International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 10 | Oct 2021 www.irjet.net p-ISSN: 2395-0072

Neighbourhood Walkability and its Impact on Elderly Well-being

P. Dharmambigai[1], Dr. S. Lakshmi[2]

[1]Research Scholar, Faculty of Architecture and Planning, Anna University, Chennai, India
[2]Professor, Division of Transportation Engineering, Department of Civil Engineering, Anna University, Chennai, India

---

Abstract - *Neighbourhood-built environment influences physical activity, especially walking in the elderly population. Elderly people experience both physical and cognitive decline as they age, travel short distances and prefer walking as the most convenient mode of commute. To encourage walking among this vulnerable population, it is essential to provide a suitable physical environment. Several studies have been conducted in this context, but they focus on the general public and not on the elderly. This paper, therefore, seeks to contribute to the literature, through a review of the neighbourhood walkability attributes and how they impact the holistic well-being (physical, mental and social) of the elderly population. The review findings support a strong correlation between walkability and the various domains of health in older adults. It also observes a paucity of literature addressing the positive impact of neighbourhood-built environments on the mental well-being of the elderly.*

***Key Words*: Neighbourhood, Walkability, Built environment, Elderly health, Physical health, Mental health, Social health.**

1. INTRODUCTION

The world population is ageing at a fast pace. In a way, this marks the success of humanity and at the same time, it poses several practical challenges to the society [1]. The global population pyramid which was triangular as of 2002 will be replaced with a more cylinder-like structure in 2025 (Fig 1)[1]. The proportion of the elderly population is expected to double from 11% in 2006 to 22% in 2050. This implies that the elderly cohort will outnumber the children aged 0 – 14 [2]. This marks a dramatic shift in the global demography. In this scenario, good health and active ageing are endorsed as milestones by WHO, European Union and the United Nation's Sustainable Development Goals [1], [3], [4]. Physical Activity (PA) has a vital role to play in healthy ageing. In support of this, the extant literature has shown that there is a positive association between PA and reduced risk of Non-Communicable Diseases [5]. Further, regular PA in the elderly helps in the improvement of functional independence [6], muscle strength [7], psychological well-being, social connectivity and cognitive function [8]. The WHO recommends the elderly to carry out moderate-intensity PA for at least 150 minutes or vigorous-intensity PA for at least 75 minutes or an equal mix of both PAs in a week's span [9]. Walking is the most common, economical, sustainable and moderate-intensity PA among the aged population [10], [11]. It does not involve any specific skills and can be included in the daily routine at ease [12]. Walking needs no special equipment and it acts as a self-regulating mode and is highly safe. It is as natural and harmless as breathing [13]. Thus the elderly regard walking as the most convenient mode, to carry out their daily errands, like shopping, accessing public spaces and for other utilitarian trips [14]. This has led the urban designers and policymakers to focus on strategies to improve the walkability of the neighbourhood. There is a growing body of literature that suggests a positive correlation between neighbourhood attributes, walking and elderly health [15]–[17]. WHO has also emphasised the importance of creating age-friendly physical environments for older adults to carry out their PA with ease and achieve healthy and active ageing[2].

Most studies have focussed on walkability, emphasising a variety of themes. Some researchers have studied the walking behaviour for specific purposes – transportation or leisure [18]–[22], some have investigated the barriers to walking [23], [24], while others have analysed the association between walking and the health outcomes [25]–[27] of the general population. Many of the existing studies in the broader literature have been limited to the general population and only a few have explored the walkability of the vulnerable population such as the elderly. Furthermore, previous studies have attempted to explore the impact of walkability on any one aspect of health, say physical, mental or social. As far as we know, no previous research has investigated the impact of a walkable neighbourhood

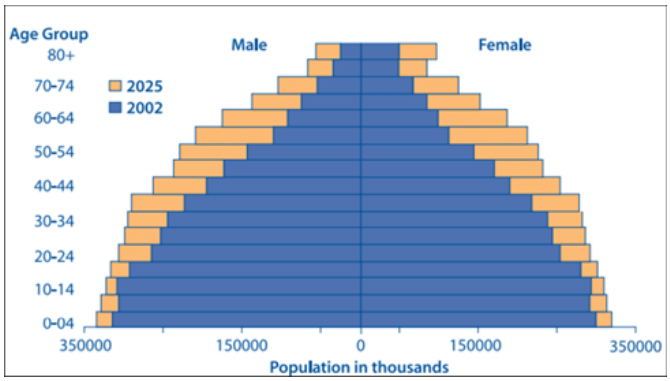

Fig -1: Global population pyramid of 2002 and 2025
Source – UN, 2001

environment on the holistic health of the elderly. This paper, therefore, seeks to review the existing body of literature and identify areas that are still not discussed elaborately in the literature.

This paper is organized as follows. It is divided into 6 sections.

1. The first section gives a brief overview of the need for the study.
2. The methodology adopted for the literature review is briefly explained in the second section.
3. Section 3 summarizes the existing body of literature under four core areas –
   - Walking and walkability,
   - Physical environment attributes (functional elements, aesthetics, security and destinations),
   - Elderly health and
   - The impact of walkability on the physical, mental and social well-being of the elderly.
4. The last section presents the concluding remarks and the possible future research directions.

2. METHODOLOGY

A systematic review of elderly walkability and health-related studies was conducted to satisfy the study objectives. Various databases like Google Scholar, PubMed, Web of Science, MDPI, Scopus, Science Direct, Taylor & Francis, Transportation Research Procedia, Transportation Research Record and Wiley Online Library were complimentary to source the literature most relevant to the topic of study. The search was limited to English articles published between 1st January 2010 and 31st August 2021.

The search terms were grouped into 5 categories – walkability, elderly, physical, mental and social health (Chart 1). The articles were screened by title and abstract to check for their relevance to the context of the study. The selected articles were then reviewed in full to decide on the suitability for inclusion.

