

Review

Accessibility in Bus-Based Public Transport Across European Cities: A Bibliometric and Thematic Review of Bus Stop and Station Infrastructure for Inclusive Urban Mobility

Melania Petrea, Carmen Gheorghe * and Adrian Soica

Department of Automotive and Transport Engineering, Transilvania University of Brasov,
500036 Brasov, Romania; melania.petrea@unitbv.ro (M.P.); a.soica@unitbv.ro (A.S.)

*Correspondence: carmen.gheorghe@unitbv.ro

Abstract

Accessibility in bus-based public transport is essential for inclusive and sustainable urban mobility, yet bus stops and stations are often overlooked compared with vehicle modernization and network planning. This study presents a bibliometric and thematic review of research (2020–2026) on accessibility in bus stop and station infrastructure across European cities. Literature indexed in the Web of Science Core Collection was analyzed using thematic synthesis supported by bibliometric network analysis. A total of 685 publications were examined to identify research trends, barriers, regional differences, assessment methods, and planning implications. The findings show that accessibility is a multidimensional concept shaped by physical design, information systems, user experience, first- and last-mile connectivity, and governance capacity. Persistent barriers include poor boarding interfaces, inadequate maintenance, weak wayfinding, safety concerns, and uneven implementation of accessibility standards. The reviewed studies suggest that evidence of stronger integration and higher user satisfaction is more frequently reported in Northern and some Western European contexts, whereas rural and smaller cities often face lower service accessibility. Emerging topics include real-time passenger information, crowding management, electric buses, and smart mobility technologies. The review concludes that bus stops and stations should be treated as strategic mobility assets. Integrated planning, participatory design, and territorially differentiated policy support are essential to advance inclusive bus-based public transport across Europe.

Keywords: bus stop accessibility; bus station design; inclusive mobility; public transport; sustainable urban transport; universal design; European cities; first-mile last-mile connectivity; transport equity; bibliometric and thematic review

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1. Introduction

Public transport systems play a central role in advancing sustainable urban mobility by reducing congestion, lowering greenhouse gas emissions, and promoting more equitable access to urban opportunities [1–3]. Across European cities, policy frameworks increasingly emphasize the transition toward inclusive and sustainable transport systems that serve the needs of all users [4,5]. Within this context, accessibility has emerged as a critical dimension of transport sustainability [6,7], ensuring that infrastructure and ser-

vices are usable by diverse population groups [8], including people with disabilities [9,10], older adults [11,12], and individuals with reduced mobility [13,14].

The policy framework supporting accessibility in Europe has been further strengthened through Directive (EU) 2019/882, commonly referred to as the European Accessibility Act. The directive aims to reduce accessibility barriers and promote equal participation of people with disabilities by establishing harmonized accessibility requirements across Member States. Although primarily focused on products and services, its principles support broader objectives related to accessible mobility and passenger information systems. In the field of bus and coach transport, accessibility is also supported by Regulation (EU) No 181/2011 concerning the rights of passengers in bus and coach transport, which establishes obligations regarding non-discriminatory access, assistance for people with disabilities and people with reduced mobility, staff training, and accessibility of travel information and ticketing services. Together, these regulatory instruments provide an important policy framework for promoting inclusive public transport systems across Europe [15,16].

Accessibility in bus-based public transport is a multidimensional concept encompassing not only the physical characteristics of infrastructure, but also the ease with which passengers can reach, understand, use, and benefit from transport services. It includes factors such as pedestrian access to stops, barrier-free boarding and alighting, service availability and frequency, affordability, access to real-time information, personal safety, comfort, and the integration of bus services with other transport modes. Consequently, accessibility is shaped by the entire travel chain rather than by individual system components in isolation [17–19].

Within this broader framework, bus stops and bus stations represent critical interfaces between passengers and the public transport network. As the primary points of access to bus services, they influence whether users can successfully complete their journeys regardless of age, physical ability, or travel experience. Unlike vehicles, which are often subject to standardized accessibility regulations, stop- and station-level infrastructure frequently exhibits considerable variation in design quality, maintenance, information provision, and compliance with accessibility standards. Features such as sidewalk connectivity, shelter availability, seating, lighting, wayfinding systems, boarding platforms, and digital passenger information can significantly affect usability and travel experience. As a result, deficiencies at stops and stations may create substantial barriers to mobility and social participation, even within otherwise well-developed public transport systems.

In the European context, accessibility in public transport is supported by a range of regulatory frameworks and policy initiatives aimed at promoting universal design and social inclusion [20–25]. However, despite these efforts, disparities persist between countries and cities in the implementation of accessibility measures [6,26,27]. Differences in urban form, governance structures, funding mechanisms, and planning priorities contribute to uneven accessibility outcomes [28–30]. Furthermore, a gap often exists between policy objectives and on-the-ground conditions, particularly at the level of local infrastructure such as bus stops and stations [31,32].

Recent research has increasingly addressed accessibility in public transport, employing diverse methodological approaches such as accessibility and safety audits, Geographic Information System (GIS)-based analyses, and user-centered evaluations [33–36]. While these studies provide valuable insights, the existing literature remains fragmented, with a strong emphasis on case-specific analyses and limited synthesis focused explicitly on bus stop and station environments within European cities. There is a need to consolidate current knowledge on physical infrastructure, information systems, user experience, and policy implementation to better understand common challenges and emerging trends [37–40].

Despite the growing body of literature on public transport accessibility, existing reviews predominantly focus on network accessibility, travel behavior, or vehicle design. Comparatively little attention has been devoted to synthesizing evidence on bus stops and stations as critical interfaces between users and transport systems. This gap is particularly important because accessibility barriers at these locations may prevent the effective use of otherwise accessible transport services.

In response to this gap, this paper presents a bibliometric and thematic review of accessibility in bus-based public transport infrastructure across European cities, with a specific focus on bus stops and bus stations. The review synthesizes recent literature (2020–2026) to identify key factors influencing accessibility, examine differences in implementation across urban contexts, and evaluate the extent to which current practices align with principles of inclusive and sustainable mobility.

The objectives of this study are threefold: to analyze the main physical, informational, and user-centered dimensions of accessibility in bus stop and station environments; to assess how accessibility is addressed in European research and practice; and to identify research gaps and propose recommendations for improving accessibility in public transport infrastructure. By providing a structured synthesis of recent evidence, this review contributes to the broader discourse on sustainable urban transport and supports efforts to enhance social inclusion and mobility equity across European cities.

To guide the analysis, this bibliometric and thematic review addresses the following research questions:

- (1) What are the principal barriers affecting accessibility at bus stops and stations in European cities?
- (2) Which methodological approaches are most used to assess accessibility in the reviewed literature?
- (3) What regional differences and contextual variations emerge across European urban settings?
- (4) What planning and policy recommendations can be derived to support more inclusive bus-based public transport systems?

2. Search Strategy and Selection Criteria

2.1. Review Design

Literature for this bibliometric and thematic review was retrieved from the Web of Science Core Collection, a widely recognized database for peer-reviewed interdisciplinary research. This database was selected due to its comprehensive coverage of interdisciplinary research related to transport systems, urban studies, and accessibility.

2.2. Search Query

A structured search strategy was developed to identify studies addressing accessibility in bus-based public transport systems, with particular emphasis on bus stops, bus stations, passenger interaction, and accessibility assessment. The search was conducted in the Web of Science Core Collection on 15 March 2026 using the Topic Search (TS) field, which searches article titles, abstracts, author keywords, and Keywords Plus.

The search was performed using the Web of Science Query Builder and combined the following topic terms through Boolean operators:

TS = ("bus stop")

OR TS = (accessibility AND "public transport")

OR TS = ("bus station" AND passenger)

OR TS = ("user integration" AND "vulnerable passenger" AND GIS)

The search strategy was intentionally designed to maximize sensitivity and capture the diverse terminology employed across disciplines investigating public transport accessibility. Because accessibility-related research is distributed across fields such as transport engineering, urban planning, geography, mobility studies, and social inclusion, a broader retrieval strategy was preferred to minimize the risk of excluding potentially relevant studies. Therefore, the bibliometric dataset includes both studies directly addressing bus stop and bus station accessibility and broader public transport accessibility research that provides relevant methodological, operational, technological, or planning perspectives. The subsequent thematic screening process was used to identify the subset of studies most directly focused on bus stop and station environments.

The term “bus stop” was included as a standalone descriptor because preliminary exploratory searches indicated that it represents one of the most frequently used terms for studies focusing on passenger-interface infrastructure within bus-based transport systems.

Similarly, the combination of “accessibility” and “public transport” was included to capture studies addressing accessibility at a broader system level. The term “bus station” was combined with “passenger” to identify research examining user experiences and interactions within transport facilities.

