ORIGINAL ARTICLE

Exploring the Role of the Built Environment on the Functional Ability and Social Participation in Community-dwelling Older Adults

Jennifer Marie J. Yang, MD, MCHealth&M[1] and Louise Stone, MBBS, MPH, MQHR, MSHCT, PhD[2]

[1]*Department of Rehabilitation Medicine, Philippine General Hospital, University of the Philippines Manila*
[2]*College of Health and Medicine, School of Medicine and Psychology, Australian National University*

ABSTRACT

Background and Objectives. The built environment or physical environment consists of surroundings and conditions constructed by human activity. It includes urban design, neighborhoods, transportation, and smaller scale structures like the design and layout of rooms within buildings. The built environment can affect the physical, social, and functional wellbeing of older adults, both within their own homes and in the neighborhoods in which they live, and additionally plays a part in promoting healthy aging. This narrative review of the literature aims to present the ways in which the built environment can influence the functional ability of community-dwelling older adults, and affect their ability to live independently and age in place.

Methods. Narrative literature review and inductive thematic analysis.

Results. Forty-five full-text, English language publications from peer-reviewed sources were selected for this review, with the majority (35) presenting quantitative research findings and originating from North America (28). Older adults in rural and developing countries were underrepresented in the literature, despite acknowledgement that health of the aging population is a worldwide problem. Three major themes emerged. First, the built environment affects older adults in the most fundamental way at home through design considerations, modifications, and technological advances promoting aging in place and accessibility. Secondly, built environments outside the home can affect older adults' physical activity and overall function with regard to mobility, transportation, and activities of daily living. The majority (22 of 45 publications) focused on this theme. Finally, the built environment in neighborhoods can affect older adults' perception of social support, their social participation, and quality of life.

Conclusion. As the built environment is created by humans and can be substantially modified, it possesses considerable potential for enhancing functional ability, social participation, and overall quality of life in community-dwelling older adults. It is possible to design a better person-environment fit, promoting safety, independence, optimal health, and quality of life. In order to support healthy aging, improvements in the built environment need to be accompanied by appropriate health and social policies, systems, and services. These changes require political will, as well as material resources that may not be readily available especially in the global South. A socioecological approach with adequate resources directed to older adults' health and healthcare is necessary in order to achieve the ultimate goal of healthy aging in this population.

Keywords: built environment, healthy aging, quality of life, social participation, physical activity, independent living

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Corresponding author:
Jennifer Marie J. Yang, MD, MCHealth&M
Department of Rehabilitation Medicine
Philippine General Hospital
University of the Philippines Manila
Taft Avenue, Ermita, Manila 1000, Philippines
Email: jjyang1@up.edu.ph
ORCiD: https://orcid.org/0000-0002-5147-2855

INTRODUCTION

Major medical and social factors impact the health of aging populations worldwide.[1] The United Nations (UN) has responded to this by declaring 2021-2030 as the Decade of Healthy Aging, an intersectoral collaboration led by the World Health Organization (WHO) that aims to "improve the lives of older adults, their families and the communities in which they live."[2] *Healthy aging* is "the process of developing and maintaining the functional ability that enables wellbeing in older age."[3] This definition emphasizing functional ability marks a shift from defining health as the absence of disease or infirmity, as many older adults have "well-controlled health conditions that minimally influence their wellbeing."[3]

Functional ability "comprises the health-related attributes that enable people to be and do what they have reason to value,"[3] which includes a person's capabilities to meet their basic needs; learn, grow, and make decisions; be mobile; build and maintain relationships; and contribute to society.[3,4] Mobility and activities of daily living (ADLs) are the most common measurable components of functional ability. ADLs can be further divided into basic ADLs (BADLs) like eating and dressing, and instrumented ADLs (IADLs) such as going shopping for food, using a telephone, or managing medications. Functional ability also involves cognition, communication, and interacting with other people.[2,5,6]

Functional ability is determined by the interaction between intrinsic capacity and a person's environment. *Intrinsic capacity* is the composite of all the physical and mental capacities of an individual.[3] Cesari and co-authors conceptualized intrinsic capacity as having five domains: cognition, locomotion, sensory function, vitality, and psychological.[7] While these domains help with understanding intrinsic capacity, they do not act in isolation but rather interact with each other to represent the individual's health status. However, standardizing and operationalizing the measurement of intrinsic capacity will need better validated and universal measurement tools.[8] Disease, injury, and age-related changes are important factors that influence intrinsic capacity,[3] which in turn affect a person's functional ability.