The articles were included based on the following selection criteria:

- The studies in which the respondents were aged 60 and above were included in the review. This age definition was based on the chronological age cut off 60-65 years and was also taken in consensus with the retirement age in the Indian context [28]. Articles on frail and elderly with physical disabilities were excluded from the study.
- The articles focussing on the association between the walkability and holistic health (physical, mental and social) of the elderly were included. In this context, the walking environment refers to the outdoor and not the indoor built environment.
- Studies on elderly living in institutions, retirement communities and old age homes were excluded from the study as they live in user-centric environments designed to cater to their special needs.
- Articles using quantitative research methods (cross-sectional and longitudinal) were included in the review.
- The selected articles were further screened, at least twice by reviewing the full contents of the articles based on the above-mentioned inclusion and exclusion criteria.

3. RESULTS

3.1. WALKING AND WALKABILITY

Walking for leisure or transportation often takes place in the outdoor environment. There is abundant scientific evidence showing a positive association between the built environment attributes and walking in the elderly population [29]–[31]. Walking is regarded as the most

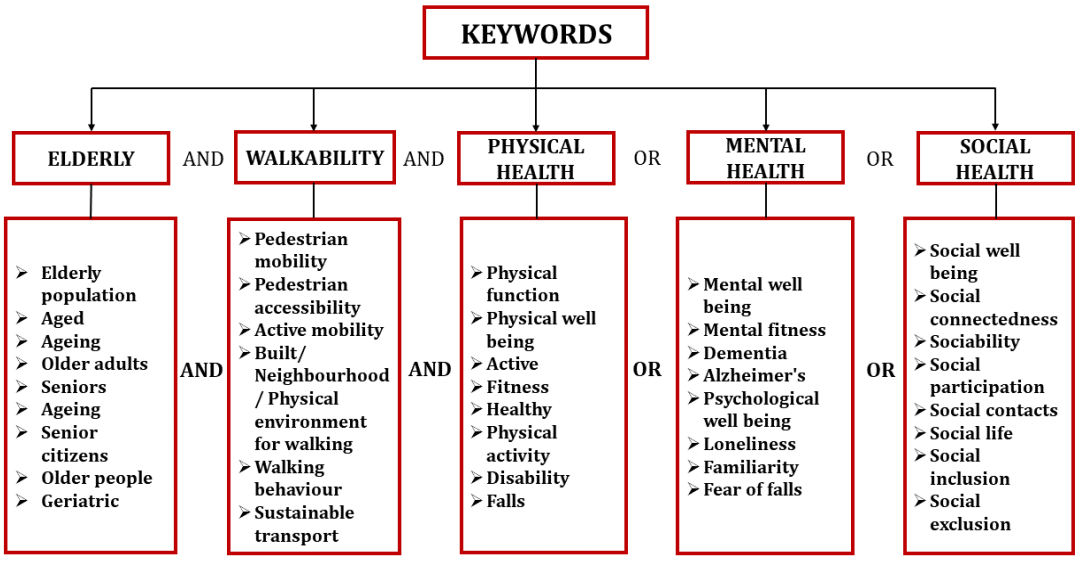

Chart – 1: Keywords and Search strategy

affordable and safe form of moderate-intensity aerobic Physical Activity (PA), especially for the elderly. It can be easily practiced across all age groups and aids in adopting a healthy lifestyle [7], [12].

Walkability refers to the suitability of an urban environment for walking. It is the degree of compatibility between the built environment characteristics and outdoor walking, irrespective of the purpose for which the trip is undertaken [20]. It is defined by M. Southworth (2005) as "the extent to which the built environment supports and encourages walking by providing for pedestrian comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort, and offering visual interest in journeys throughout the network" [32]. This emphasizes the vital role of urban planners and policymakers in creating walking-friendly built environments that enhances the overall walking experience and community health [33], [34].

3.2. PHYSICAL ENVIRONMENT ATTRIBUTES

The physical environment plays an important role in influencing the degree of participation in physical activity. To propose suitable urban design interventions that enhance walkability the knowledge of the built environment correlates and physical activity is highly recommended [35]. Pikora et al. (2003) arrived at the possible physical environment attributes which impact walkability based on published literature, policies and a Delphi study. These attributes are classified into four major categories: (Chart 2) functional, safety, aesthetics and destination [36].

3.2.1. FUNCTIONAL

The functional attributes relate to the street geometry and characteristics which explain the structural features of the local environment. It includes the sidewalk condition and finishes, street connectivity, volume and speed of traffic and intersection characteristics [36]. A corpus of literature investigated the association between the walkability of the elderly and the physical attributes of road networks such as sidewalk width, pedestrian crossings [37]. These studies have attempted to study the perceptions of the elderly on the physical environment attributes and its impact on their mode choice for daily commute, route selection, walking speed, trip frequency[38] and trip duration [39], [40].

3.2.2. AESTHETICS

The aesthetic features include the cleanliness and maintenance of streets, the presence of avenue trees and green spaces, attractive architectural elements, buildings and scenic views [36], [41]. Research studies consistently show that there is a positive influence of nature on the walking behaviour of the elderly[42], [43].

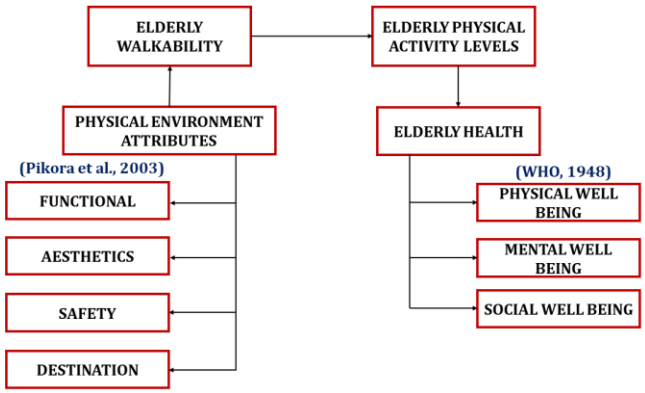

Chart – 2: Conceptual framework

3.2.3. SAFETY

The characteristics of safe walkability can be further classified as safety from traffic and safety from crime. Presence of traffic calming measures, crossing aids, segregation of pedestrians from traffic, proper street lighting [44], [45], and a greater number of windows facing the street [36], [46].

