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The Relationship between Walkability and The Built Environment: The Bibliometric Analysis

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ABSTRACT

The aim of this research is to map out existing knowledge regarding the relationship between walkability and built environment studies in order to comprehend global trends in this area within four decades between 1976 and 2022 by using two sophisticated tools called VOSviewer and CiteSpace. The issues on the dependence on motorized transportation has been receiving high attention in this 21st century. Keeping up with the high pace of publications on the holistic knowledge is significant. The bibliometric technique provides a more in-depth understanding of the knowledge and anticipates patterns for future study. This study utilizes the core collection of the Web of Science (WOS) database. The data extraction period is set from 1976 to 2022, yielding 2,004 publications. The results reveal a rapid increase of publications. The USA is the most prominent country in exploring the notion in this field, which is followed by Australia and Canada. Furthermore, the built environment, walking, and physical activity are the highly discussed topic during the four decades. The built environment is an underlying factor for walkability within the macroscale and microscale which affect environment, health, and social aspect. Those factors then influence the willingness of people to walk for their daily needs to their destinations. The findings present a development trend and a rigorous framework, which could help scholars and practitioners further investigate this subject in anticipating future development trends and lead to more advanced research in this field.

Keywords: Bibliometric analysis; CiteSpace; science mapping; the built environment; VOSviewer; walkability

INTRODUCTION

The human population globally is predicted to reach 10.4 and 12.4 billion in 2100. In 2022, Asia is the largest and most populous area (United Nations 2022; United Nations Population Division 2022). Urbanization has coincided with rapid population expansion (Barnett, 2011). Globally, urbanization is a major and rapidly growing trend (Maddah et al. 2022). In 2010, the number of people living in cities worldwide exceeded that of people living in rural areas for the first time (United Nations 2018). It is projected by 2030, 70% of the world's population will be living in urban areas (World Health Organization 2022).

Built-up areas have increased due to population growth and urbanization (Attman 2009; Gur and Yuksel 2019; Ahmed 2017; Dawodu and Cheshmehzangi 2017; Ouyang et al. 2016), that mainly the largest portion of land use is

residential (Attman, 2009; Larco et al. 2014; Yigitlancar et al. 2015; Zhang et al. 2022). Following it, motorised transportation dominates human mobility for their activities (Ferguson and Woods 2010; Ritchie 2009), that connects people and places through streets (Attman 2009; Dobbins 2009). As the population grows over the next few decades, so will the number of private vehicles such as automobiles and motorcycles (World Health Organization, 2021). It is projected that the number of light-duty vehicles (passenger and freight vehicles) on the road worldwide would increase from 1 billion to roughly 3 billion by 2050. (Fuelfreedom 2019).

Therefore, traffic bottlenecks are unavoidable as the usage of motorized transportation rises (Thorne et al. 2009; Rahman and Nahiduzzaman 2019), and public transportation is insufficient as the urban population grows. Furthermore, it increases traffic deaths and injuries, making pedestrians the most vulnerable users. Besides, pedestrian infrastructure is often insufficient and poor, particularly in developing countries, discouraging people from walking and increasing their reliance on motorised transportation to reach their destinations (Global Mobility Report 2017).

The field of walkability and built environment has received great attention in academics as critical challenges in the current and future decades. As a result, it is vital to thoroughly emphasise critical facts and evidence the evolution of this field. Because of the current rapid growth, determining and investigating the overall state of research in these disciplines is critical. In this day and age, existing publications or data gathered from database publishers could indicate trends in the work of scholars, students, and researchers (McAllister et al. 2022). Bibliometrics analysis approaches could be utilized to address obtaining thorough information and keeping up with the quick pace of scientific publishing since they allow the collection of overall understanding of knowledge structure and patterns through the application of powerful text-mining technologies (Sharifi et al. 2021; Sharifi, 2021). By taking this approach, it is easier to gain an understanding of the field's overall landscape (Sharifi et al. 2021).

To assist researchers on analyzing knowledge in specific fields, the combination of quantification and visualisation could be used (Cobo et al. 2011). Researchers can more quickly uncover the relationship and patterns in the relevant literature because of the rapid development of computational and data visualization tools. Two powerful applications for text mining and visualization are VOSviewer and CiteSpace. With the text-mining features of VOSviewer, a significant network might be constructed from a corpus of scientific literature (VOSviewer 2023). CiteSpace is utilized in over 50 countries and is updated and upgraded continuously to ensure high reliability (Chen 2006). These computational tools' capabilities could increase visualizations clarity and interpretability (Chen 2006; Van Eck and Waltman 2022). This study uses bibliometric analysis, which involves using a visualization tool to analyze scientific literature that was acquired from the Web of Science (WoS) database. A comprehensive grasp of the research issue on the relationship between walkability and the built environment in terms of its developmental features and trends is made possible by the quantitative analysis and review of previous studies.

Therefore, in order to offer a thorough picture of this topic, the aim of this study is to undertake a bibliometric analysis of the literature pertaining to the study of walkability and the built environment. VOSviewer and Citespace will be used to accomplish the following goals: (1) Analyse the developing stage of walkability and the built environment; (2) Investigate the leading authors, papers, institutions, and nations; and (3) Identify the key research topic.

METHODS, TOOLS, & MATERIALS

BIBLIOMETRICS

A popular and thorough technique for examining vast volumes of scientific data to show the intellectual structure and changing patterns of a field or study topic is bibliometric analysis. It includes analysis of quantitative and qualitative (Donthu et al. 2021), which is the quantitative inquiry of the publications relevant to a specific theme (Mayr and Scharnhorst, 20015; Liu et al. 2022). It helps scholars explore the evolutionary nuances of a particular subject while also offering insight on specific ideas in that field (Donthu et al. 2021; Sapiyi et al. 2024). This technique provides for a more in-depth understanding of the knowledge and conceptual framework at the core of any particular research topic (Shafique 2013). The analysis enables for the dissection of information in publications in terms of keywords, authors, journals, nation references, and even anticipated patterns for future study (Abramo et al. 2011). Scholars can utilise this intellectual process to explore the origins and evolution of a certain area (Hérubel 1999), as well as identify future research trends (Chen 2006).

DATA SOURCES

To ensure the scientific integrity of the data source, this research literature is sourced from the Web of Science (WOS) database's core collection. The WoS database search engine is well known for being a trustworthy resource for finding scientific publications, and it is frequently used for reviews (Arallena et al. 2019; Yang et al. 2020). The source of the database is Science Citation Index Expanded (SCI-Expanded) (1970-present), Social Science Citation Index (SSCI) (1970-Present), Arts and Humanities Citation Index (AHCI) (1975-present), and Emerging Sources Citation Index (ESCI) (2015-Present). The Web of Science is the most well-known publisher-independent global citation database in the world. WoS provides a comprehensive platform of over 115 years of high-quality research, allowing users to track ideas across domains and time by utilizing approximately 1.9 billion referenced references from over 171 million records (Clarivate, 2023). This study seeks the scientific literature for Walkability and Built Environment research using the WoS Core Collection database. The study identifies search topics (including titles, abstracts, author keywords, and keywords plus): the combinations of the search string of ("walkability" or "walkable") and ("built environment" or "built world") are used for the advanced search. The query is (((ALL=("walkability")) OR ALL=("walkable")) AND ALL=("built environment")) OR ALL=("built world"), which finds a total of 2,004 publications. The first publication associated with it is recorded in 1976. Since this study aims to explore the bibliography of the related subject, the data extraction period is defined from 1976 to 2022 to limit the omission of important studies from previous years. The database retrieves a total of 2,004 articles. The retrieved publication data is then saved as a "full record and cited references" in a "plain text file" format.

VOSVIEWER AND CITESPACE

A application called VOSviewer makes it possible to generate and view bibliometric maps. It is helpful for presenting expansive bibliometric maps in an easy-to-understand way. Additionally, a vast collection of 5,000 scientific papers can be shown using this tool (Van Eck and Waltman, 2010). Different thematic areas are represented by the size of the node and network (Van Eck and Waltman, 2022; Sharifi et al. 2021). Meanwhile, CiteSpace is a visual analysis software based on text mining, which has been widely used in various fields (Wei et al. 2020). The ability to create, construct, and evaluate scientific knowledge maps is CiteSpace's most significant feature. By applying the hot word analysis tool to visually represent the information panorama of each discipline, it creates a knowledge map of the scientific domain. The knowledge map may indicate study areas of interest and advancements, or it may forecast new trends at a certain time (Meng et al. 2020; Chen, 2016).

RESULTS

LITERATURE DEVELOPMENT TRENDS OF WALKABILITY AND THE BUILT ENVIRONMENT

The number of works of literature in the subject field in the Web of Science database is increasing year by year from 1976 to 2022. The findings indicate that the overall level of study and interest in this field is growing. Figure 1 depicts the progression of the number of articles in the walkability and built environment literature between 1976 and 2022. Jane Kay published "Habitat at Vancouver-UN Conference on Built World" in 1976 in the Journal Information with the 'Nation' publisher, New York, is the earliest publication. The Underlying Event on Research on Walkability and Built Environment based on Bibliometrics studies as shown on Figure 2.

