An Overview of Public Transport Integration: Using a Systematic Bibliometric Analysis

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ABSTRACT

From the perspectives of users, operators, and the community, public transportation integration is a critical characteristic for assessing service quality. Although studies have been conducted on the integration of public transportation, comprehensive and quantitative investigations are yet to be conducted. Additionally, the Web of Science (WOS) database contains limited assessments of public transport integration. The current evaluation provides scholars and practitioners with the most recent updates of papers on public transport integration over the last 18 years (between 2005 and 2023) to allay their worries and address inquiries about public transport integration. This bibliometric analysis encourages future research and collaboration by detailing transport integration, highlighting the paucity of relevant works, and providing a summary of the most productive nations, journals, and institutions in the field. A bibliometric analysis of the public transport integration publications obtained from the WOS database was performed using VOSviewer software to enable researchers to trace the historical and annual records of publications related to integration covering top countries, institutions, journals, most frequently used keywords, authors, citation network analysis, and most-cited publications. The findings of the analysis identify integration hotspots as well as confirm the remarkable annual increase in publications on public transportation integration.

Keywords: Bibliometric, VOSviewer, Integration, Public Transport, Literature Review, Transport

1. Introduction

Public transportation are services offered by local governments or private businesses to move city residents from one location to another. Public transportation, which includes the standard modes of transit, such as metro, tram, and bus, is typically highly recommended for reducing traffic loads, providing a sustainable solution, reducing air pollution, and creating energy efficiency, depending on the facilities offered in the city (Banister, 2005). Efficient modes of urban public transportation are essential for promoting sustainable growth in our communities (Mugion et. al., 2018). Public transportation has drawn considerable attention because it is a green and environmentally friendly mode of transportation benefiting the environment, provides people who do not own automobiles a mode of transportation, and reduces the social divide (Burinskien et al., 2011).

Strategies for coordinating urban public transportation have attracted considerable research attention (Cirillo and Xu, 2011; Nijkamp et al., 2013). Using the integration technique normally requires various transportation measures and may occur at different levels, and the perspective of integration strongly depends on urban transport system integration for managing mobility patterns (Nosal and Solecka, 2014). Additionally, incorporating sustainable mobility into the current transportation system to persuade people to switch from private transportation to public transportation and/or non-motorized transportation can achieve the goals of integrated transportation strategies (May and Roberts, 1995; Potter and Skinner, 2000; Banister, 2008). However, integration in urban transportation policy is commonly endorsed but rarely defined (Roumboutsos and Kapros, 2008).

Consolidation, combining, creating a whole out of parts, or merger are examples of integration (Tokarski, 1980). Integration can occur at various levels and may entail numerous components and actions. According to Janic and Reggiani (2001), the integration of urban public transportation is not universally defined and many authors have varied definitions. For instance, the Propolis project's (2004) measured focused on integrating transportation and spatial development in urban regions. Authors have presented options for integrating the transportation systems of various cities. Maya (1993) outlined the design guidelines for successfully integrated public transport systems and discussed several types of transport integration. Furthermore, she provided some interesting views on integration. Urban public transportation integration in the literature has numerous definitions (Dydkowski, 2005; Hine, 2000;

Hull, 2005; Ibrahim, 2003; ISOTOPE, 1997; Janic&Reggiani, 2001; May, 1993; NEA, OGM and TSU, 2003; Potter & Skinner, 2000; Preston, 2010; Propolis, 2004, QUATTRO, 1997).

"Integration" is frequently used in metropolitan public transportation services to describe strategies that ensure the continuity of a "door-to-door" journey (Janic and Reggiani, 2001). Urban transportation incorporates the following to offer a desirable chain of services in "door-to-door" connections (Nosal and Solecka, 2014):

Various means of public transport,

Public and individual transport,

Transport policy with other policies concerning the spatial planning or investments in infrastructure.

Integration of urban public transport may occur at various levels in Table 1 (Solecka, 2013; Zimmerman and Fang, 2015; Potter, 2010):

Table 1. Integration of public transport

	Solecka, 2013	Zimmerman and Fang, 2015	Potter, 2010
Levels of Integration	Infrastructure integration Organizational integration Economic and financial integration Informational integration Spatial integration	Network structure, individual route terminals/alignment/stops/stations, levels of service Schedule integration/coordination Transfer Stops/Stations/Terminals Fare integration Passenger Information	Locational Integration Timetabling Integration Ticketing Integration Information Integration Service Design Integration Travel Generation Integration

To achieve long-term public transportation goals of usefulness and competitive capacity, integrating the planning and development of public transportation, other modes of transportation, and land use may be ineffective. The state or area can plan public transportation in some nations. According to international experience, public transportation planners should consider two integration dimensions: (a) integration of all modes and routes that make up the multi-modal public transportation network, and (b) integration of the physical and operational components of each mode and service, such as a bus or metro. A superior customer-friendly experience will result from successful integration in all dimensions, which will increase the effectiveness and affordability of public transportation (Zimmerman and Fang, 2015). Although better public transportation integration makes it easier for commuters to move around and reduces travel costs and inconveniences, it does not necessarily result in better returns for each transport provider (Roumboutsos and Kapros, 2008). Local governments play a crucial role in the integration of land use planning and public transportation, particularly in nations with decentralized land use planning contexts (Hrelja, 2015).