The inclusion of “GIS” was intended to ensure the representation of studies employing spatial and accessibility-assessment methodologies, which constitute an important research stream within the field. The expression “user integration” was used to capture studies examining the interaction between transport users and public transport systems.

Given the intentionally broad scope of the search strategy, thematic relevance was subsequently verified through title and abstract screening, followed by selective full-text assessment where necessary. This broad-then-screen approach allowed for comprehensive coverage of literature while maintaining thematic consistency during the synthesis stage.

2.3. Inclusion Criteria

To ensure the relevance and consistency of the reviewed literature, a set of predefined inclusion criteria was applied during the database query stage. The literature search was conducted on the Web of Science Core Collection on 15 March 2026. Only publications indexed between 1 January 2020 and 15 March 2026 were considered, ensuring a focus on recent developments and contemporary challenges in public transport accessibility. The selected period was intended to capture post-pandemic mobility changes, the increasing digitalization of transport systems, and recent sustainability and accessibility policy developments within Europe.

In addition, one relevant publication was identified and incorporated on 5 June 2026 through supplementary screening of the literature. This publication satisfied the same inclusion criteria applied in the primary search and was considered important for ensuring comprehensive coverage of the topic.

Exclusion criteria included studies focusing primarily on rail, metro, private vehicle, or aviation systems without substantial consideration of bus infrastructure; studies conducted exclusively outside Europe; and studies not addressing accessibility at the stop, station, or passenger-interface level.

The geographical scope was restricted to European countries, including countries such as Italy, Germany, Spain, the Netherlands, Poland, France, Sweden, Belgium, Portugal, Greece, Denmark and Hungary, to capture region-specific regulatory, infrastructural, and socio-spatial contexts.

The search was further limited to peer-reviewed journal articles and conference proceedings, thereby ensuring academic rigor and methodological reliability. Only English-

language publications were included to maintain consistency in interpretation and analysis. In terms of thematic relevance, studies were required to explicitly address bus stops or bus stations in relation to accessibility, user interaction, infrastructure design, or service integration within public transport systems. No duplicate records were identified in the Web of Science export.

After applying the database filters and predefined eligibility criteria, 685 unique publications were identified and retained as the initial dataset for subsequent bibliometric analysis, as shown in Figure 1.

Of the 685 records included in the bibliometric dataset, 492 were journal articles and 193 were conference proceedings. Within the final thematic subset of 90 studies, 70 were journal articles and 20 were conference proceedings.

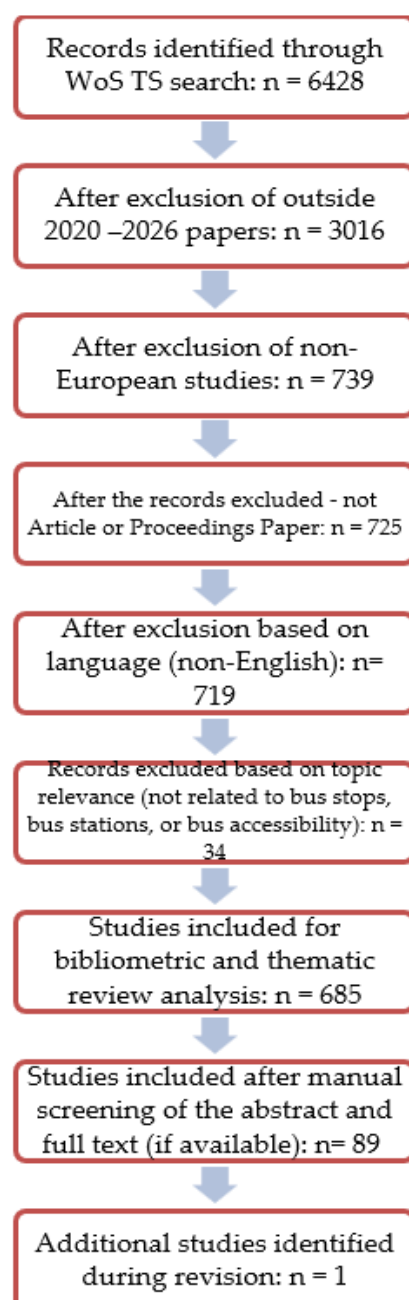


Figure 1. Flowchart of the review process.

Of the 90 studies included in the detailed thematic synthesis, 89 were identified during the primary literature search conducted on 15 March 2026. Following the peer-review

process, an additional publication was identified within the existing dataset of 685 Web of Science records and was incorporated on 5 June 2026 because of the relevance to topics highlighted by the reviewers.

So, the final thematic synthesis included 90 publications retrieved from the Web of Science, 685-records dataset. The remaining 7 references included in the bibliography consist primarily of European regulatory and normative documents, including European Union directives, regulations, and accessibility standards, which were used to provide policy and regulatory context but were not part of the bibliometric dataset analyzed through Web of Science.

2.4. Screening Process

The initial dataset comprised 685 publications that satisfied all predefined inclusion criteria and formed the basis of the bibliometric analysis. To enable a more detailed qualitative synthesis, an additional screening stage was conducted to identify studies with the highest thematic relevance to bus stop and bus station accessibility.

First, titles and abstracts of all 685 records were reviewed to assess their primary research focus and methodological orientation. This process aimed to distinguish studies directly addressing bus stop or bus station accessibility, infrastructure design, user experience, accessibility assessment, and service integration from those addressing broader public transport issues.

Based on this assessment, a subset of 90 publications directly addressing bus stop and bus station accessibility was selected for in-depth thematic analysis. For studies whose relevance could not be determined solely from titles and abstracts, the full text was consulted to clarify scope and contribution. This full-text consultation served as a refinement step rather than a formal exclusion stage. Screening and thematic classification were performed independently by two authors, and any disagreements were resolved through discussion until consensus was reached.

Finally, the 90 selected studies were classified into thematic categories according to their primary contribution, such as infrastructure design, accessibility metrics, user perception, technological solutions, and service integration.

Thus, the thematic findings presented in Sections 3.2 and 4 are derived primarily from the subset of 90 studies, while the bibliometric analyses utilize the full dataset of 685 publications.

2.5. Analytical Approach

Due to the diversity of research designs, disciplinary perspectives, and methodological approaches represented in the selected studies, a bibliometric and thematic review methodology was adopted. This approach is particularly suitable for synthesizing heterogeneous bodies of literature where statistical meta-analysis is not feasible.

The analysis was conducted using a thematic synthesis framework, allowing for the systematic organization of findings across the entire dataset. The reviewed studies were grouped into several thematic domains, with the number of references reported for each category, presented in Table 1.

Table 1. Thematic classification framework used in the literature review.

Thematic Category	Description	No. of References
Physical Accessibility	Includes infrastructure design [41–43], barrier-free access [23,44], and compliance with accessibility standards [7,10,45]	35
Information and Wayfinding	Covers real-time passenger information [29,38,46], signage [47,48], and digital navigation tools [49]	14
User Experience and Safety	Encompasses comfort [50,51], perceived security [6], inclusivity [9], and user satisfaction [52]	29
First- and Last-Mile Connectivity	Addresses integration with other transport modes and broader urban mobility systems [23,45,50,53]	16
Accessibility Assessment Methodologies	Includes audit tools, GIS-based analyses [34,45,54], and performance indicators [50] used to evaluate accessibility [55]	21
Contextual and Regional Variability	Highlights differences across European cities [5,56], planning contexts [57], and policy frameworks [4,58]	32

Studies could be assigned to more than one thematic category; therefore, category totals are non-exclusive and exceed the number of studies included in the thematic synthesis.

This structured approach enabled the identification of recurring patterns, methodological trends, and research gaps, while preserving the contextual richness of individual studies. The thematic framework was developed using a hybrid deductive–inductive approach. Initial categories were derived from established accessibility literature and subsequently refined during full-text analysis. Studies could be assigned to more than one thematic category when their contributions spanned multiple dimensions of accessibility.

A bibliometric network analysis was conducted using VOSviewer version 1.6.20. Bibliographic records were exported from the Web of Science Core Collection in plain-text format, including full records and cited references. The exported fields comprised author information, affiliations, titles, abstracts, author keywords, Keywords Plus, cited references, source information, and citation data, corresponding to the “Full Record and Cited References” export option in Web of Science. Because no thesaurus or keyword-cleaning file was used, synonymous expressions and singular/plural variants may appear as separate nodes in the keyword network.

For the keyword co-occurrence analysis, both Author Keywords and Keywords Plus were included. Full counting was applied, and the association strength normalization method was used. The minimum keyword-occurrence threshold was set to 10. Of the 3492 identified keywords, 75 met the threshold and were included in the final network visualization. No thesaurus or keyword-cleaning file was used. Clustering was performed using the VOSviewer modularity-based clustering algorithm with the default resolution parameter of 1.00.

