

# Systematic Literature Review of Walkability and the Built Environment

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## ABSTRACT

Walking is the most sustainable form of transportation. It is the socially equitable, economically viable and environmentally friendly mode of transportation. However, transportation technology has caused the desertion of the pedestrian space due to excessively motorized transport. Consequently, the pedestrian environment has degraded. In many cities, the abandonment of the pedestrian space has created a socially unfriendly environment. Walkability is a measure of how friendly an area is to walk. In measuring walkability, several criteria are considered, which include *inter alia*, the quality of pedestrian facilities, roadway conditions, land use patterns, community support, security and comfort for walking. Findings from studies are mixed; some stated that improving the built environment does not encourage people to walk more; however, there are other studies that indicated otherwise. The aim of this paper is to review the built environment characteristics that promote walking. A literature review of studies that focused on walking, walkability, the built environment, pedestrian and urban design was conducted. This study has searched the electronic databases that intertwined with the Web of Science database. The choice was made due to the comprehensiveness of quality academic studies indexed in the database, thus providing reliable sources of body of work. The database integrates numerous sub-databases such as Web of Science Core Collection, Derwent Innovations Index, KCI Korean Journal Database, Russian Science Citation Index and SciELO Citation Index. The data are then thematically coded. The fields of urban planning, urban design, geography, transportation, sociology, and other related areas were included in the research. The result of this review offers evidence to the criteria that promote walking. The review found that three criteria are somewhat constant in promoting walking, namely, population and building density, land use and land use mixes, and safety. In short, by making an area perceived as safe with the presence of land use mixes and density are the best combination to create a walkable environment.

**Keywords:** Walking; Walkability; Built environment; Pedestrian; Urban planning

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## 1. INTRODUCTION

Walking is the most sustainable form of transportation. It is the socially equitable, economically viable and environmentally friendly mode of transportation most accessible to the masses. However, advancement in transportation technology has caused the desertion of the pedestrian spaces due to the availability of primarily motorized transport. Consequently, this phenomenon has caused a degradation of the pedestrian environment (Kim & Mateo-Babiano, 2018). A vibrant pedestrian environment has been found to contribute to a more livable urban area (Shamsuddin et al., 2012). Jacobs (1961) in her book, "The Death and Life of Great American Cities (1961)" advocated a vibrant urban life that promotes pedestrian activity. This seminal book emphasizes cities as social connector, a hub where people can enjoy each other and appreciate the vitality of the community. Alas, in many cities, the abandonment of the pedestrian space has created a socially unfriendly environment (Yassin, 2019). It is reiterated in many studies that sense of community would be stronger in individuals living in pedestrian-friendly neighborhoods (French, 2014; Tsai, 2014). As an example, the finding in a study by Lund (2002) showed that pedestrian environment factors significantly influence sense of community. The surveys for the study were conducted in one pedestrian-oriented neighborhood and one automobile-oriented neighborhood in Portland, Oregon. Another study undertaken in Seoul, Korea showed that residents of pedestrian-oriented neighborhood were more likely to feel a sense of community in their neighborhood than were residents of auto-oriented neighborhood (Jung et al., 2015). Furthermore, the results of the study also revealed that social interaction factors and walkability among pedestrian environment factors positively influence a sense of community. These findings are in line with the New Urbanists' belief that a high-quality pedestrian environment will enhance sense of community by increasing opportunities for interaction among neighbors.

The pollution caused by motorized vehicles and accidents involving pedestrians are issues faced by cities when the built environment that support walking is neglected (Zhang et al., 2014; Peng & Bongard, 1999). The World Health Organization (2018) estimated that almost 12 million pedestrian road traffic injuries occurred annually. While Khan et al. (2020) found in their study on pedestrian road traffic injuries that globally, although the mortality rate is decreasing, the incidences of pedestrian injuries increased by 3.31% in 2017 compared to 1990. Compared to other road injuries, pedestrian injuries carry the highest risk of a person being severely injured, leading to significant morbidity, disability, and death (Kim et al., 2008; Mayou & Bryant, 2003). Acknowledging the importance of road safety issue, the United Nations has included this as among their main concern in Goal 11 of the Sustainable Development Goals (United Nations, undated).

Walkability is the basis of a sustainable city and a fundamental concept in sustainable urban design (Rafiemanzela et al., 2017). It is a measure of how friendly an area is to walk. In measuring walkability, several criteria are considered, which include among others, the quality of pedestrian facilities (Blečić et al., 2014; Lo, 2009), roadway conditions (Lee et al., 2013; Wang et al., 2012), land use patterns (Cowen et al., 2018), community support, security and comfort for walking (Devarajan et al., 2019; Ranasinghe et al., 2015). Findings of several studies indicated that improving the built environment did not cause people to walk more (Forsyth et al., 2009). However, there are evidence from other studies that stated otherwise (Park et al., 2014; Pearce et al., 2011). Generally, studies on walkability have several basic attributes that are cited as antecedents to walking. Some listed proximity, comfort, and aesthetic, while others have included public security and pavement safety, among others. Amidst this background, this paper aims to review the built environment characteristics that promote walking.

