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Evolution of scientific production on urban passenger transport: A bibliometric analysis

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ABSTRACT

Urban passenger transport is a key point in the progress of any city. It is a strategic area whose efficient and sustainable development requires the incorporation of multiple disciplines. It affects territorial, social, health, economic, and environmental policies, among others. In recent years, we have witnessed a series of changes, especially in the domains of technology and environmental issues. The interdisciplinary nature of transport together with these developments has produced fundamental and far-reaching changes in the scientific production related to this field of study which is difficult to cover in a traditional review of the literature. The aim of this work is thus to conduct a bibliometric analysis of urban passenger transport during the period 2001–2021, which illustrates the advances made during this period and stimulate new research in this field. SciMAT software was used for this purpose. The results show the conceptual evolution of urban passenger transport research, identifying seven main thematic areas: (1) health and physical activity, (2) travel, (3) transport policy, (4) air pollution, (5) congestion, (6) social exclusion, and (7) electric and autonomous vehicles.

1. Introduction

The efficient development of urban passenger transport (UPT) is a crucial aspect in urban mobility and sustainability (Lindkvist & Melander, 2022). One of the most studied aspects of UPT is a decrease in congestion in cities (Ewing et al., 2018; Tirachini et al., 2014). This is further associated with minimizing greenhouse gas emissions (Adams et al., 2020; Creutzig et al., 2015) and guaranteeing travel for a large part of the population (Saif et al., 2018; Shi et al., 2020). Overall, the operation and available forms of transportation affect the economic and social development of cities (Bastanchury-López & De-Pablos-Heredero, 2022; Ortega-Fernández et al., 2020; Phillips et al., 2021).

In recent years, the research and analysis of UPT systems has received a great degree of attention due to the many changes in the context in which it is embedded. These affect, fundamentally, the environmental (Heiskala et al., 2016; Okraszewska et al., 2018; Sharifi, 2021; Wołek et al., 2021; Zhao et al., 2020) and technological aspects (Golbabaei et al., 2021; Paddeu et al., 2020; Soteropoulos et al., 2019).

From an environmental perspective, climate change has accelerated the development of policies aimed at mitigating and adapting to its effects in cities. These policies aim to: increase the efficiency of public transport (Song et al., 2016), encourage the withdrawal of (older) more polluting vehicles (Epicoco & Falagario, 2022; Mounce & Nelson, 2019), spur the search for more environmentally friendly fuels (Li et al., 2010; Wang & Lin, 2019), and reduce the use of private vehicles, replacing them with alternative forms of transport (e.g., bicycles, walking) (Pucher et al., 2011; Zhao & Li, 2017). The technological perspective relates to improving the attractiveness of existing modes and the emergence of new forms of transport (Sharifi, 2021; Webb, 2019).

UPT is a complex and multifaceted issue encompassing several disciplines, including urban planning, transport engineering, environmental and social sciences, and public policy. The various perspectives from which it can be approached make it an important field of study. Its interdisciplinary nature, however, means that traditional literature reviews cannot cover the thematic diversity and large volume of scientific production on the subject (Sharifi, 2021). A bibliometric analysis counters these obstacles by offering tools that help analyze large quantities of publications (Cobo et al., 2011; Ji et al., 2023; Shen et al.,

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2023). It allows us to examine metrics related to the performance of different elements, including authors, universities, journals, and countries. Furthermore, it can map the structure of research in a given field (Ji et al., 2023), thereby illustrating the evolution of the topics in which research is conducted and allowing us to explore the interrelationships between different subfields (Cobo et al., 2011).

Based on the large body of research carried out between 2001 and 2021, this article will synthesize and analyze the most significant contributions made in the field of urban passenger transport through the analysis of their temporal evolution. This is done via a bibliometric analysis using the SciMAT tool. The broad scope of this topic has led different researchers to conduct bibliographic and bibliometric analyses, generally focused on specific areas. These areas include, for example, sustainable transportation (Sharifi, 2021), accessibility (Saif et al., 2018; Shi et al., 2020), safety (Shen et al., 2023), or smart mobility (Abduljabbar & Dia, 2022; Ji et al., 2023). This work provides a comprehensive study of the multiple thematic areas relating to the development of UPT activity (i.e., health, technology, business management, environment, urban planning). This allows us to examine the interrelationships between the different concepts and approach UPT from an integrative perspective. Likewise, the volume of research and the broad time frame covered in this study provide a complete perspective of the state of UPT research and the different stages that have led to this point.

The results show how key trends in transportation research, as well as emerging methodologies and results, have grown at a rapid pace in recent years. Seven major thematic areas are highlighted: health/physical activity, travel, transport policy, air pollution, congestion, social-exclusion, and electric vehicles.

To this end, this paper first analyzes the theoretical framework of UPT. Then follows an explanation of the methodology required to conduct the work, both in terms of the database from which the scientific publications were extracted and the bibliometric tool used for their analysis. Next, the results are presented, and finally, the most relevant conclusions are pointed out.

2. Theoretical framework

Transportation is tied to the economic and social development of cities; it facilitates the growth of the economy and the movement of people and goods, thereby improving overall quality of life (Chatziioannou et al., 2023; Kim et al., 2020; Phillips et al., 2021; Politis et al., 2021; Saif et al., 2018).

However, some transportation-related factors may compromise the quality of life in cities. Consider the use of private vehicles, deemed the greatest contributor of polluting gases and largest consumer of energy (Epicoco & Falagario, 2022; Zhao et al., 2020) together with the estimation that by 2050, 68 % of the population will be living in urban areas (Allam & Sharifi, 2022; López et al., 2019). The high population density coupled with unequal growth between different modes of transport (with road transport and specifically private vehicles given priority) can diminish the quality of life for many (Adams et al., 2020; Bastanchury-López & De-Pablos-Heredero, 2022).

Efficient urban passenger transport boasts many benefits: it supports urban mobility and sustainability (Lindkvist & Melander, 2022), facilitates accessibility to jobs or leisure, favors social and territorial equity, reduces congestion, minimizes environmental impact, and optimizes the use of healthy resources (Adams et al., 2020; Gómez-Ortega et al., 2023; Kim et al., 2020; Lopes Toledo & Lèbre La Rovere, 2018; Oviedo & Attard, 2022).

Achieving an efficient transportation system is associated with the improvement of public transportation (Das et al., 2021; Song et al., 2016) and reduction in the use of private vehicles, replacing these with alternative forms of transport (e.g., bicycles, walking, electric vehicles). The use of technology that benefits the passenger is also beginning to gain importance (Nehk et al., 2021; Pucher et al., 2011). These actions are proposed to adapt to more sustainable mobility and the changes in mobility of new generations (Delbosc & Currie, 2013) by promoting mobility as a service (Mobility as a Service - MaaS) (Alyavina et al., 2020; Lindkvist & Melander, 2022).

Improving urban passenger transport, however, involves the integration of several different disciplines, such as urban planning, transportation engineering, environmental and social sciences, and public policy implementation (Allam & Sharifi, 2022; Barnett et al., 2017; Bordagaray et al., 2014; Chatterjee et al., 2020; Epicoco & Falagario, 2022; Oviedo & Attard, 2022; Song et al., 2016).

With these guidelines, public policies aimed at achieving more efficient transport are marked in the agendas of governments worldwide. This follows the publication of documents such as “Cities on the move. A World Bank Urban Transport Strategy Review” (World Bank, 2002). The purpose of this report was to analyze the problems of urban transport, articulate strategies to improve it, and identify the role of the World Bank in contributing. Agreements such as those reached at the “World Summit on Sustainable Development” (United Nations, 2002) were signed by countries committed to include measures to improve the environment, giving a priority role to the development of policies to improve public transport. Additionally, the implementation of the Kyoto Protocol in 2005 underscored the need and urgency to limit the greenhouse effect linked to transport.

During this period, the European Union assumed an important role through the measures set out in the White Paper “European Transport Policy for 2010: Time to Decide" (European Commission, 2001). These measures achieved great progress in transport, but even so, were unable to solve problems of transport sustainability. The Commission therefore proposed the need to define lines of action to achieve sustainability in transport. The White Paper "Roadmap to a single European transport area: towards a competitive and sustainable transport policy" (European Commission, 2011) was published to guide the transportation policies of the member countries and impact the decisions adopted by international organizations.

In parallel, “The World Bank Annual Report 2010: Year in Review” (World Bank, 2010) was published to highlight the development of sustainable transportation measures to mitigate the greenhouse effect problems.

With the importance of reducing harmful gas emissions and decreasing dependence on fossil fuels gaining international relevance, the publication of the 2030 Agenda (United Nations, 2015) and the signature of the Paris Agreement (United Nations, 2015), have marked the commitment of most countries to address the environmental, social, and economic challenges caused by climate change.