For the country-level citation and co-authorship analyses, full counting and association strength normalization were also applied. The maximum number of countries per document was set to 25. The minimum number of documents per country was set to 10, and the minimum number of citations per country was set to 10. No thesaurus file was used.

Country names were harmonized according to the Web of Science affiliation records. No sub-national entities were merged because all records were indexed at the country level. The initial inclusion criteria restricted the dataset to European studies, so the non-European countries were excluded prior to generating the VOSviewer country-level networks to ensure consistency with the geographical scope of the review.

2.6. Search Limitations

Several limitations inherent to this review should be acknowledged. First, the study relies exclusively on the Web of Science Core Collection, which, despite its high-quality indexing standards, does not encompass all relevant academic or grey literature. Consequently, some pertinent studies included in other databases (e.g., Scopus, Transport Research International Documentation) may not be included.

Furthermore, the search strategy was intentionally designed to prioritize sensitivity over specificity. Although this approach reduced the risk of excluding relevant studies, some publications employing alternative terminology may not have been captured by the selected search terms.

Second, the restriction to English-language publications introduces a potential language bias, which is particularly relevant in the European context. Research on public transport accessibility is frequently published in national languages through local journals, technical reports, government documents, transport authority assessments, and consultancy studies that are not always indexed in international databases. As a result, evidence from certain regions, particularly Eastern and Southern Europe, may be underrepresented in the reviewed dataset. This limitation may contribute to a greater visibility of studies originating from countries with stronger traditions of publishing in English-language journals and may partially explain the geographical concentration of evidence identified in this review. Furthermore, local accessibility audits, municipal planning documents, and policy evaluations often contain detailed operational insights that are not captured within the academic literature included in Web of Science.

Third, although the dataset consists of 685 publications, the bibliometric and thematic review approach does not aim to provide a statistically exhaustive synthesis. Instead, it emphasizes interpretative depth and thematic integration, which may involve selective emphasis on more influential or representative studies.

Finally, variability in definitions and measurement of accessibility across the reviewed literature presents challenges for direct comparison. Differences in methodological frameworks, spatial scales, and user group considerations may affect the generalizability of findings.

As the objective of this study was to provide a bibliometric and thematic synthesis of the literature rather than a systematic review of intervention effectiveness, no formal risk-of-bias or methodological quality assessment was conducted. The review included both journal articles and conference proceedings that satisfied the predefined inclusion criteria and were indexed in the Web of Science Core Collection. Consequently, the findings should be interpreted as an overview of prevailing research themes, methodological trends, and knowledge gaps rather than as a weighted evaluation of evidence strength. To enhance reliability, greater emphasis was placed during the synthesis on studies providing detailed empirical analyses, validated methodological approaches, and comprehensive accessibility assessments.

A broader discussion of the implications of these limitations and future research needs is provided in Section 4.8.

3. Results

3.1. Network Analysis of Research Trends and Scientific Collaboration for Public Transport Accessibility

To examine the conceptual structure and geographical collaboration patterns of research on public transport accessibility, a bibliometric network analysis was performed using VOSviewer (v1.6.20). Three complementary networks were generated from the final

dataset: keyword co-occurrence, citation relationships between countries, and co-authorship relationships between countries.

Figure 2 presents the keyword co-occurrence network. Using a minimum occurrence threshold of 10, 75 keywords out of 3492 identified terms were included in the analysis. The resulting network consists of five thematic clusters connected through 1175 links, with a total link strength (TLS) of 2352. These network characteristics indicate a highly interconnected research field, where multiple themes and methodological approaches overlap and interact.

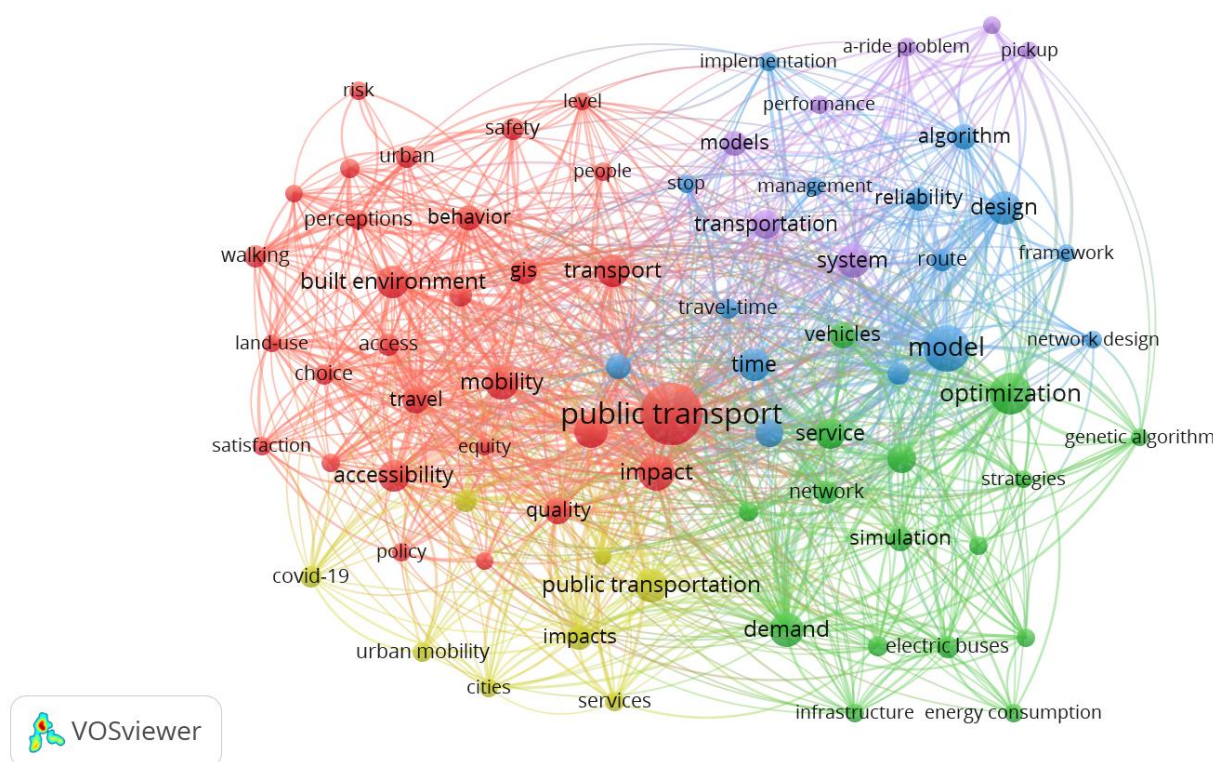


Figure 2. Keywords co-occurrence (minimum occurrence threshold = 10; full counting; association-strength normalization).

The largest cluster (red) is centered on accessibility and urban mobility issues, including terms such as public transport, accessibility, mobility, built environment, walking, behavior, safety, and GIS. This cluster reflects research focusing on user experience, accessibility assessment, urban planning, travel behavior, and social equity. The strong connectivity within this cluster highlights the central role of accessibility and mobility studies in the broader research landscape.

The second cluster (green) is associated with transport operations, infrastructure management, and sustainable mobility systems. Frequently occurring terms include optimization, network, service, demand, simulation, electric buses, infrastructure, energy consumption, and emissions. Studies within this cluster primarily address operational efficiency, network performance, and the implementation of sustainable transport technologies.

The third cluster (blue) is dominated by modelling and system-performance concepts, including model, system, route, design, reliability, implementation, travel-time, and transportation. This cluster reflects methodological and analytical approaches used to evaluate, design, and optimize public transport systems.

The fourth cluster (purple) focuses on computational and algorithmic approaches, with terms such as algorithm, pickup, a-ride problem, time windows, and models. These

studies highlight the increasing application of optimization algorithms, intelligent transport systems, and demand-responsive transport solutions within accessibility research.

The fifth cluster (yellow) contains terms such as public transportation, services, impacts, urban mobility, cities, and COVID-19. This cluster emphasizes policy impacts, service provision, urban mobility transitions, and the societal effects of major disruptions on public transport accessibility.

The network structure reveals substantial interconnections among clusters. Numerous links between accessibility-oriented studies, operational research, transport modelling, and algorithmic optimization indicate that public transport accessibility has evolved into a multidisciplinary research area. In particular, the central position of public transport and its strong links with keywords related to accessibility, modelling, optimization, and sustainability demonstrate the integration of social, technical, and environmental perspectives within the field.