## 2. METHODOLOGY

### 2.1 Research Design

The systematic literature review (SLR) methodology was applied in this study to disclose the criteria of built environment that could promote walking. Preliminary step to understand this context is through conducting systematic literature review. This step is a fundamental aspect of an academic research. Initially, systematic literature review was done on healthcare research (Nightingale, 2009), and later developed and grew in other areas of research. Systematic literature review has become an established methodology to investigate the accumulated knowledge from various fields (Al-Tabbaa et al., 2019). Prior to starting any research, literature review must be conducted to understand the breadth and depth of the existing body of work and this process led to better understanding of the research field (Liu

et al., 2020). The procedure of literature review must be valid, reliable and repeatable (Xiao & Watson, 2019). Besides that, systematic literature review helps avoid research bias and errors (Smith & Noble, 2014; Dada, 2018) and reduce implicit prejudice and discrimination towards a subject matter (Sirelkhatim et al., 2015). Systematic literature review aims to synthesize all available and accessible sources of topic or research (Tight, 2019). It provides powerful strategies to collect and combine the evidence from many studies (Mertens, 2018). This gives advantage of providing totality of evidence by incorporating and judging positive and negative studies in the literature analysis (Torgerson, 2003). Hence, it produces robust comprehension of the topic of research, which subsequently will be useful for designing robust research framework and identifying the research gap, the important pillars in any research.

## 2.2 Search Strategy

First step in operating systematic literature review is to decide and determine the search strategy (Carvalho et al., 2013) in order to obtain all relevant studies (Guo et al., 2016). With that, this study has searched the electronic databases that intertwined with Web of Science database. The choice was made due to the comprehensiveness of quality academic studies indexed in the database, thus providing reliable sources of body of work. The database integrates numerous sub-databases such as Web of Science Core Collection, Derwent Innovations Index, KCI Korean Journal Database, Russian Science Citation Index and SciELO Citation Index. This study adopts systematic search strategy proposed by Bramer et al. (2018), which consists of the following steps:

Table 1: Systematic search strategy procedure

<i>Step</i>	<i>Activity</i>	<i>Description</i>
1	Determine a clear and focused question	Research questions must be well-defined, not too broad or too vague or too specific.
2	Describe the articles that can answer the question	Find the answer for the research question in the published studies.
3	Decide which key concepts address the different elements of the question	Key concepts refer to topics or themes that should be derived from the research questions, depending on the focus and context of the study. Important to also consider relevant synonyms to all key concepts.
4	Decide which elements should be used for the best results	Do not strict search strategy to research questions elements. Consider taking all relevant elements (important and less important) into the strategy. This may avoid obtaining limited results and maximizing number of related articles to be included in the study. Consider and be careful with bias and overlapping elements in the search strategy.
5	Choose an appropriate database and interface to start with	Important to consider all relevant synonyms to all key concepts. Some areas of study may have its own specific jargons to explain about something, phenomenon or activity, which most of the time will not be used in everyday language. Some studies will also use words that refer to the same thing interchangeably in the title, abstract and content.
6	Document the search process in a text document	Record each step in search strategy taken during the process in a log document. Besides reporting this information in methodology part, it would also help other researchers to follow and reproduce the steps for other research areas or in the same research area in the future to see the development or trend of the area / discipline.
7	Identify appropriate index terms in the thesaurus of the first database	Index all terms and arrange them from most appropriate to less appropriate to the context of study. The index can also be updated while searching for the studies.

8	Identify synonyms in the thesaurus	Most databases will usually provide structure of search with options and levels. This can be utilized if the words have a few equal important meanings.
9	Add variations in search terms	Skill for searching is not least important here. Variation in search terms should be identified such as spelling difference (e.g., UK English or US English), abbreviations (e.g., World Health Organization or WHO) and relevant opposite words of the terms (e.g., integrity and corruption). In this stage also, truncation would be helpful in searching relevant studies (e.g., organization, institution*)
10	Use database-appropriate syntax, with parentheses, Boolean operators, and field codes	Utilizing parentheses and Boolean operators such as “AND” “OR” and “NOT” would help a lot in finding the right and relevant articles. For example, this can be done by combining the concepts and the context (e.g., Walkability AND built environment). Many databases provide selection of these functions.
11	Optimize the search	Step 3 to 10 should be optimized at this stage. Search strategy should combine different terms, synonyms with parentheses/ Boolean operators. At this stage also, there are several functions that can be utilized for year of publication, open access articles, languages and types of sources. Selection of these functions will affect the results.
12	Evaluate the initial results	After applying up to step 11, the initial results will be obtained. At this evaluation stage, examine all articles. Most of the time, the researcher will know which articles are considered as most important articles (for example by analyzing the most cited articles or the authors who are the expert in that specific areas). Several databases also have functions to sort it to researcher preferences such as the most relevant and oldest to newest or vice versa.
13	Check for errors	Errors sometimes not easy to be detected. However, it can be done by doing initial screening to the titles. It is also important to pay attention to irrelevant articles that appear in the search result.
14	Translate to other databases	Similar process should be done for each selected database to ensure the same procedure is conducted in maximizing the number of search results. Besides that, it is also part of the protocol of methodology to avoid bias and guarantee the research ethics.
15	Test and reiterate	It is important to carefully take note what has been done for each step, so that it can be replicated in the next cycles for different databases. Usually, the first cycle is very vital to set the ground rule for the whole search strategy.

Source: Adopted and adapted from Bramer et al. (2018)

### 2.3 Inclusion and Exclusion Criteria

It is important to establish inclusion and exclusion criteria based on the research objectives or questions (Kitchenham & Charters, 2007). There were few inclusion criteria set for searching the articles. The criteria are the articles that published in English language, published from January 2014 until January 2019, and the abstract is accessible. Whereas the exclusion criteria of searching articles were non-English articles and published outside the year range set for the study. These criteria were set based on the followings:

- (a) English language: Majority of the articles were written and published in English and most importantly all reviewers can read and understand English to do the identification and screening process.

