Mapping Knowledge Structures and Trends on Walkability Studies

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ABSTRACT

Walkability is a significant and well-known study to make the built environment to be walkable. However, there is a scarcity of material that aims to investigate the structure and research trends of walkability in recent years. Therefore, the objective of this systematic review is to investigate the structure and research trends in walkability. By applying the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) review method, a systematic literature review (SLR) identifies 50 studies by walkability from 2021 to 2022 from the 3 well-known databases for searching scientific publications including Web of Science, Scopus, and Sage. A mapping technique using VOSviewer to identify thematic focus is employed. Based on these 50 studies, it shows that the existing research on walkability within two years consists of some conceptual aspects that underlying walkability studies including 'the built environment', 'walking' and physical activity', which then leads to one or some specific problems on physical or perceived factors which ultimately aim to create a walkable area. Hence, it is significant to do more research on the integration between factors in this field to solve the dependence on motorized transportation for future scholarly work. In addition, the usage of tools could enrich the existing literature on this field. It is also noted that various age perceptions to solve walkability issues need to be considered. The research also emphasizes significant authors, journals, references, countries, and organizations that have contributed to the development of the walkability literature to elaborate in more detail on thematic focus.

Keywords: Walkability, Walkable, PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analysis, Systematic literature review, Science Mapping, VOSviewer

INTRODUCTION

The demand to live in a neighborhood that is friendly to walking has been booming in this day and age (Jensen et al. 2017). Following that, a large number of articles published in walkability studies are carried out with various topics and a particular focus of studies. In addition, studies in this field have also attracted the attention of researchers to combat pandemics that have occurred in several recent years (Erturan and Aksel, 2022; Yuan et al. 2022; Lotfata et al. 2022). Yuan et al (2022) carried out a study to identify the impact of the pandemic on walkability and determine the elements of the built environment that influence increased walkability. Along the same line, Lotfata et al

(2022) conducted research that intends to highlight how the walking behavior of individuals affected in different geographic before and during the pandemic. Meanwhile, some researchers also conducted a study that is concerned with the conceptual or specific aspect of creating a walkable place. Bari and Tekel (2022) investigated a solution for characterizing the built environment design dimensions on walking behavior. Other studies focus on the specific analysis, for example, pedestrian networks (Fonseca et al. 2022; Jabbari et al. 2021; Yang et al. 2022), or on people's perceptions of the physical environment (Hassan and Elkhateeb, 2021; Koohsari et al. al. 2021; Erturan and Spek, 2021). Khalaf and Jaafar (2020) have conducted studies on walkability that focus on the streets to make the built environment walkable.

The study of walkability has gained popularity in recent years from researchers worldwide based on the Web of Science database mainly within the last 2 years between 2021 and 2022 (https://www.webofscience.com/). However, there is a lack of literature investigating systematic literature reviews highlighting thematic areas in the field of walkability. Thus, scientific mapping and bibliographic analysis approaches could be carried out to address gaining detailed knowledge and stay up with the high pace of scientific publishing, since they allow to assist in collecting of overall understanding of knowledge structure and trends through the use of advanced text-mining tools (Sharifi et al. 2021; Sharifi, 2021). By doing that approach, it eases to get an understanding of the comprehensive landscape of the field and also could highlight several similarities among concepts or other aspects of the existing studies. It is necessary to conduct regular scientific mapping and bibliographic analyses to get insight into the recent development, and current emergent ideas, and identify the gaps (Sharifi et al. 2021). Hence, the main objective of this study is to provide a present understanding of the knowledge structure of the published research on walkability over two years period between 2021 and 2022. Another objective is to investigate major thematic areas and investigate the influential sources, authors, institutions, and references that have made considerable contributions to the field, highlighting the areas that need to be studied for further research. The finding of this study can be used as a reference to help researchers who are about to start research related to walkability or are looking for research ideas in this field to gain a quick understanding of specific aspects of walkability studies within two years (2021–2022) without spending too much time. The results also could assist researchers to develop future research ideas.

METHODOLOGY

A Systematic Literature Review (SLR) is used in this study as a means for identifying, evaluating, and interpreting all available research concerning a particular research question, topic area, or phenomena of interest (Ismail et al. 2021), through a thorough review in a small number of publications (Barn et al. 2017). An SLR seeks to search, locate, and synthesize literature systematically about previous studies in a well-organized and transparent process that employs reproducible procedures at each step (Ismail et al. 2021). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), then, are utilized to conduct an SLR, which comprises a series of stages from identification, screening, eligibility, and exclusion criteria process, to the data abstraction and analysis phase (Ismail et al. 2021; Moher et al. 2009). This study uses a search string that includes two keywords and determines a certain language, article types, and publication

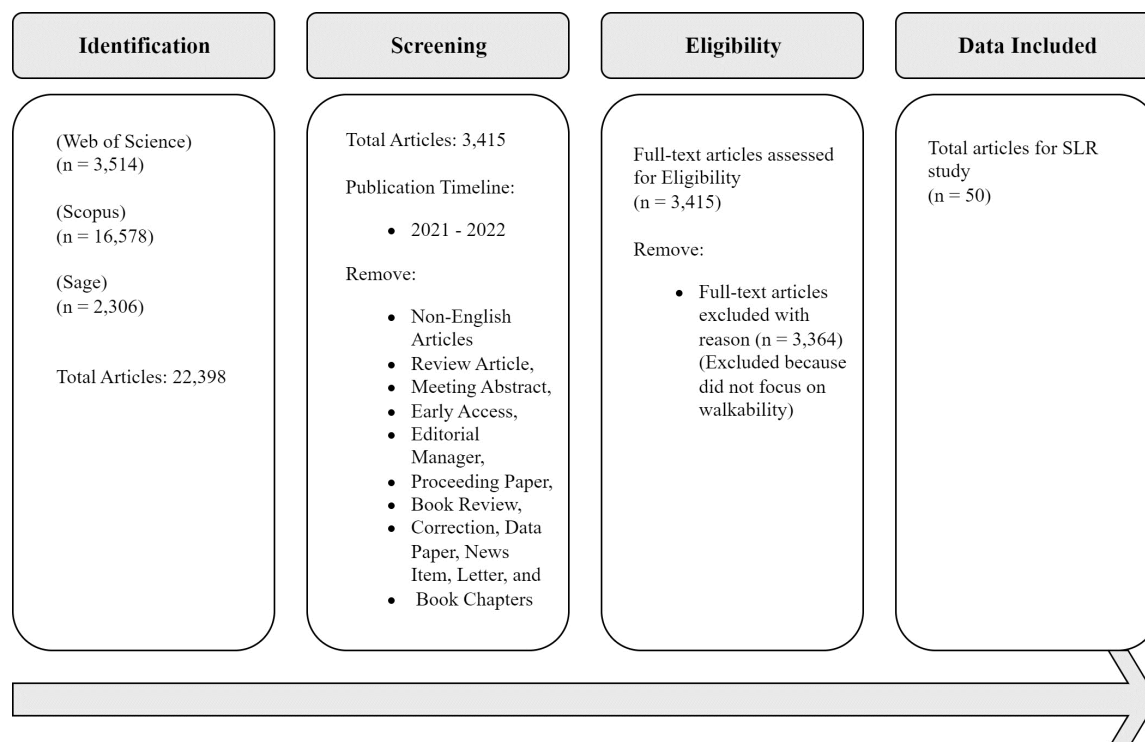| Identification	Screening	Eligibility	Data Included
(Web of Science) (n = 3,514) (Scopus) (n = 16,578) (Sage) (n = 2,306) Total Articles: 22,398	Total Articles: 3,415 Publication Timeline: • 2021 - 2022 Remove: • Non-English Articles • Review Article, • Meeting Abstract, • Early Access, • Editorial Manager, • Proceeding Paper, • Book Review, • Correction, Data Paper, News Item, Letter, and • Book Chapters	Full-text articles assessed for Eligibility (n = 3,415) Remove: • Full-text articles excluded with reason (n = 3,364) (Excluded because did not focus on walkability)	Total articles for SLR study (n = 50)

FIGURE 1. The flowchart of the PRISMA approach used in the SLR study
(Adapted from Moher et al. 2009; Ismail et al. 2021)

time. The steps of SLR using PRISMA are explained in detail in Figure 1. and Table 1.

In this study, VOSviewer is selected to be used considering its abilities to meet the objective of the study. VOSviewer is available freely on its official website (VOSviewer at: https://www.vosviewer.com). The developer of the software also provides the user manual guide and demo projects that can assist in understanding the usage of software and conducting more detailed analyses. This study uses VOSviewer for conducting different analyses. The "Full Record" of included articles in this study are downloaded in formats compatible with VOSviewer. The analyses for this study include several types of analyses and units of analysis to understand thematic focus.