Thus, the keyword co-occurrence network, comprising 75 keywords, 1175 links, and a total link strength of 2352, demonstrates that public transport accessibility research has become a highly interconnected and multidisciplinary domain, integrating contributions from urban planning, transport engineering, sustainability studies, data analytics, and intelligent mobility systems.

Figure 3 presents the co-authorship network among European countries. The network comprises 12 countries grouped into four collaboration clusters and connected through 25 links, with a total link strength (TLS) of 38. These values indicate a relatively compact but well-connected collaboration structure, reflecting active scientific partnerships among the most productive European research communities in the field of public transport accessibility.

The largest collaboration cluster (red) includes Germany, Belgium, France, the Netherlands, and Poland. Germany occupies a prominent position within this cluster and maintains strong collaborative relationships with neighboring countries, highlighting its role as an important contributor to international research activities. France and Belgium also exhibit strong collaboration links, forming a closely connected subgroup within the network.

The second cluster (green) consists of Portugal, Denmark, and Greece. These countries are linked through a common collaboration structure and maintain connections with other European research communities, particularly through the Netherlands and Spain.

The third cluster (yellow) includes Spain and Italy, which display strong bilateral collaboration and act as important connectors between Southern European research groups and the broader European network.

The fourth cluster (blue) comprises Sweden and Hungary. Although smaller in size, this cluster remains connected to the overall network through collaborative links with Italy and other countries, illustrating the integration of Northern and Central European research efforts within the field.

The Netherlands occupies an important intermediary position between several clusters, facilitating collaboration among Western, Southern, and Northern European countries. Similarly, Spain contributes to connecting multiple collaboration groups, reinforcing its role within the European research landscape.

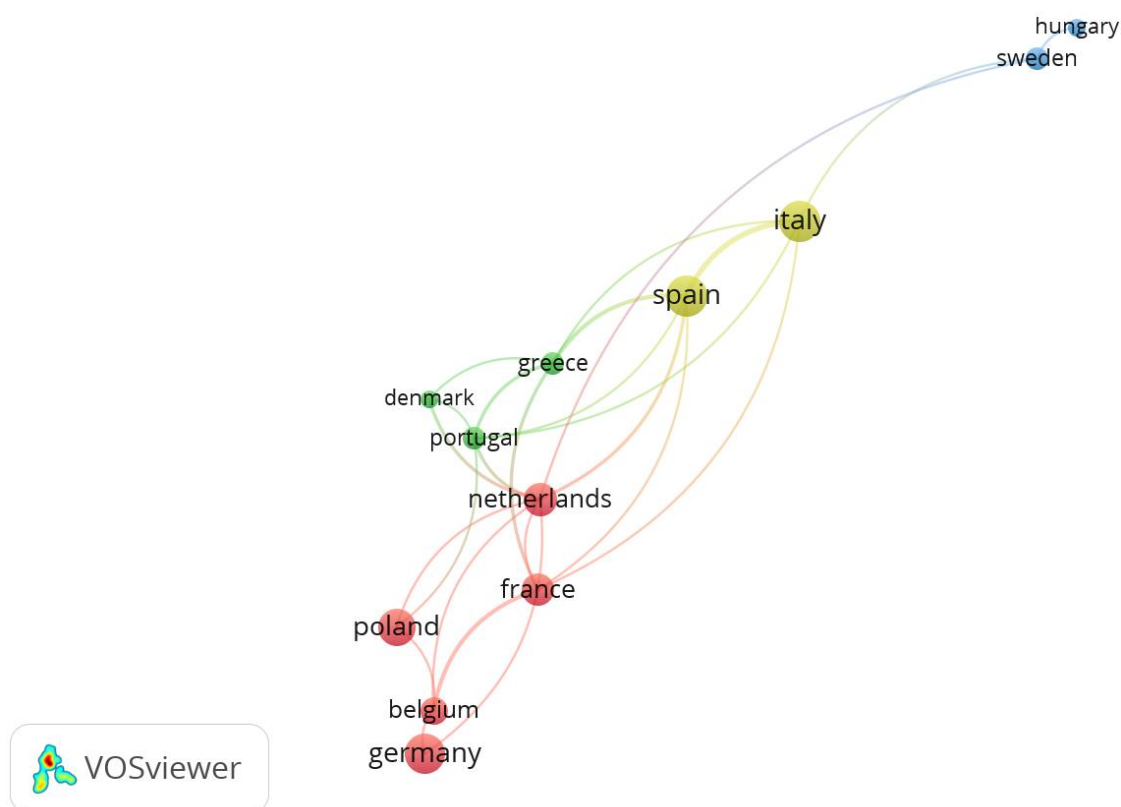


Figure 3. Co-authorship network by country (minimum occurrence threshold = 10; full counting; association-strength normalization).

The co-authorship network demonstrates a high degree of international collaboration among European countries. The presence of four interconnected clusters, 25 collaboration links, and a total link strength of 38 indicates that public transport accessibility research is supported by extensive cross-border partnerships, with Germany, France, the Netherlands, Spain, and Italy serving as contributors to scientific cooperation and knowledge exchange.

Figure 4 presents the citation network among European countries. The network comprises 12 countries grouped into four citation clusters and connected through 31 links, with a total link strength (TLS) of 66. Compared with the co-authorship network, the citation network exhibits a higher number of links and a greater total link strength, indicating stronger knowledge exchange and citation relationships among European research communities.

The first cluster (red) includes Germany, the Netherlands, Denmark, Sweden, and Greece. Germany occupies a central position within this cluster and maintains citation relationships with several countries across the network, highlighting its significant scientific influence within the field. The Netherlands also plays an important role by connecting multiple countries and facilitating citation flows between different research communities.

The second cluster (green) consists of Spain, Italy, Portugal, and Poland. Spain emerges as a major node within this group, maintaining strong citation relationships with neighboring countries and serving as an important contributor to the dissemination of knowledge within Southern and Central Europe. Portugal and Poland are closely linked to Spain, reflecting shared research interests and citation patterns.

The third cluster (blue) comprises France and Belgium, which form a highly interconnected citation subgroup. The strong relationship between these countries suggests a substantial exchange of scientific knowledge and mutual influence within literature on public transport accessibility.

The fourth cluster (yellow) contains Hungary, which appears as a more peripheral node but remains connected to the broader European citation network through links with Poland and other countries. This indicates participation in the research field despite a comparatively lower citation intensity.

The network structure reveals several cross-cluster connections, particularly involving Germany, the Netherlands, Spain, Italy, France, and Belgium. These countries act as important bridges between regional research communities and contribute significantly to knowledge diffusion across Europe. The relatively high total link strength (TLS = 66) suggests that public transport accessibility research is characterized by substantial intellectual exchange and citation interdependence among European countries.