To develop a methodology to assess the degree of integration (sustainability integration index) between two public transportation modes that incorporate sustainability, Errampalli et al. (2020) presented a study. The method was refined to identify a total of 12 indicators within the three sustainability domains of economic, social, and environmental sustainability that measure the level of integration between metro rail and buses already in place. Poliak et al. (2017) evaluated the various components of integration systems abroad and proposed an integration system technology that is appropriate in areas in which the market share of public passenger transportation is declining. Stiglic et al. (2018) studied how to improve urban mobility by merging ridesharing and public transportation and revealed that doing so can boost the use of public transportation and considerably improve mobility. Biking and micromobility vehicles can play a part in the integration of public transportation systems with urban planning. A study on cycling from the Netherlands, Denmark, and Germany (Pucher and Buehler, 2008), an analysis of bike sharing from Melbourne and Brisbane (Fisman et al., 2014), and the state of knowledge of what is the current system to integrate micromobility to public transport system (Oeschger et al., 2020) have been devised to integrate bikes to the current system to public transport.

Public transportation integration has been studied in numerous articles. However, these studies have focused on specific and constrained aspects of transportation integration. Moreover, according to the WOS database, only two review papers on the dependability of public transportation have been published. This research paper delves into transport integration comprehensively, shedding light on its multifaceted aspects and potential benefits. By emphasizing the scarcity of existing studies in transport integration, this study seeks to highlight the importance of bridging this knowledge gap to pave way for advancements and collaborations. Moreover, this paper not only provides an overview of the most productive nations, journals, and organizations in public transport integration publications, but also conducts a rigorous analysis of key terms related to integration that have prominently appeared in earlier research.

In addition to fulfilling these objectives, the present study contributes to existing literature by providing a robust foundation for subsequent investigations. By presenting a comprehensive collection of frequently encountered integration-related terms, this study facilitates easy access to data for researchers, encouraging them to explore novel dimensions of transport integration and its potential implications for various contexts. Furthermore, this paper goes beyond mere analysis and retrospective observations and provides a proactive approach by forecasting upcoming trends in transport integration. By identifying potential future developments, this study can be used as a guiding compass for scholars, policymakers, and industry professionals, helping them to anticipate and adapt to the evolving landscape of transport integration.

To encourage further advancements in this crucial domain, this paper offers insightful suggestions for future research directions. By identifying unexplored or under-researched areas, this study aims to inspire scholars to delve into novel topics and uncover new insights that could revolutionize the way we perceive, plan, and implement transport integration on both local and global scales.

This research paper goes above and beyond its initial objectives of illustrating the idea of transport integration and highlighting the dearth of studies in the field. Its broader contribution is in providing a comprehensive platform for researchers, fostering collaboration, and sparking curiosity in uncharted territories. By incorporating the most frequently cited integration-related terms and providing a glimpse into future trends, this study propels transport integration toward new horizons, unlocking its full potential for societal, economic, and environmental benefits.

2. Method of Bibliometric Analysis

Bibliometric analysis was performed using VOSviewer and bibliographic map specialist program (Nvel, 2010). To describe current research trends connected to transport integration and provide researchers a clear picture to aid them in future study and collaboration, the required data from the gathered documents were extracted and summarized using software.

To accomplish the objectives of the current review, five steps were established (Fig. 1).
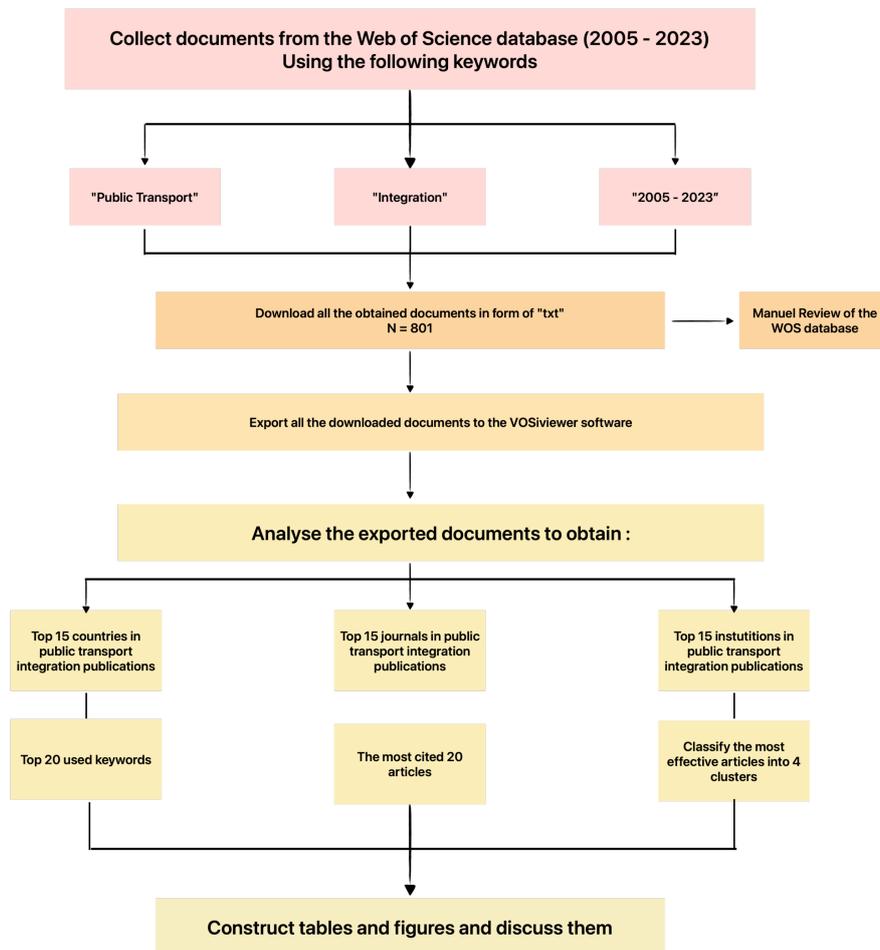

Figure 1. Bibliometric review structure methodology chart.