TABLE 1. The Steps of SLR using PRISMA

	Steps	Description	
I.	Identification	The first step of SLR is when the research question and objective are stipulated. In this step at least one database (Moher et al. 2009)	This study uses 3 well-known databases including Web of Science (WOS), Scopus, and Sage, and uses the specific search strings "Walkability" OR "Walkable"
II.	Screening	The screening process is a step in which articles are included or excluded based on criteria specified by the authors by using particular databases (Ismail et al. 2021; Moher et al. 2009).	Three criteria are determined namely article types (Research paper), publication time (2021-2022), and language (English), yielding a total of 3,415 articles.
III.	Eligibility	a manual procedure containing included or excluded articles based on the authors' particular criteria (Ismail et al. 2021; Moher et al. 2009).	Removing full-text articles which do not focus on walkability, and yielding a result of a total of 50 articles.
IV.	Data Abstraction and Analysis	The final phase, data abstraction, and analysis, is developed for organizing the information from the full paper review (Ismail et al. 2021).	The remaining articles are evaluated, reviewed, and analyzed. The 50 selected articles are discussed in detail.

TABLE 2. Type and Unit of Analysis conducted in this study by using VOSviewer

	Unit of Analysis	Keywords	References	Documents	Sources	Authors	Institutions	Countries
Type of Analysis	Co-occurrence	√						
	Citation			√		√	√	√
	Co-citation		√		√	√		
	Bibliographic Coupling						√	√

The term co-occurrence analysis shows frequently occurring terms and also the way they connect. It also indicates the total number of occurrences of a term in all documents This can be used for highlighting major thematic areas. The results of the term co-occurrence analysis are visualized as a network graph of nodes and links. The size of the node is proportional to the frequency of occurrence, and the link width is proportional to the strength of connections between two nodes. A network shows pairs of items are connected by a link. It also specifies the strength of each link. The strength of the combined link will be equal to the sum of the strengths of the individual links in the network file. Terms that co-occur more frequently then form a cluster that presents different thematic areas (Van Eck and Waltman,2022; Sharifi et al.,2021). In this study, the term co-occurrence analysis is conducted by using the 'full counting' counting method and setting 'all keywords' for the unit of analysis. Following that, citation analysis is also done by using the setting 'documents', 'authors', 'organizations', and 'countries' as the unit analysis. It is conducted to understand highly cited papers in the database. Co-citation analyses are also conducted to identify influential authors, journals, and references. The 'full counting' counting method is set

with 3 analyses including 'cited references', 'cited sources', and 'cited authors' (Cited authors in VOSviewer is defined only including the first author of a cited document), as the unit of analysis. Co-citation presents the link between two documents that are both cited simultaneously by a third document. It means that the analysis is not only the documents in the database but also their cited references. In addition, this study also uses bibliographic coupling analysis which shows a link between two items that both cite the same document. This is done to understand which countries and institutions have contributed more to this field of study. The counting method for this type of analysis uses also the 'full counting' counting method, and two settings are used including 'organization', and 'countries', as the unit of analysis.

RESULT AND DISCUSSION

PUBLICATIONS TRENDS

The review manages 50 selected documents published between 2021 and 2022. Most papers have been published from May to August 2021 with a total of 12 papers (24%), while other periods account for between 10% and 20%. The studies during the periods are mainly conducted by using the quantitative approach which account for 39 papers with the highest percentage at 78% of the total number of papers, followed by the qualitative approach with 6 papers (12%), and the mixed method approach accounting for just 5 papers (10%) of documents in the database subsequently.
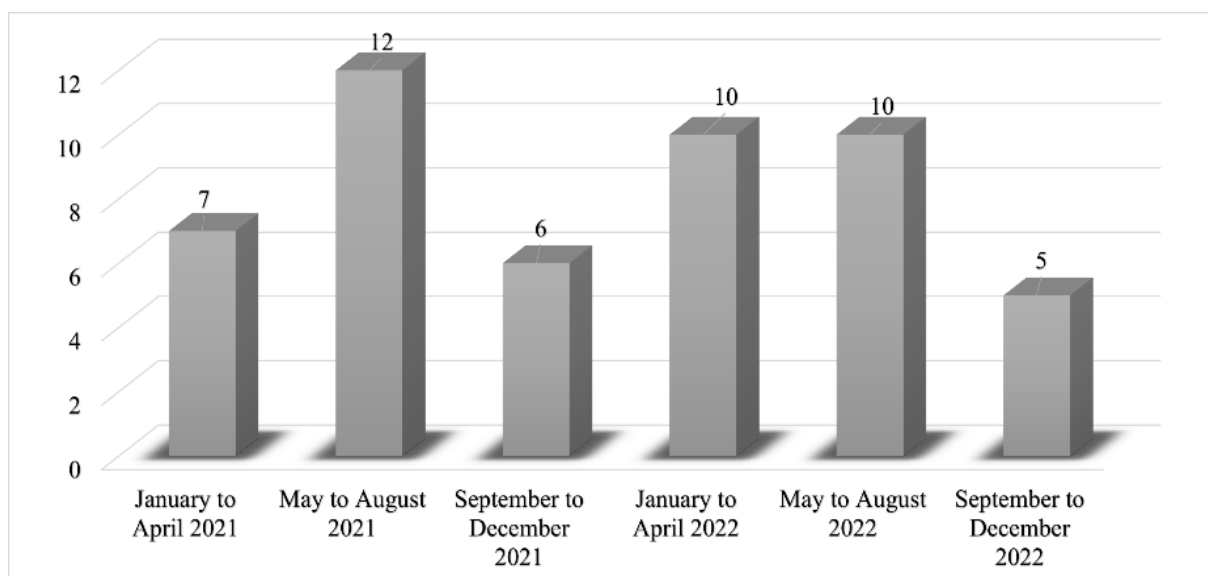

FIGURE 2. The number of articles and approaches published within 2 years from 2021 to 2022 from the SLR in this study

TABLE 3. The trend of several aspects of walkability studies based on 50 reviewed papers.

Authors	Research Object	Type of Analysis			Method		Research Approach		
		PE	PH	MX	Data Collection	Data Analysis	QN	QL	MM
Nakamura,2021	Japan Thailand Australia	√			Virtual Reality (VR) with a Ricoh Theta-v 360_ camera	Statistical Analysis	√		
Ning et al. 2022	United States		√		Aerial and street view imagery;	Spatial/Mapping-based Analysis; YOLACT (You only look at CoefficienTs)	√		
Herbolsheimer et al. 2021	Vancouver, Canada Portland, United States			√	Telephone Survey; Questionnaire; Neighbourhood Environment Walkability Scale (NEWS)	Statistical Analysis	√		

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Sylvers et al. 2022	United States	√	Reasons for Geographic and Racial Difference in Stroke (REGARDS); Cognitive function measurement using The Consortium to Establish a Registry for Alzheimer's disease (CERAD); Word List Learning (WLL); World List Delayed Recall (WLD); 5. Animal Fluency Test (AF)	Statistical Analysis	√	
Pajares et al. 2021	Munich, Germany	√	Open Street Map (OSM)	Software Development	√	
Kwon and Akar, 2022	California, USA		√	National Household Travel Survey -California Ass-on (NHTS-CA) containing daily travel data 24-h travel; Regional Transportation Plan for land use data	Statistical Analysis Walkability Index	√	
Manzoli et al. 2021	Lisbon, Portugal		√	Literature Review; Greater London Authority (GLD)	MCDA-based analysis using the PROMETHEE; Excel	√	
Fonseca et al. 2022	Guimarães, Portugal	√	Geographic Information System (GIS)- Street network data, pedestrian network data, land use	Geographic Information System (GIS); Multicriteria Evaluation (MCAs)	√	
Qazimirsaeed et al. 2022	Karaj, Iran		√	Survey; Questionnaire	Statistical Analysis	√	
Santilli et al. 2021	Italy	√	QGiS	Space Syntax; Q GIS-based software (QGIS)	√	
Jamei et al. 2021	Iran	√	Literature Review; desktop review case study; Historical document photos			√
Telega et al. 2021	Krakow, Poland	√	open-source data; Open Street Map (OSM)	ArcGIS	√	
Kato and Matsushita, 2021	Osaka, Japan	√	GPS location History	Empirical Bayesian Kriging (EBK); Statistical Analysis	√	
Jabbari et al. 2021	Qazvin, Iran	√	Geographic data Direct Observation	GIS; Angular Segment Analysis by Metric distance (ASAMeD); Space Syntax	√	
Vichiensan and Nakamura, 2021	Bangkok, Thailand Nagoya, Japan		√	Direct Observation; Video Recording using 360 Camera; Walking along the case study street	Statistical Analysis; Street Evaluation by Respondents		√
Saadi et al. 2021	Brussels	√	Questionnaire	Statistical Analysis	√	
Fonseca et l., 2022	Bologna & Porto, Italy		√	Questionnaire	Statistical Analysis; SPSS	√	