In 2020, the Covid-19 pandemic provided a portrait of the impact of displacement, as the near paralysis of economic activity managed to slow climate change and brought about greater awareness on the part of individuals (Allam & Sharifi, 2022; Barbieri et al., 2021; Beck & Hensher, 2020; Das et al., 2021).

Given the significance of these milestones, they will be taken into account for the longitudinal analysis of results by periods.

3. Methodology

The path to cover the objectives of this work is carried out in two steps: first, we identify the set of publications in the field of study, and second, we configure the bibliometric map that monitors urban passenger transport. The purpose of scientific maps as a bibliometric technique is to illustrate the structure and evolution of the field of scientific research (Alhjouj et al., 2022; Braam et al., 1991a, 1991b; Cobo et al., 2011) These are applied longitudinally in order to understand the evolution of the research field throughout the study period.

3.1. Database

The search for publications is conducted in the Web of Science (WoS) Core Collection database, as it feeds the Journal Citation Reports (JCR)

to establish the impact factor that gives prestige to scientific journals (Paule-Vianez et al., 2020). In addition, this database includes journals with a high impact factor also found in other databases (such as Scopus). In line with this, there are multiple bibliometric analysis studies in different areas of knowledge (Bastanchury-López & De-Pablos-Heredero, 2022; Ellegaard & Wallin, 2015; Merigó & Yang, 2017; Paule--Vianez et al., 2020; Sharifi, 2021; Zhao et al., 2020). From this database, the Social Sciences Citation index is selected, as it holds JCR articles from the field of Social Sciences. With this selection, commonly used for bibliometric studies in the field of management (Bastanchury-López & De-Pablos-Heredero, 2022), the intention of the work is to monitor topics of interest from the field of social science research.

The search, carried out on September 9, 2022, covers the period of analysis from 1/1/2001 to 12/31/2021, focusing on the analysis of the evolution of publications on urban passenger transport in the 21st century.

For this period, an advanced search with the criteria "urban transport," "public transport," or "passenger transport" was carried out, yielding a total of 7456 bibliographic outputs. This yield was further refined by choosing publications categorized as articles, review articles, early access, and editorial materials. Following this, the sample to start the bibliometric analysis and monitor research in the field of study was configured by 6920 references for the selected period, which were exported to the SciMAT tool.

3.2. SciMAT analysis

The SciMAT tool is used to analyze the thematic and conceptual evolution of the field of study. Of the various options for conducting bibliometric studies, this software is chosen for its flexibility in selecting measures to generate and visualize bibliometric networks, as well as for the various techniques that allow debugging of the database as input to the analysis process (Paule-Vianez et al., 2020).

The possibility that the research outputs comprising the database exported to SciMAT may be insignificant, duplicated, or contain errors is mitigated by the tool's capacity for an adequate filtering process. This enables the monitoring of a higher quality database.

In recent years, this software has been applied in multiple works analyzing different areas, such as finance (Alcázar-Blanco et al., 2021; Paule-Vianez et al., 2020), road safety (Ji et al., 2023), autonomous vehicles (Morooka et al., 2023), and sustainable transport (Sharifi, 2021).

The methodological process in SciMAT begins by choosing the unit of analysis that is the reference point for studying the research field to be analyzed. Of the different possible options, the "keywords" are chosen, since the focus is on more conceptual aspects of the research area (Cobo et al., 2012).

A clustering process is performed to locate groups of keywords based on a co-occurrence analysis, considering such a relationship will exist between words when they appear together in documents in the database (Alhjouj et al., 2022).

For the *clustering* algorithm used to extract the main themes, the simple center algorithm is chosen. In addition, the h-index (Alonso et al., 2009; Cobo et al., 2012), the total number of publications, and total number of citations are selected as quality measures (Paule-Vianez et al., 2020).

Fig. 1 shows the bibliometric outputs to be analyzed: a) the strategic diagram, b) the thematic network, c) the thematic area evolution map,

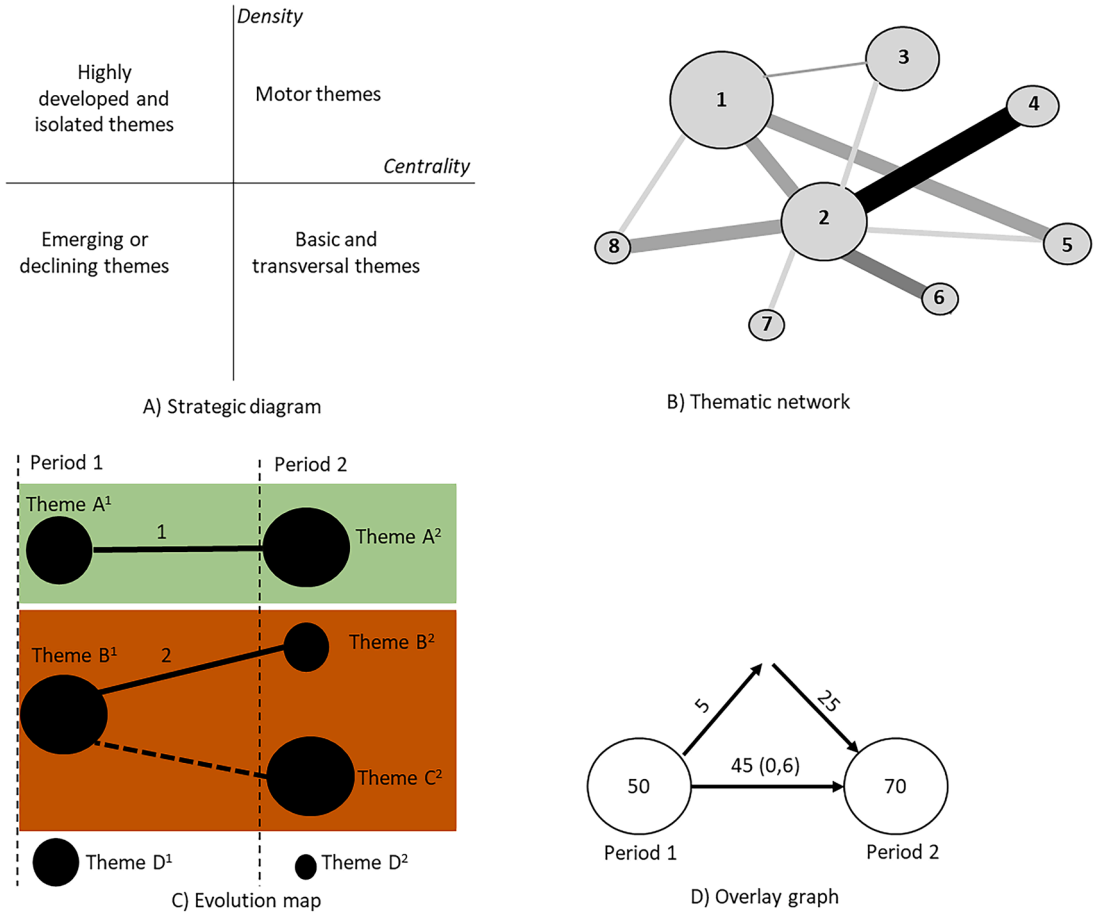

Fig. 1. Outputs of bibliometric analysis.
Source: Cobo et al. (2011); Sharifi (2021)

and d) the overlay graph.

The strategic diagram represents the research topics on a Cartesian map based on two measures that characterize each topic: density and centrality. Density measures the internal strength of the network, i.e., the internal cohesion of a topic, while centrality expresses a network's degree of interaction with respect to other networks (Callon et al., 1991; Cobo et al., 2011; Sharifi, 2021). Both measures are used to classify themes into one of four categories: driving themes, basic and cross-cutting themes, highly developed themes, and emerging or disappearing themes.

The driving themes of the research field are in the strongest quadrant of centrality and density, giving rise to themes that are well developed and important to the research field. The opposite quadrant, low centrality and density, includes underdeveloped and marginal topics, giving rise to emerging or disappearing topics. Basic or cross-cutting topics, with high centrality but low density, are topics which relate to the rest but are poorly developed in themselves. Finally, highly specialized themes are themes with low centrality but high density, being highly developed but not as connected with the rest (Alcázar-Blanco et al., 2021; Callon et al., 1991; Cobo et al., 2011; Sharifi, 2021)

As pointed out by Sharifi (2021), the thematic network complements the strategic diagram. In it, each topic is represented by a network with its nodes (keywords). The size of the sphere of each node is proportional to the number of documents associated with that keyword, and the thickness of the line between two nodes is proportional to its equivalence index (Cobo et al., 2011).

