience by improving mobility accessibility and various modes of transport towards the promotion of mobility inclusion and safety.

As such, there is a need for comprehensive and long-term strategies to address the inclusive and safe mobility needs of senior citizens. These strategies should consider the extreme variability among older people, but also the different situations of senior citizens (disabled or not disabled). Urban transport policies and services must acknowledge the preference for a repertoire of mobility options that give senior citizens flexibility, freedom, and independence as they age. Policymakers and municipalities must focus substantial attention and resources to meet the increasing mobility needs and requirements of older travelers for mobility equity and equality. Addressing the mobility needs of such a growing and large portion of the population is fundamental in solving several public transportation challenges faced by society. To do so, several measures that meet the varied needs of different groups of senior citizens based on collaborative strategies between the municipality, public sectors, private sectors, and other societal actors are needed [1]. Overall, to improve inclusive and safe mobility for senior citizens, there is a need to address the measures seen in Table 2, adapted from the literature [1,25,32,59].

As suggested in the literature [28,40], inclusive and safe mobility services for senior citizens should address the following indexes, i.e., acceptability, affordability, accessibility, availability, and adaptability, as discussed in Table 3.

Table 2. Measures to improve inclusive and safe mobility of senior citizens.

Measures	Description
Adjust the public transportation system	In general, municipalities should start by listening to senior citizens to help improve their security and safety amidst commuting. Moreover, the distances to bus terminals and stops should be reduced in relation to residential areas, more seats on buses and trains should be allocated to older people, benches should be provided to sit on the way to and from the bus stop (also at the bus stop), there should be easy ways of purchasing tickets, and city bus drivers should practice smooth, considerate driving.
Employ Universal Design (UD) standard	Standards such as UD should be adopted to help with the routine inspection of vehicles, such as space for wheelchairs with appropriate safety provisions (with raised curbs and ground-to-vehicle ramps that allow buses to stoop down to provide easier access to passengers) and boarding equipment to enable wheelchair users to get on and off different vehicles.
Provision of customized information and promotions	Information availability, dissemination, and advertising of the actual public transportation service is important. Information about mobility services and travel routes is frequently limited.
Improve walkability	Slipping and falling in the walkway or pedestrian environment is mostly caused by obstacles in the surroundings and uneven surfaces in the walkway. There is a need for the design of wider pavements, better pedestrian crossings, and signal regulation. Also, there should be fewer to no slopes where pavements traverse, as this will make it easier for senior citizens to safely move around outdoors. Similarly, winter maintenance of pavements and roads is particularly important for senior citizens. The removal of ice and snow on pavements can help to prevent falls, slippery incidents, and injuries. Senior citizens mostly feel unsafe in places where cyclists are permitted to use the same lane or area as pedestrians.
Seamless mobility service	A typical journey for senior citizens using public transportation involves finding the right service, e.g., by walking to the bus or train stop, entering the vehicle, locating a seat (possible priority seat for older people), deciding where to stop, and coping with inter-changes as either intermodal or multimodal along the journey to the final destination. To embark on such trips, senior citizens need to be confident that possible connecting (intermodal or multimodal) transport and links are available and are seamlessly manageable (accessible, connected, coherent, affordable, and available). For senior citizens, this information can be complex, resulting in them not using public transportation.
Integrated transport infrastructures	Involves the integration of different transport infrastructures such as ticketing and fare reduction for alternative special public transport. This can also involve the provision of tactile markers that can lead the way for senior citizens with reduced vision to bus and train stops and shelters to improve the safety of senior citizens.
Information about special and facilitated transport service	There is inadequate knowledge about existing mobility services provided within the municipality such as the Special Transport (TT Service) in Norway. Senior citizens often do not know of the process of obtaining this service or how they can apply for this scheme. Thus, there is a need for better information dissemination.
Economic mobility service support	Senior citizens require a type of economic support for mobility, which is connected with their health services and managed by the municipality or city where they reside. Such economic services for public transportation organized by the municipalities would be useful to senior citizens. Moreover, municipalities should be encouraged to utilize existing taxi operators through contract conditions and subsidies.
Use alternative community services	Alternative transportation resources in cities and communities can be utilized to support the mobility of senior citizens if approved or regularized by state law. For instance, municipality provision of support for volunteer networks that provide ride-sharing schemes would increase inclusive mobility options for senior citizens. Transit operators or community agencies could aid in providing more informal volunteer services via voucher programs.

Table 3. Strategies for achieving an inclusive and safe mobility service for senior citizens.