In the first phase, documents were gathered using the WOS database's basic search feature and the keywords "Integration" and "Public Transport" along with a year range of "2005–2023." The collection of documents occurred on March 21, 2023. (Any document published after the mentioned date is not included in the current work). The WOS database stated that 801 documents were downloaded and obtained for phase 2 analysis. Furthermore, using the first associated author address from phase 2 and the WOS website, a manual evaluation of the nation's publication output was performed. Phase 3 involved exporting the obtained documents to the VOSviewer program to highlight the paucity of research and pinpoint the top 15 countries, journals, and organizations for publishing on public transportation integration. Phase 3 additionally identified the top 20 most-used search terms and the top 20 most-cited academic articles. The most influential documents were gathered based on document citations to detect literary trends (only the documents with more than nine citations were chosen). The 137 documents that were cited more than nine times by the VOSviewer program were divided into four clusters, which are covered in depth in Section 3.5. In the final stage, the generated tables and bibliographic maps were examined and discussed.

3. Results and Discussion

3.1. Historical and geographical trends

From 2005 to 21 March 2023, according to the WOS database, 803 documents about public transportation reliability were published. The annual publication's historical patterns and the total number of citations from 2005 to 2023 are displayed in Figs. 2 and 3. Fig. 2 reveals that the number of annual publications increased throughout the course of the previous 15 years from 2005 to 2008 and subsequently decreased till 2010. The number of publications remained largely unchanged; it began to rise in 2011 and subsequently increased rapidly in each of the following years: 2014, 2016, and 2018. Over past 15 years, the annual publishing of public transport integration has increased. Furthermore, the publication's annual citations increased with occasional peaks and valleys between 2005 and 2018, then decreased in 2009 and 2010, before starting to increase again. This phenomenon is expected because academic papers to have a discernible impact takes time because for other people to read new research, pay attention to them, and use them as references in other works is time consuming. Therefore, research that has been published recently typically has fewer citations.
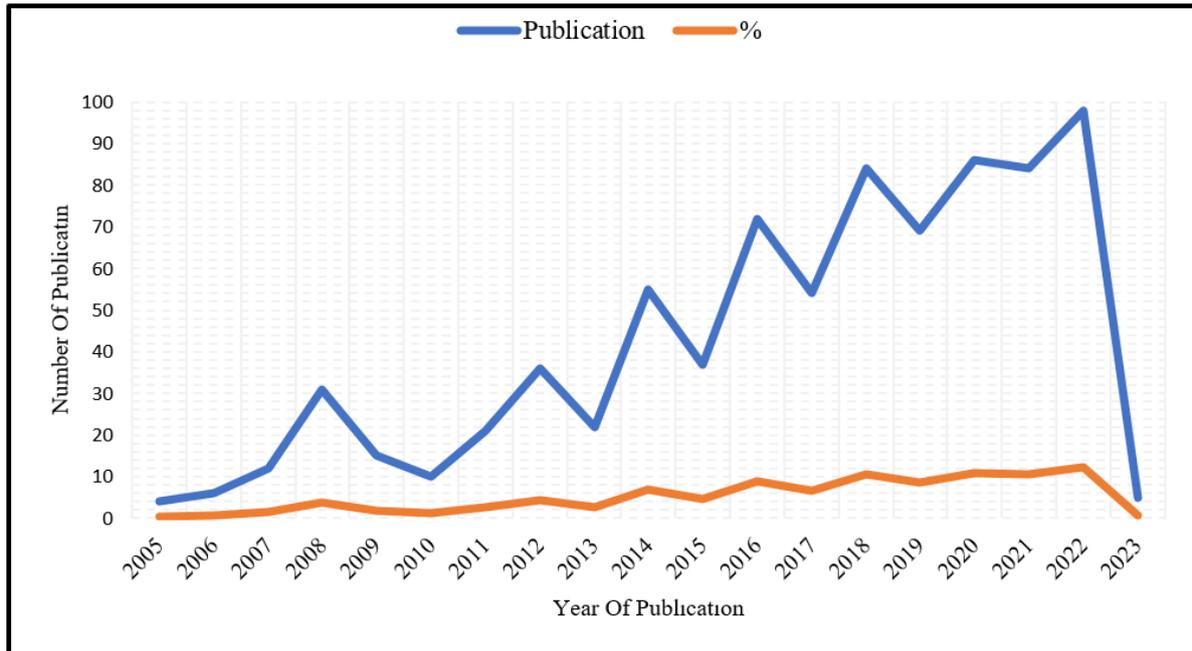