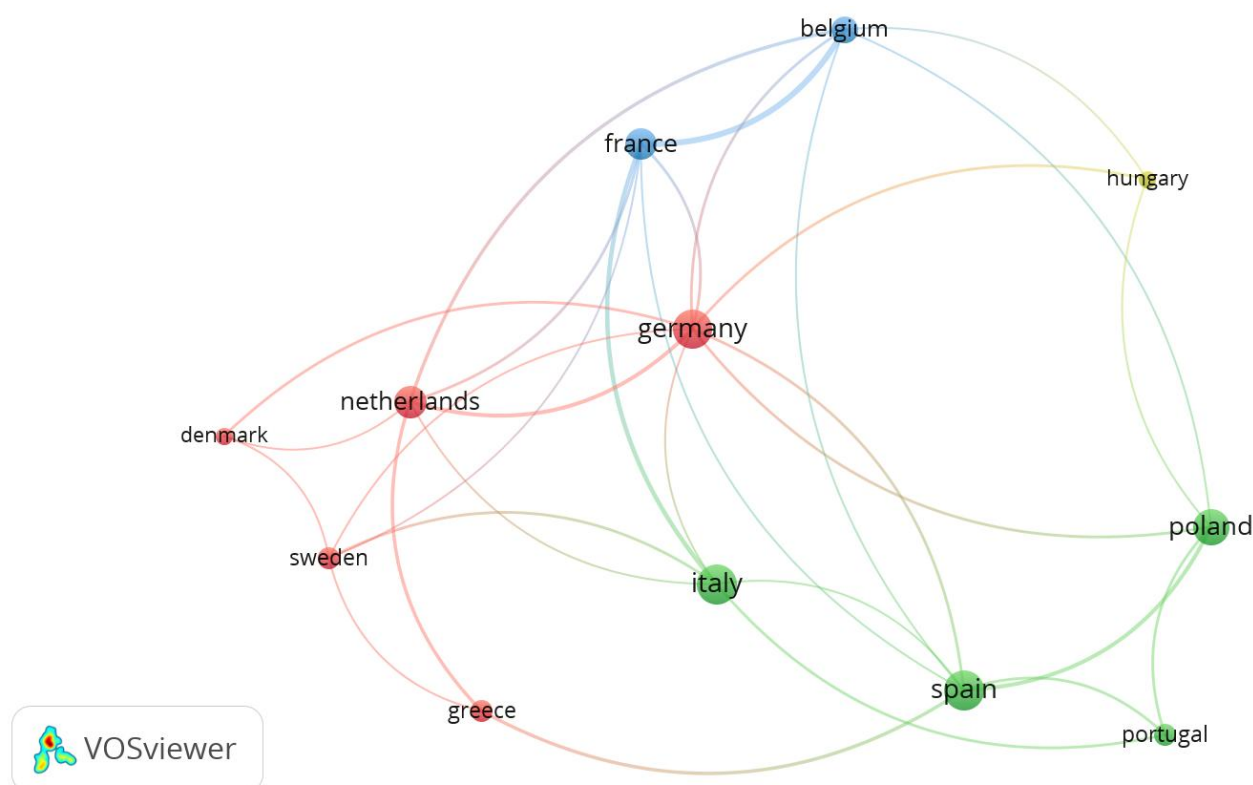


Figure 4. Citation network between countries (minimum occurrence threshold = 10; full counting; association-strength normalization).

The citation network demonstrates that scientific influence within the field is distributed across several interconnected European research hubs rather than concentrated within a single dominant country. Germany, Spain, the Netherlands, France, Belgium, and Italy occupy particularly influential positions, facilitating the dissemination and integration of knowledge across the European research landscape.

3.2. Thematic Analysis of Accessibility in Bus Stops and Stations

3.2.1. Physical Accessibility

Regarding step-free access, studies [9,10,59] highlighted that barrier-free boarding and infrastructure are fundamental for the autonomous mobility of passengers with disabilities and older adults. There was broad consensus that low-floor buses and fully low-floor tram vehicles are essential technical solutions to enable safe and efficient entry and exit [60].

Studies [9,61,62] highlighted that accessibility should be considered across the entire passenger journey, including boarding interfaces, transfer opportunities, and integration

with complementary mobility services. Studies [9,59] specifically identified raised platforms and level-boarding solutions as important infrastructure measures for reducing physical barriers and facilitating independent access to public transport.

Regarding ramps and tactile paving, refs. [9,47] identified the integration of tactile paving or signage according to standardized colors as important features for users with visual impairments. However, implementation differences were evident; while [9] focused on the co-design of tactile elements at tourist hubs, refs. [7,10] reported significant barriers where such infrastructure is either absent or poorly maintained in urban environments.

Regarding shelter and seating, studies [63–65] found that shelters are vital for thermal comfort, protecting users from inclement weather like rain or extreme heat. Refs. [64,66] explored innovative green shelters featuring extensive green roofs or walls to mitigate air pollution and provide ecosystem services. Regarding seating, ref. [9] noted that intuitive and comfortable seating is a key requirement for older tourists and people with reduced mobility.

Overall, the reviewed studies suggest that physical accessibility can be understood through several interconnected dimensions: access to the stop, boarding and alighting conditions, platform-stop interface design, wayfinding support, and waiting environment quality.

Across these dimensions, the most frequently reported barriers include the absence of step-free routes, insufficient curb ramps, gaps between vehicles and platforms, missing or poorly maintained tactile paving, inadequate shelter provision, limited seating, and deficiencies in maintenance. These barriers disproportionately affect older adults, passengers with disabilities, parents with strollers, and travelers carrying luggage.

The literature further indicates that accessibility is commonly assessed using indicators such as platform height compatibility, availability of ramps and tactile guidance systems, shelter and seating provision, obstacle-free pedestrian access, compliance with accessibility standards, and user-reported ease of use.

The physical accessibility dimensions identified in the reviewed literature are consistent with contemporary European and international accessibility standards. EN 17210:2021 ref. [67] emphasizes barrier-free movement, accessible boarding interfaces, tactile guidance systems, adequate maneuvering spaces, and universally understandable environmental information. Similarly, ref. [68] ISO 21542:2021 provides detailed requirements and recommendations for the accessibility and usability of the built environment, including pedestrian routes, ramps, circulation spaces, wayfinding elements, and access interfaces. These standards correspond closely to the recurring infrastructure barriers reported across the analyzed studies, including inadequate boarding conditions, missing tactile paving, discontinuous pedestrian routes, and insufficient wayfinding support [67,68].

Thus, these findings demonstrate that physical accessibility depends not only on individual infrastructure elements but also on the continuity of the entire access chain from the surrounding pedestrian environment to the boarding interface.

3.2.2. Information and Wayfinding

Regarding signage clarity, studies [7,47,69] indicated that clear signage is essential for all users but is often inadequately adapted, especially for people with disabilities. Ref. [47] proposed an AI-based electronic system to help visually impaired users recognize standardized signage, such as bus stops and pedestrian crossings, using audible feedback.

On audio-visual information systems, ref. [44] identified a major gap in audio information, noting that deaf and hard-of-hearing passengers frequently struggle to understand voice messages in vehicles or at stations. Conversely, for the visually impaired, refs.

[7,10] concluded that the lack of Braille and audio formats at stops remains a significant barrier to independent travel.

The authors in [38,70] consistently found that Real-Time Passenger Information (RTPI) significantly improves the attractiveness of public transport by reducing perceived waiting times. Studies [71,72] focused on providing Real-Time Crowding Information (RTCI), arguing it allows passengers to spontaneously distribute themselves more evenly across vehicles.

Beyond disability-related considerations, the effectiveness of information and way-finding systems also depends on the characteristics of different user groups. Older adults may experience difficulties associated with reduced visual acuity, hearing impairments, lower digital literacy, or increased cognitive load when navigating complex transport environments. Similarly, tourists, occasional users, and individuals unfamiliar with local transport networks often rely more heavily on intuitive signage, simplified route information, and consistent wayfinding cues. Consequently, the literature increasingly advocates for user-centered information systems that combine digital technologies with universally accessible design principles, ensuring that information remains understandable, visible, and usable across diverse passenger groups.

Particular attention should be given to the needs of older adults, who represent an increasing proportion of public transport users across Europe. According to the World Health Organization, age-friendly urban environments require accessible information systems characterized by clear signage, adequate lighting, readable displays, intuitive navigation, and safe waiting areas. These elements contribute not only to accessibility but also to confidence, autonomy, and independent mobility among ageing populations [73].

3.2.3. User Experience and Safety

Perceived safety is a major determinant of mode choice, according to [74]; low perceived safety is negatively correlated with public transport usage. Refs. [75,76] showed that women, young people, and the elderly report higher levels of fear of crime, which can restrict their daily mobility. The presence of lighting and security personnel was identified by [76,77] as a mitigating factor, though its effectiveness varies among different user groups.

Comfort was assessed through multiple dimensions, including thermal comfort through shelter design, enclosed waiting areas and passive cooling solutions [63,65]. The potential contribution of radiative-cooling approaches has also been discussed in foundational literature outside the review period [78]. Ride comfort was addressed through minimizing sudden acceleration and jerk during bus docking [55,79]. Ref. [20] also highlighted the hedonic quality or architectural beauty of stations, finding that passengers are often willing to pay more or travel longer to use high-quality terminals.

Vulnerable groups, including the elderly and people with physical or sensory disabilities, face unique challenges such as ableist attitudes from staff and physical barriers in the built environment according to [59,69]. Refs. [7,9] emphasized that inclusive design should be consistent with user expectations and involve these communities in the co-creation of transport infrastructure.

3.2.4. First-Mile and Last-Mile Connectivity

Regarding access to and from stops, refs. [35,80] studied the factors affecting the maximum distance public transport users are willing to walk to a bus stop or for transfer at the hub [2]. Study [81] emphasized walking distance to school as a critical determinant of accessibility for children.

The study also highlighted multiple benefits of walking school bus schemes and proposed defining walkability according to children's needs for comfort and safety by being

able to join any Walking School Bus (WSB) by easily reaching no more than 1–2 min walking distance from their home to the school or to the nearest pick-up point.

Studies [62,82] indicated that the integration of bike-sharing as a last-mile solution is widely explored in Budapest, with proximity to bus stops increasing bike-sharing trip intensity. Ref. [62] highlighted that while public transport and active modes often complement each other, bike-sharing can also substitute for short transit trips (one or two stops) when it is faster or avoids transfers. However, ref. [82] revealed correlations of some built environment features with bike crashes in the suburbs.