1. Initiation Stage (1976-2008). Every year for the past 32 years, the number of published articles has been less than 50, indicating that research is still in its early stages. Researchers all around the world are taking an interest in the study of the relationship between walkability and the built environment.

In nearly three decades, just eighty papers are produced, and they are referenced seldom and have minimal influence. In 1976, The United Nations convened a conference on Human Settlements-Habitat I in Vancouver, Canada (Kay, 1976). It is being driven by governments throughout the world recognising the need of sustainable human settlements and the consequences of growing urbanisation, particularly in the developing world.

Following that, the United Nations conducted a conference on Human Settlements: Habitat II, which took place in Istanbul, Turkey from 3-14 June 1996, twenty years after Habitat I. The conference is concerned with tackling two important subjects for all countries: "adequate housing for all" and "viable human settlements in a

changing world - full urbanisation." The UN General Assembly then convenes a five-year review and evaluation of the implementation of the Habitat Agenda, which tackles the massive urbanisation of the world's population and the hazards associated with its rapid speed (The United Nations, n.d.).

2. Development Stage (2009-2018). During these nine years, the number of publications in this subject begins to expand dramatically. At this point, the fundamental concerns in this subject are still population and urbanisation, which continue to confront the world, and a new urban agenda is thought required. In 2016, the United Nations holds Habitat III in Quito, Ecuador, and the 'New Urban Agenda and the Quito Declaration on Cities and Human Settlements for All' is adopted, representing a shared vision for a better and more sustainable future. Habitat III is the first United Nations Global Summit held following the establishment of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals. It addresses the major issue of how cities, towns, and villages are organised in order to fulfil their role as drivers of sustainable development, which then assists to meet sustainable development and climate change goals (The United Nations, n.d.). Since then, the research on walkability and the built environment has slowly grown to receive attention from researchers globally.

3. Rapid Development Stage (2019-Present). Since 2009, the number of articles has increased rapidly, reaching a peak of more than 200 in the previous five years. This shows that research on walkability and the built environment has entered a period of constant expansion, a tendency that may be connected to studies at many scales ranging from microscale to macroscale, spanning from street-level, neighbourhood, city, and region globally.

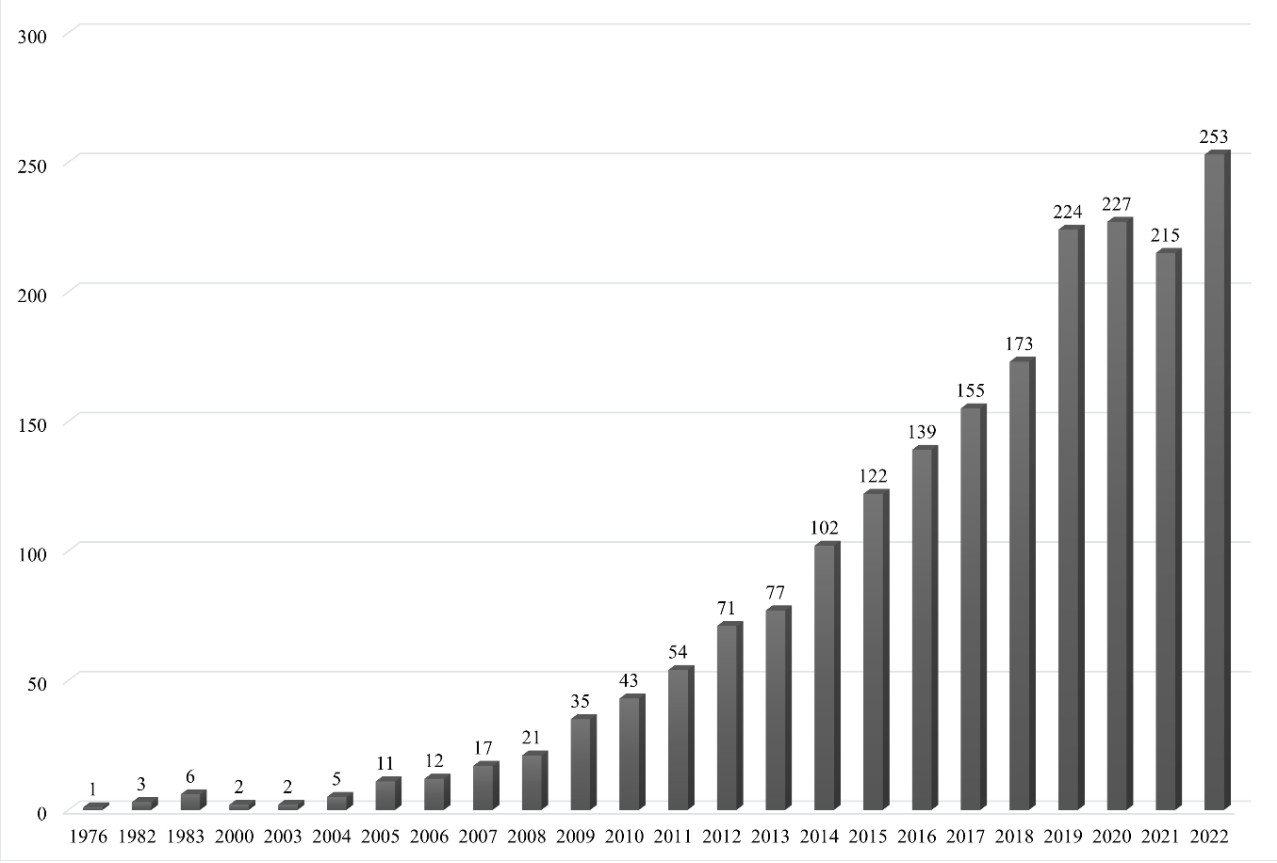

FIGURE 1. The Annual Number of Publications indexed in the WoS and Published between 1976 to 2022

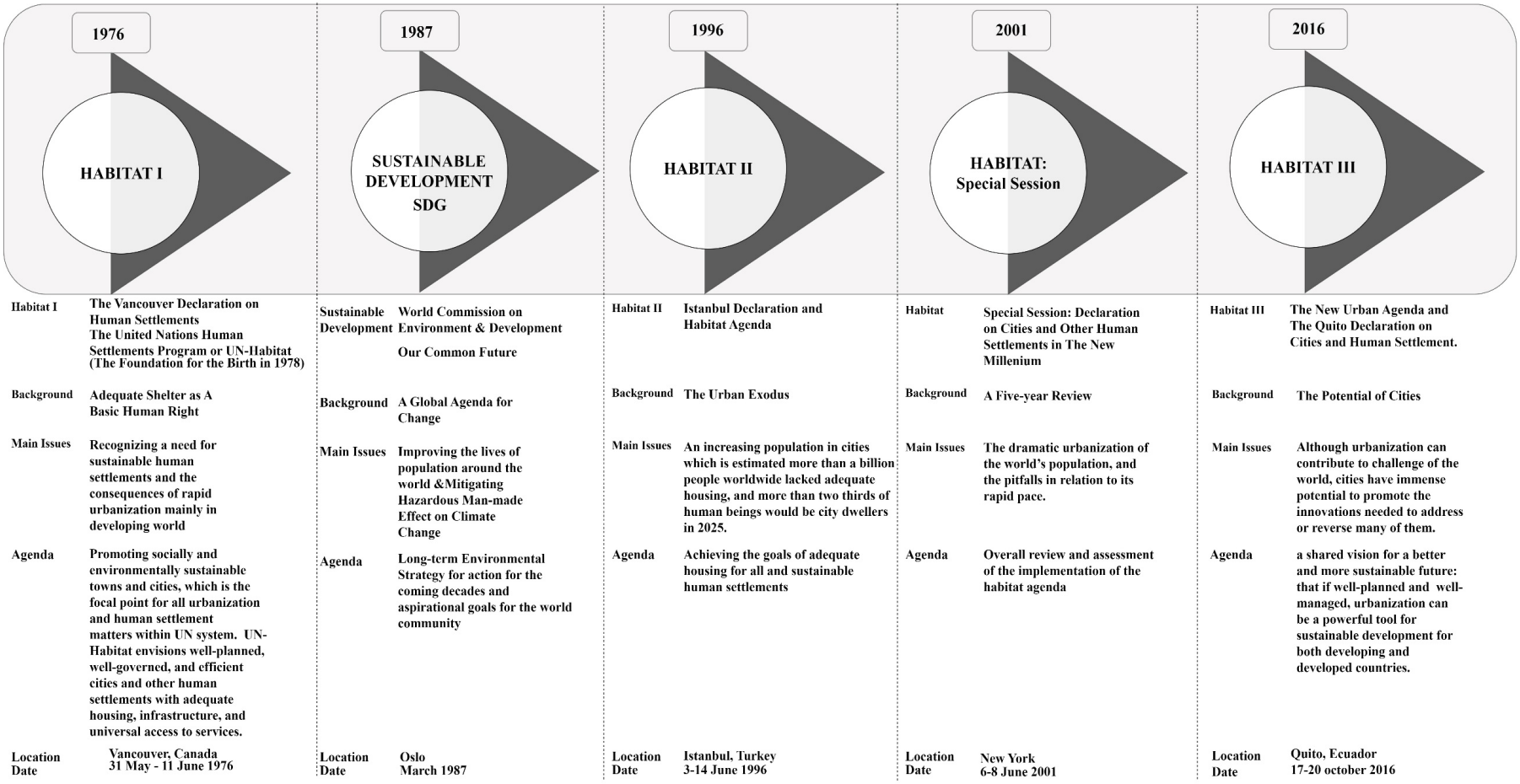

FIGURE 2. The Underlying Event on Research on Walkability and Built Environment based on Bibliometrics studies

RESEARCH DISCIPLINARY CATEGORIES' DISTRIBUTION

The CiteSpace node type "Category" is used in this study to investigate the disciplinary category distribution of walkability and built environment research. The most publications are in the fields of public, environmental, and occupational health, environmental sciences and ecology, environmental studies, engineering, science, and technology, and urban studies, as shown in Figure 3.