- (b) Published from January 2014 until January 2019: The period was chosen because this period is the second half of Decade of Action for the implementation of UN GA Resolution 64/255. The main aim of this resolution is to improve road safety at the global level through various aspects, including improving walkability. Thus, it is important to review what have been done to achieve this in the second half of its implementation through literature and empirical studies. This objective is also in line with the aim of the present study where the study purposes is to review the built environment characteristics that promote walking.
- (c) Abstract is accessible: Screening the abstract is part of the main element in PRISMA protocol. Therefore, it is important to include articles that provide abstracts.

In addition to this, the study follows suggestions by Cauwenberg et al. (2018) to exclude several types of articles published in the database such as conference proceeding and expert opinion. All these criteria were set to ensure the context of the study reflecting the current trend of the study area. To search for articles, the study has used several combinations of key terms, which were related to the objective of this study. The combinations of key terms are Walk\* AND Built Environment. The study found 133 articles resulted in search based on the set key terms. However, only 20 articles were included in the study. Three reviewers have screened the articles' title and abstract in order to ensure the articles meet the inclusion and exclusion criteria that were set earlier. Summary of the selection criteria is presented in table 2 and pathway of articles included and excluded in review is shown in figure 2.

#### 2.4 Data Extraction and Quality of Scoring

Data extraction from the reviewed studies should follow pre-established guidelines. For this purpose, this study adopts Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Protocol 2015 (PRISMA-P 2015) to guide the process. The PRISMA-P consists of a 17-item checklist in facilitating the preparation and reporting systematic review (Moher et al., 2015). This guideline helps to improve the reporting and screening of systematic review (prisma-statement.org, 2015). Three researchers conducted data extraction process using similar format to ensure relevant studies are included while minimizing bias and reducing errors (Munn et al., 2014). Screening process of each article was not only to determine the suitability of the articles with the context of this study, but also aims to extract information from each article. Data extraction flow diagram is presented in figure 1.

The extracted data consist of the details on the type of information such as title of the articles, first authors, year of publication, research objectives, study design, sample characteristics and study findings. Extraction of the data using a piloted form (table in excel document) is used to ensure that the information generated from each article is placed in the same self-created database, to create an easy screening process, especially, in identifying replicate articles, and to do contextual analysis by reviewing and analyzing all selected articles. During this screening process, the study also conducted assessment for quality of scoring for each included study. The quality indicators are adopted and adapted from Buckley et al. (2009), which are indicated in table 3.

Table 2: Summary of study selection criteria

<i>Criteria</i>	<i>Limit to</i>
Main keywords	Walk* AND Built environment
Access type	Open access
Year	January 2014 until January 2019
Document type	Article
Publication stage	Published
Source type	Journal
Language	English

### 3. RESULTS

The following results are based on analysis of the included studies, where the assessment investigated the characteristics of the articles, themes network and main theme.

#### 3.1 Characteristics of Included Studies

There are 20 articles included in the study. The range of the year of publication is between 2014 to 2018. Out of 20 articles, 7 were using qualitative approach, 12 articles were quantitative works, and 1 article adopted mixed-method approach. The research settings are various namely meta-literature analysis, survey, video analysis, focus group discussion, street connectivity, interview, and streetscape photo evaluation. In the included study, the location of the studies involved 12 countries. Details for each article can be referred to in table 4.