Figure 2. Total publication based on Web of Science (WOS) database from 2005 to 2023
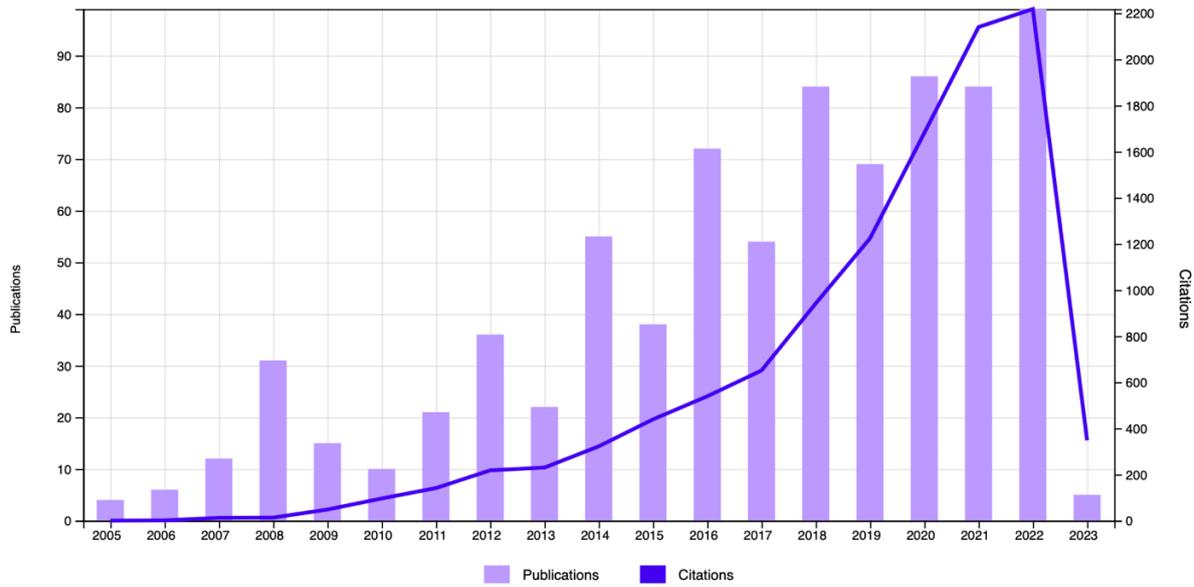
Figure 3. Sum of citations based on WOS database from 2005 to 2023.

The number of papers on public transport integration research includes contributions from more than 100 nations. Table 2 presents the 15 most-productive nations in the public transportation reliability study according to the number of publications. China maintained its top spot in public transportation integration by contributing 1.3% of all publications over previous 18 years. Germany ranked in first place with a publishing rate of 8.97% on the integration of public transportation, followed by Australia, Italy, and England with respective publication rates of 8.09%, 7.60%, and 5.98%, respectively. More than 20 publications originated from Spain, Netherlands, the USA, Poland, France, India, Sweden, South Africa, Belgium, and Portugal. Based on a review of the WOS database and VOSviewer software, the top 15 nations contributed to more than 81.57% of all publications and more than 78% of all citations between 2005 and 21 March 2023.

Table 2. Distribution of Top 15 leading countries from 2005 to 2023 according to VOSviewer.

Countries	TP	TC	TLS	TP%
CHINA	91	826	5148	11,33
GERMANY	72	565	3056	8,97
AUSTRALIA	65	1170	5358	8,09
ITALY	61	559	4050	7,60
ENGLAND	48	1154	4994	5,98
SPAIN	48	567	3945	5,98
NETHERLAND	44	1444	5591	5,48
USA	41	2805	3932	5,11
POLAND	39	217	2079	4,86
FRANCE	29	117	1953	3,61
INDIA	27	159	1080	3,36
SWEDEN	26	563	2179	3,24
SOUTH AFRICA	24	120	1006	2,99
BELGIUM	20	212	2587	2,49
PORTUGAL	20	163	1959	2,49

Fig. 4 reveals that research on public transportation integration is receiving considerable interest because of the high populations in countries such as China, India, Indonesia, and the United States as well as the significant population growth in the member states of the European Union. By contrast, based on the first related author address provided by the WOS database, a total of 803 publications were manually evaluated (one by one) to determine the number of publications created per year for each country. This inquiry was conducted because the WOS website's and VOSviewer software's limitations in determining the precise amount of publications for each nation per year. Table 3 presents the distribution of publications for the top 5 leading counties from 2005 to 2023. Table 2 reveals that most nations maintained an upward shape trend in paper publications, and China and Germany