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Study	Location				Data/Material	Method		
Zaleckis et al. 2022	Baltic Region Cities		√		Open Street Map Copernicus Living Atlas	Space Syntax; Geographic Information System (GIS)	√	
Koohsari et al. 2021	Japan		√		Healthy Built Environment in Japan (HEBEJ); GIS; Questionnaire	Statistical Analysis; Space Syntax	√	
Pooley, 2021	London	√			Textual Material; Personal diaries of mobility; individual testimonies of mobility; government documents			√
Yang et al. 2022	Guangzhou, China		√		Spatial Network (the size and types of buildings and roads)- Urban Planning Department Guangzhou, China; On-site investigation/ On-site Survey	Urban Network Analysis (UNA)	√	
Anabtawi and Scoppa, 2022	Abu Dhabi		√		Maps from GIS Software	Pedestrian Route Directness (PRD) equation using CAD and GIS software (ArcMap 18.0)	√	
Kunaratnam et al. 2022	Toronto, Canada		√		Observation of the travel children at school; Ontario Marginalization Index (ON-Marg) Canadian census according to Dissemination Area (DA); Walk Score	Statistical Analysis	√	
Guzman et al. ,2022	Bogota, Columbia.			√	A Ranking Survey	Multinomial Logit Weight Estimation (MNL)	√	
Bari and Tekel, 2022	Ankara, Turkey			√	Land use data from local Municipality; Survey; Questionnaire	ArcGis; The 3D Index; Statistical Analysis	√	
Silva and Lucchesi, 2022	Sao Paulo, Brazil		√		The origin-destination survey conducted in the metropolitan region of Sao Paulo (RMSP); Open Street Map (OSM); Survey	Statistical Analysis	√	
Hsieh and Chuang, 2021	Taiwan			√	Questionnaire; the Neighborhood Environment Walkability Scale (NEWS); International Physical Activity Questionnaire (IPAQ); face-to-face interview; Questionnaire	Statistical Analysis	√	
Tobin et al. 2022	Canada	√			Workshop / in-person discussions			√
Timmermans et al. 2021	Netherlands			√	Self-reported outdoor walking activity LASA Physical Activity Questionnaire (LAPAQ); The Walkability Index; Questionnaire	Geo Data and Model Software (GeoDMS); Statistical Analysis	√	
Wangbao, 2022	Guangzhou, China		√		Tencent (One of the largest online social media platforms in China); Open Street Map (OSM)	Statistical Analysis;	√	
Hassan and Elkhateeb, 2021	Cairo, Egypt			√	Self-report daily trips/trip report; Sketch; Questionnaire	Statistical Analysis; Description		√

... cont.

Horak et al. 2022	Czech	√		Open Street Map (OSM) street network data; Walkability Index; Walk Score	ArcGIS	√	
Chan and Li, 2022	Shenzhen, China		√	Survey Survey; Semi-strcutured Interview; Environmental Audit; the Satisfcation with Travel Scale (STS); the Neighborhood Environment Walkability Scale (NEWS)	Statistical Analysis; Thematic Analysis		√
Nakamura, 2022	Nagoya, Japan		√	Questionnaire	Statistical Analysis	√	
Bramson et al. 2021	Tokyo, Japan	√		Open Street Map (OSM) street network data; Train Station Data; Station Entrance/Exit	Weighting Score	√	
Lee, 2021	Austin, Texas		√	Data of neighborhood-level crime incidents from The Austin Police Department (APD); Tree Canopy data from The National Agriculture Imagery Program (NAIP) aerial imagery; Census block groups data from the United States Census American Community Survey (ACS)	ArcGIS; Statistical Analysis Walkscore;	√	
Hasan et al. 2021	-	√		Systematic Literature review	A Hierarchical Clustering Technique	√	
McGreevy et al. 2021	Adelaide, Australia	√		A structured observational count using the non-subjective scheduled checklist.	Statistical Analysis	√	
Koohsari et al. 2021	Japan		√	Questionnaire; Physical Activity Questionnaire; Environmental Module (IPAQ-E) for perceived walkable; Walk Score	Statistical Analysis	√	
Chan et al. 2021	China		√	Literature Review; Semi-structured Interview; Fieldwork; Author's own experience of the local environment	Statistical Analysis; Description		√
Gao et al. 2022	Shenzhen, China		√	Walk Score; Observational audit survey; attitudinal surveys of local pedestrians.	Weightage Score		√
Hellberg et al. 2021	Brisbane, Australia	√		Online survey		√	
Erturan and Spek, 2021	Delft, Netherlands		√	Go-along Walks			√
Bayar and Yilmaz, 2022	Istanbul, Turkey	√		Open Street Map (OSM)	ArcGIS, Age-Friendly Approach Index (AFAIndex); Weighted Age-Friendly Approach Index (WAFAIndex)	√	

Erturan and Aksel, 2022	Delft, Netherlands Istanbul Turkey	√	Go-along Walks Semi-Structured Interview	Spatial comparison and Temporal comparison before and during the pandemic	√
Wood, 2022	Johannesburg	√	Literature Review Policy Review Interview		√
Yu, 2021	Hong Kong	√	Face-to-face Survey Interview; Questionnaire; Geographic Information System	ArcGIS; Statistical Analysis	√
Koo et al. 2022	Atlanta, USA	√	National Household Travel Survey Data (NHTS) the city of Atlanta, Georgia, USA; Google Street View (GSV) images	Statistical Analysis; the Pyramid Scene Parsing Network (PSPNet); ArcGIS	√
Yuan et al. 2022	Xi'an, China	√	Google Street View (GSV); Maps confirmed in ArcGIS; audit tools	Deep learning (DL) street view analysis; Space syntax; Statistical Analysis; SPSS	√
Lotfata et al. 2022	USA Asia Middle East	√	Questionnaire	Statistical Analysis	√

Abbreviation for Type of Analysis: PE=Perception, PH=Physical, MX=Mixed; Abbreviation for Research Approach: QN=Quantitative, QL=Qualitative, MM=Mixed Method.

Data collection methods from existing research can be seen in several groups generally: (i) Interview, (ii) Questionnaire, (iii) Observation, (iv) audit tools, (v) Personal Diaries and GPS Location History, (vi) Literature Review and Document Review, (vii) Open Street Map (OSM), (viii) Google Street View (GSV). Meanwhile, data analysis consists of several tools including ArcGIS which is widely used by researchers to assist in analysing physical factors, Urban Network Analysis (UNA), CAD, Geo Data and Model Software (GeoDMS); Space Syntax, QGIS, and several researchers also use statistical analysis such as SPSS and STATA. Many quantitative studies aim to determine people's perceptions of physical factors in the built environment that can facilitate walking. In general, using close-ended questions and statistical analytical software. This also indicates the potential gaps in the walkability study, where subsequent research can be investigated the perception of people within the Neighbourhood or City Associated with Physical Walkability Factors by using another method that can get detailed insight from people.