Beyond walking distance alone, connectivity is influenced by the spatial configuration of transport facilities. Important elements include sidewalk continuity, pedestrian crossing density, curb ramp availability, bicycle parking facilities, bike-sharing docking stations, interchange layouts, transfer distances between modes, and wayfinding continuity. Research increasingly highlights that accessibility depends on the quality of the entire access corridor rather than solely on the bus stop itself.

These findings indicate that connectivity should be evaluated as a network-level characteristic involving the continuity and integration of pedestrian, cycling, and transfer infrastructure (Table 2). Consequently, improvements to accessibility require coordinated design of the entire first- and last-mile environment rather than isolated interventions at bus stops alone.

Table 2. Infrastructure Components Influencing First-Mile and Last-Mile Accessibility.

Component	Function	Accessibility Impact	Representative References
Sidewalk network	Walking access	Improves stop reachability	[35,80]
Pedestrian crossings	Safe street crossing	Reduces access barriers	[80,81]
Bicycle parking	Bicycle-transit integration	Encourages multimodal trips	[62,82]
Bike-sharing stations	Last-mile mobility	Extends catchment area	[82,83]
Interchange design	Transfer facilitation	Reduces transfer burden	[2,30,53]
Wayfinding continuity	Navigation support	Improves multimodal accessibility	[49,53]

Beyond cycling and walking, several studies highlighted the importance of integration with rail, metro, tram, and demand-responsive transport services. The effectiveness of bus accessibility is strongly influenced by transfer quality between modes, including transfer distances, timetable coordination, unified ticketing systems, and information continuity.

Multimodal accessibility is particularly important for vulnerable users, who often experience greater difficulties during transfers than during in-vehicle travel. Consequently, transport hubs should be evaluated not only as physical facilities but also as interfaces within broader mobility networks.

3.2.5. Accessibility Assessment Methods

Accessibility is increasingly recognized as a multidimensional concept that extends beyond simple physical proximity to transport services. Accessibility results from the interaction between transport systems, land-use patterns, temporal constraints, and individual user characteristics. Thus, accessibility assessment should incorporate not only infrastructure-related indicators but also spatial, social, and behavioral dimensions. This broader perspective supports the integrated analytical framework adopted in the present review and helps explain the diversity of methodologies identified across the reviewed studies [83].

Accessibility assessment methods identified in the literature can be organized into an integrated framework that links data collection, analytical techniques, and performance

evaluation. Rather than representing independent approaches, audits, surveys, spatial analysis tools, predictive models, and accessibility indicators are often applied sequentially to transform raw observations into measurable accessibility outcomes. Table 3 summarizes the main stages of this process and the corresponding methods, data types, and outputs reported in the reviewed studies.

Table 3. Integrated Framework of Accessibility Assessment Methods, Data Sources, and Performance Indicators.

Stage	Method	Data Collected	Output Indicators	Representative References
Data Collection	Audits and inspections	Infrastructure characteristics	Compliance scores	[6,7,33]
Data Collection	Surveys and interviews	User perceptions	Satisfaction indicators	[14,34,74]
Spatial Analysis	GIS methods	Catchment areas, connectivity	Accessibility indices	[45,54,80]
Predictive Analysis	Simulation and ML	Passenger flows, crowding	Forecast indicators	[71,72,84]
Evaluation	Composite indicators	Integrated accessibility performance	Accessibility score	[63,76,85]

As shown in Table 3, accessibility assessment generally begins with the collection of infrastructure and user-related data through audits, inspections, surveys, and interviews. These data are subsequently analyzed using spatial and predictive methods, including GIS-based accessibility modelling, simulation, and machine-learning approaches. The outputs of these analyses are then translated into performance indicators, such as accessibility indices, satisfaction measures, occupancy forecasts, or composite accessibility scores, which support the evaluation and comparison of transport facilities. This integrated perspective highlights the methodological progression from data acquisition to evidence-based decision-making.

Physical audits and in-field inspections were used to evaluate compliance with accessibility and safety standards and identify infrastructure deficiencies by [6,7]. Ref. [7] involved collaboration with disability organizations to capture the lived experiences of users, while [14] gathered data from workshops, questionnaires, observations and interviews.

In studies [80,86] GIS was the dominant tool for spatial analysis, used to delineate catchment areas, estimate demand at the stop level, and map spatial connectivity or reachability. Studies [87,88] included 3D GIS models to evaluate the service quality of bicycle paths or the solar potential of bus shelters. One example of a modelling approach employed in accessibility assessment is the use of Colored Hybrid Petri Nets (CHPNs) for studying the behavior of a multimodal transportation system (MTS) [1].

Regarding the accessibility indices, various authors have used different metrics [85]. For example, ref. [63] used the Savings-to-Investment Ratio (SIR) indicator for evaluating and improving the thermal comfort of a shelter in the winter season, ref. [39] for cost-benefit analyses based on the users' willingness to pay, and ref. [84] for indices specifically to forecast the occupancy of a public transport vehicle the day ahead. The Savings-to-Investment Ratio (SIR) compares the expected operational and user benefits generated by an intervention against the investment required for its implementation.

3.2.6. Variability Across European Cities

Comparative studies [89–91] showed that accessibility conditions vary considerably across European countries and regions due to differences in transport policies, urban form, infrastructure investment, and demographic characteristics. To provide a structured overview of these variations, Table 4 summarizes the main accessibility characteristics,

strengths, challenges, and representative findings reported in the reviewed literature [67,92].

Table 4. Accessibility Characteristics across European Contexts.

Country	Main Findings in Reviewed Literature	Strengths	Challenges	Representative References
Sweden	High senior satisfaction and sustainability orientation	Integrated planning	Rural accessibility	[89,90]
Finland	High share of environmentally friendly fleets	Service quality	Sparse rural areas	[89]
Netherlands	Strong walkability and interchange planning	Multimodal integration	Congestion in hubs	[2,35,74]
Spain	Extensive accessibility assessments	User-centered approaches	Historical urban fabric constraints	[3,7,9]
Poland	Strong GIS-based evaluations	Infrastructure modernization	Compliance gaps	[10,33,45]
Hungary	Walking accessibility and bike-sharing integration	First-last mile research	Uneven implementation	[62,80,82]
Rural Europe	Lower service levels	Lower congestion	Accessibility deficits	[22,26,37]

As shown in Table 4, Nordic countries such as Sweden and Finland generally demonstrate higher levels of sustainability and user satisfaction, supported by integrated transport planning and environmentally friendly vehicle fleets. The Netherlands is frequently cited as an example of successful multimodal integration, particularly regarding walking accessibility and interchange design. In contrast, studies from Spain and Poland highlight ongoing challenges related to infrastructure modernization, compliance with accessibility standards, and the constraints imposed by historical urban layouts.

Regarding differences between urban and rural/smaller cities, the studies [22,37,93,94] indicated that rural and smaller cities face severe accessibility gaps, with lower service frequencies leading to higher car dependency. In contrast, refs. [26,71,72] showed that larger cities often suffer from overcrowding and bus bunching on major corridors, requiring different management strategies than those used in low-demand areas.

Significant gaps between legislation and practice were noted by [8,10,80,95], where cities fail to meet mandated accessibility standards despite significant financial investments. Refs. [3,7,13,96] argued that these gaps often stem from a failure to consider the complete accessibility chain, leaving users stranded by a single inaccessible link in their journey.

3.2.7. Cross-Cutting Accessibility Impacts Across User Groups

While the preceding sections examined accessibility factors individually, the reviewed literature indicates that their impacts differ across population groups. Older adults, passengers with disabilities, women, children, tourists, and occasional users experience accessibility barriers in distinct ways. However, these barriers rarely occur in isolation. Physical accessibility, information provision, perceived safety, and first- and last-mile connectivity often interact to shape the overall travel experience.

For example, older adults may be affected simultaneously by long walking distances, insufficient seating, poor lighting, and difficulties using digital information systems, as Table 5 shows. Similarly, passengers with visual impairments may encounter combined challenges related to tactile guidance, audio information, and wayfinding continuity. The literature therefore suggests that accessibility should be evaluated not only through infra-

structure characteristics but also through the experiences of different user groups throughout the entire travel chain.

Table 5. Accessibility Impacts Across User Groups.

User Group	Main Accessibility Challenges	Relevant Themes
Older adults	Long walking distances, insufficient seating, digital exclusion	Physical accessibility, information systems, connectivity
People with disabilities	Boarding gaps, missing tactile paving, inaccessible information	Physical accessibility, wayfinding
Women	Fear of crime, poor lighting, isolated stops	User experience and safety
Children	Unsafe crossings, limited independent mobility	Connectivity, safety
Tourists and occasional users	Navigation difficulties, unfamiliar systems	Information and wayfinding

Thus, the findings demonstrate that accessibility outcomes depend on the interaction between infrastructure characteristics and user-specific needs. This reinforces the importance of universal design and user-centered planning approaches capable of addressing the requirements of diverse population groups.