the highest because the geographic dispersion of research articles on integration is expanding along. The desire of the central government to invest in science and technology as well as the country's growing academic labor market are key to the exceptional increase in Chinese contributions to integration-related research (Derudder et al., 2019).
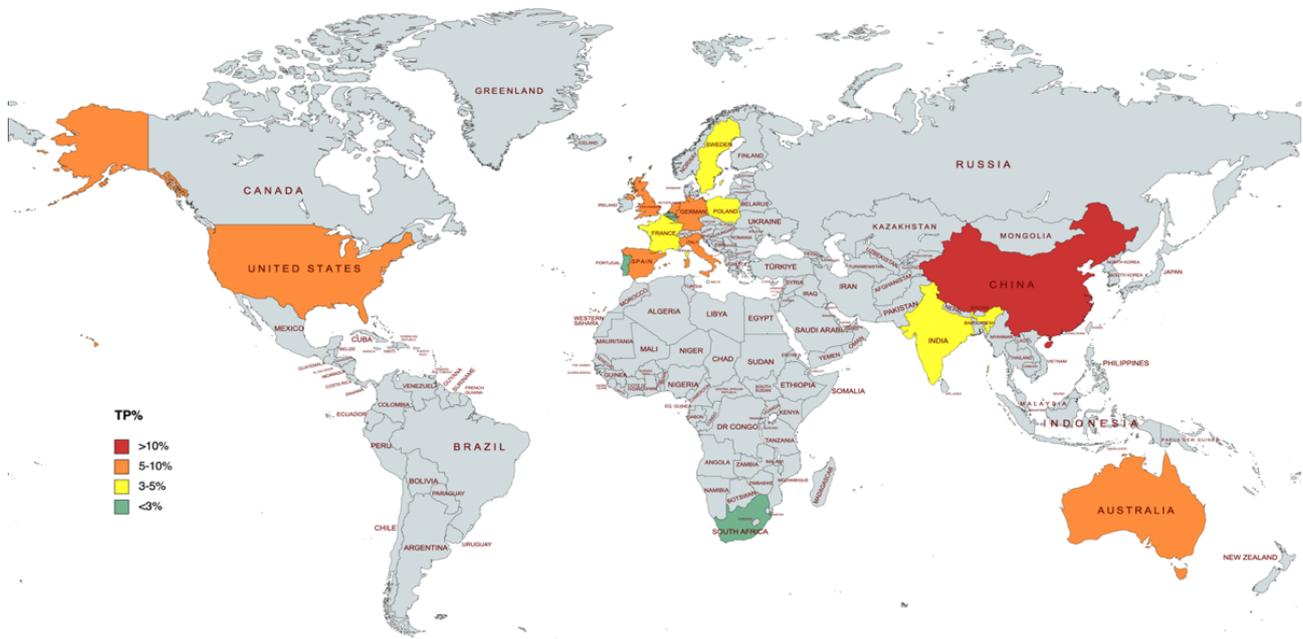

Figure 4. Distribution of top 10 leading countries from 2005 to 2023.

Table 3. Top 5 most important contributors' countries and their number of publications each year.

Publications	Years	China	Germany	Australia	Italy	England
4	2005	0	0	1	1	1
6	2006	0	1	1	0	0
12	2007	1	0	1	4	0
31	2008	0	1	3	1	1
15	2009	1	1	1	2	1
10	2010	0	1	2	1	0
21	2011	1	1	4	2	1
36	2012	5	4	1	2	3
22	2013	4	1	2	1	2
55	2014	4	7	6	2	2
37	2015	4	5	3	3	3
72	2016	5	3	4	6	4
54	2017	8	3	4	4	3
84	2018	8	8	9	3	2
69	2019	5	9	3	7	7
86	2020	11	4	11	4	4
84	2021	9	5	5	10	5
98	2022	23	17	5	8	9
5	2023	2	1	0	0	0
Total		**91**	**72**	**66**	**61**	**48**

3.2. Key journals in integration-related research

A total of 803 papers published in 58 conference or symposium proceedings and 57 journals, both of which were indexed in WOS, shows the interest in the research field of integration in public transportation. The top 15 journals and proceedings that had published the most research on integration during the previous 18 years were investigated (from 2005 to 2023). Table 4 lists journals in the rank order based on the total number of papers and citations received on public transportation integration.

Table 4. Top 15 leading journals in integration-related research from 2005 to 2023.

Journals	TP	TC	TLS
Sustainability	36	229	576
Transportation Research Part A	29	618	793
Research in Transportation Economics	27	258	358
Journal of Transport Geography	21	766	497
Transport Policy	15	499	413
Case Studies on Transport Policy	15	102	390
Transportation Research Record	14	191	206
Public Transport	10	110	168
Transport Research Arena	9	272	44
7th International Conference Environment	9	7	10
Transportation Research Part D	8	213	338
Research in Transportation Business & Management	8	85	306
Journal of Public Transportation	8	111	249
Transportation	8	180	145
Energies	8	76	65