THEMATIC FOCUS AREAS AND THEIR TRANSITION

THEMATIC CLUSTERS

Three major clusters can be identified from the output of the term co-occurrence analysis from the entire dataset. These are (1) the Walkability concept, presented by the grey color, (2) the Built Environment, depicted by the red colors, and (3) Walking and physical activity represented by the purple color. The thickness of the link among nodes shows the strength of the connection, while the size of the node refers to proportional to the frequency of the term. Thus, it is very clear that the most dominant clusters are walkability and built environment. The results from the
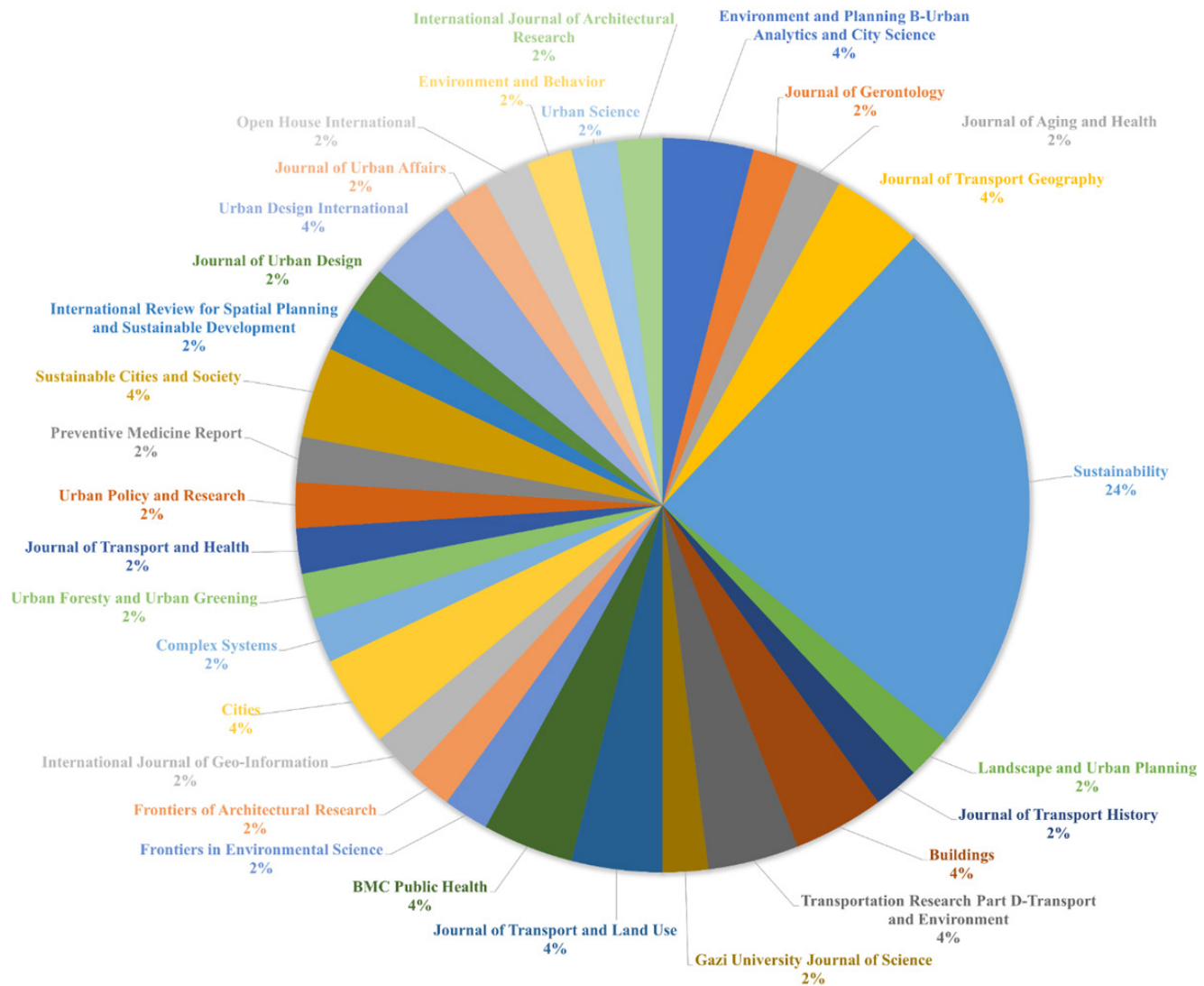
FIGURE 3. The percentage of articles reviewed based on the Journal within 2 years from 2021 to 2022

three largest clusters generally discuss 3 main things, namely the focus of the study which shows the location and scope of the research object, at the city or neighborhood level. Studies at these territories' levels have received more attention mainly in urban areas. The results also showcase that study walkability in developing countries has received less attention, which is depicted by the small proportion of nodes and long network of the term 'Developing Countries'. The analysis also shows that, in the walkability literature, the terms 'walkability', 'built environment', and 'walking' have been frequently used concerning other terms such as 'travel', 'land use', 'neighborhood walkability', 'transportation', 'health', and 'urban design'. Besides that, other terms that occur associated with these clusters are related to the tools of analysis which are being used for the studies. Space syntax and GIS are the two tools that occur in the literature of this field (e.g., Fonseca et al. 2022; Santilli et al. 2021; Telega et al. 2021; Yuan et al. 2022).
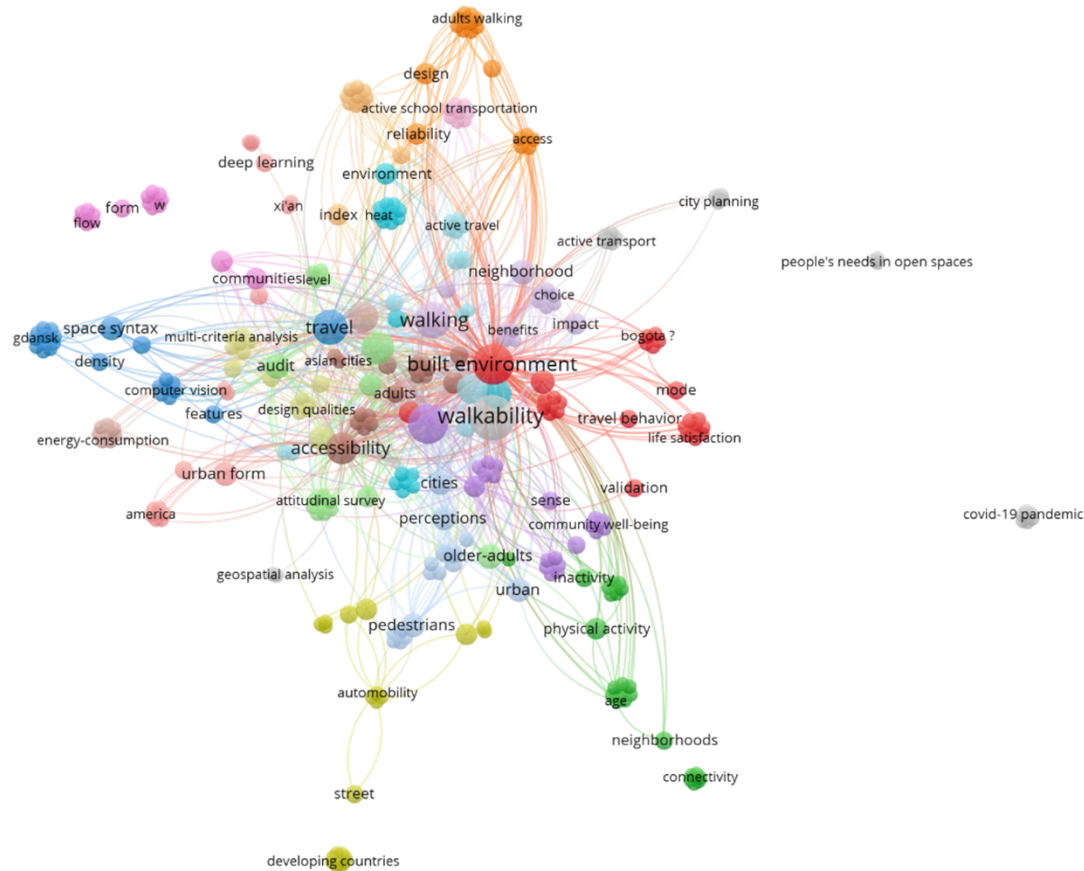
FIGURE 4. The output of the term co-occurrence analysis for the whole study period (2021–2022). (Diagram built on VOSviewer)

THE WALKABILITY CLUSTERS

The co-occurrence analysis represents that the majority of the literature with walkability is centered around the concept itself of how to make the built environment at the city or neighborhood level to be walkable. The term 'walkability' is mainly frequently used in conjunction with the term 'built environment' and 'physical activity' and 'walking'. The dominance of these two terms in this cluster is not surprising given much attention in the literature studies conducted as they are closely related to the concept of walkability. Generally, the study then demonstrates the particular focus such as pedestrian networks (e.g., Hassan and Elkhateeb, 2021; Yang et al. 2022), walking behavior (e.g., Herbolsheimer et al. 2021), Sidewalks (e.g., Gao et al. 2022), and it intends to solve an issue that has been attracting world attention in recent years, namely the COVID-19 pandemic (e.g., Kato and Matsushita, 2021; Saadi et al. 2021; Lotfata et al. 2022) and other issues, for example, health. The relatively high attention is in the urban context (Nakamura, 2021; Ning et al. 2022; Zaleckis et al. 2022; Hassan and Elkhateeb, 2021), with the various

research setting (e.g., USA, China, Netherlands, Australia), however, the developing countries have relatively received less attention. Other terms that are researched associated with walkability include 'accessibility' and 'land use', showcasing academics' interest in understanding the ease for pedestrians to reach various amenities in certain areas at certain distances.

THE BUILT ENVIRONMENT CLUSTERS

This cluster demonstrates that researchers are concerned to understand the scope of the grand concept that forms the basis of walkability. The concept of the built environment has received high attention in walkability research. It is also clear that this term has two major thematic focus areas. firstly, the research focuses on 'transportation' aspects. the associated research, it has a relation to active travel and physical activity in the city context (e.g., Sylvers et al. 2022; Santilli et al., 2021). The second thematic focus area that gains publications is in conjunction with how the behavior of pedestrians, in the term 'travel behavior' or specifically walking

behavior, with themes linking mainly to the issue of 'accessibility' which concerns distance or also called 'betweenness' among amenities. The issue depicts that the researchers are interested in solving the distance for pedestrians to reach facilities within walking distance. Substantial attention is more aimed at several categories of pedestrians including older adults and elderly, as seen from the two terms which are seen larger and show a close link to the term 'elderly' and 'older adults' in the term 'accessibility' cluster (e.g., Timmermans et al. 2021; Bayar and Yilmaz, 2022).