To show the evolution of the thematic areas in the field of research throughout the study period, the evolutionary bibliometric map is analyzed. This shows the different thematic areas, represented with different shading (Fig. 1). A thematic area or thematic line is defined as a group of topics that have evolved over several consecutive periods of time (Cobo et al., 2012). In this map, the size of the nodes is directly proportional to the number of documents of each topic, with the thickness of the line of interconnection between topics directly proportional to the importance or weight of each thematic nexus. Solid lines indicate that the linked topics or themes share the same name, i.e., both topics were tagged with the same keyword, or the label of one of the topics is part of another topic. Dashed lines signify that the topics share elements that do not fit the cluster label.

Finally, the overlay graph shows the level of stability between two consecutive periods (Gamboa-Rosales et al., 2020). The number inside the circle represents the total number of keywords in the period. The horizontal arrow shows the number of shared words. The number in parentheses refers to the similarity index between the periods. The outgoing arrow at the top represents the keywords belonging to the first period that are not included in the second period. In contrast, the incoming arrow reflects the number of newly introduced keywords which only exist in the second period (Cobo et al., 2011).

4. Results

The 6920 selected documents were imported from WoS and the corresponding filters were applied in SciMAT to avoid duplications and other incorrect records. The resulting final database was 6272 documents. To contextualize the results of the bibliometric study on the field of research on urban passenger transport, we begin by showing a descriptive analysis of the publications, focused on performance indicators during the study period.

This century has seen many milestones bearing an important influence on the evolution of UPT. However, our study considers only three of these by which to delineate the analysis to ensure a sufficient number of publications in each period. The year 2010 is identified as the first milestone. Beginning in 2010, a progressive increase in the number of publications on the subject of UPT can be clearly observed, coinciding with the publications of the White Paper "Roadmap to a single European transport area: towards a competitive and sustainable transport policy" (European Commission, 2011) and "The World Bank Annual Report 2010: Year in Review" (World Bank, 2010).

The second milestone is the year 2015, as it coincides with the publication of the 2030 Agenda and the Paris Agreement (United Nations, 2015). These agreements represent a commitment by most of the world's countries to address the environmental, social, and economic challenges caused by climate change. Finally, the third milestone selected is the year 2019, as the end of that year saw the outbreak of the Covid-19 pandemic, bringing with it a major impact on the development of urban mobility.

Consequently, the following sub-periods were selected to analyze the evolution of the field over time: 2001–2010, 2011–2015, 2016–2019, and 2020 −2021.

Fig. 2 shows the evolution of the number of documents per year. This illustrates an increase in scientific interest during the period analyzed, from 40 documents published in 2001 to 1213 in 2021. In addition, more than half of the publications are concentrated in the last five years, and the most relevant variation is seen in the last year of the study (2020–2021). As will be seen later, this can be attributed factors such as the increase in publications on Covid-19, the growing attention generated by transport in the fight against environmental degradation, and the rapid technological evolution of means of transport and their management.

Table 1 lists the number of papers and total citations for the most productive authors in this field. David A. Hensher and Corinne Mulley, both from the University of Sydney and each with more than 50 publications in WoS, demonstrate the highest performance by publication volume. Despite having fewer papers (32 publications), Billie Giles-Corti, as co-author, has the paper with the highest number of citations, which dates from 2016.

Table 2 shows the 10 documents in this set of publications with the highest number of citations, including the reference of authors, the journal, and year of publication.

The results in Table 2 show the diversity of journals that include articles related to the research field. *Transport Policy, Preventive Medicine,* and *Transportation Research Part b-Methodological* are the only ones with more than one publication in the top 10 most cited. The most cited article in this research field is "*Making cycling irresistible: Lessons from the Netherlands, Denmark and Germany*" by John Pucher and Ralph Buehler, published in 2008 in *Transport Reviews* with 880 citations (Pucher and Buehler, 2008).

The analysis of productivity by journal is shown in Table 3.

The results in Table 3 indicate that, of a total of 827 journals, the 10 journals with the highest number of papers account for 40 % of the total number of papers analyzed. The journal *Sustainability* stands out because, although not the oldest journal, it contains the largest number of documents in the research area, with 569 documents (9.07 % of the total number of papers analyzed).

Table 4 shows the most common keywords and the number of documents that include them:

The analysis highlights the words "travel," "accessibility," "air pollution," "behavior," "health," and "travel behavior," all of which are referenced in more than 500 documents.

4.1. Creation and analysis of the scientific map

To analyze the evolution of research in UPT, the sample has been divided into four periods coinciding with certain milestones that modified the way we understand transportation. Fig. 3 shows the number of publications per period.

The analysis by period is as follows:

4.2. First period (2001–2010)

As illustrated in Fig. 4, the most analyzed transport topics in this period refer to travel, health, and transport policy. The research is

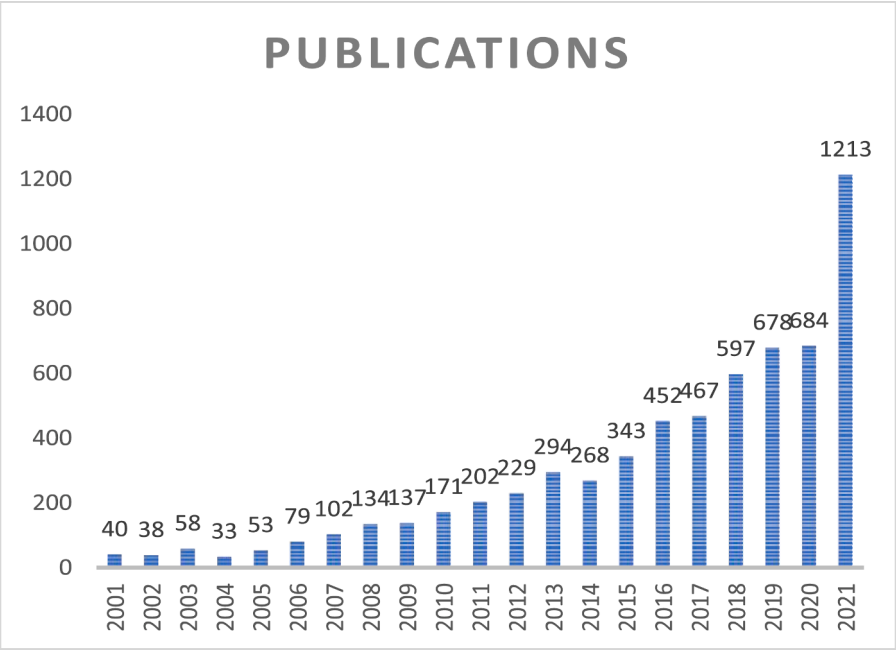

Fig. 2. Evolution of publications on UPT.
Source: Own elaboration

Table 1
Authors' production in research on UPT.

Author	Documents	Citations	Citations per document	Most cited publication	Citations of most cited publication
Hensher, David A.	61	2310	38	(Li et al., 2010)	214
Mulley, Corinne	57	1403	25	(Daniels & Mulley, 2013)	162
Cats, Oded	49	1159	24	(Abenoza et al., 2017)	120
Currie, Graham	44	1639	37	(Currie, 2010)	224
Giles-Corti, Billie	32	1885	59	(Giles-Corti et al., 2016)	462
Axhausen, Kay W.	26	808	31	(Meyer et al., 2017)	145
Friman, Margareta	24	1244	52	(Redman et al., 2013)	351
Ceder, Avishai	24	613	26	(Liu & Ceder, 2015)	95
Tirachini, Alejandro	23	906	39	(Tirachini et al., 2013).	182
Nelson, John D.	23	609	26	(Velaga et al., 2012)	138

Source: Own elaboration.

focused on analyzing the behavior of users of different types of transport and on sustainable development measures related to both urban structure and transport policy.

As seen in Fig. 4, travel and health appear as driving themes in the scientific field. Work relating to travel focuses on analyzing passenger behavior with respect to different types of transport (public transportation, private car, etc.). It also emphasizes more sustainable travel patterns such as cycling or walking, with the aim of establishing measures to alleviate car use and the accompanying congestion and pollution. When we talk about health, transport relates to modes of mobility that are considered good for health, e.g., walking or cycling, analyzing which measures of space, facilities, etc. and behavioral patterns can influence their optimal use.

Transport policy appears as an emerging issue. The reviews show that the sustainable development of mobility in cities, reduced use of private vehicles, and promotion of public transport use directly relate to urban structure and transport planning policies. Therefore, proper management of these policies will have a direct effect on urban transport emissions, congestion, accessibility, etc.

Table 5 illustrates the performance measures for this period. Travel has the largest number of documents and the highest h-index, but health, with the fewest documents, has the highest number of citations, indicating the importance of this topic in the analysis of transport. Although the number of citations for transport policy is considered low (468), most of these correspond to the last years of analysis.