3.2.4. DESTINATIONS

The destinations must be easily accessible and varied. They include shopping facilities, markets, parks, health facilities and other common facilities [36]. Most of the elderly tend to commute only short distances [47]. The elderly commute longer distances for higher-order amenities (medical facilities) than for lower-level facilities (for daily errands)[48]. Temelova and Dvorakova (2012) [49] observed that elderly people walk to the nearby shopping facilities while they commute by public transport for medical needs.

3.3. IMPACT OF WALKABILITY ON THE HOLISTIC HEALTH OF ELDERLY

WHO has portrayed physical inactivity as the main reason for the disease burden, faced at the global level. It causes high levels of blood pressure, cholesterol, and obesity [50]. Human health is defined as "the state of physical, mental and social well-being and not merely the absence of disease or infirmity" [51]. A growing number of researchers and health practitioners encourage the participation of the elderly in physical activity to enhance their physical health [52], mental health [53] and social health [54] (Chart 2).

3.3.1. PHYSICAL WELL-BEING

Physical activity (PA) is vital for elderly people to maintain a healthy and active lifestyle. In this context, the home and the immediate physical environment have a profound role to play [55]. "Physical activity is an umbrella term that includes

both structured and unstructured forms of leisure, transport, domestic and work-related activities" [56]. The WHO recommends the older adults carry out moderate-intensity aerobic physical activity (PA) for at least 150 minutes or a high-intensity aerobic PA for at least 75 minutes or a corresponding combination of both in a week's time. This tends to lower the mortality rate and the incidence of a wide range of Non-Communicable Diseases (NCDs) [9]. The elderly people are mostly retired and hence experience a reduction in PA such as job-based transportation walking. Furthermore, it is not balanced by any leisure PA [57]. This scenario emphasizes the need to create supportive conditions to enhance the physical activity levels in the aged population.

The physical environment has a prime role to play in increasing or decreasing the PA and the independent lifestyle of the community-dwelling elderly [19]. The older adults living in vital urban environments that were more vibrant and walkable possessed healthy mobility habits than their counterparts [52]. A study conducted by Hanibuchi et al. (2011) revealed that population density and the presence of parks had a positive impact on the leisure PA of the elderly[58]. Yiyang Yang et al., (2019) concluded from their study, that there exists a positive correlation between urban street greenery and the walking behaviour in older adults. The study further emphasised the importance of formulating landscape design strategies, which cater to the needs of pedestrians and in response to the human scale [59]. The physically active elderly living in high-income and high walkable neighbourhoods have more scope for engagement in moderate to vigorous physical activity [60]. These results were further reinforced by the findings of Huang et al. (2018) which revealed that urbanisation level, built environment (presence of parks, green areas, playgrounds), and the median income of the study area had a positive correlation with the elderly PA [61]. A highly walkable physical environment increases the scope of PA in older adults and the cognizance of environmental facilitators tends to promote PA in the elderly with physical restrictions [62].

Neighbourhoods with high residential density, land use mix, intersection density, and low car parking areas tend to support walking in the elderly [31], [63]. A cross-sectional analysis conducted by Cerin et al. (2020) explained that the high-density neighbourhoods with good street connectivity encourage the use of active travel modes. Very high residential density and public transport frequency would promote walking outside the neighbourhood and create barriers to walking within the neighbourhood [64]. This result was in contradiction to another study conducted in Bogotá. It stated that streets with higher connectivity tend to have a greater number of intersections and crosswalks. This increases the probability of road accidents and hence discourages the walkability of elderly people [65]. Furthermore, elderly walkability is discouraged by factors such as broken sidewalks, vacant lots, criminal activity, stray animals, overgrown vegetation, and deserted dark spots [66].

The presence of leveled sidewalks [67], [68] benches, handrails, toilets, street lighting and dropped curbs [69] encourage outdoor walking in the older adults. In addition to these attributes, attractive destinations present outside the neighbourhood motivated the elderly to move out and be physically active [70]. The older adults take to walking in the neighbourhood mainly for transport, leisure, or for utilitarian purposes. The effective distribution of urban places and services and increasing the utility of the pedestrian routes to access these services promote transport-related walking and add to the quality of life of the ageing population [71], [72].

3.3.2. MENTAL WELL-BEING

Mental well-being refers to a condition of emotional stability, conscious realisation of individual capability, ability to manage stressful conditions efficiently and carry out productive work effectively [73]. The past decade has observed a growing interest in understanding the influence of neighbourhood environment on the Mental Health (MH) of aged people [74]. Socio-economic deprivation is the most explored neighbourhood associate in the context of Mental Health (MH) in the elderly population. But the results are inconsistent across many studies [75]. Some studies revealed that the older adults living in socioeconomically deprived areas and areas with physical disorders (noise, litter, vandalism, graffiti, dilapidated buildings, drug and alcohol use) experienced anxiety and depression [76], [77]. This finding is inconsistent, with a few other studies which explained that economically backward areas housing more elderly inhabitants experienced fewer depressive symptoms. This makes it evident that the elderly MH is impacted by the ambient neighbourhood character [78].

An early study in the US reported a significant correlation between neighbourhood walkability and MH in elderly men only and not in women [79]. The poorly maintained neighbourhood environments are strongly associated with reduced outdoor mobility and fear of falls among the elderly population. This would result in activity avoidance leading to depression and poor quality of life. In contrast, the improved walkability in a neighbourhood tends to enhance the social interaction among the elderly who are retired and spend most of the time in the vicinity [80]. This aspect is proven by a cohort study conducted at Hertfordshire, in the United Kingdom, that demonstrated that older adults who had a strong sense of neighbourhood cohesion reported positive MH and higher levels of comfort in the place of residence [81].