THE WALKING AND PHYSICAL ACTIVITY CLUSTERS

According to this co-occurrence study, this cluster appears to be less dominant to the Walkability idea. The terms 'Walking' and 'Physical Activity,' on the other hand, have frequently co-occurred with other terms and occupy a central position in the figure. This is undoubtedly important for walkability studies (Erturan and Spek, 2021; Pooley,

2021). This cluster appears to be primarily focused on individuals, often known as pedestrians, who use the built environment and do their daily activities. In conjunction with the term 'Walking' and 'Physical Activity' are terms including 'sense', 'perception', 'association', 'benefit', 'impacts', and 'betweenness' that have appeared frequently on this subject, showcasing their significance to this topic. The relationship between these terms in the associated literature of this study emphasizes how people's perceptions or also called the sense that individuals feel or in other words how individuals react to the built environment (i,e., pedestrian network, density, sidewalks) when they walk between places or one point to another point. the term 'association' in this cluster appears that showcases often the study conducts research by linking among particular types and units of analysis such as street trees and crime (e.g., Lee, 2021), the physical elements with social aspects (e.g., Koohsari et al., 2021; Kunaratnam et al. 2022). Apart from that, this term also concerns the benefits of walking or physical activity (e.g., health, social) (Tobin et al. 2022; Timmermans et al. 2021; Bramson et al. 2021).

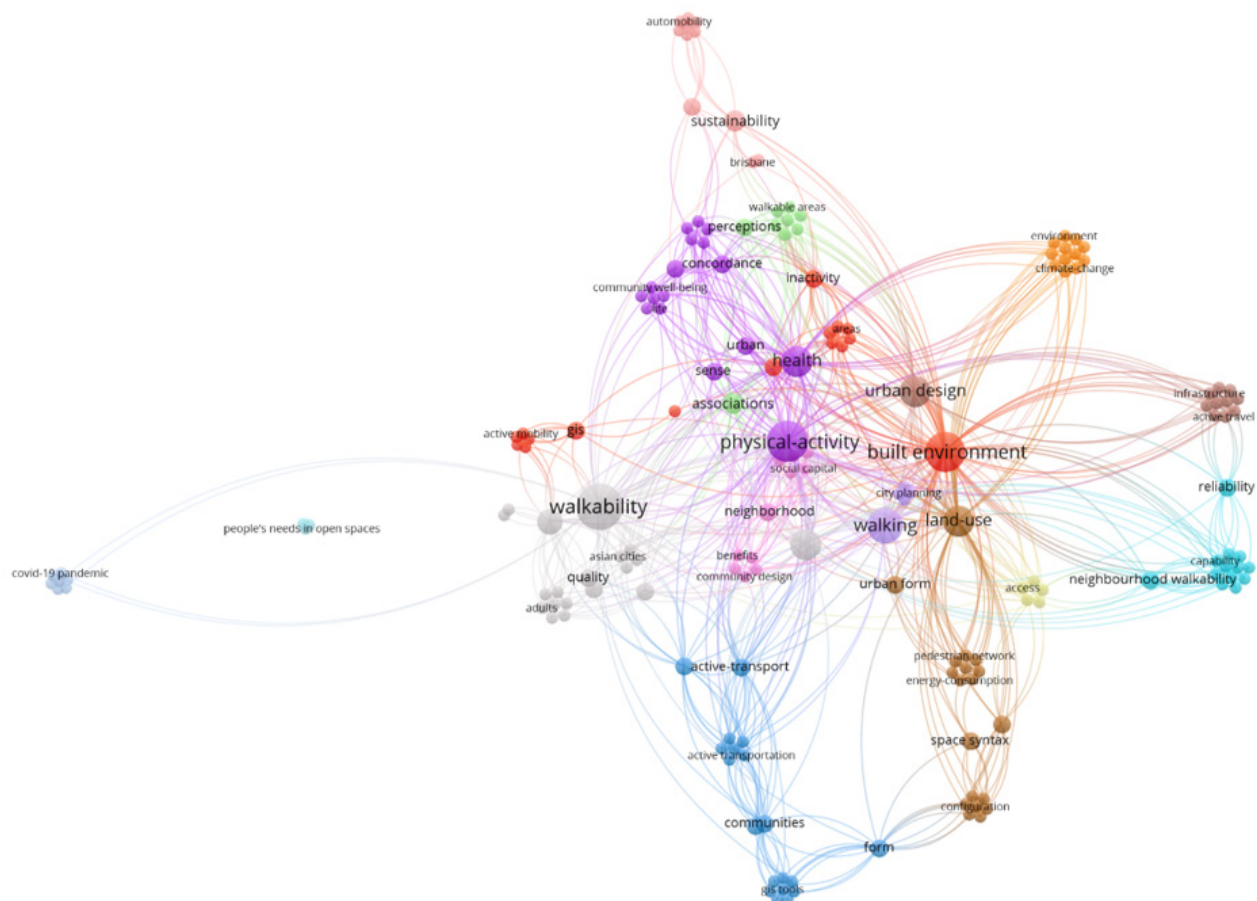First Period: The year 2021 Publications

FIGURE 5. The results of the term co-occurrence analysis for the second period (2021). (Diagram built on VOSviewer)

THEMATIC FOCUS TRANSITION BETWEEN 2021 AND 2022

This study separates the dataset into two sub-periods and conducts the term co-occurrence analysis for each period to investigate the thematic focus.

During this period, there is evidence in the co-occurrence analysis map is the frequency of many terms about the walkability concept is seen to be relatively low. Two terms that have a high proportion appearing are the term 'urban design' and 'land use' as can be seen on the analysis map. The main focus and publications on these terms are concerning land use configuration which is related to its density and diversity at the level of the city or the neighborhood. This term is also in conjunction frequently with other terms which represent the focus of the study including pedestrian network, movement, and route choice. Analysis tools such as space syntax in this period quite gain some prominence. Other terms appearing associated with walkability studies are sustainability concerning climate change and energy consumption. This is not surprising because the purpose of encouraging people to walk is to encourage people to be less dependent on motorized transportation (i.e., cars) for tackling

these issues and contribute to a better environment (Nakamura, 2021; Jamei et al. 2021; Vichiensan and Nakamura, 2021). In addition, the term that appears in this period is the term 'COVID-19 pandemic'. This indicates that there has been some interest by researchers to study the association between walkability and COVID-19 pandemic. It is understandable because the pandemic in that year is still a concern for many parties in the world. Thus, it is no wonder that publications on these topics have gained some attention (Kato and Matsushita,2021; Saadi

Second Period: The year 2022 Publications

FIGURE 6. The results of the term co-occurrence analysis for the Second period (2022).
(Diagram built on VOSviewer)

et al. 2021; Lotfata et al. 2022). Apart from that, it mainly discusses infrastructure attributes to encourage people to move on foot and is mainly related to pedestrian infrastructure and street levels such as sidewalks, street connectivity, and access to other modes of transport (Fonseca et al. 2022; Koohsari et al. 2021; Hsieh and Chuang, 2021; Hasan et al. 2021; Hellberg et al. 2021).

This period has a larger number of publications on all three major clusters. As previously explained, two tools widely used in walkability research based on publications in 2022 are Space syntax and GIS. However, the go-along interview method or also called mobile methodologies have gained more attention from researchers in this period to investigate pedestrian perception, as represented by the close and strong position between the terms 'go-along', 'mobile methodologies', 'place ', and 'pedestrian perception' (Erturan and Spek, 2021; Erturan and Aksel, 2022; Vichiensan and Nakamura,2021. Other terms that have received more attention include 'aerial imagery'. That terminology may have emerged as can effectively assist data collection in terms of cost and convenience, especially when the COVID-19 pandemic occurred several years ago and soared where physical contact and movement are

limited, so increasing research on this topic is very relevant (Kato and Matsushita, 2021; Saadi et al. 2021 Erturan and Aksel, 2022; Yuan et al. 2022). Thus, it is no wonder if the terms 'aerial imagery' and 'COVID-19 pandemic' have a strong connection in the analysis map. During this period, it is observable that walkability studies in street connectivity seem to have decreased interest among academia. This may indicate that the number of publications in this issue is still limited. in addition, several other key terms including 'children', active school transportation' attract attention and these terms emerge with a strong connection to other terms such as 'travel', 'walking', and 'physical activity' have appeared in this period (Kunaratnam et al. 2022; Wood, 2022). This may indicate that research in the field of walkability needs to consider the perceptions of various ages from children to elderly people as mentioned earlier.

INFLUENTIAL SOURCES

The co-citation analysis is used to determine which journals have had the most impact on the advancement of the discipline. Again, node size is related to the number of citations, and link width is proportional to the degree of

FIGURE 7. The most influential journals contributing to the development of walkability literature.
(Diagram built on VOSviewer)

relationship between two nodes. Results depict that journals such as Heath Place, Transportation Research Part D-Transport and Environment, Sustainability, Journal of Transport Geography, Landscape, and urban planning, journal of urban design, and Cities have had a higher influence. This indicates that these journals have played a significant role in the

advancement of walkability research. The findings of the co-citation sources analysis reveal some significant clusters depicted in blue color and grey color as can be seen on the analysis map.

