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Review

Perceived Accessibility and Key Influencing Factors in Transportation

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Abstract: Accessibility is commonly assessed using indicators calculated from spatial data. Comparatively perceived accessibility cannot be adequately reflected by these calculated measures because it involves the perception to participate in spatially dispersed opportunities. This highlights the need to understand and consider perceived accessibility for planning and evaluation of transport systems from a complementary perspective. Therefore, this study aims to offer a systematic review concerning the interpretations of perceived accessibility in transport, its concept, major social drivers, barriers, evaluation methods and key influencing factors. This review also highlights the importance of perceived safety and service quality in public transport and their relationship with perceived accessibility in daily travel. The paper argues that perceived accessibility with due consideration of perceived safety and service quality will contribute to the development from mobility-based to accessibility-based planning.

Keywords: perceived accessibility; transportation; perceived safety; service quality

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1. Introduction

Accessibility is considered as the ease of access to activities, facilities and locations. It has been regarded as a fundamental aspect of transportation and land use planning projects for years. For a long period, accessibility has been considered a critical criterion or indicator for evaluating urban policy and transportation due to its critical role in addressing social exclusion and improving the public health and wellbeing of urban dwellers [1,2]. However, in recent times, the desire to transition global cities and regions towards sustainability has prompted the concept of accessibility to be featured as a target and normative goal for many national and regional governments [3]. "Accessibility for all" has become a common catchphrase that appears in several local, regional and national government policies across the world. A practice review by the Treasury Department in the United Kingdom embedded accessibility within public policy and planning as a way of enhancing accountability in the distribution of government investments across populations [4]. The Social Exclusion Unit recognised accessibility as one of the main responses for addressing transport-based social exclusion in the UK [5]. Similarly, accessibility has featured explicitly as a policy goal for the European Commission and other European national governments that aim to promote sustainable transportation throughout their constituent territories [3].

Despite the growing interest in pursuing accessibility in the policy arena, there is growing concern that traditional objective measures relying on absolute measures of time, distance, cost of travel and other spatial data overlook differences occasioned by preferences, demographic features, socio-cultural and economic dynamics. Scholarships examining accessibility purely based on objective measures are limited in at least three ways. First, conventional accessibility often assumes homogenous access among people at a given location,

neglecting the influence of personal functional limitations and capacities to overcome social, economic and environmental barriers. Second, as Pot et al. [6], p. 4 suggested people have "inaccuracies in awareness regarding the outside world's realities that [objective] accessibility indicators aim to represent" implying that conventional accessibility fails to capture the real experiences and preferences of people. Third, conventional accessibility does not adequately address the critical differences that affect inclusion, inequality, and justice, which ultimately influence quality of life and wellbeing which have become the primary goal of public policies on accessibility.

Curl [7] argued that accessibility involves the relationship between people, land use and transport. However, conventionally, accessibility assessments consider the people as passive only defining how easy they reach transport and land use activities and location without considering their perspectives and capabilities as differentiated by socioeconomic characteristics. Nonetheless, Morris et al. [2] argued that "the proof of access" should go beyond the mere presence of activities and services to capture people's actual participation in activities and use of services. Thus, it is imperative to examine accessibility in relation to actual (or potential) behaviours of people rather than mere assessments of the quality of places. Consequently, the concept of perceived accessibility has emerged as a heuristic for reflecting, measuring and evaluating the actual (or potential) use of opportunities for interacting with services and activities. Emerging research presents different interpretations, assessments and applications scattered across multiple disciplines.

Among the factors that influence the use of a transport system, there is growing recognition that people's participation in daily activities and opportunities is determined by their feeling about the security and quality of transport service. As a result, some including Frimann et al. [8] suggest that perceived accessibility is strongly linked to the perception of safety and service quality and therefore should be carefully considered when aiming to increase accessibility to public transport. Based on the foregoing, this paper provides a systematic review of literature on the concept of perceived accessibility and the relationship with the key determining factors in the transportation domain.

This article acknowledges the fact that while perceived accessibility is growing in scholarly research, no study provides a unified discussion on the state of knowledge, unlike the case of the conventional accessibility literature [9–11]. Hence, this paper addresses three main questions. (i) What is perceived accessibility and its relationship with conventional accessibility? (ii) What are the emerging applications of perceived accessibility in transport literature? (iii) How does perceived accessibility relate to key aspects of perceived safety and service quality in transport? Ultimately, we seek to identify avenues for further research and policy development.

2. Methods

Figure 1 summarises the procedures for conducting this review. We conducted searches of keywords extracted from the research questions in popular academic databases, including Web of Science, Scopus and Urban Studies Abstracts, known for indexing diverse social science and engineering literature. The keywords include "perceived accessibility", "perceived safety", "perceived security", "perceived service quality", "social inclusion" and "health and wellbeing". Given the focus of the review, we restricted the search to English-language articles in the transport literature by including the Boolean operator "AND" and the keyword "transport".

After removing duplicates, we collected 2378 unique articles for processing. We then scrutinised the titles to check the relevance of each article especially considering the focus on perceived accessibility, resulting in 323 articles. We further reviewed the abstracts of these articles to identify the most relevant ones for the detailed study based on two criteria. First, articles exploring the concept of perceived accessibility regardless of transport mode were selected. Second, where perceived security or service quality was the primary focus, we maintained only those focused on public transport (e.g., buses, trams, rains, ride-hailing services). Non-public transport modes (e.g., walking, cycling, driving) were excluded

unless they also discussed accessibility. Following this process, 71 articles were retained but only 63 of them were useful after an in-depth review of the full papers.

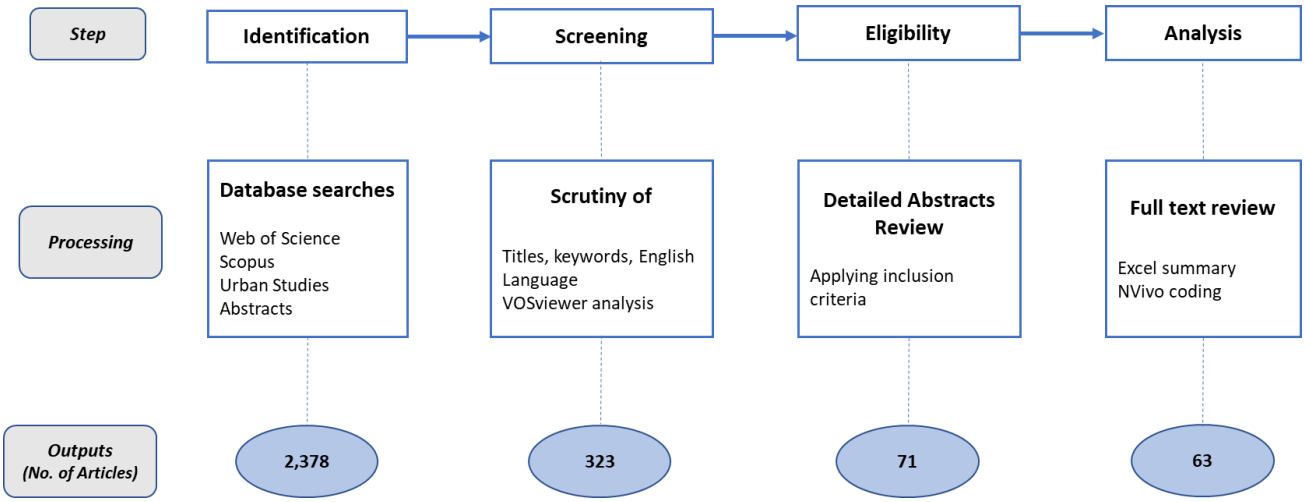

Figure 1. Procedure for conducting the review.