#	Indexes	Description	Strategies for Transport Policy and Practice	Strategies for Inclusive and Safe Mobility
1	Acceptability	Urban mobility provided by municipalities should include transport services that senior citizens are willing to utilize. For example, the mobility service should be safe, user-friendly, and comfortable. Acceptability includes the biases or attitudes senior citizens may have towards the provided transport modes [28]. The acceptability of any public transport system relies on driver attitude, safety, information availability, and transition support [13].	To improve the acceptability among senior citizens, training should be provided to the drivers of public transportation as well as to senior citizens involving how to use public transportation mode in a safe manner. Senior citizens' awareness of different public transportation modes and health benefits of walking should be increased. Safety can be improved by municipalities carrying out fall hazard assessments, allocated planning, and obtaining feedback from the community.	<ul style="list-style-type: none"> -Public transportation is available for senior citizens and there is shorter waiting time. -Senior citizens have high level of satisfaction with safety about the provided mobility service [50]. -Provision of awareness training for senior citizens. -Provision of signs/symbols for safe crossing near bus stops/stations. -Provision of handrails and assistance when needed. -Drivers stopping close to the road curb and waiting until older people sit before moving. -Provision of audio and visual announcements at bus/station stops. -Provision of visible travel route information displayed at bus/station stops [13].
2	Affordability	Affordability relates to the potentials of using low-cost mobility services [60]. Ticket and fees for mobility service should be viable within the economic means of senior citizens. If the use of a particular transport mode is too expensive, senior citizens will certainly not use such mobility mode [28].	Many senior citizens are mostly pensioners; as such, the municipality should provide schemes such as free or subsidized fares [28]. The reduction in the travel costs of public transportation for senior citizens will encourage their use of public transportation to meet their mobility needs [47].	<ul style="list-style-type: none"> -Ticket fare is reasonable such that low-income earners can use public transportation. -Municipalities and different groups work together to provide more cost-effective mobility services to senior citizens [50]. -Provision of incentives to use public transportation [61]. -Simple procedure of obtaining a ticket/pass [13].
3	Accessibility	Accessibility refers to senior citizens' ability to access the services required to meet their mobility needs through activities and facilities available within a short distance [13]. The mobility service should be implemented in a way that enables senior citizens to fulfil their mobility needs; for instance, the mobility service should be accessible to senior citizens. Accessibility entails the ease with which senior citizens can obtain access to different public transit services when needed [62,63]. This involves both digital and physical accessibility. Physical accessibility involves inaccessible bus stops/stations or buses, difficulties for senior citizens to stand, or waiting long times [23,28].	Physical accessibility for senior citizens can be improved by introducing more vehicles, routes, stations, and stops close to where older people visit or reside [50]. Stations and stops should be designed based on UD principles to include well-lit and good shelters with benches. Digital accessibility involves senior citizens capacity of finding mobility-related information digitally. This includes, for instance, using digital timetables, e-ticketing options, directions, and maps both on board and at stops. Difficulties in using mobile application resulting in a lack of awareness of available mobility options [28].	<ul style="list-style-type: none"> -More clear footpaths, ramps, and curbs as well as removal of obstacles in pedestrian walkways or walking paths. -Low-floor and ramp capabilities for buses to help senior citizens who access the buses. -Provision of on-board easy-to-use facilities. -Provision of standing and moving spaces. -Walking and cycling, bike, and pedestrian lanes should be safe to use and be split from other traffic. -Clearly visible and understandable information such as timetables, location of lifts at stations. -Provision of payment options and visible travel information all along the journey. -Accessibility across city routes to and from transport stations. -Clear footpath leading to bus/station stop with level or low road gradient. -Good crossing facility (i.e., signaled crossing) and reduced traffic speed near bus stops. -Provision of traffic island for safe road crossing to shorter distances [13].

Table 3. Cont.