The first cluster (showcased in blue color) includes a journal that is mainly concerned with promoting physical activity and pedestrian perception on some issues (e.g., pedestrian infrastructure quality, the relationship between the built environment with social factors, and walking activity). The second cluster attracts more interest as shown in grey colors clusters. In this cluster, the topic primarily is composed of walkability studies on the street level (e.g., accessibility, walking and transit use or public transportation, the association between location choice, land use, and travel behavior, street quality, quality of life/ pedestrians' life satisfaction). It also consists of journals that focus on street networks particularly pedestrian networks, a policy such as sustainable transportation policies, and also the perception of pedestrians.

MAJOR CONTRIBUTING COUNTRIES AND INSTITUTIONS

A bibliographic coupling analysis is performed to identify the prominent countries that contribute the most to the
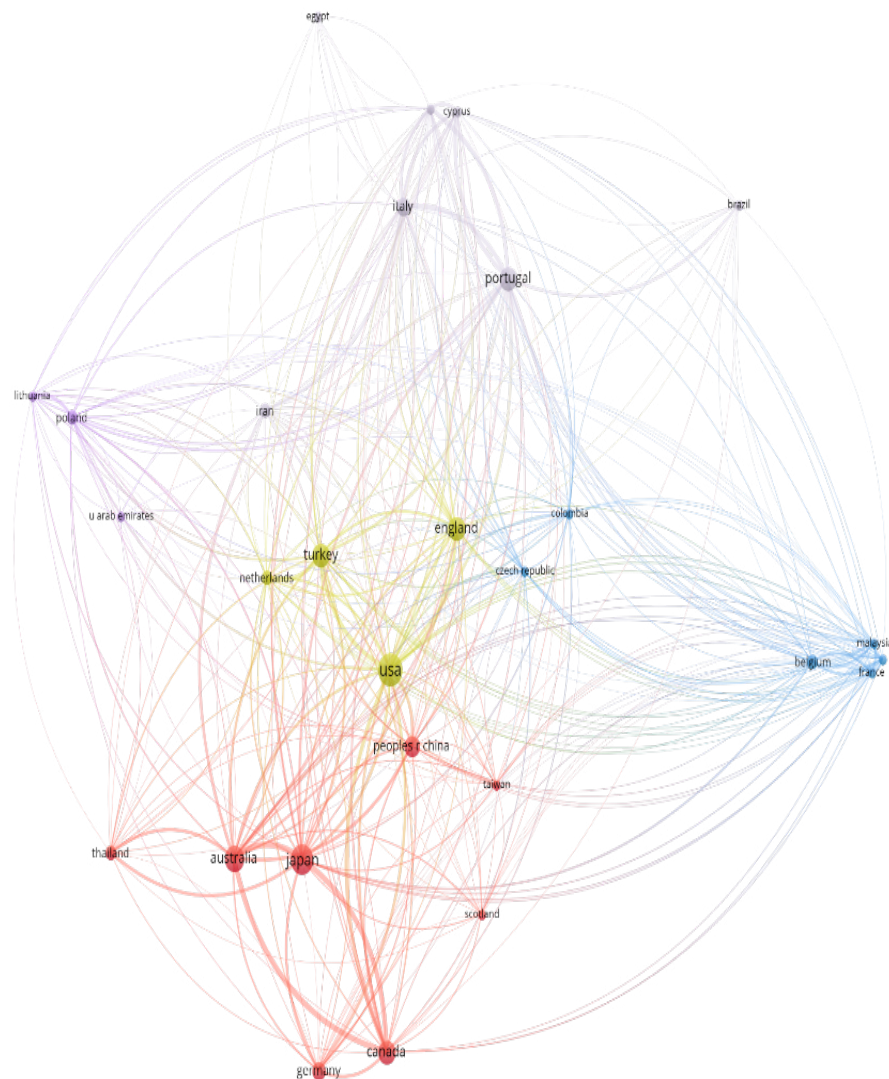
FIGURE 8. The Countries that contributed to the development of walkability literature.
(Diagram built on VOSviewer)

knowledge of walkability studies. Figure 8. below showcases the top countries with the number of documents, number of citations, and total link strength is depicted. Studies on this topic have been carried out by researchers across the world, not only from developing countries but also from less developed countries. Countries including the USA, Japan, Canada, Poland, Germany, Portugal, England, China, Iran, Thailand, Netherlands, Turkey, Italy, and Belgium have published more on this topic. However, some countries have received high contribution of publication such as USA, and Japan. The results also indicate that collaboration studies in this field occur between countries that are geographically not adjacent or between continents. For example, the red cluster primarily consists of some countries that are on different continents including European countries, and Asian Countries (Australia, Scotland, Germany, Canada, Japan, Thailand, Taiwan, and China), and also yellow clusters consist of countries from several continents are the Netherlands, the USA, Turkey, and England.

To identify the institution that is at the forefront of the knowledge in walkability studies, the bibliographic coupling analysis on an organization is conducted. The results show that universities from USA, Europe, Japan, and Australia have contributed more to the knowledge development of the discourses in this field. Those are universities including the University of Calgary, Georgia Institute of Technology, Texas A&M University, Simon Fraser University, University of Greenwich, AGH University Science and Technology, Cracow University of Technology, Oxford University, University of Melbourne, Deakin University, Tohoku University, University Tsukuba, Waseda University.
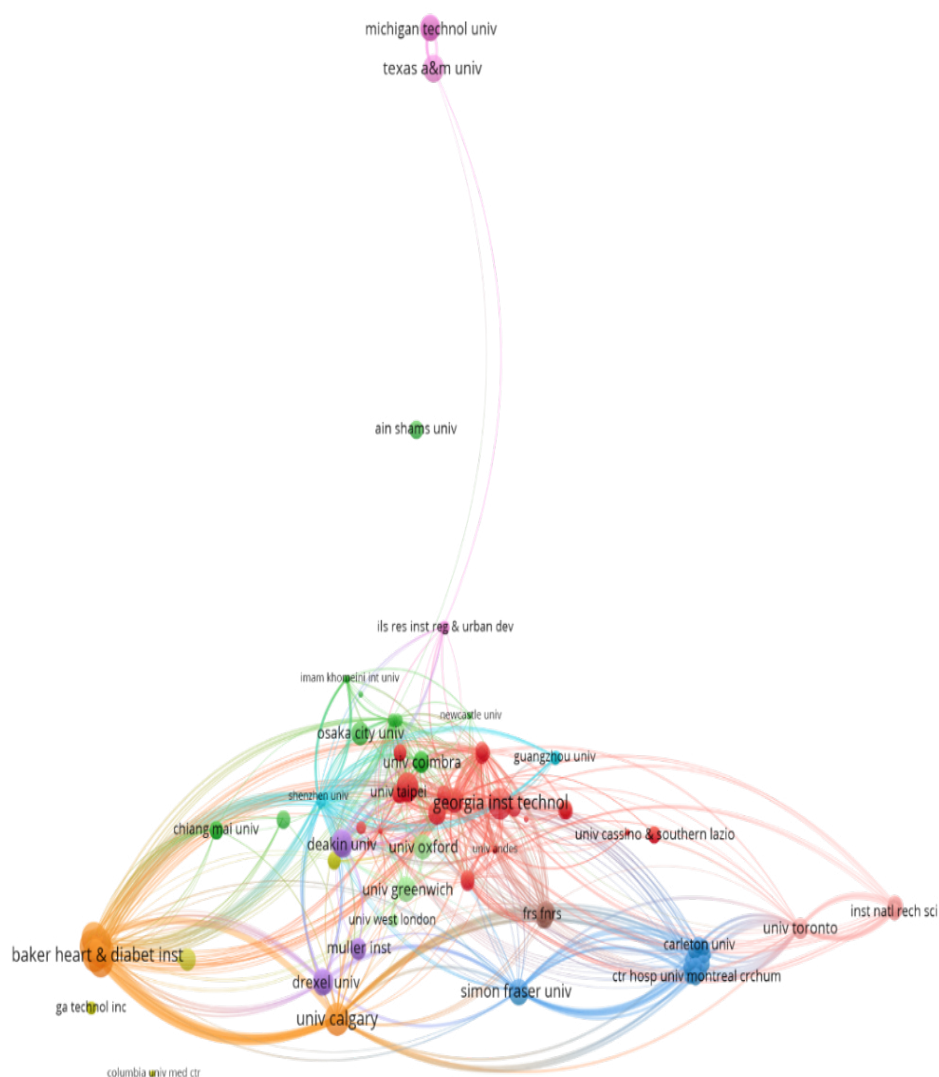
FIGURE 9. Organizations that contribute to the advancement of the field.
(Diagram built on VOSviewer)
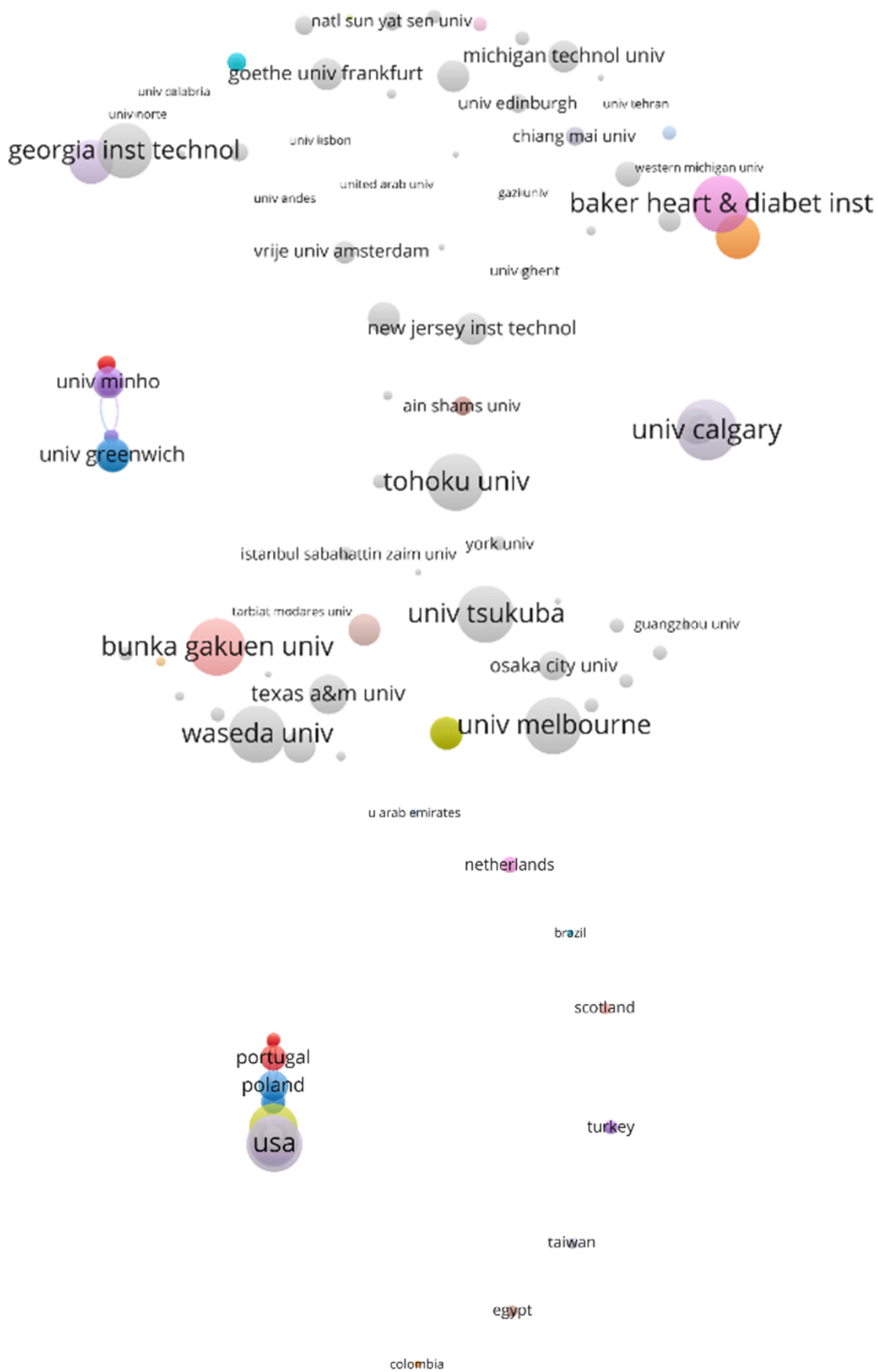
FIGURE 10. The most influential Organizations (Left) and Countries (Right) which contribute to the advancement of the field are based on Citation Analysis. (Diagram built on VOSviewer)