4. Discussion

This bibliometric and thematic review examined accessibility in bus-based public transport across European cities through four guiding research questions: (1) What barriers affect accessibility at bus stops and stations? (2) Which methods are used to assess accessibility? (3) What regional differences exist across Europe? (4) What planning recommendations emerge for more inclusive mobility systems? The findings indicate that accessibility is a multidimensional issue shaped by physical design, information quality, user experience, spatial connectivity, governance capacity, and territorial context.

Although many European cities have advanced fleet modernization and sustainability agendas, stop- and station-level environments often remain the weakest link in the passenger journey.

The reviewed literature distinguishes between bus stops and bus stations in terms of scale, complexity, and operational function. Bus stops primarily support boarding and alighting activities, whereas bus stations serve as multimodal interchange environments characterized by multiple platforms, waiting areas, information services, retail functions, and complex passenger flows. Consequently, accessibility challenges at stations extend beyond physical access and include wayfinding, transfer coordination, crowd management, and service integration.

4.1. Conceptual Interpretation of Accessibility

The reviewed evidence suggests that accessibility should be interpreted through the concept of the “accessibility chain”, according to which successful travel depends on the continuity of all journey segments rather than on isolated infrastructure components.

Physical accessibility, information provision, safety, comfort, and multimodal connectivity operate as interdependent elements. A deficiency in any link of the chain may compromise the usability of the entire transport system.

The findings also align with universal design principles, which emphasize environments that can be used by the widest possible range of users without the need for adaptation. The recurring barriers identified in the literature, such as missing tactile paving, inadequate information systems, and discontinuous pedestrian access, indicate that accessibility challenges often stem from incomplete implementation of universal design principles.

Thus, the results can be interpreted through a transport equity perspective. Differences between urban and rural areas, and between Northern and Southern European contexts, suggest that accessibility is unevenly distributed across territories and population groups.

4.2. What Barriers Affect Accessibility at Bus Stops and Stations?

The thematic synthesis identified recurring barriers across all dimensions of accessibility (Section 3.2.1), indicating that deficiencies rarely occur in isolation but interact throughout the accessibility chain.

These barriers disproportionately affect wheelchair users, visually impaired passengers, older adults, parents with strollers, and travelers carrying luggage. Even where low-floor buses are available, inaccessible boarding interfaces may prevent autonomous use of the system.

Informational barriers were also prominent. Inadequate signage, poor legibility, lack of multilingual information, missing Braille elements, and insufficient audio announcements reduce independent navigation for both disabled users and unfamiliar passengers. In increasingly complex transport environments, information accessibility is as important as physical accessibility.

Psychological and social barriers further influence travel behavior. Poor lighting, isolated stop locations, vandalism, or fear of crime may discourage use, especially among women, younger users, and elderly passengers. Negative staff attitudes or lack of assistance can also reduce perceived inclusiveness.

These findings confirm that accessibility should not be understood solely as infrastructure compliance, but rather as the extent to which users can confidently and comfortably complete a journey.

Finally, first-mile and last-mile barriers frequently determine whether bus services are practically reachable. Unsafe crossings, discontinuous sidewalks, long walking distances, and weak cycling integration can undermine otherwise efficient bus networks.

A comparison across the thematic categories reveals that accessibility barriers rarely occur independently. Physical accessibility deficiencies are frequently reinforced by inadequate information systems, safety concerns, or weak first- and last-mile connectivity. For example, a bus stop may technically provide step-free access yet remain difficult to use if wayfinding information is unclear or if unsafe pedestrian crossings discourage access.

Similarly, the absence of shelter, seating, or lighting may amplify the perceived burden of long walking distances, particularly for older adults and passengers with reduced mobility. These findings suggest that accessibility outcomes are determined not by individual infrastructure elements alone but by the interaction between multiple components throughout the travel chain.

4.3. Which Methods Are Used to Assess Accessibility?

The reviewed literature demonstrates considerable methodological diversity in how accessibility is assessed. One common approach involves physical audits and in-field inspections, which evaluate stop design, safety features, compliance with standards, and maintenance quality. These studies are particularly valuable because they identify practical deficiencies that may not appear in official datasets.

GIS-based approaches were also widely used. Spatial analysis methods help estimate walking catchments, stop reachability, demand distribution, connectivity to destinations, and territorial inequalities. Such methods are especially relevant for planners because they translate accessibility into measurable spatial indicators.

User-centered methods, including surveys, interviews, focus groups, and co-design workshops, provide important insight into lived experience. These approaches often re-

veal discrepancies between technically compliant infrastructure and actual user satisfaction. For example, a stop may meet dimensional standards while still feeling unsafe, confusing, or uncomfortable.

The review also found increasing use of predictive analytics, simulation models, and machine learning for vehicle crowding, demand forecasting, and service optimization. These methods signal a transition toward data-driven management of public transport accessibility. However, quantitative models should be complemented by qualitative evidence to avoid reducing accessibility to purely operational metrics.

Overall, no single method is sufficient. The most robust assessments combine infrastructure audits, GIS metrics, and user experience evidence within an integrated evaluation framework.

A notable contradiction emerges from the reviewed literature. Several cities demonstrate high levels of regulatory compliance while users continue to report accessibility difficulties. This suggests that compliance with technical standards does not automatically translate into positive user experience. Future assessments should therefore integrate objective infrastructure indicators with subjective user perceptions.

4.4. What Regional Differences Exist Across European Cities?

The reviewed literature suggests the presence of territorial differences in accessibility outcomes across Europe. Evidence reported in several studies is more frequently associated with Northern and some Western European contexts, particularly regarding integrated planning approaches, environmental modernization, passenger comfort, and user satisfaction. However, direct cross-country comparisons remain limited because the reviewed studies employ heterogeneous methodologies, indicators, and spatial scales.

The reviewed studies also indicate that several European regions continue to face challenges related to aging infrastructure, fragmented governance arrangements, limited funding capacity, or delayed implementation of accessibility measures. In addition, historical urban fabrics in some Southern and Central European cities may create additional constraints for accessibility improvements due to narrow streets, heritage preservation requirements, and limited availability of public space.

The literature further suggests that rural and smaller urban areas often face a distinct set of accessibility challenges. Lower service frequencies, longer walking distances, sparse transport networks, and greater dependence on private vehicles are frequently reported as barriers affecting practical accessibility. At the same time, studies focusing on larger metropolitan areas commonly identify issues related to overcrowding, bus bunching, passenger congestion, and the management of complex interchange environments.

The bibliometric analysis also revealed differences in research production and scientific influence across the reviewed literature. While collaboration networks were relatively widespread across European countries, higher citation activity was more frequently associated with countries such as the Netherlands, Sweden, Germany, and Spain. These findings suggest that the geographical distribution of scientific influence may be more uneven than the distribution of research participation itself.

Finally, the reviewed evidence indicates that accessibility outcomes are influenced not only by infrastructure investment levels but also by governance capacity, planning integration, and policy continuity. Several studies reported accessibility shortcomings even in cities with substantial financial investment, suggesting that resource availability alone does not guarantee successful implementation. Conversely, some studies documented positive accessibility outcomes where coordinated planning and stronger integration between transport modes were present. These findings highlight the importance of governance and institutional factors in shaping accessibility performance across different urban contexts.

4.5. What Planning Recommendations Emerge for Inclusive Urban Mobility?

Several practical recommendations emerge from the review. Recent policy frameworks developed by the International Transport Forum emphasize that accessibility should be considered a primary objective of transport planning rather than a secondary outcome of infrastructure provision. Accessibility-oriented planning focuses on connecting people with opportunities while reducing transport disadvantages and social exclusion. This perspective aligns with the findings of the present review, which highlight the strategic importance of bus stops and stations as critical components of inclusive urban mobility systems [97].

Firstly, the reviewed studies consistently indicate that deficiencies in boarding interfaces, shelter provision, seating, and pedestrian access remain among the most frequently reported barriers. Therefore, cities should prioritize upgrading bus stops and stations as strategic infrastructure assets.

Secondly, planning should adopt an accessibility chain approach, ensuring that walking routes, crossings, interchanges, and final destinations are considered part of the same user journey. A modern low-floor bus has limited value if users cannot safely reach the stop or transfer between modes.

Third, inclusive design should be participatory. Disabled passengers, older adults, caregivers, and local communities should be involved in stop redesign and service planning. Co-design can improve both usability and legitimacy of interventions.

Fourth, digital tools such as real-time passenger information, crowding alerts, and AI-supported navigation should be expanded, but always alongside non-digital alternatives. Smart technologies should complement, not replace, clear signage, audio announcements, and intuitive layouts.