The map distribution demonstrates that research on walkability and the built environment spans a wide range of disciplines, including the environment, health, transportation, nutrition and dietetics, and other interdisciplinary aspects. Disciplines in comparable subjects, such as urban studies, environmental studies, transportation, and engineering, have significant ties based on the thickness of the connected lines.

However, in some disciplines with a small number of papers published (such as social science, regional and urban planning, and psychology), the relatively high betweenness centrality values may reflect the fact that these disciplines play a significant role in the underlying interdisciplinary cooperation and research systems, allowing for advanced comprehensive development of this field in the coming decades. Based on Figure 4, the top ten subject categories with the strongest bursts throughout the period are history, architecture, education and educational research, general and internal medicine, biomedical social science, sport science, psychology, history and philosophy of science, psychology clinical, public, environmental, and occupational health. It is evident that Public, Environmental, and Occupational Health have the highest emergence in this sector, indicating a cross-disciplinary trend in this area during four decades.

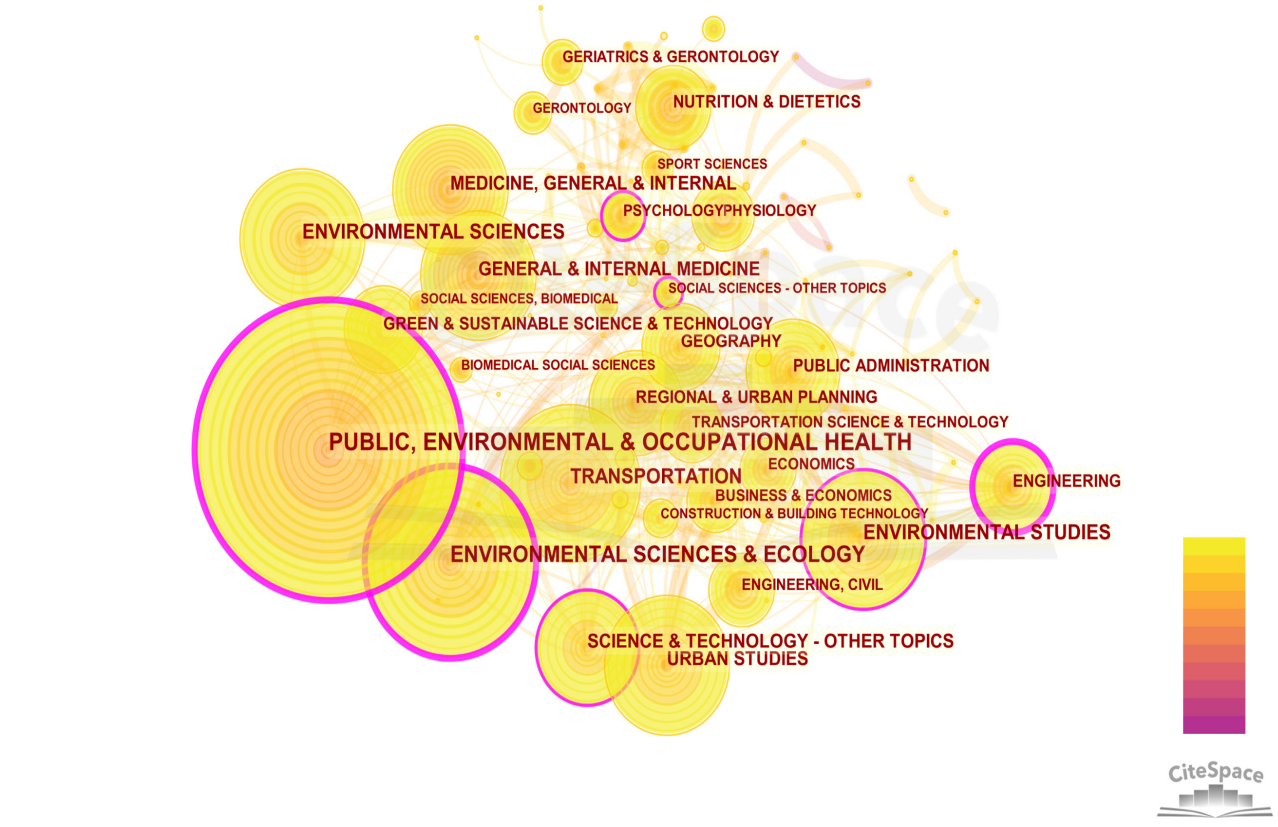

FIGURE **3.** Network of Links between research Disciplines (Diagram Built on CiteSpace)

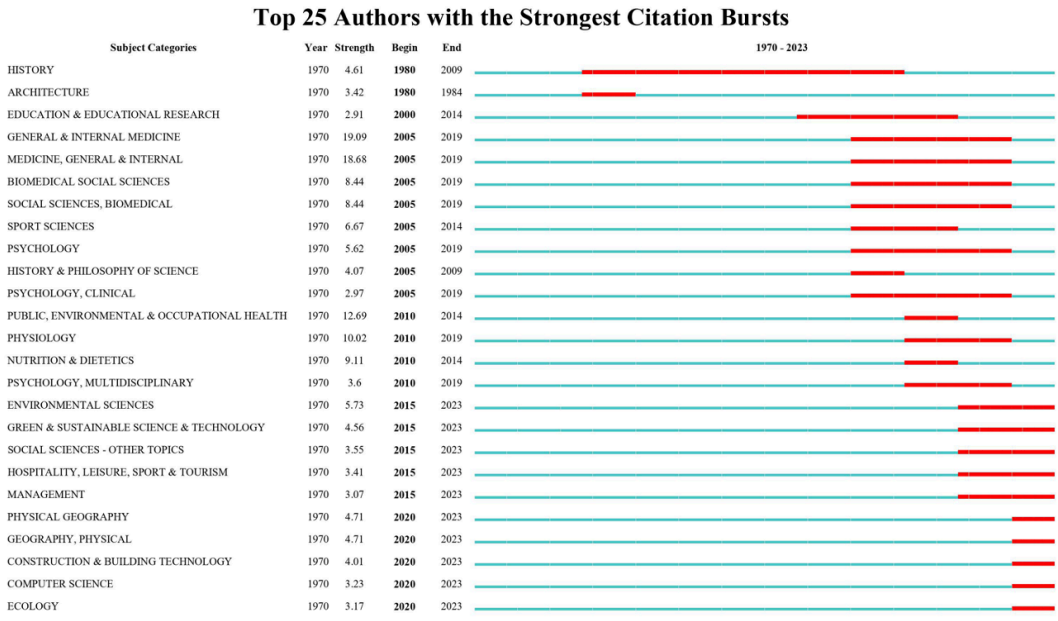

FIGURE 4. The Top 25 Subject Categories with the Strongest Citation Bursts (Diagram Built on CiteSpace)

THE NETWORK DISTRIBUTION OF RESEARCHERS

Active collaboration among researchers is essential for the advancement and progress of academic research (Kone et al. 2000). Researcher networks are used to look into the collaborations between researchers in a certain field of study. Figure 5 illustrates that the number of authors addressing walkability and the built environment is large, with considerable collaboration. The general situation of researcher collaboration indicates a closed concentration between groups and produces a widespread collaborative dynamic. Figure 6 also illustrates that several of the scholars in the top-ranked item by citation counts have substantial cooperation with other authors in this subject, including Sallis, James F et al. (2006) with citation counts of 101. They discover four domains for active living: active recreation, active transportation, occupational activities, and household activities. The second one is Frank, Lawrence D et al. (2006) with a citation count of 73. They conduct research on the association between neighbourhood walkability and active transportation. They reveal that walkable neighborhoods are distinguished by mixed-use, connected streets, high residential density, and pedestrian-oriented retail, which improves the community's health and environment, including air pollution, respiratory disease, diabetes, physical activity, and obesity. In addition, the third is Cerin, Ester et al (2006) with citation counts of 49. The study highlights that street connectivity affects walkability in a particular geographic area including intersections and alternative routes. They also discover that walking infrastructure has played an important role in the development of walkable communities.