#	Indexes	Description	Strategies for Transport Policy and Practice	Strategies for Inclusive and Safe Mobility
4	Availability	Availability relates to public transportation facilities and assess if they are within reachable distance from the homes of senior citizens. It also involves the frequencies and service times of operation [13]. The mobility service should be available to senior citizens. Thus, the routes of public transportation such as the city bus lines should travel across important public service hubs [28].	Flexible on-demand transport services such as custom transport service and taxis, dedicated services, or community transport for older and disabled people. Information relating to all available mobility alternatives should be clearly and transparently delivered to senior citizens in order to avoid presumptive and negative attitudes [28].	<ul style="list-style-type: none"> -Easy reach of amenities and basic bus service. -Public transport service and personnel have been fast to respond to the needs of senior citizens [50]. -Public transportation services that connect to senior citizens' residence or place of interest (e.g., shopping centers and medical services). -Provision of responsive point-to-point mobility service, e.g., home to destination and vice versa [13].
5	Adaptability	The design of existing or new public transportation vehicles such as city buses, trains, taxis, etc., should accommodate commuters using various apparatus to support their mobility (electric mobility, wheelchairs, etc.).	There should be available priority seats on buses, handrails to support disabled people, color contrasting features such as steps and handrails to aid partially sighted people. There should be easy-to-use stop pushes/buttons throughout a bus, visual and audible signals to request boarding or to stop the bus, and route information visualization displays.	<ul style="list-style-type: none"> -Priority seating for older people and provision of real-time information facility. -Provision of spacious seating facilities and wheelchair space. -Provision of audible announcement systems for visually impaired person. -Well-lighted and clean bus/station stop with protection [13]. -Simple infrastructures with ease of use (i.e., machine reader for tickets), flexible and transferable tickets.

6. Discussion and Implications

6.1. Discussion

The mobility needs of senior citizens today are heterogeneous, as different categories of older people are frequently faced with mobility exclusion and safety risks. This is a result of their reduced mobility and problems with existing public transportation [13]. Therefore, the current study adopts a systematic literature review and case studies method to investigate how to improve the inclusive and safe mobility of senior citizens. The findings from this study advocate for the adoption of emerging technologies such as AI-based machine learning to provide safe walkability and wayfinding for senior citizens towards an age-friendly city and communities. The evidence from this study provides policies and strategies that are being adopted in Norway, Canada, the USA, the UK, Sweden, and Northern Ireland as measures to address the public transportation needs of an aging society. The findings from a previous study indicated that there is a need for policy changes to address the mobility inclusion and safety issues that senior citizens face today [1]. Accordingly, this study offers recommendations as measures as well as strategies for achieving an inclusive and safe mobility service for senior citizens.

The findings from the literature [30] mentioned that policies designed to promote and initiate sustainable cities and communities must address the environment, safety, and mobility challenges faced by older people. As suggested in the literature [13], strategies to promote the adoption of alternative mobility services can help with the inclusion of new transport solutions. Moreover, the provision of mobility as a service (MaaS), which includes car-sharing and carpooling schemes, can promote mobility inclusion for senior citizens. However, new mobility schemes offered via digital platforms are often not compatible for senior citizens due to inadequate digital competency, a complex interface, or mostly due to the smaller font on handheld devices. One solution to this issue was described by the "Transport Innovation Deployment" for Europe project, which explicitly called for tenders to develop platforms with specifications suitable for senior citizens [57].

There is much policy debate about senior citizens' centers on the provision of alternative public transit such as subsidized taxis or special paratransit services, which are provided in European countries such as in Norway, as discussed in case studies 1 and 2. Policy recommendations to address issues related to mobility inclusion include the decrease

in public transportation costs and the utilization of emerging technologies or improvement of legacy systems that increase social contacts. The use of innovations in “in-vehicle technologies” that are powered by Artificial Intelligence or automation has proven to provide some benefits to older people, including improvements in travel safety and comfort. Thus, innovative technologies have been recommended, such as on-board vehicle interfaces, that facilitate different modes for the input, processing, and output of data, as well as novel mobility educational systems [29]. These policies provide an opportunity to improve the inclusion and safety of senior citizens’ travel options. This is because access to public transportation is a key factor of community mobility among senior citizens, mostly those that have stopped driving or do not wish to drive [36].

6.2. Implications for Research

Inclusive and safe mobility contributes to facilitating acceptability, affordability, accessibility, availability, and adaptability for vulnerable users in society such as women, children, older people, disabled people, etc. Urban transport policies directed towards older people are crucial, as the population is aging more and experiences some disabilities [63,64]. It is predicted that senior citizens will have a key impact on future public transportation systems provided in cities and communities [63,65]. As the effect of the population aging on future public transportation systems is expected to be progressively felt across the coming years in a number of countries including Norway, it is rational to recognize the significance of formulating appropriate urban mobility policies for societies [23]. The mobility requirements of senior citizens are not homogeneous. Their needs vary depending on influencing socio-demographic factors such as age, income, gender, driver license possession category, experience with driving, state (disabled or not), household size, and lifestyle (which considers if they are retired or working, and housing styles) [47]. These socio-demographic factors can substantially impact the mobility needs of senior citizens.