4.3. Second period (2011–2015)

Fig. 5 shows the seven clusters identified in the second period: physical activity, air pollution, quality, land use, demand, congestion, and social exclusion. Of these, physical activity, quality, and land use are considered driving themes. In particular, the physical activity cluster is closely related to one of the driving themes of the previous period, health. This demonstrates continuity when dealing with issues related to how choice of means of transport and physical activity performance influence the health of individuals. Quality and land use emerge as new driving themes. Growing interest in measuring the quality of public transport is shown, with a primary focus on the study of user satisfaction. Land use refers to issues such as the importance of location for public transport stations or how choice of transport mode affects the existing urban design.

In this period, the only basic or cross-cutting theme is demand. This addresses aspects such as the qualitative attributes of public transport that attract different users, estimation of demand for public transport, or modeling of citizens' behavior and identification of preferences when choosing mode of transport.

Table 2
Most cited articles on UPT research.

Title	Authors	Year	Journal	Quotations
Making cycling irresistible: Lessons from the Netherlands, Denmark and Germany.	Pucher, J.; Buehler, R.	2008	Transport Reviews	880
Existence of urban-scale macroscopic fundamental diagrams: Some experimental findings.	Geroliminis, N.; Daganzo, CF.	2008	Transportation Research Part B-Methodological	767
Infrastructure, programs, and policies to increase bicycling: An international review	Handy, S.; Pucher, J.; Dill, J.	2010	Preventive Medicine	750
Towards a theory of decoupling: degrees of decoupling in the EU and the case of road traffic in Finland between 1970 and 2001	Tapio, P.	2005	Transport Policy	704
Understanding attitudes towards public transport and private car: A qualitative study.	Beirão, G.; Cabral, J.A.S.	2007	Transport Policy	581
The Role of Customer Engagement Behavior in Value Co-Creation: A Service System Perspective	Jaakkola, E.; Alexander, M.	2014	Journal of Service Research	575
Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study	Frank, L.D.; Van Dyck, D.; Cerin, E.; Owen, N.; Sarmiento, O.L.; Davey, R.; Conway, T.L.; Adams, M.A.; Cain, K.L.; Mitas, J.; Reis, R.; Salvo, D.; Schofield, G.; Sallis, J.F.; De Bourdeaudhuij, I.; Schipperijn, J.; Pratt, M.; Smith, G.; Kerr, J.; Lai, P. C.; Troelsen, J.	2016	Lancet	573
The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050	Angel, S.; Parent, J.; Civco, D.L.; Blei, A.; Potere, D.	2011	Progress in Planning	561
Urban gridlock: Macroscopic modeling and mitigation approaches.	Daganzo, C.F.	2007	Transportation Research Part B-Methodological	543
Perceptions about the local neighborhood and walking and cycling among children.	Timperio, A.; Crawford, D.; Telford, A.; Salmon, J.	2004	Preventive Medicine	528

Source: Own elaboration.

Table 3
Journals with publications on UPT by number of papers.

Journal	Doc.	%	Year vol. 1	Impact 2021
Sustainability	569	9.07	2009	3889
Transportation Research Part A-Policy and Practice	395	6.30	1976	6615
Transport Policy	387	6.17	1993	6173
Journal of Transport Geography	346	5.52	1993	5899
Transportation	171	2.73	1972	4814
Transportation Research Part d-Transport and Environment	162	2.58	1996	7041
Transport Reviews	129	2.06	1981	10,185
Transportation Research Record	126	2.01	1996	2019
Research in Transportation Economics	114	1.82	1994	2904
International Journal of Sustainable Transportation	113	1.80	2007	3963

Source: Own elaboration.

Table 4
Number of documents by keyword.

Keyword	Number of Documents
Travel	727
Accessibility	620
Air pollution	571
Behavior	550
Health	548
Travel behavior	512
Physical activity	470
Car use	449
Quality	416
Demand	384
Networks	649
Energy efficiency	331
Land use	315
Satisfaction	299

Source: Own elaboration.

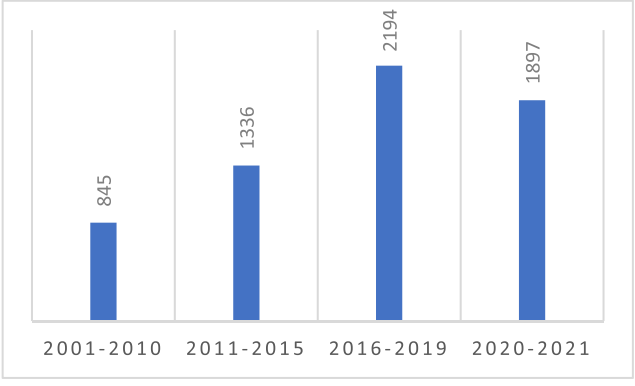

Fig. 3. Number of publications by period.
Source: Own elaboration

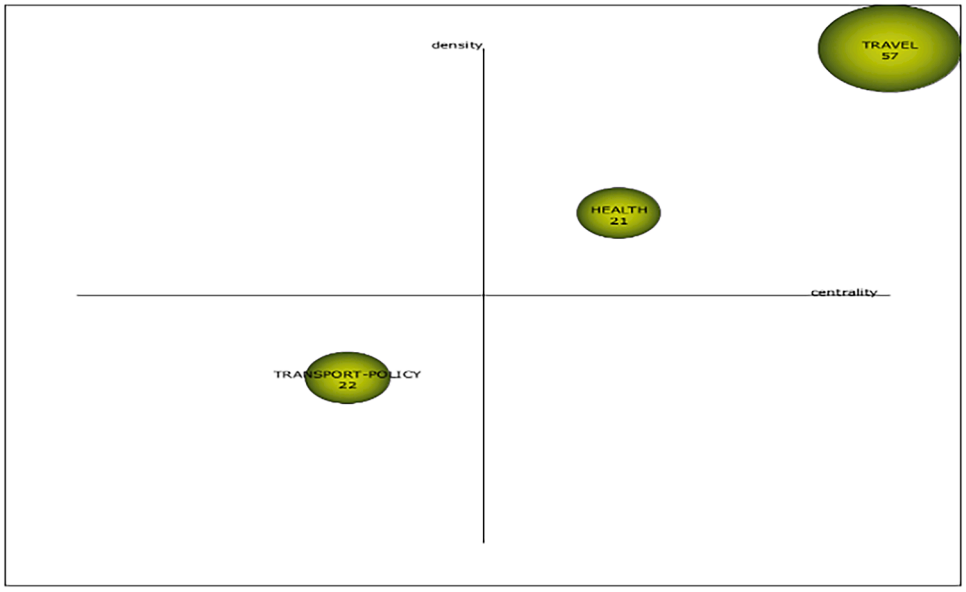

Fig. 4. Main themes 2001–2010.
Source: Own elaboration

Table 5
Measures of performance of the subjects in the period 2001–2010.

Name	Document Count	H-Index	Sum Citations
Travel	57	32	5101
Health	21	17	5027
Transportation policy	22	14	468

Source: Own elaboration.

The air pollution cluster analyzes the influence of transportation on climate change and studies the climate policies being adopted in different countries. This theme very well developed in this period but in an isolated manner.

Finally, in the quadrant of emerging or disappearing clusters, we find social exclusion and congestion. Social exclusion is a theme that primarily deals with studies on the influence of poverty on access to the transport system. Its main objective is to address public policies that allow for equitable and socially sustainable urban transport systems. It also addresses studies on the gender perspective in the use of transport. Congestion focuses on the analysis of how to manage traffic congestion through optimal urban public transport design, investment in infrastructure, or developing an appropriate pricing system.

As illustrated in Table 6, the topic with the highest performance in this period is physical activity with 107 documents published, an h-index of 47, and 6200 citations. It is followed closely by land use, which surpasses physical activity in number of documents. At the other extreme, we find social exclusion, which has the lowest number of documents and citations and a lower h-index.

4.4. Third period (2016–2019)

Here, the contribution is closely related to the use of technology for the development of sustainable mobility, the use of electric vehicles, the implementation of information systems, and measures linked to the reduction of transport-related emissions. In this period, research on transportation focuses on 12 research themes: physical activity, air pollution, satisfaction, optimization, accessibility, travel behavior, demand, performance, accidents, electric vehicles, information systems, and density (see Fig. 6).

One driving theme is physical activity, with a similar analysis to that of the previous periods. Other driving themes include air pollution, which changes from being a specialized theme in the second period to a driving theme in the third, satisfaction, travel behavior, and accessibility.