While functional ability and intrinsic capacity pertain to individual attributes, the *environment* consists of factors external to older adults, forming the context in which they live.[3] The environment is comprised of the built environment, people and their relationships, attitudes and values, health and social policies, and the systems and services that enable their implementation. Environments that support and maintain older adults' intrinsic capacity and functional ability promote and facilitate healthy aging.[3]

The *built environment*, or *physical environment*, consists of surroundings and conditions constructed by human activity. It encompasses large scale urban design, neighborhoods, land use, and the transportation system, as well as smaller scale structures like the design and layout of rooms within buildings.[9,10] The built environment influences the functional ability of older adults and conversely affects their ability to *age in place*. Aging in place refers to the preference of the older adult to live independently in their own residence and neighborhoods for as long as possible.[11-13]

Two theoretical models are key to understanding the relationship between older adults and the environment. First, the *person-environment fit* is a theoretical model explaining the relationship between the individual's capacity and demands of the environment giving rise to certain behaviors.[14,15] By lowering the demands made by the environment, the individual's capacity for activity can be improved even if functional status declines.[14]

Secondly, the *disablement process*[16] is a sociomedical model that describes a pathway through which chronic and acute conditions affect ADLs, accounting for the social, psychological, and environmental factors that can speed up or slow down disablement. Pathology (injury or diagnosis of disease) causes impairments (abnormalities in body structure or dysfunction of organ systems) leading to functional limitations (restrictions in basic physical and metal actions), and lastly to disability (difficulty doing ADLs). However, the disablement process is moderated by personal and environmental factors: the model divides these into *intra-individual factors* like lifestyle and behavior changes, activity accommodations, psychosocial attributes and coping skills, and *extra-individual factors* such as medical care and rehabilitation, medications and other therapeutic regimens, external supports, and the built, physical, and social environment.

The disablement process facilitates an understanding of how the built environment can improve or worsen a person's functional ability. Being man-made, the built environment is arguably the most easily modifiable feature of the environment: aspects of the built environment can be designed to "support health and wellbeing, social interactions, and environmental sustainability."[10] Additionally, health promotion through the built environment is something all individuals can act upon since we all live and engage with the built environment daily.[10]

This narrative review of the literature aims to present the numerous ways in which the built environment can influence the functional ability of community-dwelling older adults.

METHODS

A narrative review aims to identify and synthesize previously published evidence from the literature regarding a specific healthcare subject.[17,18] While not designed to answer a specific research question, narrative reviews enable the reader to obtain a broad perspective on the topic of interest.[18] A narrative review does not need to follow a specific protocol that guides the review,[19] nor be registered with the International Prospective Register of Systematic Reviews (PROSPERO), which accepts only systematic, rapid or umbrella reviews[20].

The search strategy was developed in consultation with an information specialist, resulting in the identification of relevant electronic databases and keywords for research.

Peer-reviewed literature from all time up to the year 2021 was searched in August and September 2021 using Scopus, PubMed, and Google Scholar databases. The search was limited to full-text articles and reviews in the English language. Keywords included "functional ability OR intrinsic capacity OR disability" AND "older adult OR aging OR age* OR elderly" AND "community dwelling" AND "environment OR social". References and citations within the literature identified were also scanned to gather other articles. Papers describing the interactions between the built environment and individuals 60 years old and above were selected for inclusion. This age limit was chosen because the UN Decade of Healthy Aging initiative addresses the healthcare needs of persons in this age group. UN and WHO publications were also included in the search since their definitions of functional ability, intrinsic capacity, and environment form the framework for healthy aging.

Database searches yielded a total of 2,626 articles; within these articles, additional relevant references brought the total number to 2,635. These were screened by title and abstract to yield 491 papers for consideration. After removal of duplicates (154 papers), the remaining 337 full-text articles were assessed for eligibility. Ultimately, 67 articles discussed the built environment and its effect on older adults; however, only 45 papers remained after removing studies which included participants younger than 60 years old.