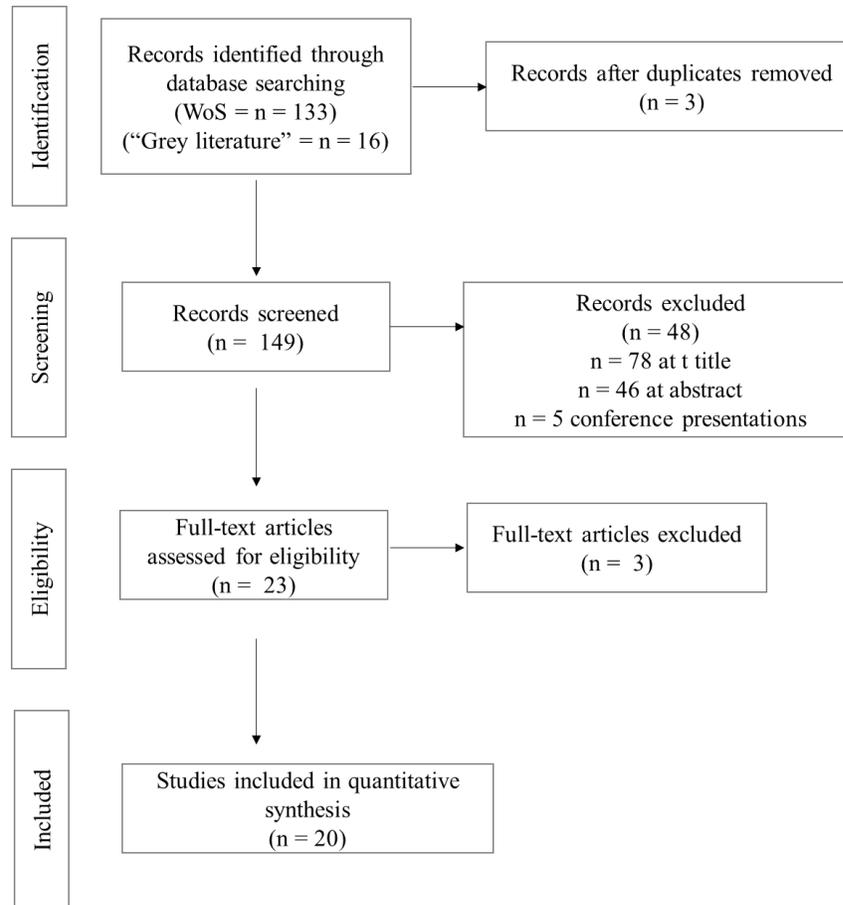


Figure 1: Pathway of articles included and excluded in the review

Table 3: Quality Indicators

<i>Indicator</i>	<i>Detail</i>
Research question	Is/are the research question(s) clearly stated? Note: If the study has not stated the research question, the research will look for the research objectives.
Study subjects	Is the study group appropriate (size, characteristics, selection)? Note: For some studies, especially from qualitative social science disciplines, the information is not available for example the size, but those studies will still be included during selection process.
Data collection methods	Are the methods reliable and valid?
Completeness of data	What is the drop-out / response rate? Note: Most quantitative studies do not have issues in terms of presenting drop-out or the response rate. However, oftentimes, this information is not presented in studies using qualitative approach.
Control for confounding	Have confounding variables been removed / minimized / accounted for?
Analysis of results	Are the methods of analysis appropriate?
Conclusions	Can the data justify the conclusions?
Reproducibility	Could the study be repeated by another group?
Prospective	Is the study prospective (forward looking), as opposed to retrospective?
Ethical issues	Were ethical issues addressed adequately?
Triangulation	Are the results supported by data from other studies?

Source: Adopted and adapted from Buckley et al. (2009)

### 3.2 Themes Network Mapping Analysis

The study employed Gephi Software Tools to map the key findings to show the linkages between themes and selected studies. Fahimnia et al. (2015) proposed that Gephi Software Tools can be utilized to implement literature metric analysis for systematic literature review. Prior to conducting themes network mapping analysis, the keywords co-occurrence analysis was constructed using Excel file. Relevant information namely sources, year of publication and themes were keyed-in in the file. A generated .csv file format was then imported into Gephi Software Tool to map themes co-occurrence network. The contraction layout algorithm has been used to position the themes that are linked to each selected article. The results of themes network analysis mapping are presented in figure 2. Based on figure 2, it indicates that population and building density, safety as well as land use and land use mixes have the most linkages towards the selected studies compared to the other four identified themes. This analysis presents that these three themes received much attention from the literature, which also demonstrates that the importance of these three themes to be examined in walkability and built environment research.