Air pollution grows in importance in this period as a result of the 2030 Agenda (United Nations, 2015) and the signature of the Paris Agreement (United Nations, 2015), with countries joining efforts to combat climate change and adapt to its effects. Work linked to the development of measures and plans to reduce greenhouse gas emissions thus increases, especially in association to the use of private vehicles. Regarding satisfaction, studies relate to the identification and characterization of current and potential users of public transport to determine the most important factors that influence satisfaction and loyalty in public transport use. The analysis of transport as regards accessibility is focused on evaluating accessibility both in terms of equity and the implementation of improvements in mobility, such as the use of autonomous vehicles.

Lastly, travel behavior appears as a driving theme, with a similar theme to that analyzed by travel in the first period, focusing on passenger behavior by mode of transport.

Performance and demand are basic and cross-cutting themes. In the case of performance, transport studies focus on the use of models to evaluate the performance of the transport system from the viewpoint of both sustainability and innovation. Demand maintains the line of the previous period, where it was already located in this quadrant, but it nears that of emerging or disappearing issues in the third period.

The main emerging themes that appear in the cluster review relate to electric vehicles, information systems, and density. The theme of electric vehicles focuses on analyzing the different possibilities that electric vehicles assume in the future of sustainable mobility in cities. In information systems, studies focus on mobility improvements in cities through vehicle automation, schedule optimization measures, connectivity services, and the application of artificial intelligence systems in transportation. Density could be considered a disappearing theme, as the works analyzed are in the early years of the period, with studies referring to the relationship between the built environment and chosen mode of transport.

Accidents appears as a marginal theme in this period, with focus on explaining the causes of traffic accidents in cities from the point of view of both driver and pedestrian.

Optimization falls between marginal and emerging or disappearing

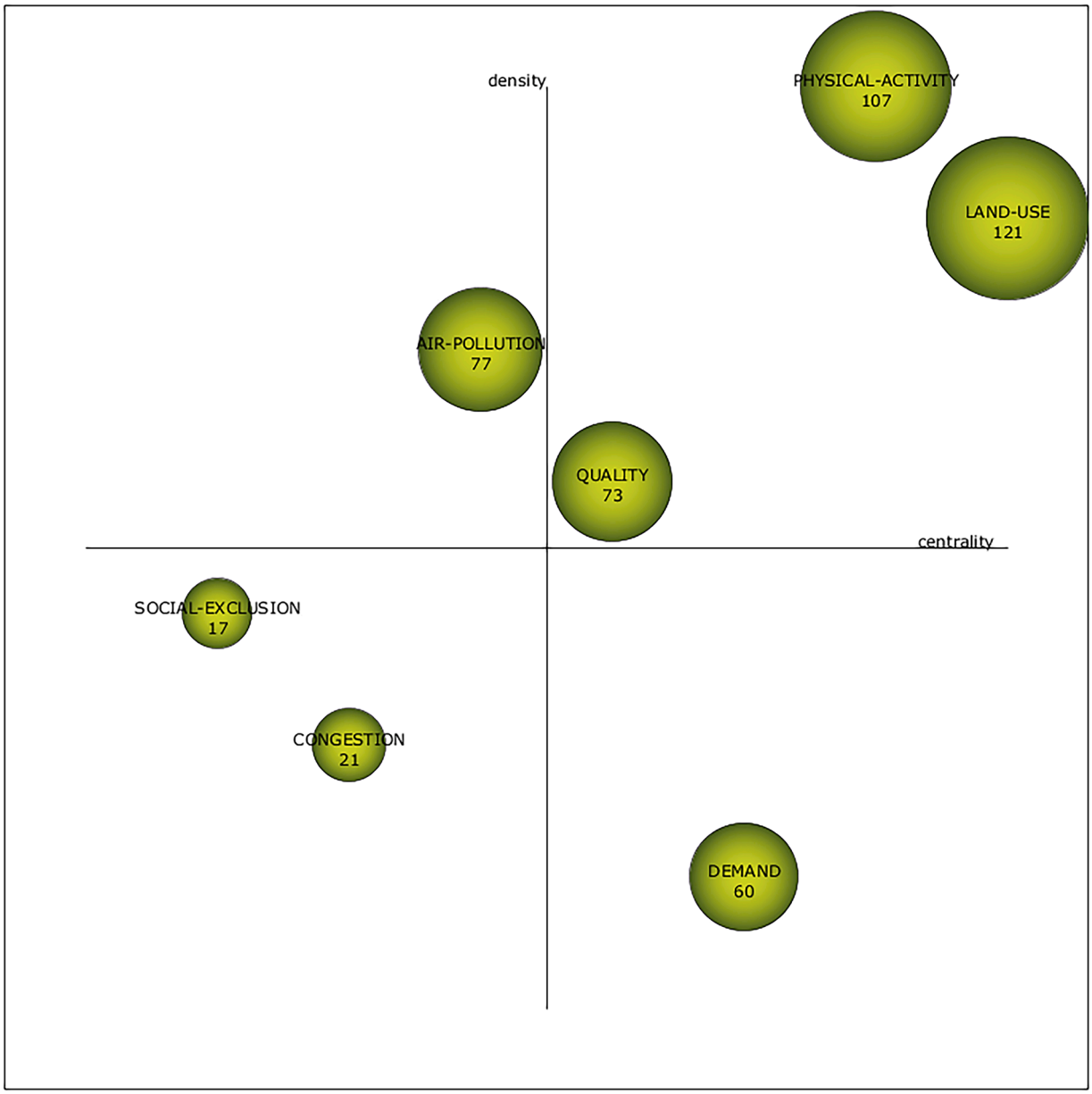

Fig. 5. Main themes 2011–2015 period.
Source: Own elaboration

Table 6
Performance measures of subjects in the period 2011–2015.

Name	Document Count	H-Index	Sum Citations
Physical activity	107	47	6200
Air pollution	77	36	3450
Quality	73	28	2765
Land use	121	42	5405
Demand	60	26	2161
Congestion	21	15	732
Social exclusion	17	13	843

Source: Own elaboration.

topics. It is focused on proposing scheduling models, allocation, etc. to optimize transportation use.

Table 7 shows that physical activity continues to have the highest number of documents and highest number of citations. Air pollution has the highest h-index in this period. The number of documents on travel behavior increases from the first period but not the number of citations (4249).

4.5. *Fourth period (2020–2021)*

The strategic diagram in Fig. 7 demonstrates how transportation research in recent years has focused on ten topics: satisfaction, physical activity, accessibility, air pollution, networks, sustainability, efficiency, Covid-19, autonomous vehicles, and service. Research in this period shows thematic areas present in previous periods, but a new trend is observed with the appearance of topics such as efficiency, sustainability, and Covid-19, which impacted transportation greatly in these years.

The driving themes identified in the 2020–2021 period are satisfaction, physical activity, accessibility, and air pollution. All were identified as driving themes in the previous period and maintain relevance over time.

Service is clearly positioned as a basic theme in this period, within which disparate issues relating to transportation service and user