An observational epidemiological study conducted in Australia stated that individual perceptions of the physical environment attributes have a profound impact on neighbourhood satisfaction and in turn on the MH. The

attributes include public open space, access to utilities, safety, security and traffic conditions [53]. The presence of green and blue space in the vicinity of the residence of the less mobile population has a direct implication on their MH [82]. Public open spaces play a vital role in enhancing the mental well-being of the elderly. It brings them close to nature, aids in social cohesion and improves their emotional ties with the natural environment [83]. Furthermore, from the MH perspective, the residents of neighbourhoods with high quality and well-maintained public open spaces had better MH than their counterparts living in neighbourhoods with poor quality open spaces [43]. Several studies have shown a significant correlation between traffic conditions and MH in the elderly population. Senior residents who were less exposed to heavy traffic and pollution experience, lesser depression [84], [85]. This finding was further emphasized by Melis et al. (2015) that proper access to public transport and dense urban areas contributes to a reduced risk of depression in the elderly [86]. However, a study conducted by Saarloos et al. (2011) stated that a higher degree of land use mix and retail facilities increases the chances of depression in elderly men [87].

Most of the studies in this review focus on the depression caused by environmental attributes. But the other aspects of psychological disorders have not been addressed. Moreover, there is a paucity of information on the positive aspects of the neighbourhood environment contributing to mental health.

3.3.3. SOCIAL WELL-BEING

Jan Gehl (1989) has classified human outdoor activities into three broad categories – necessary activities, optional activities and social activities. He defines social activity or social interaction as an activity that is based on the presence of other people in public spaces, which can be active or passive such as meeting and greeting others, talking, or other kinds of collective activities[88]. Social health or well-being is defined as the health beyond the physiological, physical and psychological condition of individuals and it refers to the inter-personal relationships between people together with the extent of their participation in the community [89]. Social connectivity impacts the elderly health and active ageing and it aids in ensuring an active lifestyle [90].

The physical environment and its attributes help in social interaction among the elderly and add to the quality of their social life. The presence of amenities nearby, pedestrian infrastructure, neighbourhood aesthetics, public transport access, pavements, presence of landscape and lower crime level encourage social participation in the elderly people [38]. On the contrary, a local environment that hindered walkability would result in reduced social interaction leading to physical decline and exclusion in old age [54]. A study on the impact of built environment attributes on the elderly sociability demonstrated that safety was the prime factor that determined the use of open spaces by the elderly and next in order were aesthetics and inclusive design of infrastructure [91]. Jane Jacobs (1961) explained the correlation between neighbourhood safety and social interaction. She stated that shorter blocks ensured more safety as they created more opportunities for social interaction and frequent encounters between the pedestrians [46]. Another study on the association between neighbourhood open space, walking and social interaction explained that walking in the elderly was determined by the presence of shade along the walking trails, seating, and landscaping. The study results showed that walking was negatively associated with social interaction. This is supported by elderly people's preference to sit and participate in social activities [92].

Effective design of neighbourhood streets can enhance the independence of the elderly, promote social interaction and community participation. The street physical elements include even pavements, ramps, plain dropped kerbs without tactile paving, proper pedestrian and traffic segregation, seating with armrests, street greenery, bus stops with shelter, toilets and proper signboards. These facilities would aid in the easy commute of the elderly without fear of falls and unfamiliarity with space. In turn, this would enhance social interaction of the elderly [80], [93].

4. CONCLUSIONS

This literature review presents substantial evidence that physical factors of the built environment significantly contribute to the holistic well-being of the elderly population. Only very few studies demonstrated a negative association between walkability and elderly health. As defined by WHO, the three dimensions of health – physical, mental and social well-being are interrelated and play a key role in the context of active ageing. Neighbourhood walkability influences both physical and functional capability of the elderly and in turn impacts their social interaction and positive mental well-being.

This literature review reveals that neighbourhood environments that are vibrant, with parks, playgrounds and high population density [58], encourage more physical activity. A barrier-free physical environment [94], accessible destinations [20], [31], [95] and well-maintained pedestrian infrastructure, increase outdoor mobility and thereby aid the elderly to lead a physically active lifestyle [69]. Safe walkability, frequent encounters with fellow residents and active community cohesion help the elderly to be socially interactive and overcome loneliness and depression [80], [92].

However, several studies have analysed the positive association between neighbourhood walkability and the physical and social well-being of the elderly. But there is a paucity of knowledge on the positive impact of walkability

on the mental health of the elderly. Future research must explore the various facets of walkable environments which enhance holistic health with an exclusive focus on the mental well-being of the elderly. Further, the implications of this study will help urban planners/ policymakers to formulate inclusive design solutions in the neighbourhood planning process and create age-friendly physical environments including the elderly along with other stakeholders.

REFERENCES

[1] WHO, "Active ageing: a policy framework.," Madrid, Spain, 2002. [Online]. Available: http://www.who.int/hpr/ ageing.

[2] WHO and W. H. Organization, "Global Age-friendly Cities: A Guide," World Health Organization, 2007.

[3] K. Hamblin, *Active ageing in the European Union: Policy convergence and divergence*. Springer, 2013.

[4] United Nations. Department of Economic and Social Affairs Population Division., "Ensure healthy lives and promote well-being for all at all ages." https://sdgs.un.org/goals/goal3.

[5] I.-M. Lee *et al.*, "Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy," *Lancet*, vol. 380, no. 9838, pp. 219–229, 2012.

[6] M. Rantakokko *et al.*, "Fear of moving outdoors and development of outdoor walking difficulty in older people," *J. Am. Geriatr. Soc.*, vol. 57, no. 4, pp. 634–640, 2009.

[7] D. E. R. Warburton, C. W. Nicol, and S. S. D. Bredin, "Health benefits of physical activity: the evidence," *Cmaj*, vol. 174, no. 6, pp. 801–809, 2006.

[8] T. Rantanen, E. Portegijs, K. Kokko, M. Rantakokko, T. Törmäkangas, and M. Saajanaho, "Developing an assessment method of active aging: University of Jyvaskyla active aging scale," *J. Aging Health*, vol. 31, no. 6, pp. 1002–1024, 2019.

[9] WHO, "Global recommendations on physical activity for health: 65 years and above," *Geneva World Heal. Organ.*, p. 60, 2011, [Online]. Available: https://www.who.int/dietphysicalactivity/physical-activity-recommendations-65years.pdf?ua=1%0Ahttp://medcontent.metapress.com/index/A65RM03P4874243N.pdf%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Global+Recomendations+on+physical+act.