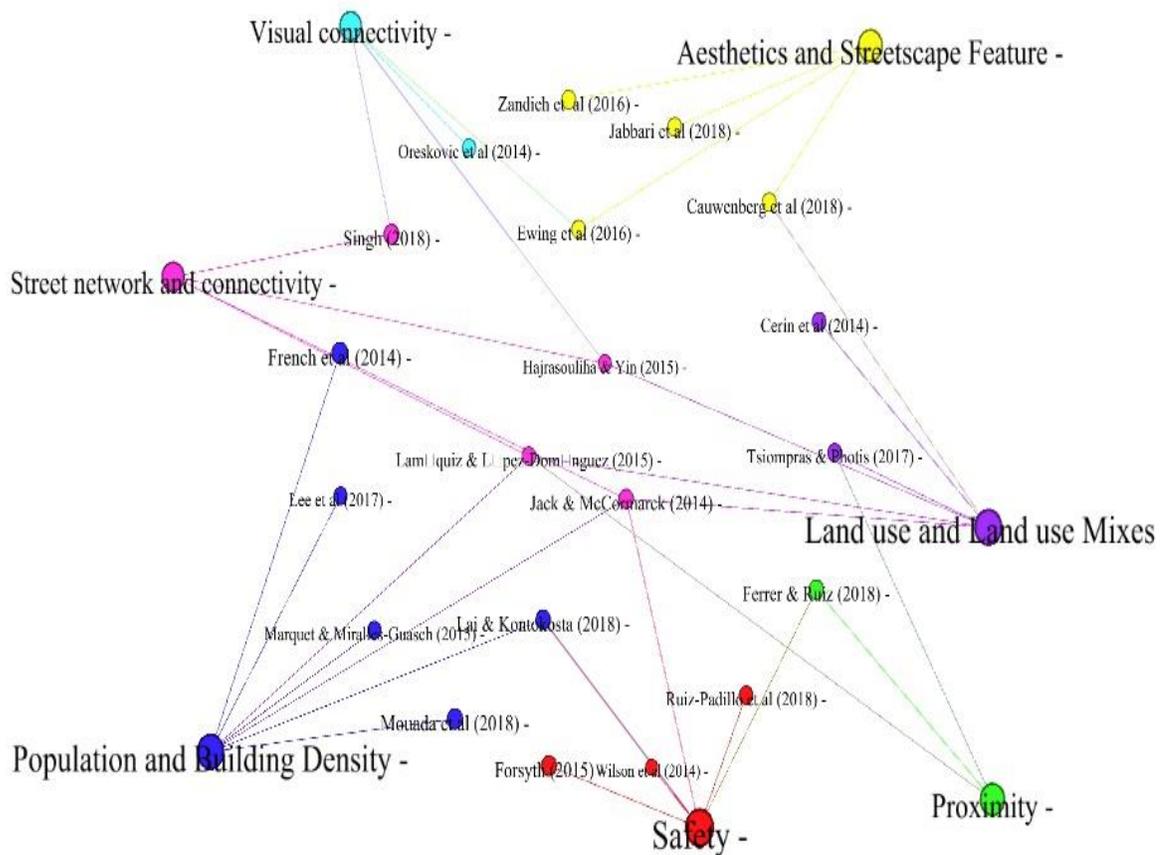


Figure 2: Themes network mapping analysis of walkability and built environment

Table 4: Characteristics of studies included in the review

<i>ID</i>	<i>Author (Label)</i>	<i>Year</i>	<i>Research objectives</i>	<i>Study design</i>	<i>Research setting</i>	<i>Location of study</i>	<i>Main findings</i>
1	Cauwenberg et al.	2018	Reviewing statistically and quantitatively summarise study findings on the relationships between physical environmental attributes and leisure-time physical activity among older adults.	Qualitative	Meta-literature analysis	Not applicable	<ul style="list-style-type: none"> <li>i) There are positive associations for walkability, land-use mix—access and aesthetically pleasing scenery with leisure-time walking.</li> <li>ii) Leisure-time walking within the neighbourhood has positive associations with land-use mix—access and access to public transit and a negative association with barriers to walking/cycling (<math>p = 0.03</math>).</li> <li>iii) Positive relationships between overall LTPA and access to recreational facilities and parks/open space.</li> </ul>
2	Cerin et al.	2014	Examining associations of perceived environmental attributes with overall and neighbourhood-specific walking for transport among the elderly.	Quantitative	Survey	Hong Kong, People's Republic of China	<ul style="list-style-type: none"> <li>i) The degree of perceived access to shops, crowdedness, presence of sitting facilities and easy access of residential entrance were positively related to frequency of overall and within-neighbourhood walking for transportation.</li> <li>ii) Infrastructure for walking and access to public transport were predictive of higher frequency of transport-related walking irrespective of location.</li> <li>iii) The perceived degree of land-use mix was predictive of higher levels of within-neighbourhood walking.</li> </ul>
3	Ewing et al.	2016	Identify main variables associated with pedestrian traffic volumes.	Qualitative	Video analysis	Not applicable	There are significant positive correlations between three out of twenty streetscape features with pedestrian counts after controlling for density and other built environmental variables, namely proportion of windows on the street, the proportion of active street frontage, and the number of pieces of street furniture
4	Ferrer & Ruiz	2018	Comparing factors of the built environment influencing the decision to walk for short trips in two different Spanish cities.	Qualitative	Focus Group Discussion	Valencia and Granada, Spain	<ul style="list-style-type: none"> <li>i) Respondents perceive more facilitators to walking in Granada than in Valencia, explained by the smaller size of the former city and the driving restriction policy in the city centre of Granada for private cars.</li> </ul>

ID	Author (Label)	Year	Research objectives	Study design	Research setting	Location of study	Main findings
							ii) The main common barriers to walking in the two cities were insecurity from crime. (absence of people, a poor street lighting or walking along a conflictive area), a high density of traffic lights and walking along large avenues.
5	Forsyth	2015	Reviewing the range of walkability definitions and conceptualising the area by identifying relevant themes.	Qualitative	Meta-literature analysis	Not applicable	There are six themes identified related to walkability definitions, namely, lively and sociable, sustainable transport option, exercise-inducing, proxy definitions, multidimensional and measurable and holistic solution.
6	French et al.	2014	Investigating the influence of neighbourhood built form on sense of community.	Quantitative	Street connectivity	Perth, Australia	Sense of community was positively associated with walking for transport and positive perceptions of neighbourhood quality, and negatively associated with residential density.
7	Hajrasouliha & Yin	2015	Investigating the impact of street network connectivity on pedestrian volume	Quantitative	Street connectivity	New York, United States	The conventional metric-based measure of physical connectivity and geometric based measure of visual connectivity has significant positive impacts on pedestrian volumes, together with job density and land use mix.
8	Jabbari et al.	2018	Assessing a pedestrian network by combining multi-criteria and space syntax	Quantitative	Street connectivity	Oporto, Portugal	i) The city centre offers various conditions, but overall, they are poor for pedestrians. ii) The streets, which scored best, are not integrated into the network.
9	Jack & McCormarck	2014	i) Comparing self-reported measures of the neighborhood built environment between objectively-determined low, medium, and high walkable neighborhoods. ii) Estimating the relative associations between self-reported and objectively-determined neighborhood characteristics and walking. iii) Examining the extent to which the objectively-determined	Qualitative	Phone interview	Canada	i) Respondents positively perceived access to services, street connectivity, pedestrian infrastructure, and utilitarian and recreation destination mix, but negatively perceived motor vehicle traffic and crime related safety. ii) Majority of the respondents who live in high walkable neighbourhoods participate in and spend more time per week on walking. iii) Perceived access to services, street connectivity, motor vehicle safety, and mix of recreational destinations were also

<i>ID</i>	<i>Author (Label)</i>	<i>Year</i>	<i>Research objectives</i>	<i>Study design</i>	<i>Research setting</i>	<i>Location of study</i>	<i>Main findings</i>
			built environment moderates the association between self-reported measures of the neighbourhood built environment and walking.				significantly associated with transportation walking.
10	Lai & Kontokosta	2018	Bridging in-situ observations of pedestrian counts and urban computing by integrating high-resolution, large-scale, and heterogeneous urban datasets and analysing both fixed attributes of the urban landscape with dynamic environmental and socio-psychological factor.	Quantitative	Street connectivity	New York, United States	<ul style="list-style-type: none"> <li>i) Overall pedestrian count increase over the last seven years.</li> <li>ii) Relative stable local pedestrian volumes regardless of season.</li> <li>iii) Places with high building density, large local populations, and well-connected transit have large intra-day fluctuations in pedestrians.</li> <li>iv) Complex interaction between pedestrian activity, urban context, and situational factors</li> <li>iv) Building density, transit access, and the proportion of local residents are found to drive pedestrian activity regardless of the specific day or time of day.</li> </ul>
11	Lamíquiz & López-Domínguez	2015	Analysing the influence of the built environment on the decision to walk	Quantitative	Street connectivity	Madrid, Spain	Configuration of the urban grid can influence the proportion of pedestrians (as a part of total trips in any transport mode) who choose to walk on single-journey trips
12	Lee et al.	2017	Examining the impact of the multidimensional concepts of the built environment on pedestrian volume in a high-density urban environment.	Quantitative	Survey	Seoul, Korea.	<ul style="list-style-type: none"> <li>i) Most built environment variables such as density, diversity, distance, connectivity, and design have statistically significant associations with pedestrian volume.</li> <li>ii) Relationships between some built environment measures and pedestrian volume have different associations depending on whether they are in residential or commercial zones</li> </ul>