We used multiple methods in analysing the selected articles. To understand research trends on perceived accessibility, we used the software VOSviewer (v1.6.18) to visualise the results of a co-citation analysis of the 323 titles initially shortlisted on perceived accessibility in transport. Co-citation analysis is a method for measuring how often two or more studies are cited together to give an indication of the influential scholars and publications in a given research domain [12]. In this research, two approaches were adopted for the detailed review of the 63 articles. We developed a table using Microsoft Excel to extract the details such as the region of the author's institutional affiliation, type of research article and geographical focus (if empirical). We also used NVivo 12 Plus to develop a word cloud of the abstracts and conduct a thematic analysis of the key findings relating to definitions, applications and implications for transport policy and planning to address the research questions.

3. Results of the Literature Review

3.1. Understanding Conventional versus Perceived Accessibility

Although the concept of accessibility, in its conventional sense, can be traced back to the 1920s application in location theory and regional economic planning [9], its positive treatment in empirically describing and quantifying the ease of access to services has been widely attributed to the seminal work of Hansen [13]. Hansen [13] (p. 73) defined accessibility as "the potential of opportunities for interaction", in that accessibility reflects the opportunity an individual at a given location possesses to take part in a particular activity or set of activities such as work, shopping and social activities. Since then, many studies have explored the concept in terms of theorisation, assessments and measurements in application to urban and rural geography, economic geography, health, spatial economics, transport and urban planning. Despite this popularity, the concept has been described as a 'slippery notion' suggesting that although it is widely accepted and used in planning literature and policy, it faces definition and measurement problems [14,15].

As indicated in Table 1, most scholarships define conventional accessibility based on the proximity or ease of reaching destinations and activities, typically focusing on the travel or destination rather than the traveller. Some scholars also highlighted the important link between land use and the transport system. For example, Iacono et al. explained accessibility as a tool to monitor land use, and therefore suggest using it for quantifying the impact of proposed policies on land use [16].

Table 1. Definitions of conventional accessibility.

Author (Reference)	Definition
Morris et al. [2]	"measure of spatial separation of human activities. Essentially, it denotes the ease with which activities may be reached from a given location using a particular transportation system" p. 91
Páez et al. [17]	" . . . the potential for reaching spatially distributed opportunities (for employment, recreation, social interaction, etc.) . . . " p. 141
Preston and Rajé [5]	"the ease of reaching . . . " a location p. 154
Saif et al. [11]	" . . . the physical access to goods, services, and destinations" p. 36
Scheepers et al. [18]	" . . . how easily an individual can pursue an activity of a desired type, at a desired location, by a desired mode, and at a desired time" p. 97
Geurs and van Wee [10]	"the extent to which land-use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s)" p.c128
Vitman-Schorr et al. [19]	"The physical distance or proximity to a service with the goal of making it as short as possible" or "the simplicity with which activities in society can be reached, including trading areas, industries, and public services" p. 114

Geurs and van Wee [10] also conceptualised four dimensions of accessibility; transport, land use, temporal and individual components. However, with transport studies and policies often treating accessibility as a passive feature relating to infrastructure, services, buildings, and locations, there has been limited or no regard for the individual or people accessing these urban features. Such a focus makes accessibility lack "behavioural content" [13] (p. 117) disregarding the needs and abilities of individuals. Thus, perceived accessibility emerged as a concept for integrating the subjective features of people.

Defining perceived accessibility is a very complex endeavour because it ought to capture sociocultural, attitudinal/experimental and behavioural dimensions of people which are themselves hard to define. Some scholars highlighted the effect of socioeconomic variables in defining accessibility [7–9]. However, despite appearing in the literature more than four decades ago, research addressing this concept within transport and land use planning research areas remains limited [7].

In general, perceived accessibility is used to describe how individuals or groups understand or experience their own accessibility. Like conventional accessibility, these experiences may be assessed based on personal evaluations of spatial access measured in terms of resistance, distance, time and cost. However, an individual's assessment of their (perceived) accessibility often extends to consider availability, affordability and acceptability based on the appropriateness of accessibility opportunities in meeting one's needs [7].

Burns defines accessibility as "the freedom of individuals to decide whether or not to participate in different activities" [20]. Similarly, Weibull described accessibility as the freedom and ability of people to participate in different activities [21]. According to Huisman [22], "accessibility is a significant concept employed to understand patterns in the location of facilities and to indicate broad features of the behaviour of people, as well as evaluating the ability of services to meet people's needs" whereas, El-Geneidy et al. [23], define accessibility as a measure or indicator of the performance of transportation systems in serving individuals living in a community.

The concept has also been explained to capture the perceptions and experiences of participating in available opportunities. Perceived accessibility is seen as a means of reducing social exclusion among individuals and groups. According to Sundling [24], measuring accessibility from individuals' perspectives does not only capture their own assessment of their personal ability to function or travel behaviours but also their assessment of the

barriers encountered when accessing facilities. These barriers differ among different people based on social characteristics such as personal abilities, age, income, gender as well as the associated travel costs/fares which have varying impacts on different groups of people [25,26]. Monetary considerations often become a major barrier limiting people's access and use of facilities such as public transport and can hinder their ability to enjoy services and economic activities.

A common theme underpinning the definition of perceived accessibility relates to satisfaction with living one's desired life. Lättman and colleagues [3,8,27,28] suggested that perceived accessibility is akin to the ease of living a satisfactory life with help of the transport system, which incorporates the perceived opportunities of getting to the transport system, the ease of using the (available) system and the ease of reaching preferred activities and destinations. Thus, the concept is also related to the total utility individuals obtain from their locations in terms of (the potential of) accessing available opportunities and services. Notwithstanding the varying definitions, perceived accessibility is widely acknowledged to capture the subjective dimension of accessibility because it measures the perception of individuals on the ease of reaching opportunities based on their own experiences and abilities which are excluded from the conventional measurements [29]. Table 2 summarises some of the common definitions of perceived accessibility in the current literature whereas Table 3 indicates how it differs from conventional accessibility.

Table 2. Common definitions of perceived accessibility in the literature.