[10] P. C. Hallal *et al.*, "Global physical activity levels: surveillance progress, pitfalls, and prospects," *Lancet*, vol. 380, no. 9838, pp. 247–257, 2012.

[11] A. E. Stuck, J. M. Walthert, T. Nikolaus, C. J. Büla, C. Hohmann, and J. C. Beck, "Risk factors for functional status decline in community-living elderly people: a systematic literature review," *Soc. Sci. Med.*, vol. 48, no. 4, pp. 445–469, 1999.

[12] E. M. Murtagh, M. H. Murphy, and J. Boone-Heinonen, "Walking–the first steps in cardiovascular disease prevention," *Curr. Opin. Cardiol.*, vol. 25, no. 5, p. 490, 2010.

[13] Walk21, "International Charter for walking," Toronto, 2007. [Online]. Available: www.walk21.com.

[14] J. Garrard, "Senior Victorians and walking: obstacles and opportunities," 2013.

[15] E. Cerin, A. Nathan, J. van Cauwenberg, D. W. Barnett, and A. Barnett, "The neighbourhood physical environment and active travel in older adults: A systematic review and meta-analysis," *Int. J. Behav. Nutr. Phys. Act.*, vol. 14, no. 1, pp. 1–23, 2017, doi: 10.1186/s12966-017-0471-5.

[16] J. Van Cauwenberg *et al.*, "Physical environmental factors related to walking and cycling in older adults: The Belgian aging studies," *BMC Public Health*, vol. 12, no. 1, p. 142, 2012, doi: 10.1186/1471-2458-12-142.

[17] T. Sugiyama and C. W. Thompson, "Outdoor environments, activity and the well-being of older people: Conceptualising environmental support," *Environ. Plan. A*, vol. 39, no. 8, pp. 1943–1960, 2007, doi: 10.1068/a38226.

[18] C. S. Gomes, F. P. Matozinhos, L. L. Mendes, M. C. Pessoa, and G. Velasquez-Melendez, "Physical and social environment are associated to leisure time physical activity in adults of a Brazilian city: A cross-sectional study," *PLoS One*, vol. 11, no. 2, pp. 1–11, 2016, doi: 10.1371/journal.pone.0150017.

[19] R. C. Brownson, C. M. Hoehner, K. Day, A. Forsyth, and J. F. Sallis, "Measuring the built environment for physical activity: state of the science," *Am. J. Prev. Med.*, vol. 36, no. 4 Suppl, pp. S99-123.e12, Apr. 2009, doi: 10.1016/j.amepre.2009.01.005.

[20] E. Leslie, N. Coffee, L. Frank, N. Owen, A. Bauman, and G. Hugo, "Walkability of local communities: Using geographic information systems to objectively assess relevant environmental attributes," *Health Place*, vol. 13, no. 1, pp. 111–122, 2007, doi: https://doi.org/10.1016/j.healthplace.2005.11.001.

[21] S. Mavoa *et al.*, "How do neighbourhood definitions influence the associations between built environment and physical activity?," *Int. J. Environ. Res. Public Health*, vol. 16, no. 9, 2019, doi: 10.3390/ijerph16091501.

[22] M. J. Koohsari, N. Owen, E. Cerin, B. Giles-Corti, and T. Sugiyama, "Walkability and walking for transport: Characterizing the built environment using space syntax," *Int. J. Behav. Nutr. Phys. Act.*, vol. 13, no. 1, pp. 1–9, 2016, doi: 10.1186/s12966-016-0448-9.

[23] M. Rantakokko, S. Iwarsson, S. Vahaluoto, E. Portegijs, A. Viljanen, and T. Rantanen, "Perceived environmental barriers to outdoor mobility and feelings of loneliness among community-dwelling older people," *Journals Gerontol. - Ser. A Biol. Sci. Med. Sci.*, vol. 69, no. 12, pp. 1562–1568, 2014, doi: 10.1093/gerona/glu069.

[24] J. Phillips, N. Walford, A. Hockey, N. Foreman, and M. Lewis, "Older people and outdoor environments: Pedestrian anxieties and barriers in the use of familiar and unfamiliar spaces," *Geoforum*, vol. 47, pp. 113–124, 2013, doi: 10.1016/j.geoforum.2013.04.002.

[25] L. Sedigheh, K. M. Javad, S. Lotfi, and M. J. Koohsari, "Neighborhood Walkability in a City within a Developing Country," *J. Urban Plan. Dev.*, vol. 137, no. 4, pp. 402–408, Dec. 2011, doi: 10.1061/(ASCE)UP.1943-5444.0000085.

[26] A. A. Zuniga-Teran, B. J. Orr, R. H. Gimblett, N. V. Chalfoun, D. P. Guertin, and S. E. Marsh, "Neighborhood design, physical activity, and wellbeing: Applying the walkability model," *Int. J. Environ. Res. Public Health*, vol. 14, no. 1, 2017, doi: 10.3390/ijerph14010076.

[27] I. M. Sulaiman, "Walkability in Different Contexts in Neighbourhood Planning : An Overview," vol. 10, no. 1, pp. 27–43, 2020, doi: 10.5923/j.arch.20201001.04.

[28] G. Giridhar, K.S. James, and Sanjay Kumar, "Caring for Our Elders: Early Responses India Ageing Report-2017," 2017. Accessed: Jul. 17, 2020. [Online]. Available: https://india.unfpa.org/sites/default/files/pub-pdf/India Ageing Report - 2017 %28Final Version%29.pdf.

[29] Y. Liao, P. H. Huang, C. Y. Hsiang, J. H. Huang, M. C. Hsueh, and J. H. Park, "Associations of older Taiwanese adults' personal attributes and perceptions of the neighborhood environment concerning walking for recreation and transportation," *Int. J. Environ. Res. Public Health*, vol. 14, no. 12, 2017, doi: 10.3390/ijerph14121594.

[30] D. Van Dyck, M. Teychenne, S. A. McNaughton, I. De Bourdeaudhuij, and J. Salmon, "Relationship of the perceived social and physical environment with mental health-related quality of life in middle-aged and older adults: Mediating effects of physical activity," *PLoS One*, vol. 10, no. 3, pp. 1–16, 2015, doi: 10.1371/journal.pone.0120475.