INFLUENTIAL DOCUMENTS

The co-citation analysis is also utilized to determine the most influential publications on this subject. The results of the co-citation analysis by cited references are presented in the figure below. The analysis reveals that there are two clusters of the most prominent publications (grey and brown). Primarily, the studies that the most cited references including in the brown clusters are from the Journal of urban design, journal of Environment and Behavior, Transportation Research Part D-Transport and Environment, journal of applied geography, Health Place, and Sustainability. It is also noted that the cited references also are dominated by grey clusters. These clusters cover several journals such as the Journal of the American Planning Association, Landscape, and Urban Planning, Urban Studies, and Journal of Urbanism.
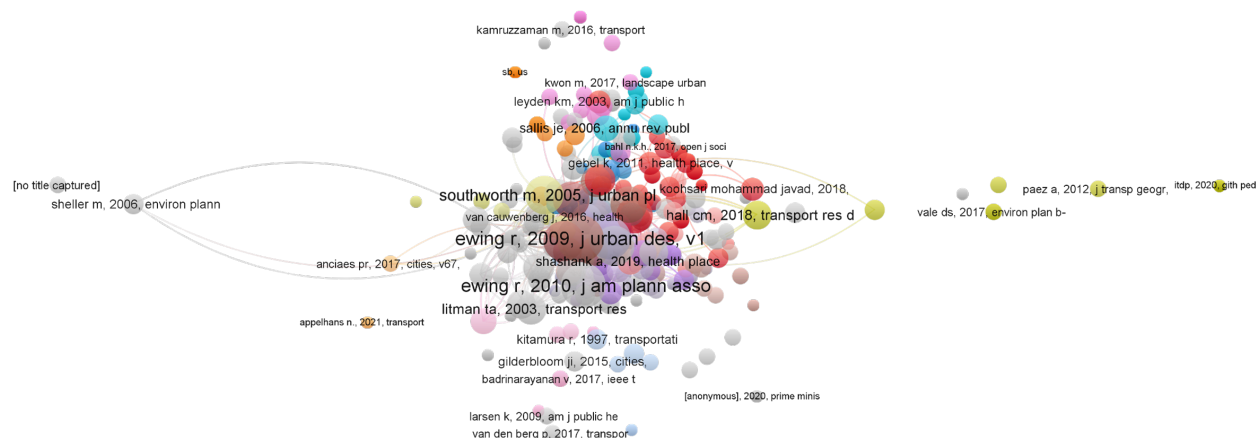
FIGURE 11. The most influential documents which contribute to the development of the field are based on co-citation analysis. (Diagram built on VOSviewer)
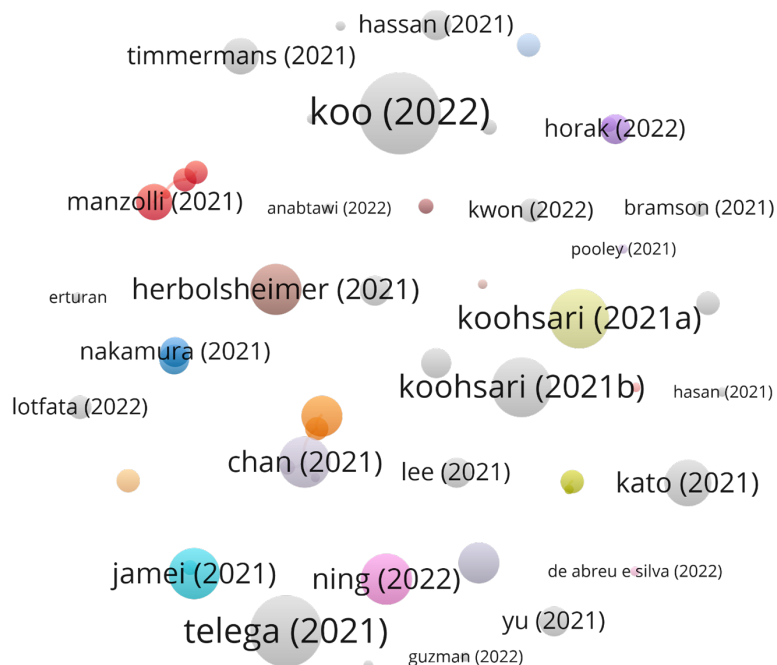
FIGURE 12. The most influential documents contributing to the development of the field are based on citation analysis. (Diagram built on VOSviewer)