The primary cause of this pattern could be the global issue of rapid population growth, which has been accompanied by urbanization and reliance on motorized transportation. The world population increased by one billion people between the beginning of human history and the turn of the nineteenth century. During the 1800s, the population grew at a faster rate, reaching 1.7 billion people in 1900 (Attman 2009). Based on the most recent UN projections, the global population could reach 8.5 billion in 2030, 9.7 billion in 2050, and between 10.4 and 12.4 billion in 2100 (United Nations 2022). Following that, individuals mostly use motorised transportation to go between locations or to access everyday activities (Ferguson and Woods, 2010; Ritchie, 2009). As the population grows over the next few decades, so will the number of private vehicles such as automobiles and motorcycles (World Health Organization, 2021). By 2050, there will be approximately 3 billion light-duty vehicles on the road worldwide, including passenger and freight vehicles, up from 1 billion currently. More than 2 billion will be powered by internal combustion engines that use petroleum-based fuels, indicating a reliance on oil. The global light-duty vehicle is growing rapidly with the majority of this increase in the developing world (Fuelfreedom 2019). Asia is the largest number of vehicles, accounting for 48% of global sales in 2019 (Asian Development Bank, 2022). There are a rising number of private motor cars in the developing globe (Xiao et al. 2020). It leads to other problems in the environment such as air pollution and CO2 emission (Cervero, 2017), health problems such as respiratory disease and lung cancer

(Tumlin, 2012), and social such as decreasing social interaction (Stroope 2021; Yang et al. 2018). For that reason, researchers around the world have gained high attention to the study of walkability and the built environment to contribute to solving issues on the environment, health, and social simultaneously.

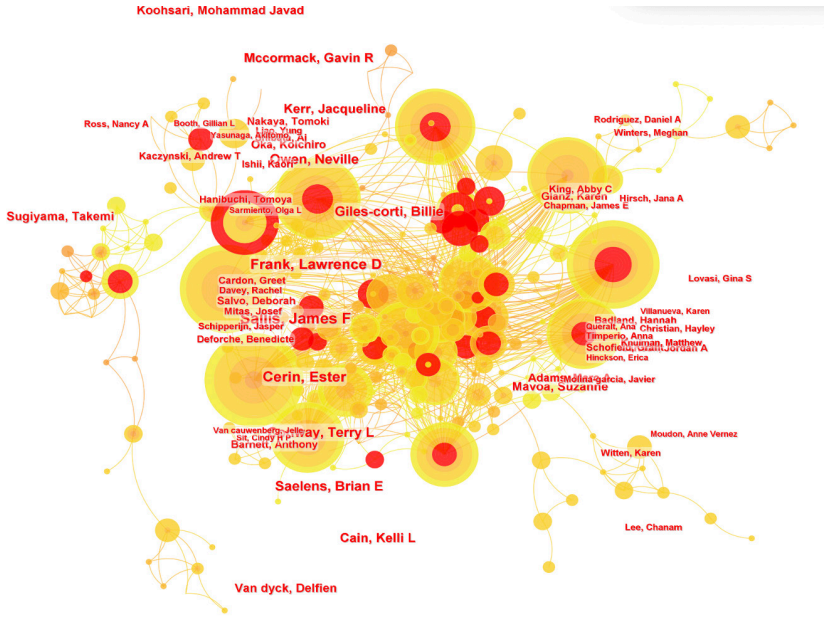

FIGURE 5. Network of Researchers Collaboration (Diagram Built on CiteSpace)

Top 25 Authors with the Strongest Citation Bursts

Authors	Year	Strength	Begin	End	1976 - 2023
De bourdeaudhuij, Ilse	2010	7.97	**2010**	2015	
Van dyck, Delfien	2010	5.85	**2010**	2015	
Deforche, Benedicte	2010	5.52	**2010**	2015	
Cardon, Greet	2010	5.18	**2010**	2015	
Owen, Neville	2007	4.95	**2007**	2015	
Leslie, Eva	2007	4.92	**2007**	2010	
Knuiman, Matthew	2008	4.89	**2008**	2015	
Kowaleski-jones, Lori	2008	4.27	**2008**	2015	
Saelens, Brian E	2006	3.77	**2006**	2015	
Kerr, Jacqueline	2008	3.72	**2008**	2015	
Sallis, James F	2006	3.57	**2006**	2015	
Winters, Meghan	2014	5.16	**2014**	2020	
Foster, Sarah	2011	3.96	**2011**	2015	
Macfarlane, Duncan J	2013	3.85	**2013**	2015	
Oka, Koichiro	2016	6.19	**2016**	2023	
Mccormack, Gavin R	2009	4.76	**2016**	2023	
Nakaya, Tomoki	2011	4.6	**2016**	2023	
Koohsari, Mohammad Javad	2011	4.39	**2016**	2023	
Shibata, Ai	2016	4.29	**2016**	2023	
Hanibuchi, Tomoya	2011	3.91	**2016**	2020	
Ishii, Kaori	2016	3.65	**2016**	2023	
Yasunaga, Akitomo	2018	3.43	**2018**	2023	
Molina-garcia, Javier	2017	3.36	**2017**	2023	
Boulange, Claire	2017	3.33	**2017**	2020	
Vich, Guillem	2021	3.9	**2021**	2023	

FIGURE 6. Top 10 Authors with the strongest Citation Bursts (Diagram Built on CiteSpace)

COUNTRY AND RESEARCH INSTITUTE DISTRIBUTION

As seen in Figures 7 and 8, VOSviewer is used to visually examine the cooperation and influence of the nation and research institutes based on the author's collaboration relationship. From 1976 to 2022, 56 major research countries are active in worldwide research on walkability and the built environment. The criterion is set at 5, and 56 of the 84 nations meet it. It should be highlighted that the absolute cooperative impact is the United States of America (USA), which has a total document of 872 articles over a four-decade period with 34,332 citations and 716 in overall link strength. Australia, Canada, and the People's Republic of China account for the top 3 countries in author's cooperation after the USA for 334, 331, 255 documents with a total link strength are 573, 362, 431 subsequently. However, some countries also show a high link strength which means to have high collaborations such as between USA, Brazil, Columbia, and Belgium. In addition, Japan also has a high cooperation with Australia in the field of walkability and built environment studies.

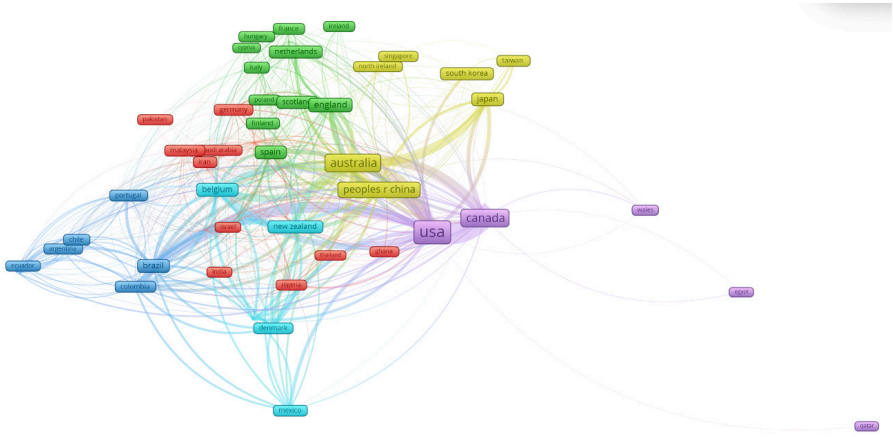

FIGURE 7. Influence Map of National Cooperation based on Bibliometrics studies (Diagram Built on VOSviewer)

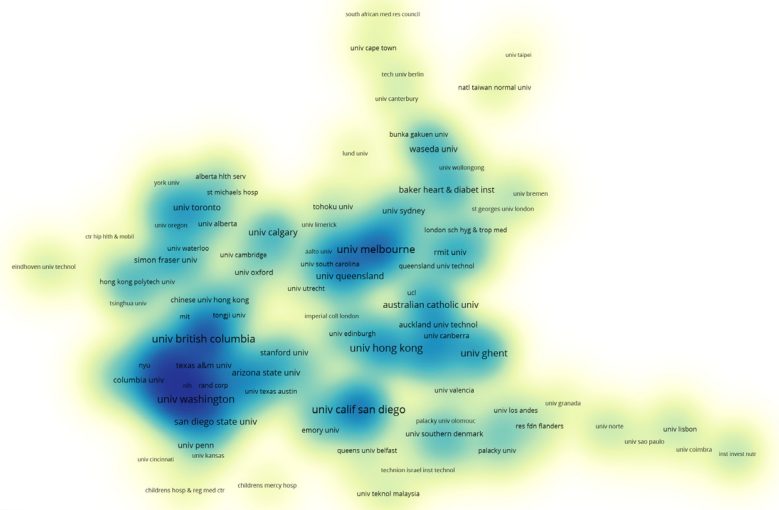

FIGURE 8. Influence Diagram of Institutional Cooperation in research field based on Bibliometrics studies (Diagram Built on VOSviewer)

From 1976 to 2022, a total of 1866 research institutes were participating in the subject of walkability and the built environment research. The criterion is set at 5, and 265 research institutes satisfy this standard. Figure 8 shows that the most influential research institution is the University of California San Diego, which has 120 documents and 5,594 citations. The major study topics include the built environment of a neighbourhood, the

relationship between transportation and walking, the built environment and physical activity, street-scale infrastructure, and so on. The University of Melbourne is rated second, with 119 documents and 3,904 citations. Its core study subjects include the effects of the urban neighbourhood environment on physical activity, greenspace, urban design features, and modes of transportation choice for walking, street connectivity, land use and walking, and so forth. The third-ranked institution is the university of British Columbia, whose documents are 107, with 10,364 citations. The main research contents are transport-related walking, perceived neighbourhood environmental attributes associated with walking, land use mix, access to destinations, etc.