<i>ID</i>	<i>Author (Label)</i>	<i>Year</i>	<i>Research objectives</i>	<i>Study design</i>	<i>Research setting</i>	<i>Location of study</i>	<i>Main findings</i>
13	Marquet & Miralles-Guasch	2015	Analysing proximity travel in Barcelona.	Quantitative	Street connectivity	Barcelona, Spain	<ul style="list-style-type: none"> <li>i) Proximity is more related with personal activities than professional ones and strongly links neighborhood utilization with the personal and domestic realm.</li> <li>ii) Density acts both as a precondition and a facilitator of proximity uses. However, in highly homogeneous environment it cannot provide the sole explanation for the intensity of local-scale uses.</li> </ul>
14	Mouada et al.	2018	Investigating the different urban environments in the hot, dry city of Sidi Okba, (Biskra) during the summer season.	Quantitative	Street connectivity	Sidi Okba, Algeria	<ul style="list-style-type: none"> <li>i) The results show that urban morphology (building density, height/width ratio and tree density) is significantly associated with the outdoor thermal conditions and potential pedestrians over short distances.</li> <li>ii) In order to provide a comfortable climate and to increase pedestrian choice in the urban environment, the public space should include high building density, combined with deep streets with a high connection between them, and a large amount of vegetation along the lower parts of streets.</li> </ul>
15	Oreskovic et al.	2014	Assessing the impact of specific form-related attributes of the built environment have on perceived walkability using cognitive methods	Qualitative	Streetscape photo evaluation	Massachusetts, United States	The results showed that perceived walkability varied according to the degree to which a particular design attribute was present, with the presence of ground-floor windows and a street focal point most consistently associated with a space's perceived walkability.
16	Ruiz-Padillo et al.	2018	<ul style="list-style-type: none"> <li>i) Determining the importance of the urban environment characteristics to encourage walking trips from the point of view of the pedestrian using Fuzzy Analytic Hierarchy Process (FAHP).</li> <li>ii) Comparing the values obtained by FAHP with those from other, simpler multi-</li> </ul>	Qualitative	Meta-literature analysis	Porto Alegre city, Brazil	<ul style="list-style-type: none"> <li>i) The three most important walkability attributes were: Public Security, Traffic Safety and Pavement Quality.</li> <li>ii) The most important aspect is public security, which closely related with urban violence such as thefts, robberies, and assaults.</li> <li>ii) The second most important attribute is traffic safety, which is motivated by the</li> </ul>

ID	Author (Label)	Year	Research objectives	Study design	Research setting	Location of study	Main findings
			criteria decision analysis techniques. iii) Analysing the existence of differences between various population strata in the walkability evaluation.				high importance attributed to the security/safety criterion. iii) The aspects considered less important by the individuals are slope and connectivity. Majority of the respondents are more concern about their safety and the convenience of the route.
17	Singh	2018	Identify factors that contribute to increase urban walkability in order to improve neighbourhood sustainability and public life	Quantitative	Survey	New Delhi, India,	The most important factors affecting pedestrians' perception of walkability were related to the built envelop on either side of the streets. Factors relating to urban morphology like enclosure block length and edge conditions were found crucial in creating the perception of a walkable neighbourhood.
18	Tsiompras & Photis	2017	Present a weighted approach of a GIS-based walkability index, adapted to the Greek urban environment and either for utilitarian or recreational walking trips.	Quantitative	Survey	Greece	Majority respondents choose walking / cycling to their daily destinations. The study also found that proximity to basic urban destinations is assigned the highest weight and population density is the lowest value.
19	Wilson et al.	2014	(i) Examining the feasibility of using a simple survey instrument to assess the quality of street-connecting walkways (ii) Determining whether such walkways would be suggested routes on a commonly used internet-based service (Google Maps)	Quantitative	Street connectivity	Wellington, New Zealand	Walkways are very feasible for and favourable by the respondents.
20	Zandieh et al.	2016	Examining inequalities in perceived built environment attributes and its possible influences on disparities in older adults' outdoor walking levels in low- and high-deprivation areas	Mixed method	Survey and interview	Birmingham, United Kingdom	Inequalities in perceived neighbourhood safety, pedestrian infrastructure and aesthetics in high- versus low-deprivation areas. The attributes influence disparities in participants' outdoor walking levels.

### 3.3 Thematic Analysis of the Systematic Literature Review

The following sub-sections present the details explanation of the systematic literature review results. The results have been divided into seven sections, based on themes constructed through analysis of literature.

#### 3.3.1 *Population and Building Density*

Several literatures have mentioned density as a very fundamental precursor for walking. Using a multi-variate model, Lamíquiz and López-Domínguez (2015) found density as one of the five indices that consistently influence the preference for walking. While the findings from a research undertaken by Mouada, Zemmouri and Meziani (2018) show that building density and tree density, which is known as urban morphology, are among the attributes that are significantly associated with the outdoor thermal conditions and potential pedestrian activity over short distances. This finding is supported by a study by Lai and Kontokosta (2018) who found building density to drive pedestrian activity regardless of the specific day or time of day.