INFLUENTIAL AUTHORS

The most influential authors are identified by using the analysis 'cited authors' as the unit of analysis in the co-citation analysis. It is identified from the analysis that there are several of the most influential authors in this field namely Reid Ewing, Lawrence D. Frank, Ann Forsyth, Mohammad Javad Koohsari, Brian E. Saelens, and Robert Cervero subsequently. The three of the highest 'cited authors' have mainly contributed to the walkability studies associated with the Built environment, urban design qualities, transportation, and land use diversity and density, and also primarily work on the core concepts and definition of walkability. Meanwhile, to know the influential authors in the database included in this study, a citation analysis is also conducted. Results show that there are three major influential authors including Gavin R. McCormack, Mohammad Javad Koohsari, and Kaori Ishii. It is noted that the key author that appears in the Co-citation and citation analysis is Mohammad Javad Koohsari whose expertise revolves around Urban Design and Health.
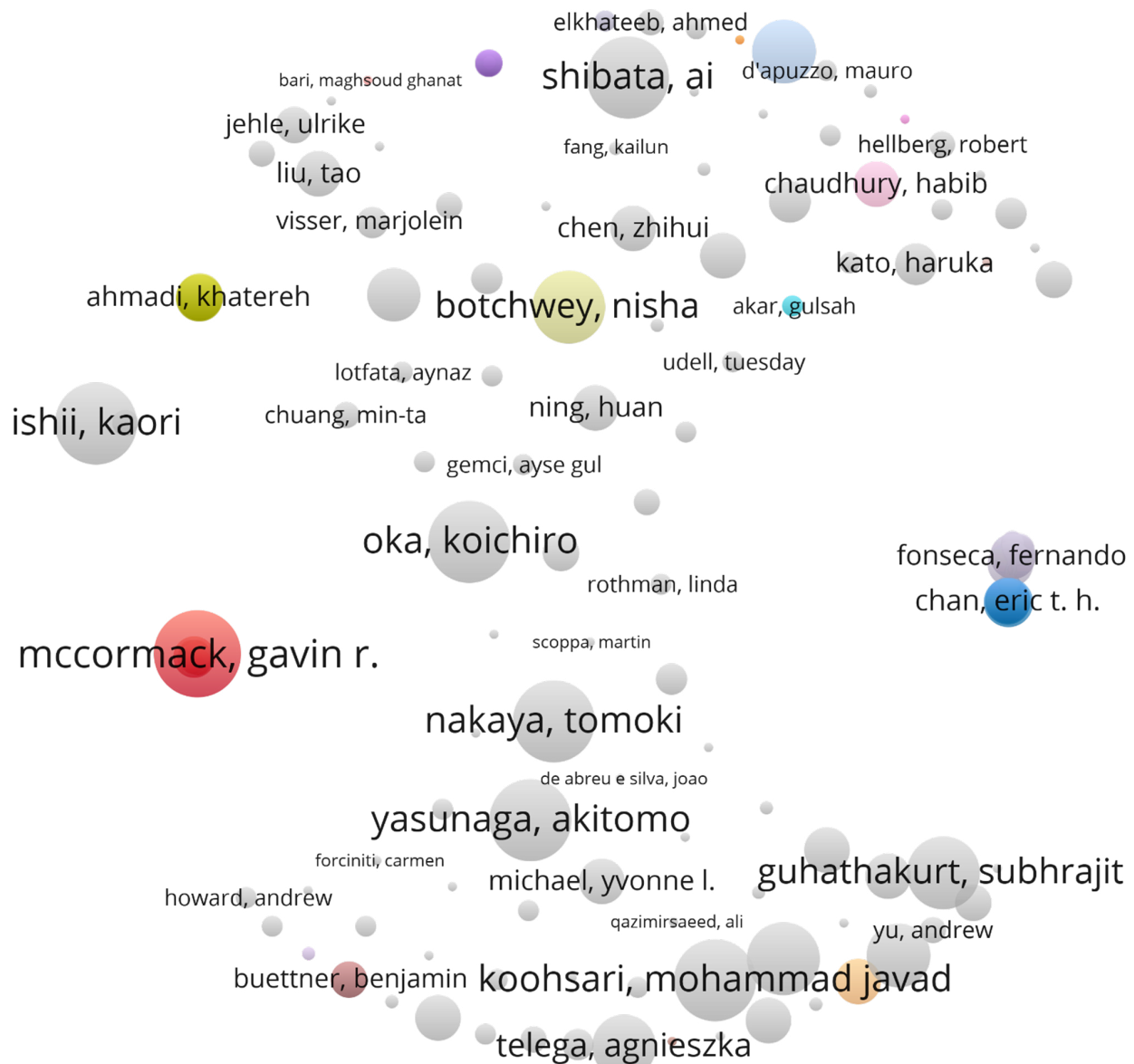
FIGURE 13. The most influential Authors based on Citation Analysis. (Diagram built on VOSviewer)

FIGURE. 14 The most influential Authors based on Co-citation Analysis. (Diagram built on VOSviewer)

DISCUSSION

The concept of walkability has attracted various academic researchers with various backgrounds, countries, and various fields in the last two years, from 2021 to 2022. Walkability research is generally aimed at making a place walkable or also called pedestrian-friendly, which is conducted at the greater level and territories on the city scale, or the lesser which is on the neighborhood scale. In doing so, walkability studies contribute to encouraging people to move more on foot and less dependence on motorized transportation. The primary goals of this research are to provide an overall grasp of the knowledge structure and trends in the walkability of literature within the two years (2021-2022), as well as to determine which sources, references, countries, institutions, and authors have made major contributions to the field's development. This study, for this purpose, relies on bibliometric analysis and scientific mapping tools (VOSviewer) to analyse performance and visualize knowledge domains in this field.

The thematic focus of the field over two years is understood by conducting a term co-occurrence analysis for the whole study period on the first mapping analysis. The results depict clearly from the existing literature that three major clusters are focusing on Walkability, Built Environment, walking, and physical activity. It is noted that the existing literature concerning walkability studies in two years is conducted on the city or neighborhood scale and mainly concerned with urban areas. The result also shows that the study in developing countries has received less attention and further research in this area is needed. It could be caused that pedestrian infrastructure in developing countries has not become the main focus in development in relation to the built environment. According to the United Nations (2022), developing nations have poor physical infrastructure

Concerning walkability clusters, the existing research within two years primarily focused on the issues around the concept itself of making walkable places. While the other cluster, namely the built environment, concerns the underlying concept as the basis of walkability. The third cluster, which is walking and physical activity, mainly has high attention to the people and their perception associated with the physical environment (i.e., the built environment, sidewalks) and other aspects (i.e., health, social).

To better understand the thematic structure of the field within the two years (2021-2022), this study divides the periods into two sub-periods namely 2021 and 2022 to provide a clearer insight. The first period (2021) attracts research interest including pedestrian network, land use configuration, movement, route choice, sidewalks, street connectivity, and access to other modes of transport. It is also noted that walkability studies are being conducted to contribute to combating the pandemic, and this is understandable because the pandemic issue during that period is still the main focus globally. Obviously, for the second period, some methods of walkability studies have gained more attention including mobile methodologies that primarily involve the 'go-along' method. Another method, called 'aerial imagery' is also has received more interest. This is not surprising because the pandemic in early 2022 is still a global concern. Using the 'aerial imagery' method allows researchers to obtain data efficiently in terms of cost and convenience, especially because physical contact is limited during the pandemic. In addition, there is an increased of researchers in publicly available data to solve data limitations, high costs, and time-consuming research such as by using Open Street Map (OSM), Google Earth, Google Street View (GSV), Bing Maps (Telega et al,2021). Within two years period, attention to the walkability studies has focused on different people's attention that is more older adults and the elderly, while children have gained more interest in the year 2022. This might imply that studies on the subject of walkability should take into account the perception of people of different ages.

CONCLUSION

Overall, what can be learned from the thematic analysis is that existing research on walkability within two years (2021-2022) consists of some conceptual aspects that underlying walkability such as 'the built environment', 'walking and physical activity', which then leads to one or some specific problems on physical or perceived factors which ultimately aim to make an area walkable. Therefore, it is noted that there is discordance in walkability studies

(Herbolsheimer et al., 2021), so it is significant to do more research on the integration between factors in this field to solve the dependence on motorized transportation. Terms related to the tool that is being used in walkability are also highlighted in the term co-occurrence analysis. It is dominated by using software such as space syntax and GIS. This, then, indicates that there is a need for other tools or new tools that can integrate between factors for enriching the walkability studies and solving the issues in that field. In addition, terms related to people who are major users also pay more attention, targeting certain ages, for example, older adults (Timmermans et al.,2021), elderly people (Horak et al.,2022), or children (Kunaratnam et al.,2022). It indicates another potential gap, so research in the field of walkability needs further studies on the perceptions of various ages.

In addition, to analyze the theme structure, this paper highlighted key journals, authors, references, institutions, and countries that have made relatively considerable contributions to the development of walkability studies. This information can be used for researchers or readers to better and easily understand the structure of the walkability literature in the last two years (2021-2022) for future scholarly work. The finding of this study can also help find potential gaps in research so that it also could assist to find the 'novelty' of research in future walkability studies. Finally, it is also important to mention the approach used in this study. The existing software for science mapping and bibliometric analysis needs to be improved so that it can process various formats of data literature from various databases to facilitate analysis more easily and obtain more comprehensive results. Lastly, conducting systematic reviews by focusing on specific contexts or geographical locations is important to solve the challenges faced such as health, social, or environmental related to walkability studies.

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DECLARATION OF COMPETING INTEREST

None

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