THEME AND DOMAIN CO-OCCURRENCE ANALYSIS

The term co-occurrence analysis displays frequently recurring terms as well as the relationships between them. It also shows the total number of times a phrase appears in all papers. This can be used to highlight important topic areas (Van Eck and Waltman, 2022; Sharifi et al. 2021; Meng et al. 2020).

KEYWORDS CO-OCCURRENCE

Keyword co-occurrences and keywords are mapped using VOSviewer and CiteSpace during four decades (1976-2022) as shown in the Figure 9. VOSviewer is used to study the cluster of high-frequency keywords; the threshold is set at 10, and 317 terms exceed this level. Figure 11 shows that there are 6 clusters with the top three highest keyword co-occurrences, including the built environment 'green cluster,' walking'red cluster,' and physical activity 'blue cluster'. The top keywords as shown in the Figure 10 are mostly found in the international journals 'international journal of environment,' 'health and place,' and 'BMC public health,' which are highlighted on green clusters. The highest keyword co-occurrence appears on 'journal of physical activity,' which is shown by yellow clusters. Furthermore, the frequently used terms are mostly found in the journal "sustainability."

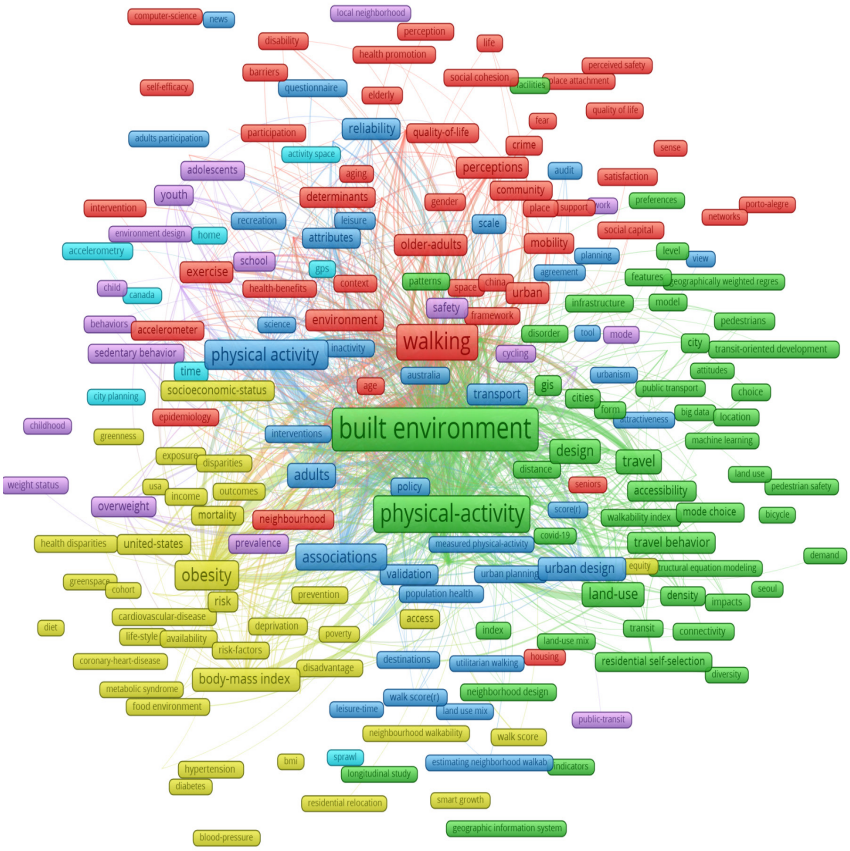

FIGURE 9. Keywords co-occurrence network (Diagram Built on VOSviewer)

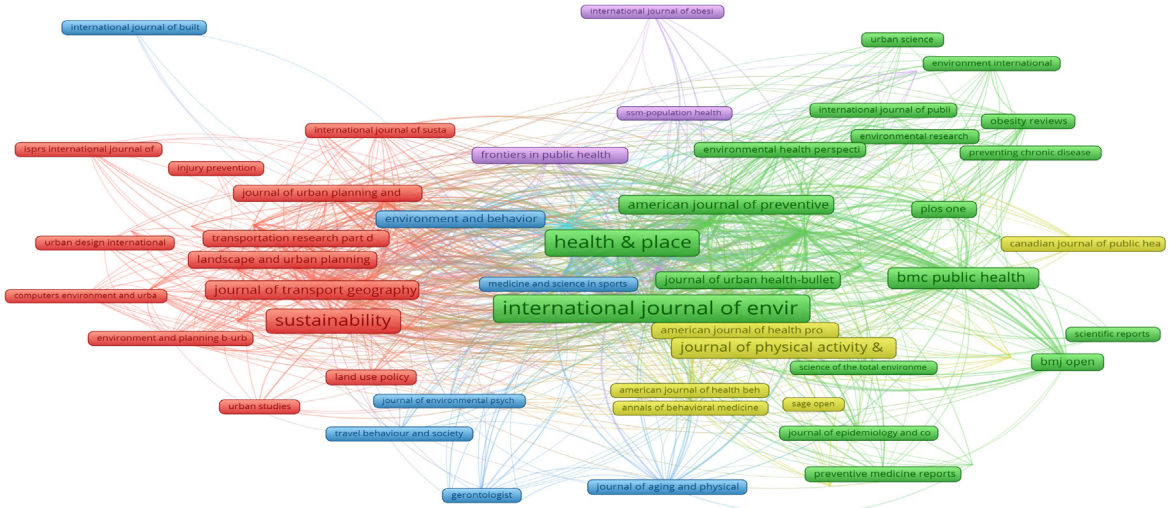

FIGURE 10. Co-occurrence Network (Diagram Built on VOSviewer)

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	1970 - 2023
determinant	2003	7.22	**2003**	2013	
exercise	2003	4.62	**2003**	2014	
overweight	2005	9.3	**2005**	2010	
urban form	2005	9.03	**2005**	2012	
transportation	2005	4.56	**2005**	2010	
environment	2005	4.48	**2005**	2010	
urban sprawl	2008	6.54	**2008**	2013	
united states	2008	5.42	**2008**	2014	
atherosclerosis risk	2008	4.28	**2008**	2013	
activity questionnaire	2009	4.65	**2009**	2014	
walking activity	2010	4.76	**2010**	2016	
multilevel analysis	2010	4.35	**2010**	2013	
accelerometer	2011	4.99	**2011**	2016	
walkability scale	2012	6.43	**2012**	2017	
weight	2012	6.11	**2012**	2015	
validity	2009	4.85	**2012**	2014	
reliability	2009	6.03	**2013**	2014	
self selection	2013	5.25	**2013**	2019	
crime	2009	4.44	**2015**	2017	
spatial analysis	2019	4.55	**2019**	2021	
transit	2015	4.3	**2019**	2021	
city	2002	7.83	**2020**	2023	
green space	2016	6.81	**2020**	2023	
health benefit	2018	5.97	**2020**	2023	
exposure	2017	4.27	**2021**	2023	

FIGURE 11. The Top 25 Keywords with the Strongest Bursts (Digram Built on CiteSpace)

The term "burst of keywords" describes a set of terms that have experienced a sharp rise in frequency of use in a brief amount of time and are being utilized to explore the cutting edge dynamics of the field of study (Chen, 2006). It illustrates the current research hotspots and scientific trends as shown in the Figure 11. The 'Begin' year represents the start year of the keyword burst, the 'End' year is the end year of the burst, and the red line shows the duration of the burst 'determinant,' 'exercise,' 'overweight,' 'urban form,' and 'transportation' were the top five most popular terms in studies on walkability and the built environment between 2003 and 2010. As can be seen in the top five most popular terms in the previous year,