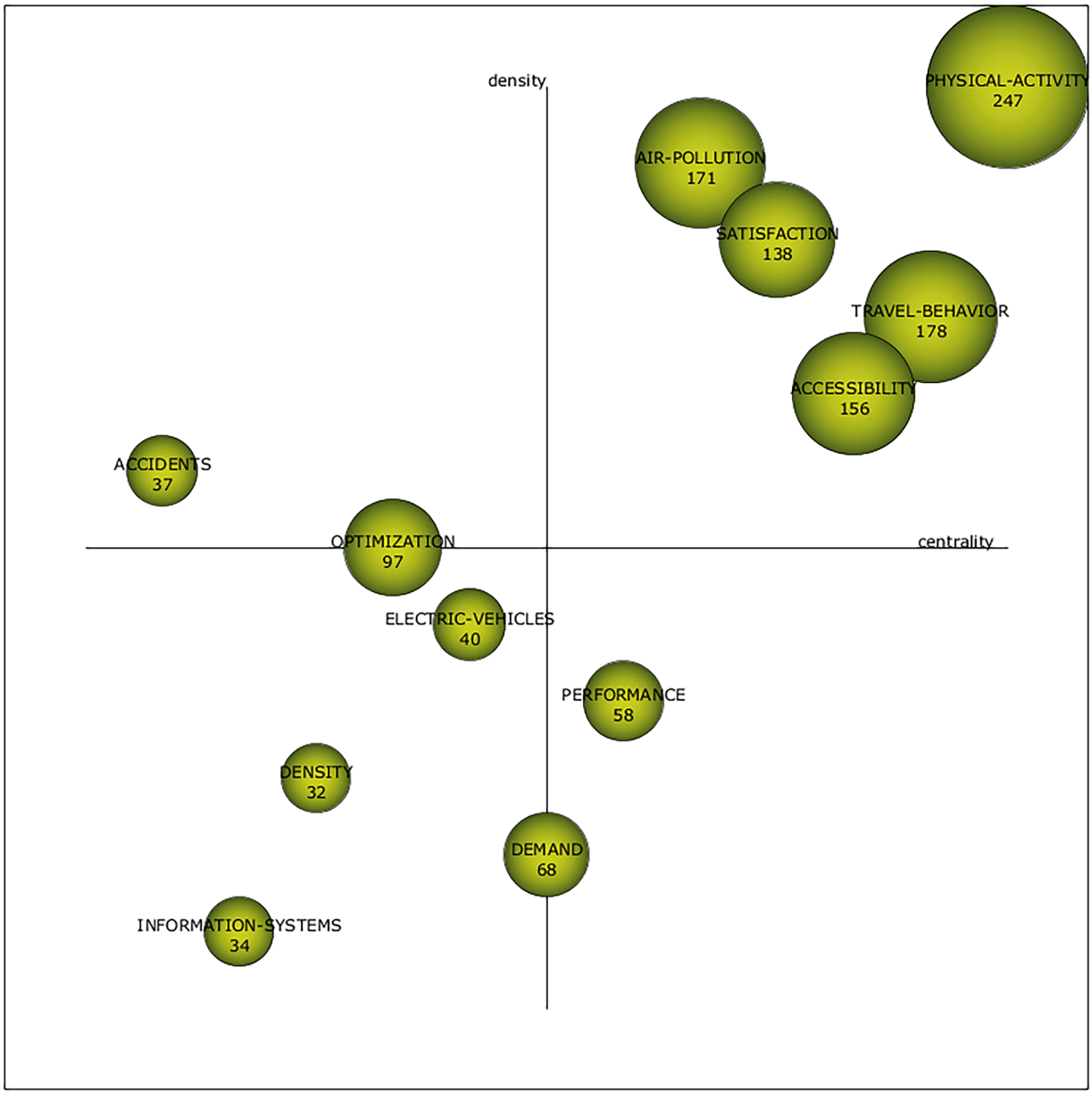

Fig. 6. Main themes period 2016–2019.
Source: Own elaboration

Table 7
Performance measures for 2016–2019 themes.

Name	Document Count	H-Index	Sum Citations
Physical activity	247	35	6000
Air pollution	171	37	3943
Satisfaction	138	27	2752
Optimization	97	26	2029
Accessibility	156	34	4022
Travel behavior	178	35	4249
Demand	68	23	1374
Performance	58	17	884
Accidents	37	13	531
Electric vehicles	40	20	860
Information systems	34	14	559
Density	32	16	600

Source: Own elaboration.

preferences on different transportation options are addressed.

Networks is a highly developed but isolated theme in this period, with work focusing on how to efficiently design transport networks to optimize mobility, in some cases verifying whether the existing transport networks are sufficiently robust.

We identified efficiency, Covid-19, and autonomous vehicles as emerging or disappearing themes in this period. Efficiency addresses issues related to innovation in transportation using innovative technologies, the forecast development of zero-emission vehicles, or cost reduction in the use of transportation. Covid-19 analyzes the impact that the pandemic has had on the transport sector and how public transport planning was adapted when the pandemic broke out worldwide. The autonomous vehicles cluster analyzes possibilities for the use of autonomous vehicles in facilitating sustainable mobility in the future. This is in line with another closely related cluster identified in the previous period, electric vehicles.

Finally, the sustainability cluster is located between the quadrants delineating marginal and emerging or disappearing themes. It focuses on

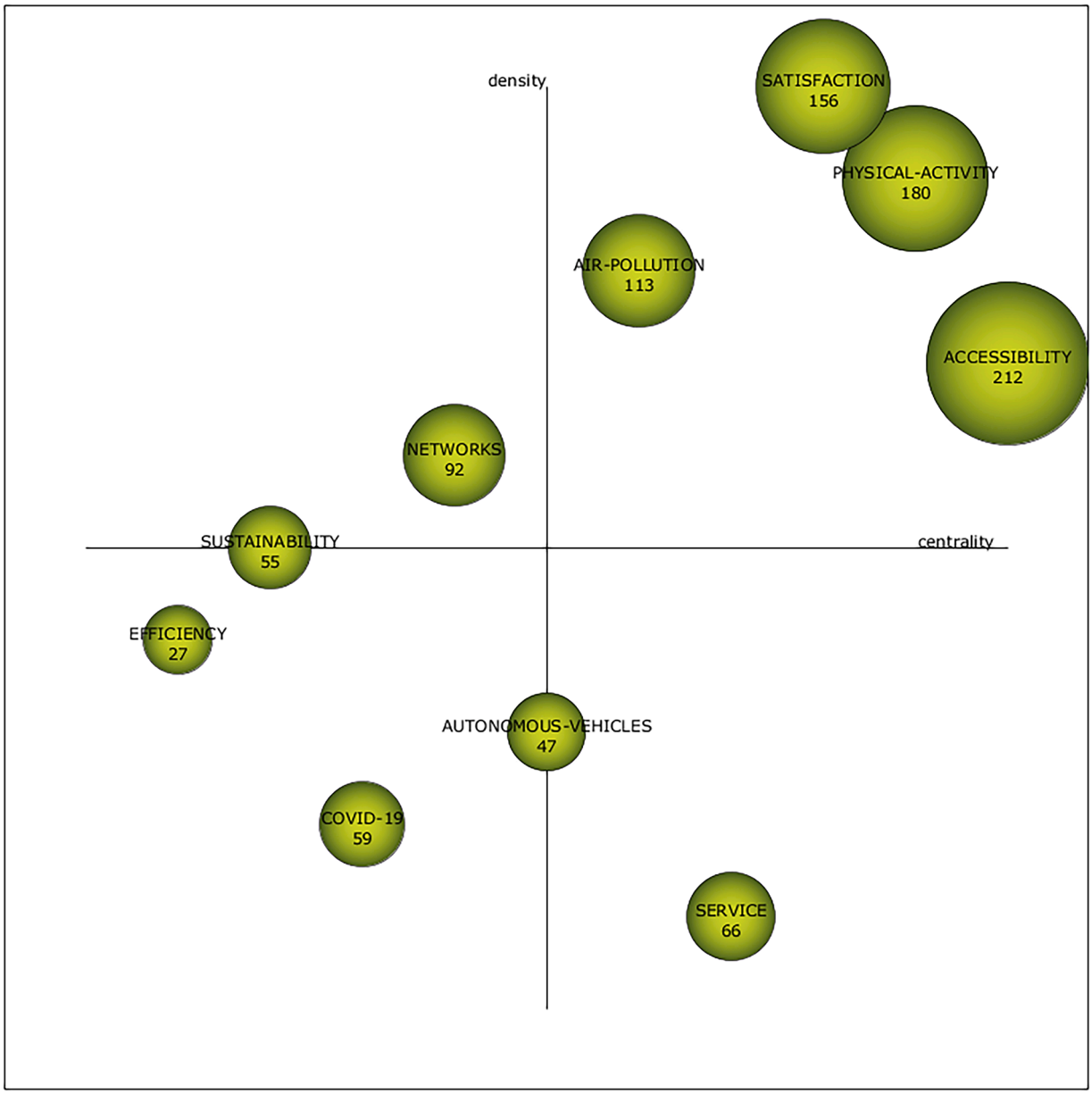

Fig. 7. Main themes 2020–2021 period.
Source: Own elaboration

studying how to improve sustainability from different perspectives, such as the development of integrated mobility policies, efforts to use low-carbon vehicles, or the use of artificial intelligence.

As shown in Table 8, the topic with the highest performance is accessibility, with 212 documents published in this period, an h-index of 16, and 1226 citations. However, all the driving topics in this period have similar performance measures. The topic with the lowest measures of performance is efficiency, which is considered an emerging or disappearing topic.

Table 8
Performance measures of the 2020–2021 topics.

Name	Document Count	H-Index	Sum Citations
Satisfaction	156	16	1089
Physical activity	180	17	1262
Air pollution	113	17	1022
Accessibility	212	16	1226
Networks	92	11	601
Autonomous vehicles	47	11	422
Sustainability	55	9	245
Service	66	12	510
Covid-19	59	15	885
Efficiency	27	6	142

Source: Own elaboration.

4.6. *Thematic lines*

The overlay graph (Fig. 8) demonstrates the level of thematic stability between two consecutive periods. As shown in Fig. 8, the number of keywords increased significantly in the first three periods before decreasing slightly in the fourth period. This indicates that the field of study has expanded during the period analyzed to include a wide number of topics. However, in the last period, the slight reduction may be due to a maturity in the topics studied, the length of the period, which is shorter than the previous sub-periods or time periods, or a combination of these two factors.