Author (Reference)	Definition
Curl [7]	" . . . how an individual, or groups of individuals, understand or experience their own accessibility" p. 1148
Lättman et al. [27]	" . . . how easy it is to live a satisfactory life using the transport system" which includes accessibility while using the transport system per se, ease of getting to the transport system, and the perceived possibilities and ease to live the life one wants with help of the transport system" p. 258
Pot et al. [6]	"the perceived potential to participate in spatially dispersed opportunities" p. 2
Ryan et al. [29]	" . . . an individual's perception on how easy it is to reach opportunities based on their own experiences" p. 406
Saif et al. [11]	"a measure of living a satisfactory life using public transportation" p. 37
Coppola and Silvestri [30]	" . . . overall location utility, perceived by individuals, computed as a function of proximity to different transportation and urban facilities" p. 137
Friman et al. [31]	" . . . the individual experience and evaluation of these [objective/environmental conditions of travel such as service quality in terms of travel time, punctuality, information, and comfort] conditions based on individual preferences and prerequisites" p. 2.

Table 3. Comparing conventional and perceived accessibility.

Perceived Accessibility	Conventional/Objective Accessibility
PA captures behavioural dimensions including perceptions of reliability, affordability and convenience.	CA focuses on objective spatial measures such as time, distance and cost. It does not consider individual circumstances (e.g., variations of income, tolerance of distance, etc.) which affect affordability and reliability.

Table 3. *Cont.*

Perceived Accessibility	Conventional/Objective Accessibility
PA considers the experiences of dealing with barriers to travel such as feeling of safety and assessment of service quality.	CA considers only physical barriers
PA distinguishes the levels of accessibility among individuals and specific groups (including vulnerable people)	CA measures accessibility for a given area or location which might comprise different categories of people
PA can have direct impacts on personal wellbeing since it captures people's ability and satisfaction with travel	CA does not reflect personal wellbeing but rather convenience based on technocratic indicators
PA is a subjective measure meaning two identical people could assess their accessibility differently	As objective accessibility, CA introduces less biases and can be replicated with same data and methodology
As a subjective construct, the impacts of competition on accessibility are largely ignored in PA	CA sometimes capture competition effect based on the density and levels of demand of opportunities

3.2. Perceived Accessibility—A New Concept

Conventionally, accessibility is seen as a cross-disciplinary concept and has been investigated from different angles including mobility, planning and transportation systems [21,32,33], travel behaviour and choice theory [34,35], social interaction [4] and reachability [36]. In all these theories, only objective measures have been considered in evaluating accessibility. However, a growing body of knowledge has suggested that subjective indicators, which capture perceptions and experiences of the users, are lacking in the accessibility concept/theory. According to Geurs and van Eck [37], accessibility is defined as "the extent to which the land-use transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s) (p. 36)". This definition of accessibility, which is generally accepted, has a strong focus on land use, transport, temporal and individual dimensions that affect accessibility of individuals. However, the individual dimension is often under-estimated during empirical assessment of accessibility.

Individual perspectives on accessibility such as experiences, skills and assumptions are about the prospects and potential to gain connection to a particular activity. These perceptions are valuable because they inform individuals' behaviour within the public transport domain category [2,38].

Findings on perceived accessibility studies, as a general contentment with accessibility, imply that those outcomes range from the traditional established indicators which are mainly related to distance or time. Conventional methods of measuring accessibility define the time needed to reach from point A to point B by bus, but they do not include the views and experiences of the population or a designated target group. Therefore, development of perceived accessibility can complement existing accessibility theory by adding the subjective experience and awareness of travellers [39].

Accessibility on an individual basis is well-documented in principle, but in practice lacking in empirical assessments. According to Farrington [40], adding perceived accessibility to the concept of accessibility is necessary because it focuses on human right and also acts as a prerequisite for social exclusion. For instance, in Sweden, perceived accessibility is considered an important goal for the public transportation sector, and research has shown that a sense of accessibility is significantly motivated by the quality of service such as safety, comfort, disabled access, etc. [41]. Neglecting perceived accessibility in accessibility studies would lead to serious challenges in evaluation and follow-ups with such visions. Therefore, understanding individual perspectives towards accessibility is critical to obtaining accurate measurement of accessibility [42].

Budd and Mumford [43] and Lotfi and Koohsari [44] pointed out that solely relying on objective indicators leads to insufficient information for thoughtful decision-making, only benefiting people who already use transport systems. Furthermore, objective measurements of accessibility may be extremely high, despite the fact that the measure may subjectively consider possibilities or places of which the residents of that area are unaware of or interested in going to. Similarly, accessibility may be considered low in some areas where the population is satisfied because they may still have a high perceived ease of access to the locations and activities are important to them. Such discrepancies often waste government and transportation resources, or misguided interference. As a result, exclusion from society continues to increase, and subjective happiness and life satisfaction will suffer as a result.

Although Morris et al. [2] pointed out distinct distinction between subjective and objective evaluations of accessibility as early as the 1970s, but the subjective aspects were not implemented in transportation studies. Some studies acknowledged perceived accessibility briefly, but mostly used demographic characteristics in highlighting user experiences [45–47] or surveys and interviews to collect subjective data [1,44]. In a study conducted in Tehran, Iran, subjective and objective measures of accessibility were compared through a single-question interview question with four options presented to the participants to describe degree of satisfaction (low, moderate, good, excellent) [44]. If the participant's satisfaction was low, they were asked to explain why in response. The findings of this study showed that while objective accessibility can be low in one neighbourhood, subjective (perceived) accessibility can be ranked as high within the same neighbourhood. Curl et al. [1] carried out an investigation by comparing subjective and objective measures of accessibility through semi-structured interviews. The study found a significant difference between perceived and objective accessibility, thereby highlighting the urgent need to conduct further research in this area. The majority of contemporary studies on accessibility do not acknowledge the lack of subjective measures in the calculation but assume that individuals' perceptions are taken into account in objective measures [43].

Accessibility as it is perceived also refers to how people evaluate their living conditions; how easy it is to do everyday activities with a specific travel mode or if it is possible to continue living the life he or she desires using, for example, public transportation as the primary mode of transportation. These parameters are impossible to measure objectively because they overlook the significance of contextual, climatic, cultural and geographical features and eliminate walking and cycling preferences [39].

Morris et al. [2] proposed assessing accessibility from two perspectives: process indicators such as the availability of opportunities to travel to specific places and outcome indicators such as actual use and satisfaction levels. Their research indicated that any metric that does not incorporate both signs is inadequate. Some scholars highlighted the ease of reaching certain activities in terms of time and cost [48], whereas others defined accessibility from interaction and the opportunities to interact perspective [13]. Curl et al. [1] concluded that accessibility can be split into prospective and actual travel, strengthening the distinction between a standard accessibility measure and a specific measure for perceived accessibility. Sha AI Mamnun and Lowned defined trip, spatial and temporal coverage (where I wish to go, for example, proximity to a bus stop) and (when I feel like going) accordingly and concluded that these components are important to measuring accessibility [49]. Several studies have shown that adding measures of perceived accessibility sheds light on the future direction of transportation resources, in terms of reducing social exclusion and improving subjective wellbeing and higher quality of life [1,32,43,44].