[31] M. W. C. Giehl, P. C. Hallal, C. W. Corseuil, I. J. Ceola Schneider, and E. D'Orsi, "Built environment and walking behavior among Brazilian older adults: A population-based study," *J. Phys. Act. Heal.*, vol. 13, no. 6, pp. 617–624, 2016, doi: 10.1123/jpah.2015-0355.

[32] M. Southworth, "Designing the Walkable City," *J. Urban Plan. Dev.*, vol. 131, no. 4, pp. 246–257, Dec. 2005, doi: 10.1061/(ASCE)0733-9488(2005)131:4(246).

[33] K. Brookfield and S. Tilley, "Using virtual street audits to understand the walkability of older adults' route choices by gender and age," *Int. J. Environ. Res. Public Health*, vol. 13, no. 11, 2016, doi: 10.3390/ijerph13111061.

[34] D. Adlakha, J. A. Hipp, and R. C. Brownson, "Adaptation and evaluation of the neighborhood environmentwalkability scale in India (NEWS-India)," *Int. J. Environ. Res. Public Health*, vol. 13, no. 4, pp. 1–24, 2016, doi: 10.3390/ijerph13040401.

[35] D. A. Rodríguez, A. J. Khattak, and K. R. Evenson, "Can new urbanism encourage physical activity?: Comparing a new Urbanist neighborhood with conventional suburbs," *J. Am. Plan. Assoc.*, vol. 72, no. 1, pp. 43–54, 2006.

[36] T. Pikora, B. Giles-Corti, F. Bull, K. Jamrozik, and R. Donovan, "Developing a framework for assessment of the environmental determinants of walking and cycling," *Soc. Sci. Med.*, vol. 56, no. 8, pp. 1693–1703, 2003.

[37] G. Pulvirenti, N. Distefano, and S. Leonardi, "Elderly perception of critical issues of pedestrian paths," *Civ. Eng. Archit.*, vol. 8, no. 1, pp. 26–37, 2020, doi: 10.13189/cea.2020.080104.

[38] H. C. Borst, H. M. E. Miedema, S. I. de Vries, J. M. A. Graham, and J. E. F. van Dongen, "Relationships between street characteristics and perceived attractiveness for walking reported by elderly people," *J. Environ. Psychol.*, vol. 28, no. 4, pp. 353–361, 2008, doi: https://doi.org/10.1016/j.jenvp.2008.02.010.

[39] L. Cheng, X. Chen, S. Yang, Z. Cao, J. De Vos, and F. Witlox, "Active travel for active ageing in China: The role of built environment," *J. Transp. Geogr.*, vol. 76, no. November 2018, pp. 142–152, 2019, doi: 10.1016/j.jtrangeo.2019.03.010.

[40] Y. Xiong, Q. Lu, and Y. Hu, "Elderly Fitness-Oriented Urban Street Design : Case Study in Nanchang , China," *J. Urban Plan. Dev.*, vol. 146, no. 1, 2020, doi: 10.1061/(ASCE)UP.1943-5444.0000547.

[41] N. Humpel, N. Owen, E. Leslie, A. L. Marshall, A. E. Bauman, and J. F. Sallis, "Associations of location and perceived environmental attributes with walking in neighborhoods," *Am. J. Heal. Promot.*, vol. 18, no. 3, pp. 239–242, 2004.

[42] S. Kaplan, "The restorative benefits of nature: Toward an integrative framework," *J. Environ. Psychol.*, vol. 15, no. 3, pp. 169–182, 1995, doi: 10.1016/0272-4944(95)90001-2.

[43] J. Francis, L. J. Wood, M. Knuiman, and B. Giles-Corti, "Quality or quantity? Exploring the relationship between Public Open Space attributes and mental health in Perth, Western Australia," *Soc. Sci. Med.*, vol. 74, no. 10, pp. 1570–1577, 2012, doi: 10.1016/j.socscimed.2012.01.032.

[44] F. Alves, S. Cruz, A. Ribeiro, A. B. Silva, J. Martins, and I. Cunha, "Walkability index for elderly health: A proposal," *Sustain.*, vol. 12, no. 18, 2020, doi: 10.3390/SU12187360.

[45] N. Distefano, G. Pulvirenti, and S. Leonardi, "Neighbourhood walkability: Elderly's priorities," *Res. Transp. Bus. Manag.*, no. August, 2020, doi: 10.1016/j.rtbm.2020.100547.