We can also observe how the number of shared words has increased

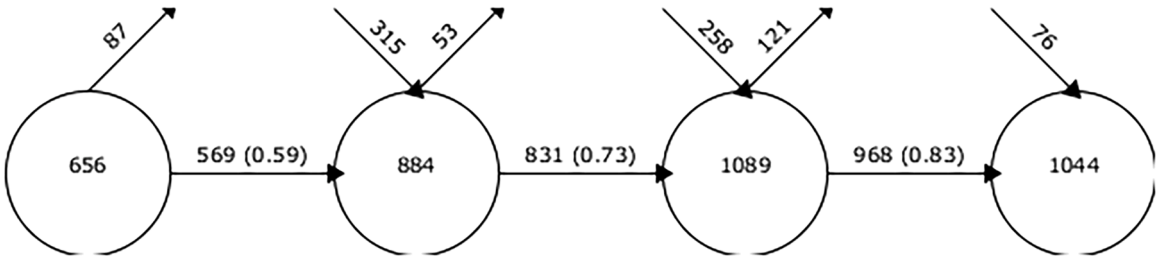

Fig. 8. Overlay graph.
Source: Own elaboration

from 569 to 968, which can also be interpreted as a certain level of consolidation in the keywords used in the field. The same occurs with the stability index, which rose from 0.59 to 0.83. The number of outgoing keywords is much lower than the number of incoming words, which reflects the dynamism of the field of study.

Finally, the thematic areas or lines are analyzed. Solid lines indicate that the linked topics or themes share the same name, i.e., both topics were labeled with the same keyword, or the label of one topic is part of another. Dashed lines demonstrate that the topics share elements that do not fit the cluster label.

The analysis of the evolution map shown in Fig. 9 identifies seven thematic areas. It should be noted that these thematic areas are not mutually exclusive and that there are overlaps between them, as for example, between health (physical activity) and travel. The evolution of the area shows its dynamism and the different thematic incorporations that refer to social, economic, and technological phenomena. It should

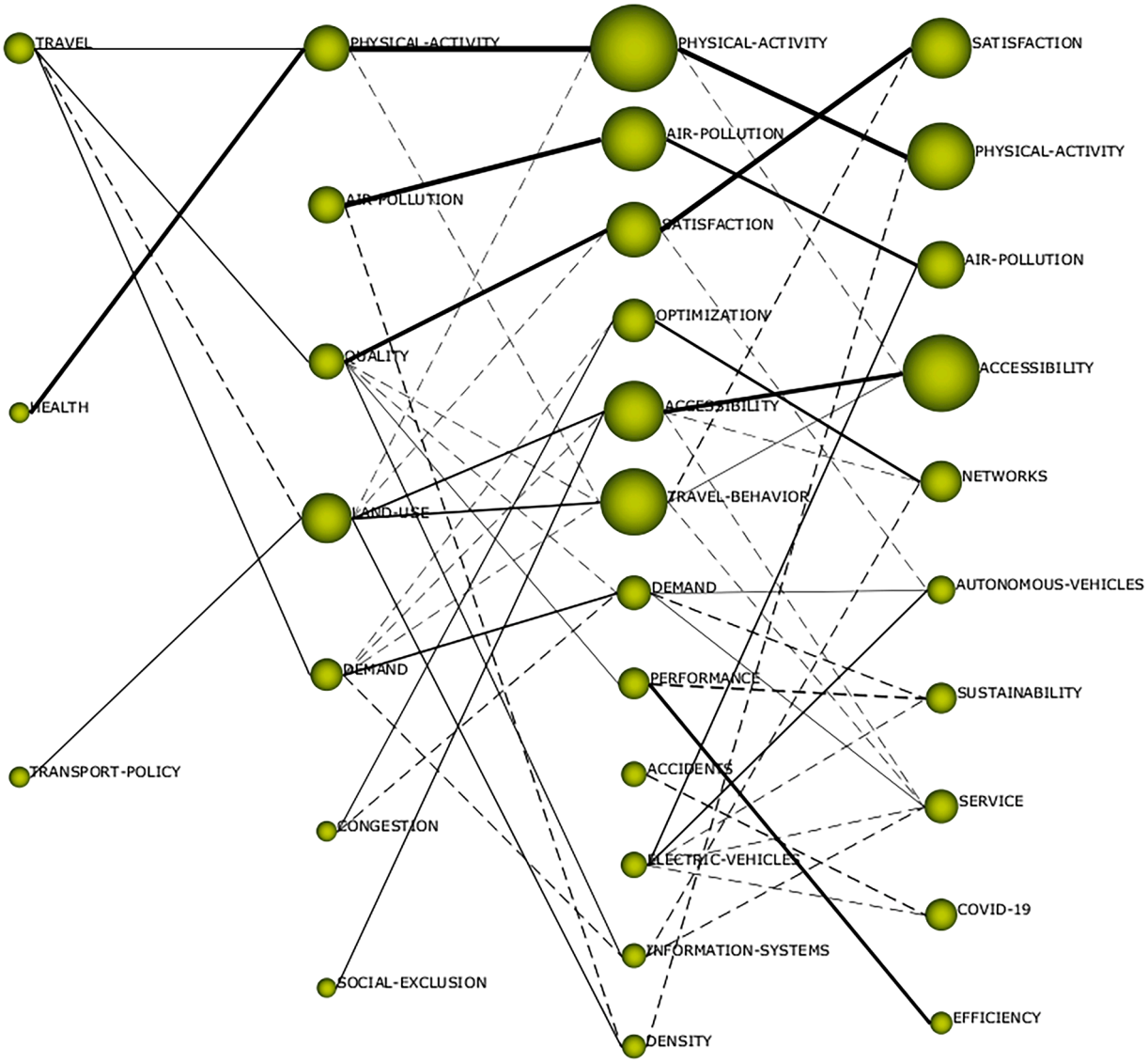

Fig. 9. Evolution map.
Source: Own elaboration

be noted that in the last period analyzed, the influence of the Covid-19 pandemic is shown in all thematic lines.

4.7. Thematic line 1: health/physical activity

This thematic line focuses on the study of the health consequences of physical activity related to transport modes, emerging in the first period and remaining one of the most important throughout the study area. A variety of issues related to health and well-being are analyzed, such as the relationship between physical activity (Giles-Corti et al., 2013), emotional well-being (Chatterjee et al., 2020; Martin et al., 2014), and physical well-being (Böcker et al., 2020) related to the choice of transport mode and the use of alternative forms of mobility such as cycling (Pucher et al., 2011). In addition, the influence of pollution on people's health is studied (Buehler et al., 2017) and more recently, the interaction between Covid-19 and transportation (Nikitas et al., 2021). Finally, it is worth noting the link between this line and transportation planning, an issue that is addressed in different studies (Barnett et al., 2017).

4.8. Thematic line 2: travel

This thematic line examines different aspects of urban travel, such as the information systems used to analyze them, customer satisfaction, the performance of different modes of transport, demand for service, and understanding mobility as a service (Alyavina et al., 2020). This line emerges in the first period and evolves toward studies relating to the quality of transportation (De Oña & De Oña, 2015; De Oña et al., 2013; Redman et al., 2013), customer satisfaction (Abenoza et al., 2017; Dong et al., 2021), safety (Su et al., 2021), and its influence on transportation demand (Acheampong et al., 2021; Tirachini et al., 2013). The relationship between travel mode choice and traveler behavior is also studied (Beirão & Sarsfield Cabral, 2007), as well as how these impact the sustainability of the system (Alyavina et al., 2020; Rajak et al., 2016) and other aspects such as innovation (Sovacool et al., 2020). Choice of transport mode sees overlap with another of the main lines detected in this study, health/physical activity, as discussed above. The influence of Covid-19 on how mode of transport may be affected by health issues is further noted (Barbieri et al., 2021).

Different types of models (fuzzy logic, Delphi, mobility patterns, interval-AHP decision support model) are applied for this analysis (Bordagaray et al., 2014; Hirschhorn, 2019; Rajak et al., 2016). In a last phase, and correlating with the thematic line of electric vehicles, reference is made to the influence of the demand for autonomous vehicles on the urban planning model (Acheampong & Cugurullo, 2019).

4.9. Thematic line 3: transport policy

This thematic line arises in the first period and studies the planning of urban transport modes, evolving from territorial organization and use of territory (Buehler, 2011; Giles-Corti et al., 2013) to aspects such as accessibility and urban transport. The sustainability of transport systems economically, socially, and environmentally has made this line of vital importance. This area deals with topics such as strategic transport planning, network efficiency, and environmental issues. This line of study focuses on indicators and decision-making techniques used in planning processes. Several studies analyze the strengths and weaknesses of different urban transportation alternatives and address strategic planning decisions (Ewing et al., 2018). Public transport plays a critical role in urban transport planning.