3.3. Social Drivers of Perceived Accessibility

A groundswell of research in examining the social determinants of perceived accessibility is revealing significant differences among social groups based on gender, age, income and education. Although many of the studies did not find any significant variations in perceived accessibility between men and women [19,50,51] contrary evidence was found in a few cases like Sweden where women held higher perceptions of accessibility than men

when specific travel mode is not considered [3]. However, the oldest women still perceived accessibility lower than their counterpart men [52]. In general, when travel mode (e.g., public transport and carpooling) is considered, no significant differences arise between gender [27,31,52].

Age is regarded as an influential sociodemographic factor in differentiating perceived accessibility, but the direction remains inconclusive. Sundling et al. [24] argue that older adults have limited functional abilities and become less mobile, making them highly dependent on the help of other people or devices. The design of the built environment and urban infrastructure also sometimes inhibit the capacities of the older generation to use them. Thus, older people are commonly found to have lower perceived accessibility than younger people [27,29,53]. Ryan et al. [29] investigated perceived accessibility of a major train station in Perth, Australia and discovered that regardless of the form of transportation used to reach the station, (i.e., driving, walking or bus), elderly adults were less satisfied with access to the station. Curl [7] also found that older people reported longer public transport and travel times to urban facilities such as supermarkets and hospitals than younger people even in the same residential area. With increasing population ageing in many countries, people's mobility is commonly impaired due to age, consequently lowering their access to facilities and services within their neighbourhoods, which affects their quality of life [54]. However, retirees can indicate higher perceived accessibility when urban services are appreciably accessible by public transport [52]. When older adults experience reduced capabilities to drive, they are likely be more satisfied with accessible public transport. In a single study, Van der Vlugt et al. [50] found that age's effects on perceived accessibility are not conclusive as perceived accessibility decreased significantly with age in the United Kingdom but not in Germany. This is surprising because the focus in the latter case was on pedestrian accessibility and thus measured how satisfied people are with walking as the main mode for accessing facilities and destinations.

Socioeconomic status has also been identified as a crucial determinant of perceived accessibility in recent studies. Some studies [53,54] imply that individuals with low incomes often perceive less accessibility of transport systems and urban services in some parts of the city. The primary reason is that low-income neighbourhoods are usually located at the fringes and unplanned sections of most cities that lack adequate access to transport and other urban facilities. However, at the neighbourhood level, higher-income individuals commonly have less perceived accessibility potentially due to their higher expectations from local transport systems. In Hamburg, Germany, Van der Vlugt et al. [50] found that people with lower incomes had higher perceived walking accessibility when using local public transport was easier for them. Thus, low-income individuals only feel comfortable with accessing their urban facilities when they have a convenient public transport system. The clear correlation between income and perceived accessibility was not established in Malmö, Sweden where Lättman et al.'s [3] study found no significant differences among income groups. Like income, educational qualification has also been a sociodemographic variable of interest in perceived accessibility research but is generally found to be insignificant [52,53]. Friman et al. [31] found that years of education was negatively associated with perceived accessibility of carpooling, indicating that less educated people expressed satisfaction with carpooling services. Table 4 provides the key social drivers of perceived accessibility presented by different researchers.

Table 4. Key social drivers affecting perceived accessibility.

Study	Age	Gender (Women)	Income	Education
Friman et al. [8]	+	+	n/a	n/a
Friman et al. [31]	0	0	n/a	-
Lättman et al. [3]	0	+	0	n/a

Table 4. *Cont.*

Study	Age	Gender (Women)	Income	Education
Lättman et al. [51]	0	0	n.a	-
Lättman et al. [52]	−/+	+	n/a	n/a
Marquez [54]	-	n/a	+	n/a
Olsson et al. [28]	−/0	+/0	n/a	0
Ryan et al. [29]	-	n/a	n/a	n/a
Vitman-Schorr [19]	-	0	n/a	0
Van der Vlugt et al. [50]	0	0	-	0

Notes: positive (+), neutral (0) and negative (−) relationship with perceived accessibility.

3.4. Barriers to Perceived Accessibility

Accessibility is subject to several barriers that limit people's ability to move [55,56]. To plan for a socially inclusive society, knowing how accessibility barriers relate to perceived accessibility is also relevant. Decreasing the barriers to accessibility improves people's access to activities and destinations. Some of the well-documented accessibility barriers in the literature are time/financial resources, organisation functions, uncertainty and danger and geographical accessibility difficulties. Removing these impediments would result in a socially inclusive society where all people have access to public transport.

The time that people must travel, and their budget to undertake the travel (and/or uncertain time between transfers and unreliable services) are the first barriers listed in the literature. Work, household, and child-care responsibilities are all common schedule limitations [57,58]. Previous research showed that perceived accessibility to public transport has a positive association with travel time and trip coordination [21]. However, no study has examined the link between constraints relating to people's socioeconomic level (e.g., access to a personal vehicle, family status), or time management barriers (e.g., challenges in unplanned travelling).

Several studies have investigated the relationship between perceived functionality and usability of public transport systems. Tiznado-Aitken showed that low-quality bus service and non-accessible public transport stops have negative effects on perceived accessibility [59]. This study also showed that traffic congestion caused by operational breakdowns has a detrimental impact on perceived usability. Perceived accessibility of bus users in Sweden was improved by improving the efficiency with which public transportation systems operate such as displayed information at the bus stop, better boarding and departing, and on-board vehicle announcement [27]. In a similar study, accessibility was positively associated to perceived information, comfort, and functioning satisfaction [8].

Another accessibility barrier is insecurity and unsafety and apprehension of being a victim of a crime [60]. Accessibility is further hampered by the possibility of injury and/or disease transmission, which limits people's mobility. As a result, accessibility is linked not only to the capacity to use public transportation but also how safe people feel when travelling. A number of studies have found a link between perceptions of accessibility and security [8,27].

Another type of accessibility barriers is geographical barriers that limit people's ability to move. Therefore, where a person lives define their access to public transportation [37]. In [61], scattered locations limited an individual's ability to undertake their daily activities in immediate areas. Geographic accessibility barriers are related to a lack of public transportation infrastructure and a preference for private vehicles over public transportation services. Furthermore, when designing new residential areas, the provision of bus stops is not often considered in the preliminary planning stages, in resulting bus stops relocated further away from people's homes.

Lättman, et al. [3] found that participants in a study in Malmö, Sweden confined ideas of accessibility to active travel and public transportation while respondents still had

the option of travelling by automobile, which were consistent across geographical area. The perception of accessibility varied greatly amongst residential zones, and, surprisingly, the city centre was not seen as the place with the highest level of perceived accessibility. Weather in various locations can also be a barrier to accessibility because most people dislike waiting at bus stops in extremely cold weather.