Fifth, policy support should be territorially differentiated. Metropolitan areas may require congestion and interchange management, whereas smaller cities and rural areas need better coverage, frequency, and demand-responsive solutions. European and national funding programs should account for these differing needs.

4.6. Broader Implications for Sustainable Transport Policy

The results demonstrate that accessibility is closely linked to wider sustainability goals. Better stop environments can increase public transport attractiveness, reduce private car dependency, support healthier walking access, and improve social inclusion. In this sense, investment in bus stop accessibility should be understood not only as a welfare measure, but also as an environmental and economic strategy.

The growing prominence of electric buses and smart mobility technologies further reinforces the need to align decarbonization with inclusion. A transport system cannot be considered fully sustainable if zero-emission vehicles remain difficult to access for significant user groups.

The research questions are synthesized in Table 6.

Table 6. Synthetic Summary of Discussion Findings Based on Research Questions.

Research Question	Main Findings	Practical Implications	Representative References
(1) What barriers affect accessibility at bus stops and stations?	Major barriers include steps, poor curb alignment, uneven pavements, lack of ramps, missing tactile paving, inadequate shelter and seating, poor signage, insufficient audio/visual information, and perceived insecurity.	Accessibility improvements should address both physical and psychological barriers through universal design, maintenance, and safer waiting environments.	[6,7,9,10,44,59,74,76]

(2) Which methods are used to assess accessibility?	Studies commonly use infrastructure audits, GIS-based spatial analysis, surveys, interviews, co-design workshops, simulation models, and predictive analytics.	Cities should adopt mixed-method frameworks combining objective indicators with user experience evidence.	[6,7,14,33,34,45,54,84]
(3) What regional differences exist across European cities?	Northern and Western cities often perform better in planning integration and user satisfaction, while other areas face funding, governance, or legacy infrastructure challenges; rural areas face lower accessibility.	Accessibility policies should be territorially differentiated according to local spatial, economic, and institutional conditions.	[3,22,26,37,89–91,93]
(4) What planning recommendations emerge for inclusive mobility?	Priorities include level boarding, tactile guidance, shelters, seating, lighting, safer access routes, participatory design, integrated first-/last-mile planning, and inclusive smart technologies.	Municipalities and operators should treat stops and stations as strategic mobility assets and not minor roadside elements.	[9,23,35,47,52,62,64,80]

4.7. Accessibility Within Multimodal Mobility Systems

The findings demonstrate that accessibility cannot be evaluated exclusively at the bus stop level. Bus stops and stations function as nodes within wider multimodal systems involving walking, cycling, rail, tram, metro, and shared mobility services. Accessibility therefore depends on the quality of transfers, continuity of information, and integration between transport modes.

Peer-reviewed studies suggest that transfer penalties often represent a greater barrier than in-vehicle travel time. Thus, future planning should prioritize seamless modal integration through coordinated infrastructure design, unified information systems, and reduced transfer complexity.

4.8. Research Gaps, Future Directions, and Limitations of the Review

Although the literature on accessibility in bus-based public transport has expanded rapidly in recent years, several important gaps remain. Building upon the methodological limitations outlined in Section 2.6, more comparative studies are needed across Eastern, Southern, and Northern European contexts in order to better understand how governance models, funding capacity, urban form, and policy priorities shape accessibility outcomes. Rural and smaller urban areas also remain underexplored relative to metropolitan systems, despite facing distinct challenges such as lower service frequencies, greater car dependency, and weaker multimodal integration. In addition, longitudinal evidence on the long-term effects of stop and station upgrades, digital passenger information systems, and climate-resilient shelter design is still limited.

Future research should place greater emphasis on combining objective accessibility indicators with subjective user perceptions such as comfort, dignity, autonomy, confidence, and perceived safety. This is particularly relevant for vulnerable groups, including older adults, passengers with disabilities, women, and occasional users, whose experiences are not always adequately captured through conventional infrastructure audits or GIS-based metrics. More interdisciplinary approaches integrating transport planning, urban design, public health, and social inclusion perspectives would further strengthen the evidence base.

At the same time, the findings should be interpreted in light of the methodological limitations discussed in Section 2.6. These include the exclusive use of the Web of Science Core Collection, the restriction to English-language publications, variability in accessibility definitions and measurement approaches, and the interpretative nature of thematic

synthesis. While these limitations may affect the comparability and generalizability of individual findings, the broad multidisciplinary dataset nevertheless provides a robust overview of recent research trends and emerging priorities.

Furthermore, definitions and measurement approaches to accessibility varied substantially across disciplines, methods, and case studies, which limits direct comparability of findings. Nevertheless, the inclusion of a broad multidisciplinary dataset provides a robust overview of recent research trends, recurring barriers, and emerging priorities in the field of inclusive bus-based mobility.

Two additional cross-cutting themes, broader sustainability implications and remaining research gaps, are summarized in Table 7.

Table 7. Summary of Cross-Cutting Findings on Sustainability and Research Gaps.

Research Question	Main Findings	Practical Implications	Representative References
What broader sustainability implications arise?	Accessible bus infrastructure can increase ridership, reduce car dependence, support walking, and improve social inclusion while complementing fleet decarbonization.	Accessibility investment should be framed as both a social equity and climate strategy.	[4,5,20,39,65,89]
What research gaps remain?	Limited evidence exists for Eastern Europe, rural contexts, long-term infrastructure impacts, and subjective experiences of vulnerable users.	Future studies should expand comparative, longitudinal, and user-centered research designs.	[22,26,37,56,93,96]

Beyond the research gaps summarized in Table 7, this review provides several broader insights into the evolution of accessibility research in bus-based public transport.

A contribution to this review is the identification of a clear shift in the accessibility literature from purely physical infrastructure considerations toward a broader understanding of accessibility as a multidimensional concept.

Across the analyzed studies, accessibility was increasingly linked not only to stop design characteristics such as shelter quality, boarding conditions, and pedestrian connectivity, but also to digital passenger information, perceived safety, comfort, social inclusion, and environmental sustainability.

The review further reveals a strong concentration of evidence from Western and Northern European urban contexts, while Eastern European regions, rural areas, and small and medium-sized cities remain substantially underrepresented. Another important finding is the limited integration of objective accessibility indicators with user-centered assessments, resulting in a fragmented evidence base that often evaluates infrastructure performance separately from passenger experience.

By synthesizing these trends across 90 thematically relevant studies and a broader bibliometric dataset of 685 publications, this review provides a structured overview of the evolution of accessibility research in bus-based public transport and identifies priority areas for future investigation and policy development.

5. Conclusions

This bibliometric and thematic review examined recent research (2020–2026) on accessibility in bus-based public transport infrastructure across European cities, with a particular focus on bus stops and stations. Drawing on 685 publications identified through the Web of Science Core Collection and a thematic synthesis of the most relevant studies, the review explored accessibility barriers, assessment approaches, regional differences, and emerging research directions.

The findings indicate that accessibility is a multidimensional concept shaped by the interaction of physical infrastructure, information and wayfinding systems, user experience and safety, first- and last-mile connectivity, and broader governance and territorial factors. Across the reviewed literature, the most frequently reported barriers include deficiencies in boarding interfaces, inadequate pedestrian access, limited shelter and seating provision, insufficient information systems, safety concerns, and discontinuities within the accessibility chain.

The review also showed that accessibility outcomes vary across European contexts, with differences associated with urban form, planning practices, service provision, and infrastructure investment. Furthermore, the literature demonstrates increasing attention to multimodal accessibility, digital information systems, predictive analytics, and user-centered approaches for evaluating transport accessibility.

The review highlights several areas requiring further investigation. Future research would benefit from greater methodological integration between infrastructure assessments, spatial analysis, and user experience studies. Additional comparative research across underrepresented European regions, particularly rural and smaller urban contexts, is also needed.

More evidence is required on how emerging technologies, and multimodal transport systems influence accessibility outcomes for diverse user groups. Thus, the findings confirm the importance of considering bus stops and stations as critical components of inclusive and sustainable urban mobility systems.

From a practical perspective, the findings suggest three priority actions: integrating accessibility considerations throughout the entire passenger journey, including first- and last-mile connections; strengthening the deployment of accessible information and wayfinding systems; and ensuring that accessibility standards are consistently implemented across both urban and rural contexts. These measures can support more inclusive and sustainable bus-based public transport systems across Europe.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/urbansci10070399/s1>, Table S1: Derived metadata table; Data S2: Citation network (VOSviewer JSON file); Data S3: Co-authorship network by country (VOSviewer JSON file); Data S4: Keyword co-occurrence network (VOSviewer JSON file).

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