The Sustainability Journal, which has published 36 articles on public transportation integration and had 229 total citations over the previous 18 years, is at the top of the list of all journals (from 2005 to 2023). However, the Journal of Transport Geography has the best reputation in terms of citations. Additionally, most publications on integration-related total link strength (TLS) are in Transportation Research Part A. Furthermore, the transport policy (TP) journal, which ranks fifth in terms of publications, has the highest percentage in terms of both publication count and total citations. Fig. 5 displays the top 15 journals' relationships on their networks according to the VOSviewer. The most striking aspect of this circumstance is that the two nonjournals, 7th International Conference Environment and Transport Research Arena (TRA) 2016, have contributed the integration-related public transport research as the most reputable journals.
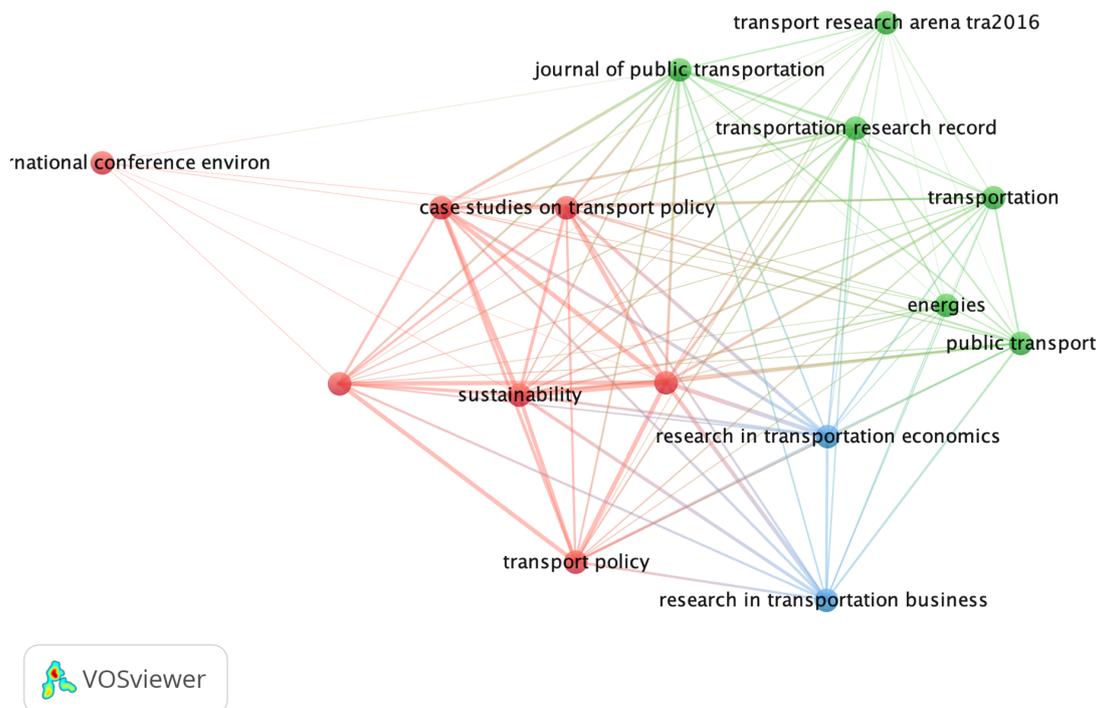

Figure 5. Top 15 leading journals in integration-related research from 2005 to 2023.

3.3. Key institutions in integration-related research

Table 5 and Fig. 6 list the top 15 institutional contributors to integration in public transport research over the previous 18 years (from 2005 to 2023), ranked by the number of publications on integration. With the exception of Vilnius Gediminas Tech University from Lithuania and Pontificia Universidad Católica from Chile, most studies are from the top 15 leading countries with the most publishing years (Fig. 7). With the largest publications share of (20), the largest producer of integration-related research among 201 institutions tracked in this analysis is Delft University of Technology (TU Delft) in the Netherlands. By contrast, University College London in England has the largest share of citations (513) from 2005 to 2023. With 17 publications, The University of Sydney in Australia is the second-best provider, but Curtin Technological University holds the second-place spot with 352 citations. Other top-15 institutions contribute with more than five publications apiece. However, the top leading nations and institutions including the Netherlands, Australia, and England have excellent citation records.

Table 5. Top 15 leading organization in reliability-related research from 2005 to 2023.

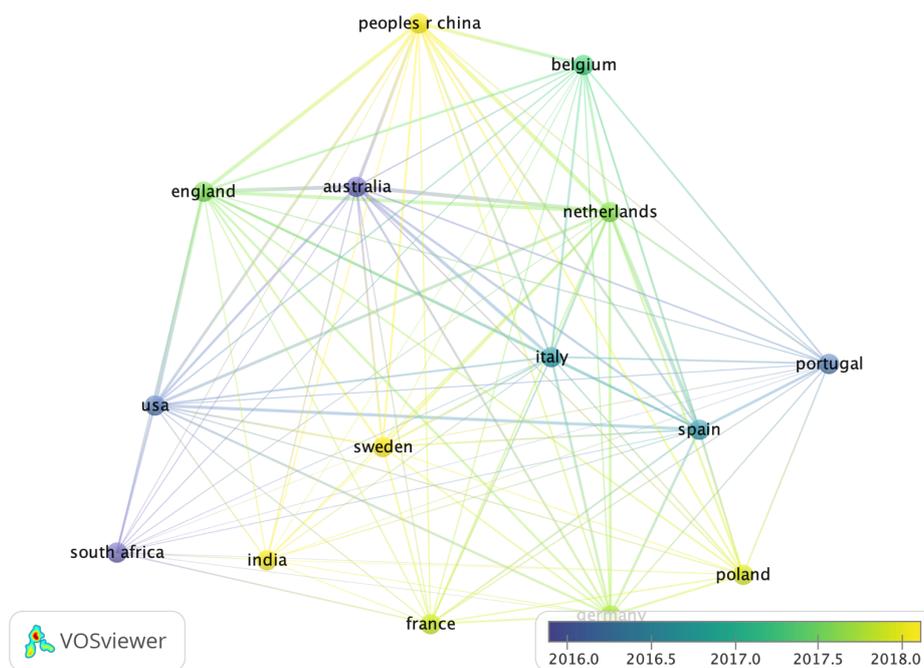| Organization	TP	TC	TLS	Country
Delft Technology University	20	206	461	Netherlands
Sydney University	17	265	351	Australia
University College London	12	513	573	England
Vilnius Gediminas Tech. Univ	12	16	28	Lithuania
Pontificia Univ. Catolica Chile	11	160	191	Chile
Auckland University	10	139	478	Australia
Beijing Jiaotong Univ	10	49	232	China
Granada University	9	112	653	Spain
Southeast University	8	78	478	Bangladesh
Leeds University	8	95	227	England
Cracow Technology University	8	76	102	Poland
Amsterdam University	7	310	638	Netherlands
Curtin University	7	103	326	Australia
Curtin Technology University	7	352	270	Australia
Ghent University	6	78	638	Belgium