The result of a study undertaken by Lee et al. (2017) in Seoul, Korea indicates that density has statistically significant association with pedestrian volume in Seoul. Meanwhile, a study involving adults in Calgary, Canada shows that a high walkable (HW) neighborhood has high population density compared to medium and low walkable neighborhood (Jack & McCormack, 2014). Although density is considered fundamental in promoting walking, some studies have shown that it has limitation. As an example, a research by Marquet and Miralles-Guasch (2015) suggests that beyond a certain level of density, income and sociological factors gained dominance in determining walkability at a local level.

#### 3.3.2 *Land Use and Land Use Mixes*

Lamíquiz and López-Domínguez (2015) in their study found land use as one of the indices that influence walking. Different land use attracts different characteristic of people, which is then very much associated with the usage of the type of transport mode. Many studies have shown the importance of land use mix in attracting walking. Land use mix is the level of integration among different land use types in an area, which means that it shows the spatial intensity of heterogeneous land use types (Tsiompras & Photis, 2017). In their study, Tsiompras and Photis (2017) found that other than proximity, land use mix is the next most popular motivation for walking. Another related study associated to land use mix was undertaken by Jack and McCormack (2014) who found that utilitarian and recreation destination mix is positively perceived as an inducer to walking in HW neighborhood. The findings from the two studies are consistent with a study by Hajrasouliha and Yin (2015) who suggest that land use mix has significant positive impacts on pedestrian volumes.

There is a growing body of literature on the elderly, ageing and their relationship with walkability. In this context, many a times, it is related to the importance of mobility as a precursor to a healthy lifestyle for the elderly. A study of the elderly in Hong Kong shows that the perceived degree of land use mix was predictive of higher levels of within neighbourhood walking (Cerin et al., 2014). A systematic review and meta-analysis study of relationships between neighbourhood physical environmental attributes and older adults' leisure-time physical activity observes that there are positive associations for walkability and land-use mix-access (Cauwenberg et al., 2018).

#### 3.3.3 *Safety*

Many studies show that the lack of safety is a key barrier to walking. This is true of safety from crime as well as traffic (Forsyth, 2015). For instance, a study of a random cross-section of 1875 Canadian adults found that respondents in HW neighbourhood have a negative perception on motor vehicle traffic and crime related safety (Jack & McCormack, 2014). Meanwhile, the finding in another study undertaken in two cities, Granada and Valencia, shows that the main common barriers to walking were insecurity from crime (Ferrer & Ruiz, 2018). The insecurity was due to the absence of people, a poor street lighting or walking along a conflictive area. According to Wilson et al. (2014), perceptions of safety may also impact walking levels.

Local crime events have a constant negative impact on pedestrian activity (Lai & Kontokosta, 2018). On similar note, a study by Ruiz-Padillo et al. (2018) in Porto Alegre, Brazil found that the most important aspect in promoting walkability is the public security. They further stated that the result is not surprising, as urban violence, related mainly to thefts, robberies, and assaults, is one of the principal social

problems in Brazil. The next important aspect after public security or safety from crime, according to the study, is traffic safety.

### *3.3.4 Aesthetics and Streetscape Feature*

Aesthetic refers to a sense of beauty and visual appearance of a neighbourhood (Zandieh et al., 2016), while streetscape feature is the micro features of the street environment (Ewing et al., 2016). A study by Ewing et al. (2017) in New York found significant positive correlation between three out of twenty streetscape features with pedestrian counts. The significant streetscape features are the proportion of windows on the street, the proportion of active street frontage, and the number of pieces of street furniture. The street furniture is defined as all kinds of signs, benches, parking meters, trash cans, newspaper boxes, bollards, streetlights, and other things related to this category. The next feature is the percentage of active uses, which are defined as shops, restaurants, public parks, and other uses that generate significant pedestrian traffic. The final feature is 'windows as a percentage of ground floor façade'. According to the study, the last feature is a common operational definition of transparency. A high level of transparency at the ground level can facilitate interaction between adjacent buildings, which has been known to promote street vitality.

Cauwenberg et al. (2018) in a systematic review observes that there is a positive association for walkability and aesthetically pleasing scenery with leisure time walking. Among the elements that can contribute to aesthetically pleasing scenery are greeneries and street furniture. A study by Jabbari et al. (2018) shows that green spaces are linked to higher walkable scores. They further stated that the green spaces create more attractive walking environments and have positive impact on the microclimatic conditions at the pedestrian level.

### *3.3.5 Street Network and Connectivity*

Many studies have shown the importance of street network in motivating walking. Network design has been said to help in determining the ability of pedestrians to reach their destinations. Grid networks with short blocks allow for relatively direct routes, while long blocks and curvilinear streets lengthen pedestrian trips by requiring circuitous routes. A study by Singh (2016) in India concluded that block length and perceived walking distance are directly proportional to each other. He further stated that shorter block lengths make the streets more walkable as people perceive the distances to be shorter and prefer taking such routes, thus increasing street activity.

Finding in a study by Hajrasouliha and Yin (2015) suggests that physical connectivity has significant positive impacts on pedestrian volumes. Similarly, Jack and McCormack (2014) found in their study that respondents in HW neighborhoods positively perceived street connectivity. This is in line with the suggestion by Lamíquiz and López-Domínguez (2015) that the design of a street network configuration could insert multiple activities along the routes, and thus shorten distances if done appropriately. The findings introduce the idea that the configuration of the urban grid can influence the proportion of pedestrians who choose to walk on single-journey trips.