3.5. Evaluating Perceived Accessibility

To determine the appropriate policy measure to address accessibility challenges, the ability to measure within given times and places is imperative. Measurements also allow for monitoring of progress or evaluating the effectiveness of policy interventions. Within the emerging literature, varying indicators have been adopted for measuring perceived accessibility. On the one hand, indicators of perceived accessibility have used single questions as proxies. Examples of such indicators include self-reported journey times [7] and ratings of ease of reaching specific locations through different travel modes [29]. On the other hand, some empirical assessments have sought to capture the multidimensionality of the concept by measuring multiple dimensions of people's travel and living experiences (for example, [62]).

Based on the empirical literature, the assessments of perceived accessibility can be categorised under six main approaches as summarised in Table 5.

Table 5. Common indicators for measuring perceived accessibility.

Approach	Example of Indicators	References
Destination- and/or activity-focused	Satisfaction or ease of accessing services and locations Possibilities of performing preferred activities	[19,27,51]
Travel-focused	Perception of journey/travel times Perceptions of travel distance and average speed	[7]
Modal-focused	Satisfaction of travelling with a particular mode of transport Ease to perform activities using mode	[24,31]
Utility-focused	Assessment of values or satisfaction with specified range of distances	[30]
Trip-focused	Assessment of perceptions about whole-trip components including quality of service, feeling of safety at and to stations as well as walking environments. It captures the whole-trip experience.	[62]
Overall accessibility	Assessment of ease of performing daily activities Satisfaction of perceived access to preferred activities	[3]

Most commonly (and directly related to objective accessibility), some scholars (e.g., [19,63] apply the concept in examining the perceptions of individuals in reaching specific destinations or performing activities. This approach classified as destination (or activity-focused) examines the ease of reaching specific activity locations and facilities such as train stations, residential suburbs and shopping centres. Assessment can range from understanding people's perspectives of how specific facilities, services or activity locations are accessible [29], combinations of activities [19] or either of the two while considering the specific travel mode [17]. Perceived accessibility in this context also considers varying perspectives of individuals in accessing different activities or services given that perception of easily reaching a health facility may differ for retail shops even in the same location.

The travel-focused accessibility assessment also focuses on perceptions about the time or distance needed to reach specified locations or facilities [7]. In reality, destination-focused and travel-focused accessibility are similar because they both capture perceptions of reaching specific locations or facilities. However, a key distinction relates to the former mainly focusing on how easy it is to reach the facility or location, with the latter mostly

being concerned about the subjective assessment of the time, distance or cost needed in travelling to the facility or location.

In transportation planning literature, a key area of accessibility assessment relates to the use of specific modes of transport. Such modal-focused accessibility often examines the experience or satisfaction of travelling by a particular mode of transport such as railway [24], carpooling [8] and bus or public transport in general [27]. However, some scholars argue that accessibility assessments, especially in relation to public transport, need to identify the experiences of an entire trip capturing the planning, making and finalisation of trips. Thus, trip-based accessibility captures whole trip experiences by examining the perceptions and experiences of easily planning a trip through arriving at the final destination [24].

In theorising accessibility among the elderly, Sundling et al. [14] suggested that perceived accessibility is a complex construct such that its measurements should take the personal abilities, functional limitations, barriers of the travelling environment and actual travel behaviours into account. This is because while the distance to given services and locations may be identical in two instances, different people are likely to have different accessibility perceptions due to varying experiences with certain design characteristics that affect travel, (e.g., functional abilities that differ based on factors such as age, gender and disability). For instance, although the UK's policy interventions have improved London's public transport in general, wheelchair users still faced significant barriers in the use of ramps in bus services [15].

Studies have adopted trip-based accessibility to examine the entire experience of moving from one's origin to destination including weather conditions, safety and quality of service [62]. Lattman et al. [3] extended trip-based accessibility to consider overall accessibility, which captures people's ability to engage in daily activities and opportunities without taking specific travel modes or a combination of modes into account.

Coppola and Silvestri [30] examined perceived accessibility based on the utility individuals place on specific distances to urban facilities and locations. Thus, while not entirely focusing on distance impedance which characterises objective accessibility, the utility-based approach allows different groups of people to rate the value they place on a range of distances covered for accessing facilities.

3.6. Perceived Safety and Service Quality: Prominent Factors Affecting Perceived Accessibility

This section discusses the literature on perceived safety and service quality, two concepts seen to strongly influence perceived accessibility of transport systems [8]. Since this relationship is only now being explored, the section primarily contextualises the studies developed in the original domain into the perceived accessibility discourse.

Perceived safety is referred to as appraising the accessibility with the perception of the scale of appraisal being modified to achieve sustainability in transport [64]. Perceived safety is also defined as subjective feeling by a traveller's risk awareness of crime and public disturbance [65]. Examining what constitutes perceived safety as a rationale for a traveller's choice of transport mode requires an urgent investigation of critical issues regarding perceived safety.

Eboli and Mazzulla [66] found perceived safety to be one of the key contributors to public transport passengers' satisfaction. Improving safety perceptions will affect a traveller's satisfaction with a better quality of the system. For instance, safety was found to be the most important contributor affecting bus passengers' satisfaction in Edinburgh [67]. Concern [68] pointed out a study in the UK indicating that some travellers are changing transport choices due to perceived safety. Another study examining passengers having different safety perceptions found that security concerns of specific locations affect how these individuals perceived their access to transport [69].

Perceived safety is also significant and essential for accessibility to transport [70]. Travellers are hesitant to drive their cars, walk and cycle in a region that has a high percentage of criminal misconduct and wrongdoing, thereby affecting their access to travel modes. Litman [71] also highlighted that perceived safety is a contributing factor to

the perception of accessibility with a significant moderating role in affecting the quality of service.

3.7. Factors Affecting Perceived Safety

3.7.1. Demographic Aspects

The criminology literature has extensively examined the effect of demographics on fear of crime. Past research [72,73] suggests that the fear of crime was perceived highly among vulnerable groups including the elderly, women and people living with disabilities. The transport literature generally underscores the implications of several demographic features on perceived safety [72,74] but not all investigations reveal a strong correlation between sentiments of traveller's ageing and safety [72,75–77].

3.7.2. Financial Attributes

In fact, socioeconomic characteristics are also thought to influence the dread of wrongdoing. For example, it is common for individuals to perceive their neighbourhood as a low socioeconomic area and unsafe to be generally anxious and doubtful of other travellers [78,79]. According to Loukaitou-Sidaris et al. [80] wrongdoing rates at light rail stations were higher in low-paying and high-density regions. Pantazis [73] also found people living in poverty will undoubtedly feel danger on their streets and in residing in their houses at night-time [80]. According to Kennedy [81], most travellers are bound to feel risky making a trip by bus or train. Almost certainly, neighbourhood qualities are a significant attribute for travel that starts or ends at home. A review by Morse and Benjamin [77] observed that crime percentages in census data very much intensified sentiments of uncertainty on travelling in public transport.