CO-CITED ANALYSIS

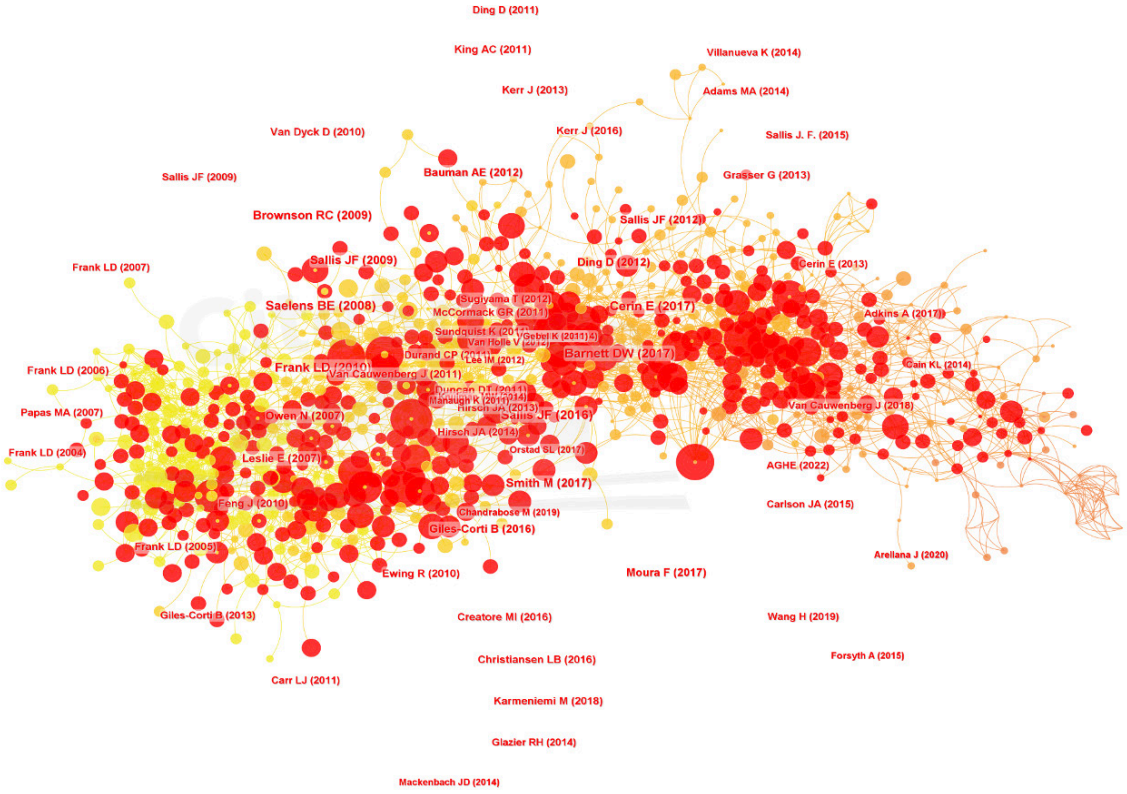

FIGURE 12. Co-cited Reference (Digram Built on CiteSpace)

A scientific mapping technique called co-citation analysis makes the assumption that articles are frequently referred together and share a common theme (Hjorland, 2013). A co-citation network is formed when two publications appear in the reference list of another article. The use of co-citation analysis can assist researchers in identifying the most influential publications and subject clusters, as well as the most influential publications and theme clusters (Donthu et al. 2021). Figure 12 shows co-cited reference, Figure 13 shows references with the strongest bursts, and Table 1 depicts the top 10 articles by number of co-citations. Sallis et al. produced the most often co-cited work in 2016. Physical inactivity is described as a global epidemic in the urban setting in the study. They find that physical activity is influenced by four environmental factors: residential density, junction density, public transportation density, and park density Barnett (2017), on the relationship between the built environment, older persons, and walking, is the second-most co-cited study. The article analyses built-environmental characteristics linked to higher levels of physical activity. According to the findings, there is a favourable environmental effect on older individuals' physical activity, such as safe, accessible, visually beautiful neighbourhoods with access to both general and specialised destinations and services. The third-most-cited article is by Saelens and Handy (2008). Their study focuses on the interaction of the built environment and walking. The article investigates the

environment that supports and encourages walking, as well as knowledge of the specific built environment elements that are closely associated with walking. They find a connection between walking for transportation and density, distance to non-residential destinations, land use mix, street connection, parks and open space, and personal safety.

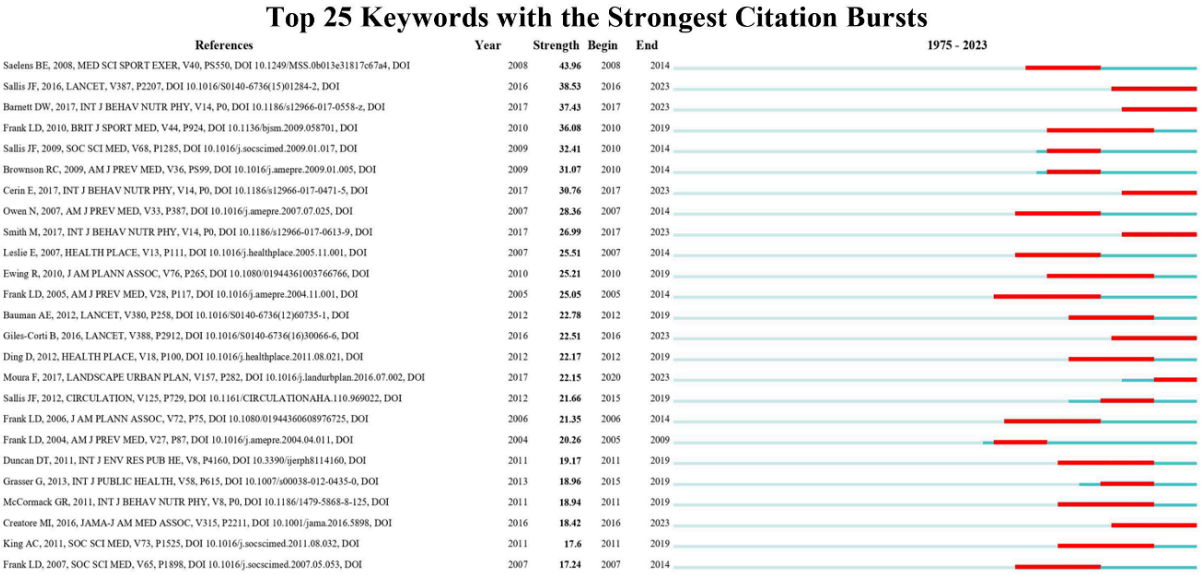

FIGURE 13. The Top 25 References with the Strongest Bursts (Digram Built on CiteSpace)

TABLE 1. The top 10 References with the most citation counts

Citation Counts	Authors	Title	Journal	Year
115	Sallis JF., Cerin, E., Conway, T.L., et al	Physical Activity in Relation to Urban Environments in 14 Cities Worldwide: A Cross-Sectional Study	The Lancet	2016
110	Bamett, D.W.	Built Environmental Correlates of Older Adults' Total Physical Activity and Walking: A Systematic Review and Meta-Analysis	International Journal of Behavioral Nutrition and Physical Activity	2017
98	Saelens, B.E and Handy, S.	Built Environment Correlates of Walking: A Review	Medicine and Science in Sport and Exercise	2008
95	Cerin, E., Nathan, A., Cauwenberg, V.,et al	The Neighbourhood Physical Environment and Active Travel in Older Adults: A Systematic Review and Meta-Analysis	International Journal of Behavioral Nutrition and Physical Activity	2017
93	Frank, L.D.	The Development of a Walkability Index: Application to The Neighbourhood Quality of Life Study	British Journal of Sport Medicine	2010
80	Smith, M., Hosking, J., Witten, K., et al	Systematic Literature Review of Built Environment Effects on Physical Activity and Active Transport – An Update and New Findings on Health Quality	International Journal of Behavioral Nutrition and Physical Activity	2047
74	Sallis, J.F., Saelens, B.E., Frank, L.D., et al	Neighbourhood Built Environment and Income: Examining Multiple Health Outcomes	Social Science and Medicine	2009

continue ...

... cont.

71	Browson, R.C., Hoehner, C., Day, K., et a;	Measuring the Built Environment for Physical Activity State of the Science	American Journal of Preventive Medicine	2009
62	Giles-Corti, B., Vernex-Mouldon, A., Reis, R., et al	City Planning and Population Health: A Global Challenge	The Lancet	2016
60	Ding, D., and Gebel, K.	Built Environment, Physical Activity, and Obesity: What Have We Learned from Reviewing the Literature?	Health and Place	2012

KNOWLEDGE TOPIC IDENTIFICATION AND LANDMARK LITERATURE ANALYSIS

KNOWLEDGE TOPIC RECOGNITION

A time map could be used to conceptualize the study field. The literature data set comprises of the referenced literature as the knowledge foundation of the specific study subject. Subject clustering of the citing documents based on co-citation relationships of the highly cited articles that compose the knowledge base can aid in identifying the forefront knowledge base of the study area. Furthermore, it highlights crucial information turning points in the research trend development throughout a certain era (Meng et al. 2020). In this study, CiteSpace is used to build a knowledge map of the research field based on the literature co-citation network in order to analyze research themes in the study of walkability and the built environment. Figure 14 shows that the network consists of 24 clusters in the topic clustering maps of the study domain of walkability and the built environment from 1976 to 2022. These clusters highlight the field's hot topics throughout the last 20 years shown in the Table 2 and Figure 14 and 15. Each subject cluster has a distinct amount of documents and a varied time duration. The time duration between hot issues varies. The #9 cluster utilising geographic information systems was one of the hot topics. Some clusters, such as #0 cluster physical activity, #2 cluster neighbourhood environment, #3 cluster neighbourhood walkability, and #12 environment characteristics, arise between 2003 and 2010. Furthermore, some study subjects have emerged intensely in the previous ten years from 2013 to the recent 2022 studies, such as #1 systematic review, #4 walk score, #10 walking behavior, #11 cross-sectional study, #17 environment correlate, #18 sedentary behavior, #19 independent mobility, and #22 Multigroup analysis. Furthermore, it is noted that the longest period of the emergence of hot research topics is #4 cluster walk score and #14 environmental attribute.