### *3.3.6 Visual Connectivity*

Visual connectivity has significant positive impacts on pedestrian volumes (Hajrasouliha & Yin 2015). The results of a study by Oreskovic et al. (2014) show that perceived walkability varied according to the degree to which a particular design attribute was present. According to the study, the presence of ground-floor windows and a street focal point are two attributes that most consistently associated with a space's perceived walkability. The presence of a window at the eye-level of pedestrian, which indicate retail presence is an important attribute towards promoting walkability. This idea is similar to the study by Ewing (2016) that mentioned the importance of windows at the ground floor façade. A study by Singh (2016) also has a parallel concept with the above two studies where he found most of the recorded answers from the respondents stated that the presence of blank walls was the factor they thought made them feel unsafe or claustrophobic on the street. This factor discourages pedestrians to be on the roads and, as a result, decreased the walkability of that area.

### *3.3.7 Proximity*

Basically, many definitions of walkable places are places that support short walking trips to essential facilities and services for running daily errands. Studies have shown that proximity to destinations supports active transport and mobility (Tsiompras & Photis, 2017). The results of a survey

by Tsiompras and Photis (2017) indicate that proximity (up to 400 m) to urban destinations is the main motivation for people to walk. This finding is consistent with a study by Lamíquiz and López-Domínguez (2015) that found distance, either real or perceived, is one of the most principal barriers for travelling on foot. In general, smaller cities are more walkable because distance between different activity locations is shorter than in larger cities (Ferrer & Ruiz, 2018). Therefore, Ferrer and Ruiz (2018) suggested for large cities to pay more attention to the provision of mixed land uses as an important characteristic of the built environment in encouraging walking for transport. They suggested that proximity to destinations in conjunction with the land use mix seems to be the fundamental keys for walkability. Their result also show that participants perceive more facilitators to walking in Granada than in Valencia due to the smaller size of the former city.

#### 4. DISCUSSIONS

Walking relies not only on the infrastructure but also on the state of the built environment (Cauwenberg, 2018). While pedestrian infrastructure is an imperative to fulfil certain pedestrian needs, others such as proximity, safety or aesthetics, depend not so much on the pavements, but on the surrounding environment. In this context, how pedestrian-friendly buildings are, or the type of land use found in the area, do influence walking. Some discourses on walkability focus on environmental features or means of making walkable environments. These environmental features include areas being passable, compact, physically enticing, and safe, while others are more concerned with the outcomes fostered by such environments (Forsyth, 2015). Among the potential outcomes are making the places lively, enhancing sustainable transportation options, and encouraging the physical exercise.

Many of the criteria found to be the antecedents to walking are not a detached or unconnected element. Many of them must be combined to create a walkable environment. For instance, a study by Mouada, Zemmouri and Meziani (2018) shows that to provide a comfortable condition and to increase pedestrian choice in the urban environment, the public space should include high building density, combined with deep streets with a high connection between them, and an abundance of vegetation along the lower parts of streets. This example shows that density is combined with street network, connectivity and aesthetic or pleasing scenery to encourage walking (Raja Noriza et al., 2019).

The review found that three criteria are somewhat constant in promoting walking, namely, population and building density, land use and land use mixes, and safety. Mixed or different uses in the same place tend to strengthen the identity of the place according to Jacobs (1961), while density or proximity of the mixed uses strengthen the economy of the place and enable people to travel less distance to access daily needs. Undoubtedly, safety is a very fundamental precursor to walking. Studies have indicated that people are very much reluctant to walk in the absence of safety. It means that although they are presented with pleasing scenery and good infrastructure, people do not want to jeopardize their safety by walking.

#### 5. CONCLUSION

Jacobs (1961), who triggers the concept of New Urbanism that advocated pedestrian-friendly design, mixed land use, and transit-oriented development has championed the 'eye on the street' concept, which emphasized the needs of having high pedestrian volume in an area. The presence of pedestrian, according to her, can deter crime and increase sense of community. There is an element of safety in promoting walking in this concept. In short, the literature review shows that by making an area perceived as safe and the presence of land use mixes and density are the best combination to create a walkable environment. Hence, cities need to consider these three fundamental criteria in formulating policy towards creating a friendly pedestrian environment. This review has some limitations. It does not differentiate between walking for leisure, walking for public transit or any other reasons for walking, such as commuting, going to work, running errands and others. Nor does it differentiate between the Eastern and Western countries. There may exist variance between the East and the West due to the environment, cultural and behavioral differences. Thus, we recommend that future systematic review to differentiate between these fundamental attributes.

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## AUTHORS' DECLARATIONS AND ESSENTIAL ETHICAL COMPLIANCES

### *Authors' Contributions (in accordance with ICMJE criteria for authorship)*

<i>Contribution</i>	<i>Author 1</i>	<i>Author 2</i>	<i>Author 3</i>
Conceived and designed the research or analysis	Yes	Yes	Yes
Collected the data	No	Yes	No
Contributed to data analysis & interpretation	Yes	No	Yes
Wrote the article/paper	Yes	Yes	No
Critical revision of the article/paper	Yes	No	Yes
Editing of the article/paper	Yes	Yes	No
Supervision	No	Yes	No
Project Administration	Yes	No	No
Funding Acquisition	Yes	No	No
Overall Contribution Proportion (%)	40	40	20

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### *Research involving human bodies (Helsinki Declaration)*

Has this research used human subjects for experimentation? No

### *Research involving animals (ARRIVE Checklist)*

Has this research involved animal subjects for experimentation? No

### *Research involving Plants*

No plant was used to conduct this research.

### *Research on Indigenous Peoples and/or Traditional Knowledge*

Has this research involved Indigenous Peoples as participants or respondents? No

### *(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)*

Have authors complied with PRISMA standards? Yes

### *Competing Interests/Conflict of Interest*

Authors have no competing financial, professional, or personal interests from other parties or in publishing this manuscript.

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