3.7.3. Psychological Attributes

The psychological health component is relatively complex with the diversity of travellers in transport systems, but this component is notably vital in forming safety perceptions. A study on teenagers saw that fear of bad behaviour lessened impressions of trust in other travellers [82]. Additionally, a study revealed in an investigation of elderly travellers that forming relationships and having a sense of connection and attachment contribute to moderating concerns in relation to safety, crime and public disturbance [83]. Security is a huge concern for elderly travellers because they will probably be more seriously harmed, take more time to recuperate and experience more prominent mental effects than younger travellers.

Generally, elderly travellers stress over their security and are hesitant to take public transport because of elements such as public threats, disturbances and risks of injury or harm. In some countries, elderly commuters are susceptible to social shame relating to the usage of public transport, potentially hindering their travel choices. This issue could be overcome by initiatives to prepare plans that can assist with introducing the certainty and access abilities in people expected to travel on public transport. Such initiatives will be significant for elderly travellers who have quit any pretence of driving because of wellbeing reasons but will be relying to travel on public transport.

3.7.4. Situational Determinants

Travellers feel considerably less protected on a dim road alone compared with travelling in a group in the daytime. Various circumstances of situational determinants can derive different reactions to public transport where these elements are viewed when planning the travelling system that will cause travellers to feel more secure [84]. Despite the variables under the immediate control of transport organisations, demographic aspects and financial attributes that support the perception of health and wellbeing should be understood as fundamental to the sentiment of safety. Wallace et al. [85] summarised by stating that improving safety initiatives is pointless in the efficacy of shaping perceived safety due to traveller attributes and not service quality. These different determinants also are likely

to interact (at least situational determinants) with the individual attributes (demographic aspects) and psychological components.

3.8. Models for Service Quality

There is emerging research evidence suggesting that perceived accessibility is influenced by perceived service quality [8] but the latter has also received significant attention as a standalone concept in transport research. Sudaryanto and Kartikasari [86] defined service quality as the level to which a service meets customers' needs and expectations. However, in its long treatment in the literature, there are notions suggesting that the perceived quality of public transport service is multidimensional. Thus, studies reviewing perceptions of service quality have considered elements relating to functionality (reliability, travel time, frequency, distance), information (reliable and timely) and comfort (clean and access to a seat). Others [69]) also underscore the monetary factors such as cost of travel, fare structures and ticketing validity as important dimensions.

Three main models have been used for assessing service quality: the perceived service quality model, gap analysis model and dynamic process model of service quality [87–90]. Grönroos [87] proposed the perceived service quality model based on two dimensions: technical outcome and functional process quality. The technical outcome represents what customers receive whereas the functional process refers to how customers receive the outcome or how the service is delivered. Thus, this model postulates that service quality evaluation should not solely depend on the outcome of service but also involves the way the service is delivered. Although these two quality dimensions are quite different, they are interrelated in affecting the perceived service quality from customers [87].

Under the gap analysis model, a series of discrepancies or gaps are identified in relation to the customers' expectations, perceptions of service delivery and the external communications from service providers [86]. According to Parasuraman et al. [88], customers' assessment of service quality involves ten overlapping dimensions. They are tangibles (physical aspects of the service), reliability (consistency of performance), responsiveness (readiness to provide service), communication (keeping customers informed), credibility (trustworthiness), security (freedom from danger), competence (with required knowledge and skills), courtesy (respect and friendliness), understanding/knowing the customer (aware of customers' needs) and access (ease of contact) [88]. Further refinement led to the development of the SERVQUAL scale for measuring service quality. SERVQUAL comprises five dimensions in which the first three original dimensions of tangibles, reliability and responsiveness are maintained. On the contrary two dimensions—i.e., assurance and empathy—consolidate the remaining seven original dimensions [89]. Assurance refers to the knowledge and courtesy of service providers and their ability to provide confidence and trust to customers whereas empathy indicates individualized attention to customers' needs by the service providers [89].

Boulding et al. [90] proposed the dynamic process model which captures the change in customers' perceptions of service quality over time and considers their prior expectations and the actual service experienced. These perceptions of quality dimensions form the basis for customers' overall service quality evaluation. Customers revise their expectations when they receive relevant updated information about the service through various ways, such as word-of-mouth, advertising campaigns and contact with the service delivered by companies and their competitors [90].

Among these three models of service quality, Parasuraman et al.'s [88,89] SERVQUAL methodology has received widespread attention in research and application across industries such as banking, hospitality and tourism [91–93]. SERVQUAL has also been extensively used in the transport sector because of its ease of implementation and interpretation [94]. For example, SERVQUAL was to analyse the public bus service quality in Ghana [95] and passenger railway service quality in China.

SERVQUAL is useful to measure customer expectations and perceived service quality based on the relative importance of service dimensions or attributes. Under this tool,

customer satisfaction is examined by comparing their expectations with the actual performance. The findings enable an organization or service provider to prioritize the use of resources and action items to address the issues and improve the most critical service dimensions [86]. The expectations-perceptions gap also allows for continuous improvement of the service quality.

As indicated earlier, the five dimensions of SERVQUAL ensure that quality is examined across a broad spectrum of service dimensions. The tangibility dimension evaluates the physical facilities, equipment and personnel whereas reliability assesses the performance of the promised service accurately and punctually. Responsiveness refers to the willingness to provide timely service and prompt assistance to customers. The last two dimensions are the assurance to customers in terms of the expertise and knowledge of the service providers and their empathy for customers' individual needs [89].

Despite its widespread recognition, there has been criticism about the universality of the SERVQUAL dimensions and the application to measuring service quality for all scenarios [96]. However, it has been argued that the original idea of the SERVQUAL scale was to be used as a framework allowing for modifications based on context-specific characteristics of an organisation or service [97]. Consequently, Prasad et al. [98] developed the RAILQUAL tool as an adaptation of SERVQUAL to evaluate the passenger railway service quality in India. Through interviews with passengers, three additional elements (i.e., comfort, connection and convenience) were proposed in relation to railway passenger service. The empirical findings of this study revealed that passengers' perception of tangibles, convenience and assurance performed highly compared with reliability and responsiveness which received the lowest score. The study was useful for the railway operator to monitor and improve the service provided [98]. Barabino et al. [94] also proposed a modified SERVQUAL version that is compatible with EN13816 (the European standard on service quality in public passenger traffic) in examining the service quality in urban bus transport in Italy. Consistent with the macro areas of EN13816, eight dimensions of service were unravelled, namely, accessibility, availability, comfort, customer care, environmental impact, information, security and time. This study provided a service quality evaluation tool readily applicable to the certification of transport service operators in Europe [94].

As a determinant of perceived accessibility in relation to public transportation, it is expected for the five generic SERVQUAL dimensions to be adjusted. Reliability may reflect punctuality of the service and the availability of bus service information [99] whereas assurance refers to the knowledge, skills, courtesy and trustworthiness of drivers and their ability to convey confidence [94]. The tangibility dimension covers the neatness and tidiness of bus drivers, the cleanliness on-board and the provisions to cater to disabled and older adults [95], with empathy relating to concern and attention given to addressing passengers' needs, which includes the ease of finding the information about transport routes, service frequency and adequacy of the connection of different modes of transport [100]. The responsiveness dimension is about the readiness to assist passengers and the communication to passengers in advance of service availability and any changes, including planned and unplanned buses not in service [101].