However, the top ten clusters as hot topics over the last four decades have been represented by a high member and a high silhouette value. A cluster's silhouette score evaluates its homogeneity, which answers the question of whether cluster members are grouped based on what they share in specific features. In other words, a high silhouette score cluster is seen to be more significant than a low silhouette score grouping (CiteSpace, n.d.). The outcomes are as follows:

TABLE 2. Summary of the Largest 10 Clusters

Cluster ID	Size	Silhoutte	Label	Average Year
#0	52	0.916	Physical Activity	2006
#1	47	0.951	Systematic Review	2016
#2	47	0.976	Neighbourhood Environment	2009
#3	45	0.949	Neighbourhood Walkability	2006
#4	44	0.959	Walk Score	2017
#5	43	0.951	Environmental Characteristics	2007
#6	40	0.976	Body Mass Index	2011
#7	38	0.984	Neighbourhood Walkability	2016
#8	38	0.926	Neighbourhood Environment Walkability	2016
#9	37	0.986	Using Geographic Information System	2001
#10	34	0.953	Walking Behavior	2018

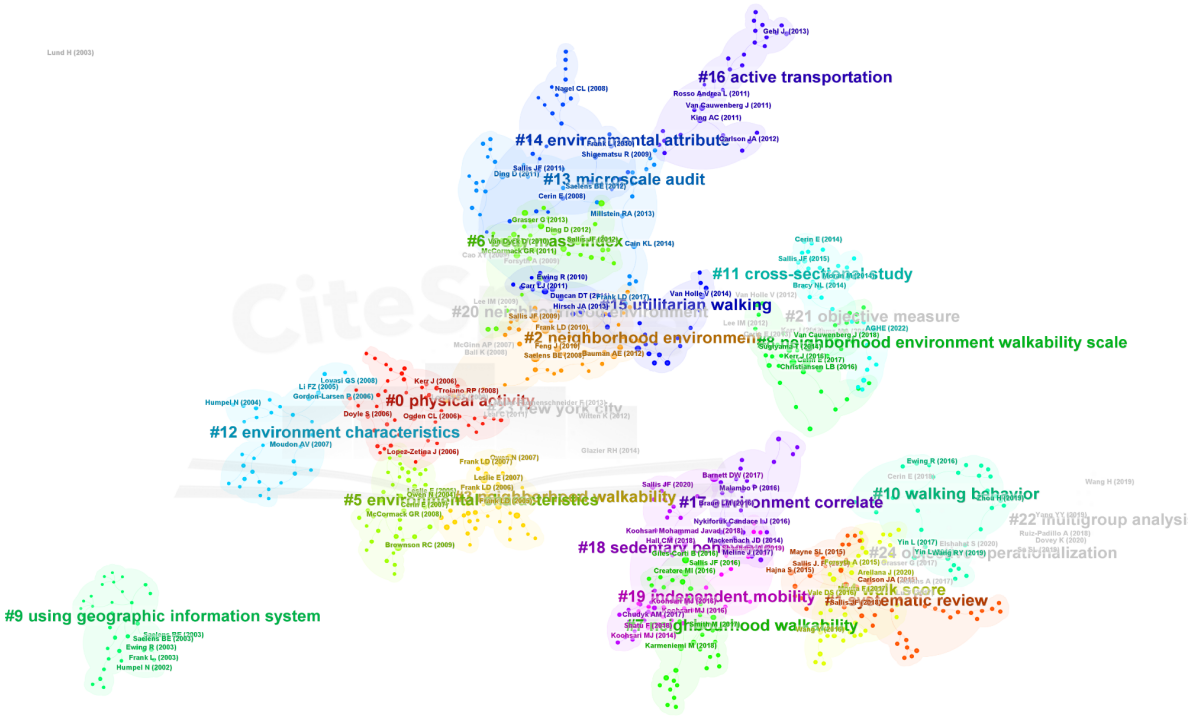

FIGURE 14. Cluster of Research Topics (Digram Built on CiteSpace)

FIGURE 15. Research Topics Timeline View (Digram Built on CiteSpace)

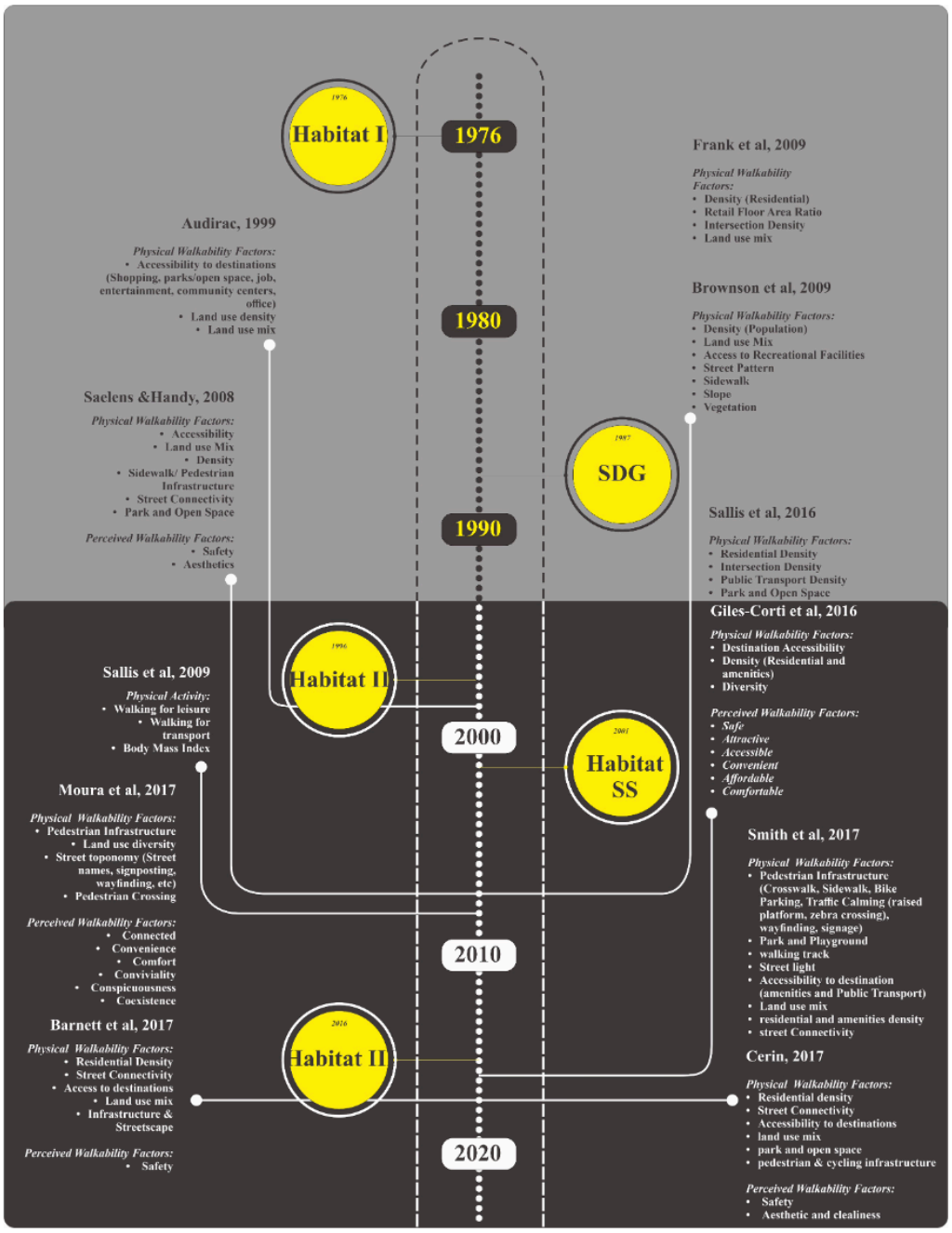

FIGURE 16. Walkability Timeline based on the TOP 10 citation counts and centrality of the earliest publication

Clustering in the year 2003-2010 – During this time period, the research with the most members in the greatest clusters in the subject is closely connected to how built-environment qualities impact walking on a macroscale. Saelens and Handy (2008) study a place that facilitates and encourages walking. They further analyze based on specific built environment characteristics, transportation walking, and recreational walking. In a similar vein, Doyle et al (2006) investigate active community environment and health with neighbourhood safety. Individuals will be healthier if they live in communities that promote exercise and activity by being walkable and having a lower crime rate, as these are the factors that encourage people to walk more. Frank et al (2005) identify physical activity with the physical environment. In the study, they indicate that several of the attributes of the built environment influence people to walk to go to their destination including land-use mix, residential density, and intersection density. In a similar vein, Leslie et al. (2007) find built environment elements that impact adult physical activity as a factor of

chronic illness. They show that persons who live near various and diversified retail likely to make more frequent journeys than those who reside farther away from retail and prefer to drive. The study suggests that the more diverse the land use mix in a place, the easier it is to walk to various locations. Furthermore, they remark that increased junction density, which also signifies network connectedness, offers a broader diversity of viable walking paths to destinations.