Therefore, the findings from this study provide an understanding of how to develop policies for promoting the safe and social inclusive mobility of senior citizens. The inclusive and safe mobility campaign aims to create more age-friendly cities, expanding public transportation to senior citizens towards increasing mobility acceptability, affordability, accessibility, availability, and adaptability in and between cities and communities. The findings from this article provide theoretical implications on the state of the art for age-friendly mobility for the wellbeing and welfare of senior citizens. More importantly, the findings provide policy recommendations for inclusive and safe mobility, measures to improve inclusive and safe mobility, as well as strategies for achieving an inclusive and safe mobility service for senior citizens. This study enables practitioners, researchers, and policy makers to examine the barriers that impede inclusive and safe urban transport faced by senior citizens and help urban developers and planners, transport businesses, and community organizations to design new mobility services and infrastructures that are more inclusive to older people in society.

6.3. Implications for Practice

Mobility inclusion and safety for senior citizens is a fundamental factor for assessing the quality of life of senior citizens since many day-to-day activities for daily living involve being mobile [29,66,67]. The issue of transport availability and accessibility has been proven to contribute to decreased levels of mobility for senior citizens [47,65,68]. Hence, there is a need for municipalities to adopt policies to improve the inclusive and safe mobility of senior citizens. In particular, the findings from this study contribute to the sub-goals of the United Nations’ (UN) sustainable development goals 11.2, which aim to provide access to accessible, safe, affordable, and sustainable transport systems for society by 2030, and also to improve pedestrian/road safety towards achieving vision zero in cities. This study advocates for deploying emerging technologies (i.e., providing data-driven mobility services that upgrade or replace existing mobility systems) to improve the viability of public transportation systems, for instance, in regions where there are limited public

transportation infrastructures available for senior citizens. The findings from this study provide evidence on how to provide safe walkability and wayfinding for senior citizens, and advocates for the use of AI-based machine learning for inclusive and safe mobility for senior citizens. This study discussed policies for addressing urban mobility needs and requirements of an aging population. The findings highlight areas in which municipalities and transport providers can contribute to increase the mobility of senior citizens.

The findings have policy implications for decision makers and transport planners not only regarding the policy options for addressing inclusive and safe mobility needs of senior citizens, but also for guiding the planning and implementation of sustainable transport policies for addressing vulnerable people's mobility needs. A key challenge that has become apparently important in society is that the provision of sustainable transport services and infrastructures for future transport policies that address senior citizens' mobility needs and requirements necessitate the consideration of senior citizens. Thus, in providing inclusive and safe mobility, there is a need to provide institutional and legislative policy support for senior citizens such as a desirable public transportation service that is enjoyable, convenient, affordable, comfortable, efficient, and fully accommodates senior citizens' travel concerns and characteristics.

7. Conclusions

As urban mobility is a primary aspect needed for senior citizens to achieve their activities for daily living, access to mobility and community participation for senior citizens is an important part of maintaining function and deterring further disability [42]. In terms of the mobility needs of senior citizens, guidelines for achieving mobility acceptability, affordability, accessibility, availability, and adaptability are important. Therefore, this study contributes to the body of knowledge by investigating how to improve the inclusive and safe mobility of senior citizens towards an age-friendly city and communities. A systematic literature review and case study methodology was employed to examine evidence from previous research, existing documents, and case reports as preliminary data to provide insights in urban transportation policies related to senior citizens. The findings from this study will be beneficial to society by identifying urban design, planning, and transport policy interventions that will aid mobility service organizations, municipalities, and other stakeholders.

Furthermore, this study proposes the adoption of emerging technologies such as AI-based machine learning and data mining to help enhance the mobility, walkability, and wayfinding of senior citizens. There are fewer studies that explore the use of AI-based machine learning by senior citizens to improve their mobility experience when they travel either using public transportation or when they walk within and across cities. Moreover, it is not certain if the introduction of these digital assistance platforms will be accepted and used by senior citizens. Hence, future work will be directed to examine the role of emerging technologies in facilitating mobility inclusion and safety for senior citizens. These emerging technologies can provide opportunities to older people to easily utilize public transportation as well as on-demand mobility services. Additionally, only secondary data were employed in this study; thus, primary data will be collected from representatives of older people to provide relevant data and insights on the mobility needs and requirements of senior citizens. The collected data will be used to develop a personalized mobility solution that is co-developed with senior citizens and relevant stakeholders in society that are involved with the care of senior citizens.

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