4.10. Thematic line 4: air pollution

This line studies the effects of transportation on pollution. Emerging in the second period, it remains well defined. The environmental impact of transport systems has been extensively studied. The specific topics included are carbon emissions (Adams et al., 2020), environmental impact assessment (Ortega-Fernández et al., 2020), ecological footprint, and climate change (Adams et al., 2020).

4.11. Thematic line 5: congestion

This thematic line concerns the problems that urban transport generates or avoids in cities. This line arises in the second period and evolves toward the optimization of transport networks. The works included in this line analyze and propose substantial changes in terms of logistics and modes of transport, as well as individuals' habits, to improve the quality of life by reducing traffic accumulations (Sharifi, 2021). Studies in this thematic line also attach great importance to urban planning and road pricing policies (Tirachini et al., 2014) for combatting the negative effects of congestion on traffic flow by optimizing routes (Phillips et al., 2021), and individual and collective transportation models (networks) (Ma et al., 2020).

4.12. Thematic line 6. social exclusion

This line is directly related to social sustainability and transportation, focusing especially on accessibility to urban transportation. This relates closely to social equity, freedom, community livability, and security (Pereira et al., 2017). In addition, the interactions between transportation planning and social progress, poverty alleviation, quality of life, and safety are analyzed (Jaramillo et al., 2012). There is a strong tie to the subsequent thematic line with regard to autonomous vehicles emerging as a mode of augmenting transportation accessibility for individuals with mobility issues (Soteropoulos et al., 2019).

4.13. Thematic line 7. electric vehicles

The focus of this thematic line is the development of vehicles powered by electric energy, specifically, their impact on urban mobility systems (Dogan et al., 2020) and pollution (Heiskala et al., 2016), as well as autonomous vehicles (Acheampong et al., 2021; Dogan et al., 2020). Growing environmental concerns have led to the search for new forms of vehicle propulsion gaining ground in this area, and the study of hybrid and electric vehicles has received significant attention from researchers (Acheampong et al., 2021; Dogan et al., 2020; Mounce & Nelson, 2019). The technological boost received by transportation has further generated research in the area of driving alternatives, with the phenomenon of autonomous vehicles gaining notoriety (Golbabaei et al., 2021; Nastjuk et al., 2020), including how developments in autonomous transportation can improve mobility for certain groups such as the elderly or individuals with disabilities.

Finally, Table 9 shows the performance indicators of the thematic lines, with travel and transport policy having the greatest number of documents. However, health/physical activity takes first place for number of total citations and h-index.

5. Conclusions and implications

This bibliometric analysis shows that urban passenger transport has received significant attention in the literature, experiencing exponential

Table 9
Performance of the thematic areas.

Thematic area	Document count	H-index	Sum citations
Health/Physical activity	555	47	18,489
Travel	763	25	16,473
Transport policy	721	25	15,970
Air pollution	361	30	8415
Congestion	210	17	3362
Social exclusion/Accessibility	385	21	6091
Electric vehicles	200	16	2304

Source: Own elaboration.

growth in recent years. This work set out to perform a bibliometric analysis of the scientific production of the last 20 years to identify the main thematic areas and most relevant authors and publications in the field. Our aim was to analyze the temporal evolution of the topics addressed by researchers in this field. The results show a large body of work published in the 20 years of the study. Furthermore, we note a special concentration in the last five years that is the result of the growing interest in a subject marked by constant technological evolution (e.g., vehicle improvements, greater energy efficiency, improved safety), changes in social trends (e.g., car sharing, greater prevalence of cycling and other alternative means of transport), and the profound effects of Covid-19.

The results of the bibliometric analysis using the SciMAT tool offer an approach to the intellectual foundations of the field of study and its evolution throughout the period analyzed. The 20-year period was divided into four sub-periods (2001–2010, 2011–2015, 2016–2019, 2020–2021), revealing a great diversity of topics and, in some cases, fragmentation. Such variety can be attributed to the fact that multiple disciplines are involved in the development of urban passenger transport, from medicine and network engineering to economics (Behrooz & Hayeri, 2022; Myronenko et al., 2023). This is reflected, as derived from the SciMAT analysis, in the identification of seven thematic areas around which the research has revolved: (1) health/physical activity, (2) travel, (3) transport policy, (4) air pollution, (5) congestion, (6) social exclusion/accessibility, and (7) electric vehicles. Of these, the first three have been the germ of the thematic development of this field.

Worth note is the growing importance shown by the themes of air pollution (representing the environmental aspect of sustainability), accessibility (the social aspect), efficiency (the economic aspect), and sustainability (the inclusion of all three dimensions). The results suggest a greater focus on environmental aspects as opposed to social and economic aspects (Lindkvist & Melander, 2022; López et al., 2019; Mugion et al., 2018). This is a consequence of the increasing concern for environmental issues, manifested in documents, agreements, summits, and action plans such as those mentioned above (European Commission, 2001, 2011; United Nations, 2002, 2015; World Bank, 2010). Nevertheless, this difference is narrowing as the research increasingly understands sustainability as a concept that encompasses the three dimensions in an integrated manner (Heiskala et al., 2016; Okraszewska et al., 2018; Sharifi, 2021; Zhao et al., 2020).

The impact of technology has also grown in importance throughout the study period, which concurs with, e.g., Sovacool et al. (2020). This is exemplified by topics such as technological changes in the means of transport themselves, including electric (Mounce & Nelson, 2019; Soteropoulos et al., 2019) and autonomous vehicles (Acheampong & Cugurullo, 2019; Foroughi et al., 2023), or in networks, through intelligent planning systems ((Abduljabbar & Dia, 2022; Gamboa-Rosales et al., 2020; Heiskala, Jokinen, & Tinnilä, 2016; Phillips et al., 2021).

As demonstrated throughout this paper, research in the field of study reflects changes derived from the physical, social, and economic evolution of cities. Concerns for health and social welfare, changes in behavior due to the different needs of travelers (Ceder & Jiang, 2020; Filippi et al., 2023; Myronenko et al., 2023), transport planning in cities (Epicoco & Falagario, 2022; Gkiotsalitis & Cats, 2021; Okraszewska et al., 2018), improvement of urban mobility (De Oña & De Oña, 2015), multimodal transport (Buehler, 2011; Filippi et al., 2023; Tirachini et al., 2014), and economic and social sustainability (Heiskala et al., 2016; Lindkvist & Melander, 2022; Velaga et al., 2012) have evolved over time, and in conjunction, the topics garnering scholarly attention.

The bibliometric analysis tool, SciMAT, is a useful and effective tool for visualizing and outlining scientific progress, especially considering the quantitative magnitude and thematic variety of the field of study (Ji et al., 2023; Sharifi, 2021; Shen et al., 2023). This allows us to track emerging trends in addition to less relevant thematic lines over time (Cobo et al., 2011; López-Robles et al., 2021). However, this is not to say that traditional literature reviews should be discarded in favor of such tools; at present, artificial intelligence and data mining tools do not allow for the in-depth analyses which should be performed through systematic reviews (Sharifi, 2021; Walsh & Rowe, 2023). For example, clusters or themes have been generated through algorithms based on co-occurrence (i.e., the number of times two terms occur at the same time) but do not offer any information on the type of relationship between these keywords (Sharifi, 2021). Therefore, both approaches should be complementary.

Although this work improves our understanding of different areas within the field of study and offers promising avenues for future study, future work should more closely examine the role of technology, electric and autonomous vehicles, and how they can change the physiognomy of cities and modes of transportation (Acheampong et al., 2021; Golbabaei et al., 2021; Nastjuk et al., 2020).

When considering directions for future research, it should be noted that only peer-reviewed scientific articles from WoS were used for our analysis. This approach is frequently used in bibliometric studies (Bagheri et al., 2023). However, expanding the database to include grey literature (reports produced by municipal authorities, consulting firms, NGOs, and other agencies) could provide a wealth of information concerning public and private policies related to urban transport and mobility that has been excluded from this (Sharifi, 2021). The SciMAT tool is limited in that it can currently only work with the Scopus and WoS databases. Publications in Scopus have also been excluded from this work for the reasons outlined in the methodology section.

Furthermore, the scope of this work ends in 2021, but already we can glimpse the importance of the pandemic in UPT research (Caballero-Galeote & García-Mestanza, 2022), as well as the impact of the technological and energy transformation of transport modes, the social aspects of transport and others themes that are dominating the debate at present (e.g., Abduljabbar et al., 2022; Anik & Habib, 2023; Christidis et al., 2022; Fazio et al., 2022; Niu & Zhang, 2023; Vega-Gonzalo et al., 2023). Future work in this area should include the last few years of intense publication pace.

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