4. Discussion

Despite the acknowledgement of the long history and relevance for urban and infrastructure planning, no consensus has been reached about the concept of perceived accessibility in transport literature, evaluation methods, and key influencing factors that shape this concept. Although the idea emerged back in the 1970s, perceived accessibility has only recently received significant research attention. An analysis of studies on the use of this concept in the transport literature indicates that more than 85% were published within the last decade (2012–2022) (Figure 2).

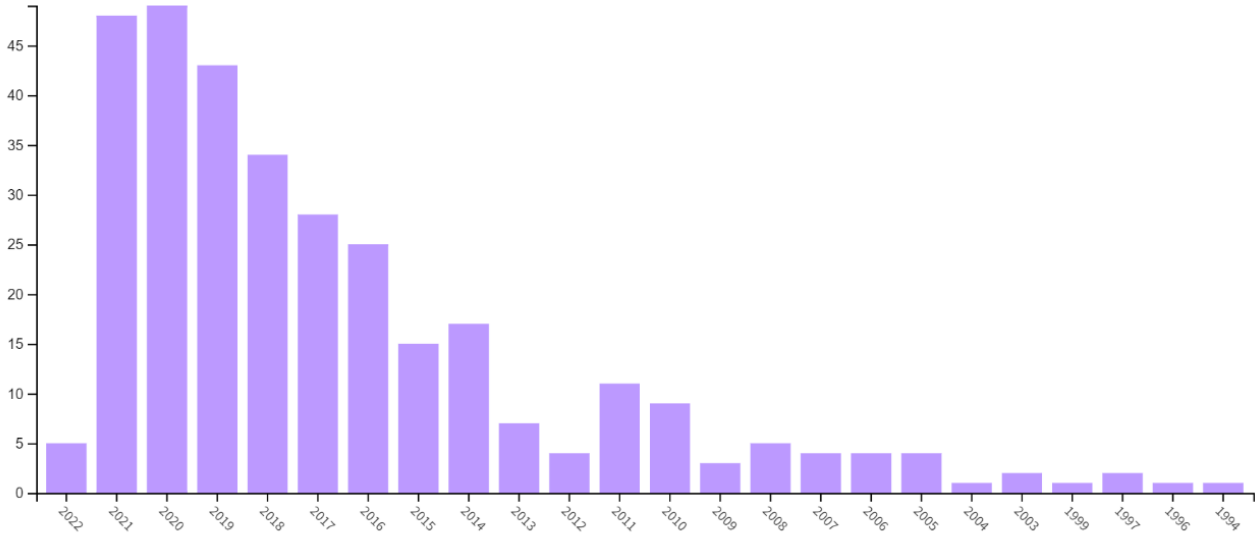

Figure 2. Published literature on the acknowledgement of perceived accessibility in transportation (Visualisations from Web of Science as of 6 April 2022).

The bibliometric co-citation analysis of the data from the Web of Science indicates that the emerging research on perceived accessibility in the transport literature draws heavily from four interrelated influential nodes of literature (Figure 3). Co-citation analysis is a unique method for studying the cognitive structure of science by tracking pairs of papers that are cited together in sourced articles. Combined with single-link clustering and multidimensional scaling techniques, co-citation analysis can literally map the structure of specialised research areas as well as science as a whole.

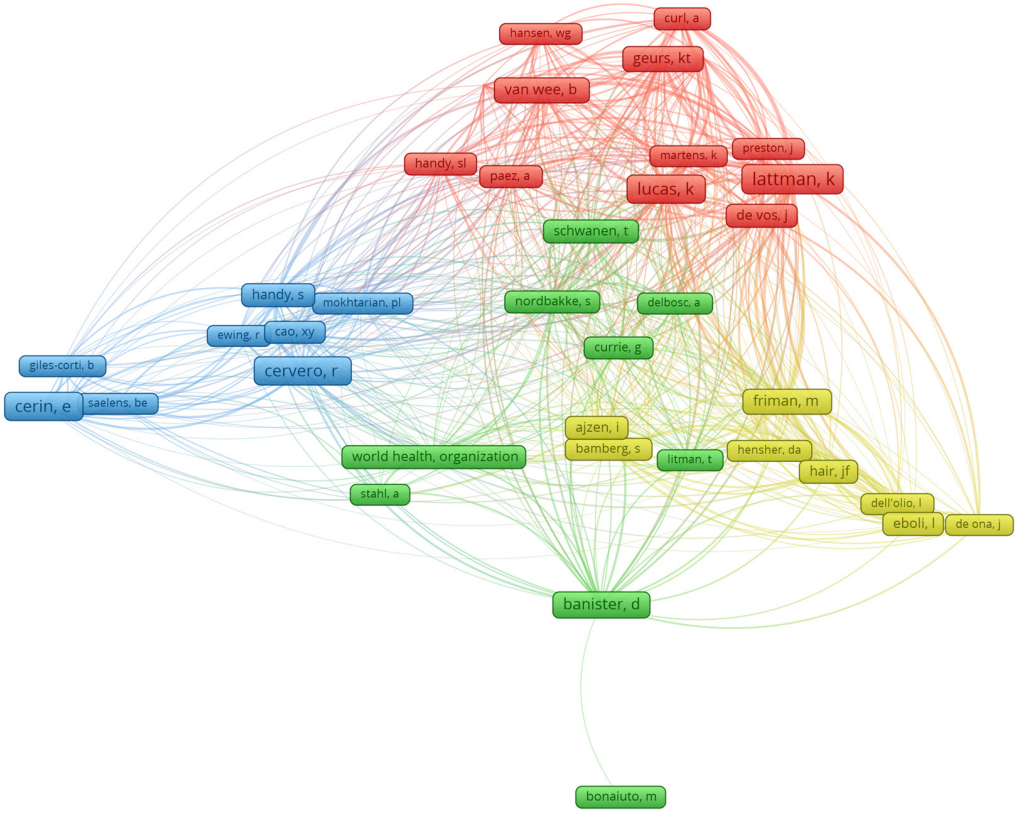

Figure 3. Influential authors in perceived accessibility in transport literature.

The first node (red) reflects the emerging studies integrating the concept of perceived accessibility in transportation research [1,5,27]. It covers the body of work that has begun to explore perceptions and behavioural dimensions as an alternative to the conventional accessibility literature. Farrington [40] argued for a "new narrative of accessibility" that is as much about people as it is about places. This indicates that accessibility is best measured by people's perception of their ability to engage with life opportunities. Such consideration is particularly important given the obvious gaps between what is measured and what is actually desired by communities and stakeholders [1]. In other words, this body of literature defines accessibility as an "attribute of people . . . rather than transport modes or service provision" [4] (p. 12).