Clustering 2010-2022 – Over the last 12 years, the topic research has expanded to include not only the built world, but also people's or pedestrians' perceptions of their local environment linked with walking, as well as the use of a computer tool for spatial analysis. It also discusses the fundamental idea of walkability. Arallena et al (2019) determine pedestrians' perception of the real world on a city scale. They observe that when the environment is secure and safe, people prefer to move on foot, which is supported by the presence of a sidewalk. Security is significantly linked with a subjective dimension represented by crime fear. Meanwhile, Forsyth (2015) study on the conceptualization of walkability in the built world, in the subject of urban design. The study suggests that there are a set of considerations that affect people to walk including lively and sociable, transport options, and exercise-inducing which is the issue of the most supportive environments for walking outdoors and their link to exercise or physical activity. Moura and Goncalves (2017) undergo an assessment of walkability for pedestrian in urban areas of Lisbon, Portugal, which demonstrate the improvements that can be made through urban design and planning mobility strategies such as introducing a pedestrian network accessible to all age groups, by making the local-oriented environment more accessible and appealing for walking. Ewing et al (2015) investigate Pedestrian activity is represented by streetscape features. They find that the most crucial elements in establishing walkable streets and a pedestrian-friendly environment are the percentage of street windows, the percentage of active street frontage, and the quantity of street furniture. Figure 16 shows Walkability Timeline based on the TOP 10 citation counts and centrality of the earliest publication

DISCUSSION

RESEARCH ON WALKABILITY AND THE BUILT ENVIRONMENT

This study is a bibliometric analysis that investigated the scientific literature in connection to walkability and the built environment in the WoS database from 1976 to 2022 with the use of VOSviewer and CiteSpace tools. It has been discovered that study on walkability and the built environment has developed dramatically during the last four decades. This indicates that more researchers are interested in this topic. According to the findings of this study, the United States has received the most attention of research in this subject, followed by Australia, Canada, and China. Furthermore, the majority of the work is in the fields of public, environmental, and occupational health, that is followed by Environmental Sciences and ecology, environmental studies, engineering, science and technology, and urban studies. The link between walkability and built environment development has long been a source of debate in academic circles. When the globe is faced with population and urbanisation concerns that happens in the past, present, and future decades. These issues lead to a growth in built-up areas, which is followed by an increase in motorised transportation and traffic fatalities, demonstrating people's reliance on motorised vehicles. Since 1976, the environmental, social, and health consequences of these challenges have been unavoidable.

Because these issues cannot be resolved by one nation acting alone, the United Nations (UN), the only truly global organization that crosses national boundaries, has emerged as the main forum for addressing them. The UN hosted conferences to tackle problems across four decades, beginning with Habitat I: The UN Human Settlements Program or UN-Habitat in 1976 and continuing with the Sustainable Development: World Commission on Environment and Development programme in 1987. In addition, Habitat II: Istanbul Declaration and Habitat Agenda were organised in response to rising population and housing concerns, particularly in urban areas. During that 20-year era, study in this field was still quite limited. Research reveals a fairly significant growth to the present beginning in the 2000s, following the Habitat Special Session: Declaration on Cities and Other Human Settlements in the New Millennium. Lastly, the United Nations is hosting Habitat III: The New Urban Agenda and The Quito Declaration on Cities and Human Settlement in 2016. Following that, the interest of researchers in this field has skyrocketed.

The concept of walkability is defined as the extent to which a neighbourhood could encourages people to walk from their home to other places (Forsyth 2015; Campoli 2012; Fonseca et al. 2021; Hijriyah et al. 2023; Hijriyah et al. 2024). It entails walking behaviour, which can be classified as walking for transit or walking for transportation (Shuaib and Rana 2021; Fonseca et al. 2021; Rahman Nahiduzzaman 2019), and walking as physical activity (Dovey and Pafka, 2020; Fonseca et al. 2021).

The term walkability refers to a multidimensional construct made up of several aspects that combine to form a single theoretical idea. It is regarded as a walkable place in the built environment at many scales in territories

ranging from macroscale or bigger territories such as region, city, and neighbourhood to microscale such as street scale. Walkability refers to the physical environment that encourages and facilitates walking to destinations such as shopping, job, school, and other facilities, making it a better place to live while also contributing to the environment, i.e., (reducing environmental harm) (Vichiensan and Nakamura, 2021; Jamei et al. 2021), social (i.e., lively and sociable) (Koohsari et al. 2021; Hellberg et al. 2021), and health (i.e., reducing respiratory disease) (Saadi et al. 2021; Timmermans et al. 2021). It is accomplished by providing a holistic answer that is a quantitative and qualitative approach to how inviting or uninviting a physical environment is to pedestrians (Congiu et al. 2019; Middleton, 2022; Qureshi et al. 2020), including physical walkability factors (i..e., land use density and diversity, street connectivity (i.e., the directness of links and the density of connections), distance to destinations, block size, sidewalk (Forsyth 2015), and perceived walkability factors (Chan et al. 2020; Berg et al. 2022; Langdon, 2017; Middleton, 2022). Furthermore, perceived walkability factors include safety (Burton and Mitchell, 2006; Chen et al. 2022), aesthetic (Forsyth 2015), comfort (Chen et al. 2022; Forsyth 2015), direct (Jensen et al. 2017), connected (Duncan et al. 2016). Figure 17 below shows The Conceptualization of the relationship between walkability and built environment

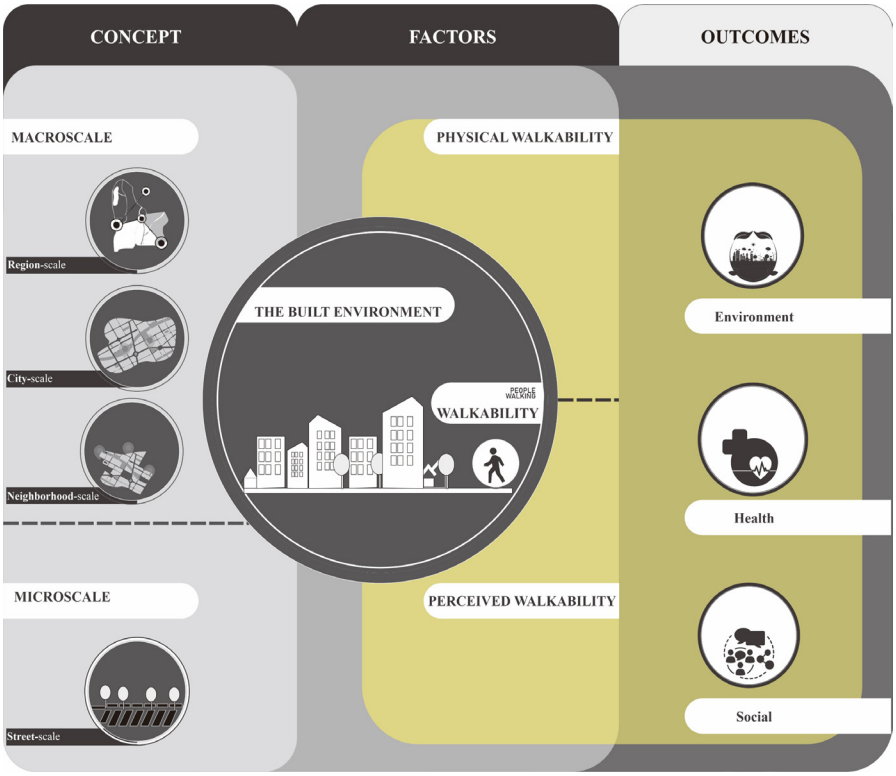

FIGURE 17. The Conceptualization of the relationship between walkability and built environment

ADVANTAGES OF BIBLIOMETRIC ANALYSIS BY USING VOSVIEWER AND CITESPACE

The most significant benefit of bibliometric analysis is its ability to investigate enormous amounts of data and objectively assess the influence of academic research (Wei et al. 2020). It is a great tool for assisting researchers in better understanding the present state of research and future research directions in a certain research subject (Zhang et al. 2023). Bibliometric analysis has been widely utilised to analyse literature and to investigate emerging trends in the evolution of (Chen et al. 2021; Stout et al. 2018; Mulet-Forteza et al. 2019). VOSviewer-created visualisations are clearer and user-friendly (Markscheffel and Schroter, 2021; Van Eck and Waltman 2022). CiteSpace, on the other hand, provides advantages in the evaluation of network visualizations, such as the ability to analyze cluster nodes using a Cluster Explorer (Markscheffel and Schroter 2021).

CONCLUSION AND FUTURE PERSPECTIVE

This study fully integrates the benefits of bibliometric visualisation tools by using CiteSpace and VOSviewer, two sophisticated tools with an intuitive user interface that provide text mining functionality to construct and visualize data networks from a body of scientific literature. CiteSpace and VOSviewer are used to centrally integrate literature related to walkability and the built environment as a data source. By arranging the overall development path in this field, this study discovers trends by identifying knowledge-based analysis, including knowledge topic recognition and the evolution route of the research field over the last four decades (1976-2022).

FUTURE DIRECTION FOR THE STUDY OF WALKABILITY AND THE BUILT ENVIRONMENT

Multidisciplinary research collaboration in this subject may increase the richness of research findings that can contribute to numerous factors such as environment, social, and health, which can therefore help to speed the process of producing a better environment. Aside from that, studying the evolution of research development in specific geographic locations in developed or developing nations is important in providing a grasp of understanding in the field of walkability and the built environment. Furthermore, a systematic literature review (SLR) is required to research the precise aspects that impact interrelationships in this subject in order to conduct an in-depth analysis. The study in this topic will give a thorough knowledge and aid in the advanced development of future academic work by utilising a visualisation tool and an SLR.

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DECLARATION OF COMPETING INTEREST

None.

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