[46] J. Jacobs, "Jane Jacobs The Death and Life Cities of Great American Cities." 1961.
[47] S. Srichuae, V. Nitivattananon, and R. Perera, "Aging society in Bangkok and the factors affecting mobility of elderly in urban public spaces and transportation facilities," *Iatss Res.*, vol. 40, no. 1, pp. 26–34, 2016.
[48] S. Nordbakke, "Capabilities for mobility among urban older women: barriers, strategies and options," *J. Transp. Geogr.*, vol. 26, pp. 166–174, 2013.
[49] J. Temelová and N. Dvořáková, "Residential satisfaction of elderly in the city centre: The case of revitalizing neighbourhoods in Prague," *Cities*, vol. 29, no. 5, pp. 310–317, 2012.
[50] WHO, "Annual global move for health initiative: a concept paper," World Health Organization, 2003.
[51] WHO, "Definition of health," *http//www. who. int/suggestions/faq/zh/index. html*, 1948.
[52] O. Marquet and C. Miralles-Guasch, "Neighbourhood vitality and physical activity among the elderly: THE role of walkable environments on active ageing in Barcelona, Spain," *Soc. Sci. Med.*, vol. 135, pp. 24–30, 2015, doi: 10.1016/j.socscimed.2015.04.016.
[53] E. Leslie and E. Cerin, "Are perceptions of the local environment related to neighbourhood satisfaction and mental health in adults?," *Prev. Med. (Baltim).*, vol. 47, no. 3, pp. 273–278, 2008, doi: 10.1016/j.ypmed.2008.01.014.
[54] L. Richard, L. Gauvin, C. Gosselin, and S. Laforest, "Staying connected: Neighbourhood correlates of social participation among older adults living in an urban environment in Montréal, Québec," *Health Promot. Int.*, vol. 24, no. 1, pp. 46–57, 2009, doi: 10.1093/heapro/dan039.
[55] H. Chaudhury, M. Campo, Y. Michael, and A. Mahmood, "Neighbourhood environment and physical activity in older adults," *Soc. Sci. Med.*, vol. 149, pp. 104–113, Jan. 2016, doi: 10.1016/j.socscimed.2015.12.011.
[56] J. Bangsbo *et al.*, "Copenhagen Consensus statement 2019: physical activity and ageing," *Br. J. Sports Med.*, vol. 53, no. 14, pp. 856 LP – 858, Jul. 2019, doi: 10.1136/bjsports-2018-100451.
[57] A. S. Slingerland *et al.*, "Aging, retirement, and changes in physical activity: Prospective cohort findings from the GLOBE study," *Am. J. Epidemiol.*, vol. 165, no. 12, pp. 1356–1363, 2007, doi: 10.1093/aje/kwm053.
[58] T. Hanibuchi, I. Kawachi, T. Nakaya, H. Hirai, and K. Kondo, "Neighborhood built environment and physical activity of Japanese older adults: Results from the Aichi Gerontological Evaluation Study (AGES)," *BMC Public Health*, vol. 11, 2011, doi: 10.1186/1471-2458-11-657.
[59] Y. Yang, D. He, Z. Gou, R. Wang, Y. Liu, and Y. Lu, "Association between street greenery and walking behavior in older adults in Hong Kong," *Sustain. Cities Soc.*, vol. 51, p. 101747, 2019.
[60] V. Van Holle *et al.*, "The association between Belgian older adults' physical functioning and physical activity: What is the moderating role of the physical environment?," *PLoS One*, vol. 11, no. 2, pp. 1–17, 2016, doi: 10.1371/journal.pone.0148398.
[61] N. C. Huang, S. F. Kung, and S. C. Hu, "The relationship between urbanization, the built environment, and physical activity among older adults in Taiwan," *Int. J. Environ. Res. Public Health*, vol. 15, no. 5, pp. 1–20, 2018, doi: 10.3390/ijerph15050836.
[62] E. Portegijs, K. E. Keskinen, L. T. Tsai, T. Rantanen, and M. Rantakokko, "Physical limitations, walkability, perceived environmental facilitators and physical activity of older adults in Finland," *Int. J. Environ. Res. Public Health*, vol. 14, no. 3, 2017, doi: 10.3390/ijerph14030333.
[63] S. Lotfi and M. J. Koohsari, "Neighborhood Walkability in a City within a Developing Country," *J. Urban Plan. Dev.*, vol. 137, no. 4, pp. 402–408, Nov. 2011, doi: 10.1061/(ASCE)UP.1943-5444.0000085.
[64] E. Cerin, A. Barnett, C. J. P. Zhang, P. C. Lai, C. H. P. Sit, and R. S. Y. Lee, "How urban densification shapes walking behaviours in older community dwellers: A cross-sectional analysis of potential pathways of influence," *Int. J. Health Geogr.*, vol. 19, no. 1, pp. 1–18, 2020, doi: 10.1186/s12942-020-00210-8.
[65] L. F. Gómez *et al.*, "Built Environment Attributes and Walking Patterns Among the Elderly Population in Bogotá," *Am. J. Prev. Med.*, vol. 38, no. 6, pp. 592–599, 2010, doi: 10.1016/j.amepre.2010.02.005.
[66] N. A. Gallagher, K. A. Gretebeck, J. C. Robinson, E. R. Torres, S. L. Murphy, and K. K. Martyn, "Neighborhood factors relevant for walking in older, Urban, African American adults," *J. Aging Phys. Act.*, vol. 18, no. 1, pp. 99–115, 2010, doi: 10.1123/japa.18.1.99.
[67] B. I. Chen, M. C. Hsueh, R. Rutherford, J. H. Park, and Y. Liao, "The associations between neighborhood walkability attributes and objectively measured physical activity in older adults," *PLoS One*, vol. 14, no. 9, pp. 1–12, 2019, doi: 10.1371/journal.pone.0222268.
[68] J. Van Cauwenberg *et al.*, "Using manipulated photographs to identify features of streetscapes that may encourage older adults to walk for transport," *PLoS One*, vol. 9, no. 11, 2014, doi: 10.1371/journal.pone.0112107.
[69] K. Brookfield, C. W. Thompson, and I. Scott, "The uncommon impact of common environmental details on walking in older adults," *Int. J. Environ. Res. Public Health*, vol. 14, no. 2, 2017, doi: 10.3390/ijerph14020190.
[70] E. Portegijs, K. E. Keskinen, J. Eronen, M. Saajanaho, M. Rantakokko, and T. Rantanen, "Older Adults' Physical Activity and the Relevance of Distances to Neighborhood Destinations and Barriers to Outdoor Mobility," *Front. Public Heal.*, vol. 8, no. August, pp. 1–

11, 2020, doi: 10.3389/fpubh.2020.00335.

[71] E. Cerin, C. H. P. Sit, A. Barnett, J. M. Johnston, M. C. Cheung, and W. M. Chan, "Ageing in an ultra-dense metropolis: perceived neighbourhood characteristics and utilitarian walking in Hong Kong elders," *Public Health Nutr.*, vol. 17, no. 1, pp. 225–232, 2014, doi: 10.1017/S1368980012003862.

[72] F. Gaglione, C. Gargiulo, and F. Zucaro, "ELDERS' QUALITY OF LIFE. A METHOD TO OPTIMIZE PEDESTRIAN ACCESSIBILITY TO URBAN SERVICES," *TeMA - J. L. Use, Mobil. Environ.*, vol. 3, pp. 295–312, Dec. 2019, doi: 10.6092/1970-9870/6272.

[73] D. Ettema and M. Schekkerman, "How do spatial characteristics influence well-being and mental health? Comparing the effect of objective and subjective characteristics at different spatial scales," *Travel Behav. Soc.*, vol. 5, pp. 56–67, 2016, doi: 10.1016/j.tbs.2015.11.001.