The second node of research (yellow) draws strong linkages between perceived accessibility and other transport-related concepts such as service quality and safety. The literature under this node mostly suggests that perceived quality and safety of services are critical determinants of participating in daily activities through the use of public transport [8,31]. Thus, it draws from existing studies on service quality and customer satisfaction such as Eboli and Mazzulla [66] to evaluate the relationship with perceived accessibility.

Perceived accessibility is by no means restricted to transportation research. Applications in urban studies [100], urban health and social science medicine [24,51,102] are growing. This literature node (blue) typically introduces perceptions in exploring accessibility in relation to physical activity, walking and use of neighbourhood facilities and services [103,104]. However, another strong node (green) has explored measures perceived to significantly affect accessibility and quality of life within residential neighbourhoods among the vulnerable such as the elderly. With transportation regarded as a social determinant of health, this cohort of studies places perceptions of accessibility at its centre.

In this study, we systematically reviewed the literature related to perceived accessibility in the transportation context. The results showcase a strong focus on the first and second nodes, where research demonstrated applications of perceived accessibility in transportation and the strong linkages with the quality of transport services and their safety. Figure 4 shows the word cloud generated from the abstracts of the articles reviewed in greater detail indicating the common terms appearing in the literature. As expected, words such as accessibility, perceived, transport and services are the most dominant words. Other major keywords include opportunities, safety, quality, older adults (elderly), mobility, people, indicators, perceptions, services, quality and satisfaction, which feature in the core parts of the analysis. Thus, the review indicates that addressing barriers in relation to the safety and quality of services might contribute greatly to improving the perceived accessibility of public transport. Given previous findings, such an endeavour will not only facilitate mobility in urban areas but also help in ensuring satisfaction and equity in accessing opportunities for the health and wellbeing of people.

Safety and security issues can be interpreted as sentiments of concern, doubts and unease from uncertain circumstances. Previous studies point out that the perceived safety of travellers usually entails an assessment of injury risk [105,106]. Eboli and Mazzulla [66] found that perceived safety is one of the key contributors to public transport passengers' satisfaction. Improving safety perceptions will affect travellers' satisfaction with the quality and lead to better service.

Evidence has suggested that travellers' safety perception is the main attribute of transport choice. A UK study revealed that some travellers change transport choices due to perceived safety [68]. Another study examined passengers having different safety perceptions that security concerns of specific locations with an effect on how these individuals would perceive safety in transport [69].

Our review also shows an increasing amount of research exploring the effect of perceived safety and service quality on perceived accessibility. Variations of perceived accessibility across different geographical areas with different safety levels are shown in a study conducted by Vitman-Schorr et al. [19]. In this study, which was conducted among older adults in Israel, rural residents perceived their environment as more accessible

than their urban compatriots. The findings indicate that rural residents displayed better perceptions of accessibility because they perceived their living environment to be relatively safer and as enabling social participation.

Figure 4. Common keywords in the abstract of selected publications.

Urban dwellers of one city may report different levels of perceived accessibilities. However, our review also shows that proximity to the CBD of cities (known to be objectively highly accessible), does not necessarily lead to increased levels of perceived accessibility or perceived safety. In a study of administrative districts in Moscow, Lukina et al. [107] found that proximity to the city centre did not necessarily improve perceptions about accessibility. Instead, some districts located farther away from the city centre reported higher perceived accessibility than areas close by. This finding corroborates Lättman et al.'s [3] study, which found that nearness to the CBD did not necessarily improve residents' perception of accessibility or safety in their neighbourhoods.

In this review, the service quality perceptions by public transport customers have been thoroughly investigated, its various models have been particularly discussed and its link with perceived accessibility was explored. Our review shows that to understand customers' needs and expectations, regular service quality evaluations need to be carried out. These findings will be valuable for assessing the adequacy of current public transport services and identifying potential areas for continuous improvement.

Studies in transport have recommended that perception of public transport accessibility [108,109] and security influence the satisfaction of service quality [109,110]. Safety perception will likely shape the decision of choice, behaviour and frequency in travelling with public transport. Safety perception can be expected to direct the relationship between accessibility and service quality in public transport. In general, the ability to access public transport will enhance service quality when travellers perceived no threats while commuting in public transport. Similarly, the availability of public transport will not contribute to accessibility and service quality when a perception is formed that public transport is dangerous, with concerns of threats when travelling.

Upon satisfying essential requirements, people will endeavour to accomplish a more significant level of necessities with an increased feeling of safety. Satisfied travellers with the

most significant levels of need are prone to experiencing better service quality. In general, a high safety perception can be expected to increase public transport accessibility, thereby improving service quality for travellers.

5. Conclusions

Although the concept of accessibility can be traced back to its 1920s application in location theory and regional economic planning, its positive treatment in empirically describing and quantifying the ease of access to services particularly from the perspectives of people is only developing. In reality, accessibility is only as good as the ease with which people experience the services and activities, but this has received little research attention. To fill this gap, we conducted a systematic literature review on the concept of perceived accessibility and focused on its definition, barriers, evaluation methods and its key influential factors.

This systematic review shows that to reduce the differences in qualitative perceptions between service providers and end users, we need to put customers at the core of public transport policies. The study shows that perceived safety and service quality must be addressed in transportation and planning policies to ensure that unsafe and low-quality perceptions, which would reduce the level of perceived accessibility, are decreased. Therefore, it is paramount to address the awareness and understanding of feeling safe, without fear of crime or accidents, and assure the users of high-quality public transport. A range of studies has examined different factors affecting safety that make people more or less likely to feel safe in various situations. These components included situational, demographic, socioeconomic and psychological factors.

Urban morphology, planning policies and public transportation policies will play critical roles in highlighting the importance of perceived accessibility. The concept can be easily applied in compact, dense and mixed-use urban developments. However, its implication in dispersed urban forms, where urban sprawl is a normal phenomenon, requires a long-term vision and strategies. Further research is required to generate empirical evidence on where these efforts are working or failing to develop lessons for the sustainability agenda. Progress has been made in this regard, with about four out of every five research articles undertaking empirical assessments of related topics. However, these empirical studies are mostly Euro-centric, with more than 50% of existing empirical studies using an European city as their research focus. Sweden is the most studied country, featuring in 12 out of the 26 studies conducted in Europe. Other common countries include Great Britain, China, Vietnam, the Netherlands and Canada. Future work should aim to find methods in not only quantifying perceived accessibility in different contexts but also find innovative solutions to increase the perceptions towards accessibility. One of the greatest barriers to this goal is a difference in the concept of perceived accessibility between policymaker and community (end-users) perspectives. End users may think of perceived accessibility in certain ways, which might be totally different from policymaker beliefs. Similarly, the actions that need to be considered may seem crucial for stakeholders but unnecessary for communities. Therefore, paving the way to sustainable transportation with high levels of perceived accessibility will not be feasible without having clear and honest communication between communities (i.e., users of the transport systems) and stakeholders.

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