Figure 6. Top 15 leading countries by time in integration-related research from 2005 to 2023.
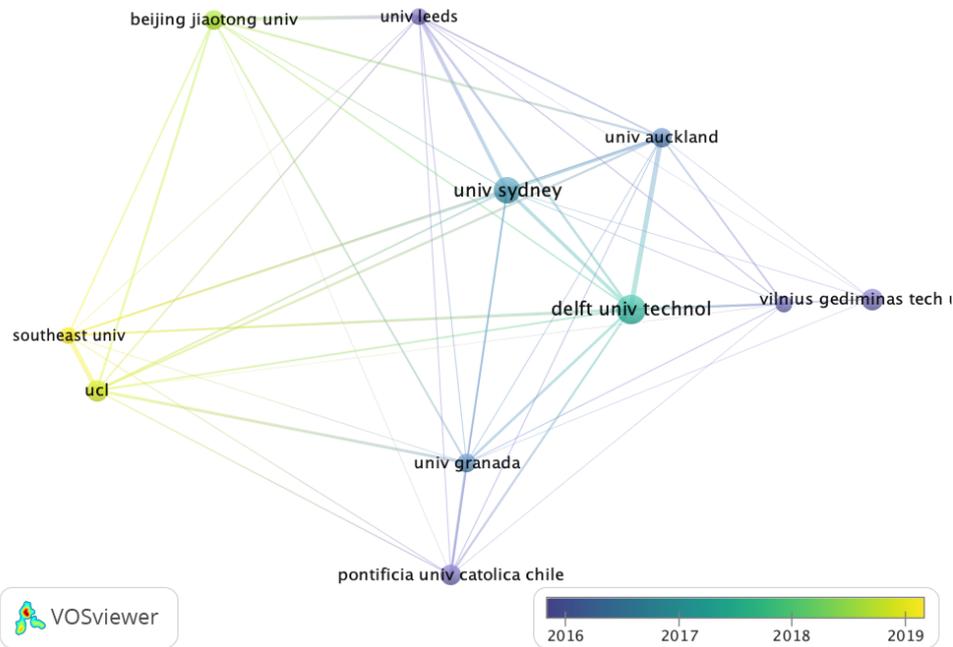
Figure 7. Top 15 leading organizations by year in integration-related research from 2005 to 2023.

3.4. Keyword's characteristics

A total of 3286 keywords, or an average of 5 keywords per article, are provided by the chosen 803 articles. Furthermore, 3286 keywords were divided into two categories to prevent duplication, and Table 6 presents the corresponding frequencies of these groups. Only 178 separate keywords—or 5,42% of all keywords—appear more than once. Furthermore, the top used keyword was "public transport" (219 times), and "integration" (99 times) was the second top keyword used. Other keywords with more than 20 times appearances include "transport" (63 times), "accessibility" (58 times), "mobility" (45 times), "system" (40 times), "impact" and "model" (38 times), "transit" (36 times), "travel" (33 times), "land use" (31 times), "demand", "city", and "optimization" (29 times), "built environment" (26 times), "policy" (25 times), "design" (24 times). Finally, "behavior", "choice," and "sustainability" have been used equally 22 times.

Table 6. Top 15 leading organization in reliability-related research from 2005 to 2023.

Keywords	Frequency	TLS
Public Transport	219	1384
Integration	99	640
Transport	63	404
Accessibility	58	421
Mobility	45	296
System	40	292
Impact	38	384
Model	38	236
Transit	36	314
Travel	33	293
Land-use	31	294
Demand	29	248
City	29	194
Optimization	29	189
Built Environment	26	254
Policy	25	231
Design	24	176
Behavior	22	202
Choice	22	176
Sustainability	22	133

3.5. Citation network analysis

The most significant studies with more than ten citations (216 documents) were chosen from documents and classified into four clusters (Fig. 8) to categorize the publications. Table 7 presents the most-cited articles related to the topic of integration in public transport, what can be done to entice car users to shift to using public transport with the integrated systems, and what should be the changes used to encourage public transport use, building the network for the public transport systems and its impact on passengers' perception, service integration of the whole system. The authors labeled each cluster by its content after classifying each cluster using VOSviewer. A total of 89 documents were published to investigate and evaluate the facets of public transportation mode choices included in Cluster 1 in red. Public transportation and mode choice of use were among issues discussed in the publications. Documents on public transportation accessibility and integration were under cluster 2, which was highlighted in yellow. A total of 42 documents, including an examination of the evaluation of land use and an information system analysis of public transportation, are used to estimate the service accessibility of public transportation and determine the effects of inaccessibility.