[74] M. J. Koohsari *et al.*, "Urban design and Japanese older adults' depressive symptoms," *Cities*, vol. 87, no. April 2018, pp. 166–173, 2019, doi: 10.1016/j.cities.2018.09.020.

[75] J. Kerr, D. Rosenberg, and L. Frank, "The Role of the Built Environment in Healthy Aging: Community Design, Physical Activity, and Health among Older Adults," *J. Plan. Lit.*, vol. 27, no. 1, pp. 43–60, 2012, doi: 10.1177/0885412211415283.

[76] A. Bierman, "Marital status as contingency for the effects of neighborhood disorder on older adults' mental health," *Journals Gerontol. - Ser. B Psychol. Sci. Soc. Sci.*, vol. 64, no. 3, pp. 425–434, 2009, doi: 10.1093/geronb/gbp010.

[77] D. Fone, F. Dunstan, K. Lloyd, G. Williams, J. Watkins, and S. Palmer, "Does social cohesion modify the association between area income deprivation and mental health? A multilevel analysis," *Int. J. Epidemiol.*, vol. 36, no. 2, pp. 338–345, 2007, doi: 10.1093/ije/dym004.

[78] L. D. Kubzansky, S. V. Subramanian, I. Kawachi, M. E. Fay, M. J. Soobader, and L. F. Berkman, "Neighborhood contextual influences on depressive symptoms in the elderly," *Am. J. Epidemiol.*, vol. 162, no. 3, pp. 253–260, 2005, doi: 10.1093/aje/kwi185.

[79] E. M. Berke, L. M. Gottlieb, A. V. Moudon, and E. B. Larson, "Protective Association Between Neighborhood Walkability and Depression in Older Men," *J. Am. Geriatr. Soc.*, vol. 55, no. 4, pp. 526–533, Apr. 2007, doi: https://doi.org/10.1111/j.1532-5415.2007.01108.x.

[80] A. Curl, H. Fitt, and M. Tomintz, "Experiences of the built environment, falls and fear of falling outdoors among older adults: An exploratory study and future directions," *Int. J. Environ. Res. Public Health*, vol. 17, no. 4, 2020, doi: 10.3390/ijerph17041224.

[81] A. A. 2011 Gale, C. R., Dennison, E. M., Cooper, C., & Sayer, "Neighbourhood environment and positive mental health in older people," *Heal. Place*, vol. 17, no. 4, pp. 687–74, 2011.

[82] M. Dennis, P. A. Cook, P. James, C. P. Wheater, and S. J. Lindley, "Relationships between health outcomes in older populations and urban green infrastructure size, quality and proximity," *BMC Public Health*, vol. 20, no. 1, pp. 1–15, 2020, doi: 10.1186/s12889-020-08762-x.

[83] C. Wen, C. Albert, and C. Von Haaren, "The elderly in green spaces: Exploring requirements and preferences concerning nature-based recreation," *Sustain. Cities Soc.*, vol. 38, pp. 582–593, 2018.

[84] G. Gee and D. Takeuchi, "Traffic stress, vehicular burden and well-being: A multilevel analysis," *Soc. Sci. Med.*, vol. 59, pp. 405–414, Aug. 2004, doi: 10.1016/j.socscimed.2003.10.027.

[85] S. Ivey *et al.*, "Neighborhood characteristics and depressive symptoms in an older population," *Aging Ment. Health*, vol. 19, pp. 1–10, Oct. 2014, doi: 10.1080/13607863.2014.962006.

[86] G. Melis, E. Gelormino, G. Marra, E. Ferracin, and G. Costa, "The effects of the urban built environment on mental health: A cohort study in a large northern Italian city," *Int. J. Environ. Res. Public Health*, vol. 12, no. 11, pp. 14898–14915, 2015, doi: 10.3390/ijerph121114898.

[87] D. Saarloos, H. Alfonso, B. Giles-Corti, N. Middleton, and O. P. Almeida, "The Built Environment and Depression in Later Life: The Health In Men Study," *Am. J. Geriatr. Psychiatry*, vol. 19, no. 5, pp. 461–470, 2011, doi: https://doi.org/10.1097/JGP.0b013e3181e9b9bf.

[88] J. Gehl, *Life Between Buildings: Using Public Space*, vol. 8, no. 1. 1989.

[89] R. D. Russel, "Social health: An attempt to clarify this dimension of wellbeing," 1973.

[90] L. Fratiglioni, S. Paillard-Borg, and B. Winblad, "An active and socially integrated lifestyle in late life might protect against dementia," *Lancet Neurol.*, vol. 3, no. 6, pp. 343–353, 2004, doi: 10.1016/S1474-4422(04)00767-7.

[91] H. Khosravi, F. Gharai, and S. Taghavi, "The impact of local built environment attributes on the elderly sociability," *Int. J. Archit. Eng. Urban Plan.*, vol. 25, no. 1, pp. 21–30, 2015.

[92] T. Schmidt, J. Kerr, and J. Schipperijn, "Associations between neighborhood open space features and walking and social interaction in older adults-a mixed methods study," *Geriatr.*, vol. 4, no. 3, 2019, doi: 10.3390/geriatrics4030041.

[93] R. Newton, M. Ormerod, E. Burton, L. Mitchell, and C. Ward-Thompson, "Increasing independence for older people through good street design," *J. Integr. Care*, vol. 18, no. 3, pp. 24–29, 2010, doi: 10.5042/jic.2010.0246.

[94] E. Portegijs, L. T. Tsai, T. Rantanen, and M. Rantakokko, "Moving through life-space areas and objectively measured physical activity of older

people," *PLoS One*, vol. 10, no. 8, pp. 1–12, 2015, doi: 10.1371/journal.pone.0135308.

[95] S. Lotfi and M. J. Koohsari, "Neighborhood Walkability in a City within a Developing Country," *J. Urban Plan. Dev.*, vol. 137, no. 4, pp. 402–408, 2011, doi: 10.1061/(asce)up.1943-5444.0000085.