Table 7. Top 20 most-cited publications in integration-related research from 2005 to March 2023.

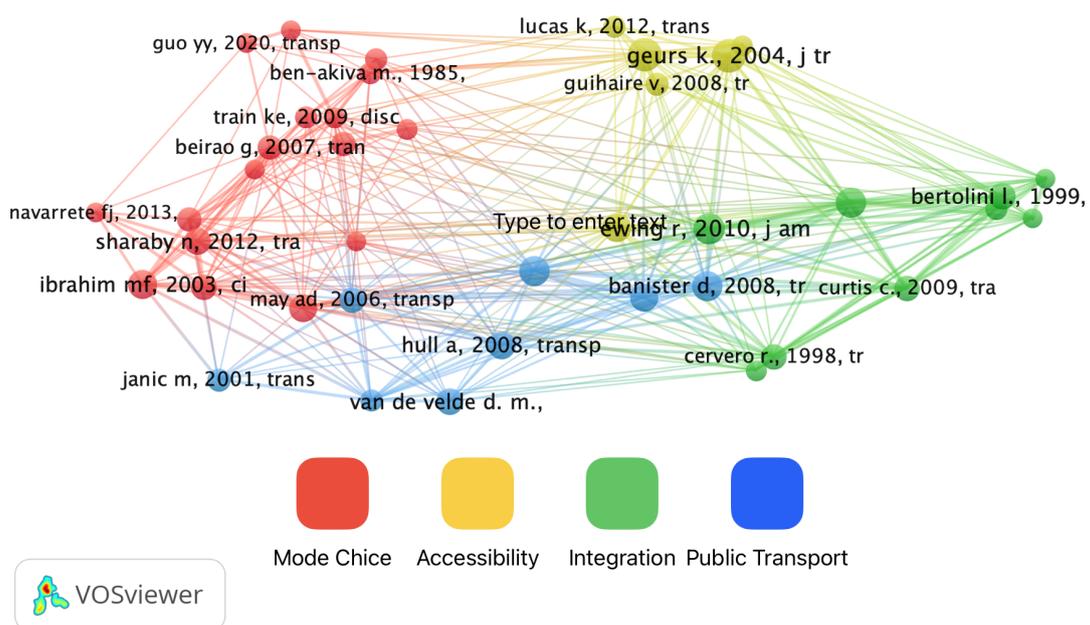| Publication	Citiation	TLS
Carvero, R	167	1107
European Comission	103	236
Hansher, DA	84	482
Pucher, J	80	578
Banister, D	73	675
Bertolini, I	67	556
Curtis, C	66	554
Litman, T	66	443
Fishman, E	59	288
Ceder, A	54	107
Currie, G	48	367
Newman, P	47	358
Buehler, R	43	394
Mulley, C	43	283
Lucas, K	41	321

Figure 8. Illustration of clusters of the publications as the most significant studies with more than ten citations.

Studies on the integration of transportation were categorized under cluster 3 in green (49 papers). Documents in this cluster delineate the principles of public transport integration strategies, examine and assess them, enhance new strategies, and pinpoint the variables influencing such strategies. In cluster 4, a common problem of public transportation as well as the network of transportation systems occurred. A total of 42 documents that discussed various network-related topics were grouped under this cluster. Models and methodologies in significant studies to assess public transportation service quality and network usage was mentioned.

3.6. Future trends of public transport integration publications

Numerous studies have used a constrained methodology to identify problems with public transportation. Discoveries that the majority of public transportation problems are connected, either directly or indirectly, have forced them to devise fresh methods for contemporary research and coin the term "transport integration," which encompasses and assesses the majority of public transportation problems. As noted, according to the WOS database, a strongly trending period from 2005 to the 21st of March 2023 had 803 documents published.

One of the factors that led the authors of the current work to forecast an increase in publications on public transportation reliability over the next 5 years was the increase in publications and citations. This investigation demonstrated inadequate conceptualization through cluster classification in the public transport integration components of investigating the integration techniques and network, transportation information evaluation, and other public transport-related variables. By contrast, the majority of publications on public transportation integration concentrated on sustainable modes, micromobility, mode selection, and public transportation. The cluster categorization indicated the necessity for additional research in the public transportation integration components highlighted in the current work and predicted an increase in publications in these areas over the next 5 years.

4. Conclusions

A prevalent problem worldwide is public transportation. Most studies have focused on travel time difficulties but ignored other factors. All public and private transportation-related concerns are covered, studied, and analyzed under "integration in transport." The inability to discuss the utilization of public transportation in urban and rural settings is just one of the numerous restrictions this study has considered. The purpose of the current assessment is to clarify the integration of public transportation and demonstrate the necessity for additional research. The current effort has analyzed several areas that define transport reliability and gather sufficient data.

This study has discovered that some factors, including sustainability, mode choice, accessibility, and network system, must be considered when analyzing public transportation integration. By contrast, our research revealed several useful suggestions for fostering sustainable growth and development. Based on the present number of publications and citations in the WOS database and the cluster classification by the VOSviewer program, growth in publications linked to public transport integration in some aspects was expected.

The current review confirmed the importance of focusing on public transport integration, which plays a prominent and influential role in achieving high-quality and efficient transport requirements with complete satisfaction in the future.

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