Both authors agreed upon the papers to be included in the narrative review. Disagreements were resolved by discussion among authors. The articles were read and re-read by one author (JMJY) to enable familiarization with the literature. The papers were then subjected to thematic analysis in order to identify recurring themes, patterns, commonalities, and differences.[21] The inductive approach was aided by thematic coding with the assistance of NVivo software version 12 (QSR International) for storage, organization, and retrieval of data. This research was exempt from ethical review because it met the criteria for negligible risk research and involved the use of existing collections of data or records that contain only non-identifiable data about human beings.[22]

RESULTS

This narrative review encompasses publications from the last two decades, with the majority being published in the mid-to-late 2010s (Table 1). The literature reflects the world's aging population and a growing interest in their overall health and prevention of disability. The 45 articles in this review included 28 originating from North America, seven from Asia, five from Europe, two from Australia, two from South America, and one from Africa. Thirty-five publications demonstrated findings from quantitative research, five described qualitative research, four were literature reviews, and one was an opinion piece.

Three main themes emerged from the literature search. First, the built environment affects older adults in the most fundamental way at home. Secondly, built environments outside the home can affect older adults' physical activity and overall function; the majority (22 of 45) studies included in this review centered around this theme. Finally, the built environment in neighborhoods can affect older adults' perception of social support, their social participation, and quality of life.

Home Environments

Designing the Home

Community-dwelling older adults interact most frequently with the built environment in their own homes. Removing environmental barriers in the homes of older adults with disabilities may improve functional performance. Stark implemented an occupational therapy program that made architectural modifications of the home and provided adaptive equipment for ADLs. The study found that older adults were more satisfied and performed ADLs more easily after this intervention.[23]

An American study found the most common modifications included adding grab bars and shower seats, special railings, ramps at street level, and the presence of wheelchair access. Being older, female, having higher income, poorer self-ratings of health, having fallen in the last 12 months, fracturing a hip and surgically repairing a joint, having diseases like arthritis, diabetes, and stroke were correlated with having grab bars and showers. However, Hispanic and African American older adults were underrepresented among those with home modifications, indicating a socioeconomic and ethnic divide among the participants in the study.[24]

Mackenzie, Curryer and Byles conducted a qualitative study consisting of semi-structured interviews of Australian individuals 75-79 years old. The study focused on their ability to age in place and explored reasons for wanting to stay in their homes as they aged.[13] Participants were satisfied with their homes and its functionality as a space for children, family, socializing, and activities; they perceived houses as their castles, in which they had poured personal investment and built themselves. However, some participants noted difficulty keeping up with home maintenance problems over time, while others had ongoing improvement projects involving re-organizing the home, adding extensions or modifications. Their solutions included getting tradesmen to undertake these tasks, slowing down, avoiding strenuous activities, and using ladders, and planning to live downstairs in a two-storey home.

Home Accessibility

A Japanese study further demonstrated the complex relationship between home accessibility and disability. Women who have stairs to access the home had a lower risk of decline with regard to performing IADLs, compared to women who live in homes with elevator access.[25] This aligns with other studies showing that greater amounts of physical activity

Table 1. Papers Included in the Review

No.	Authors	Year	Country of origin	Title	Type of paper	No. of participants	Age of participants (in years)	Culture/ethnicity of participants	Comments
1	Barnett et al.	2017	Australia	Built environmental correlates of older adults' total physical activity and walking: a systematic review and meta-analysis	Literature review	N/A	65+	N/A	
2	Brown et al.	2009	USA	The relationship of built environment to perceived social support and psychological distress in Hispanic elders: the role of "eyes on the street"	Research - quantitative	273	70+	Hispanic (criteria: born in a Spanish-speaking country)	Hispanic Elders' Behavioral Health Study
3	Brown et al.	2009	USA	The relationship of neighborhood climate to perceived social support and mental health in older Hispanic immigrants in Miami, Florida	Research - quantitative	273	70+	Hispanic (criteria: born in a Spanish-speaking country)	Hispanic Elders' Behavioral Health Study
4	Carlson et al.	2012	USA	Interactions between psychosocial and built environment factors in explaining older adults' physical activity	Research - quantitative	718	74.4 (SD 6.3)	70.7% Non-Hispanic white	Population from two areas – Baltimore, Maryland/ Washington, DC; and Seattle-King County, Washington
5	Cho, Cook and Bruin	2012	USA	Functional ability, neighborhood resources and housing satisfaction among older adults in the U.S.	Research - quantitative	10,146	65+	82% White, 94% Non-Hispanic	American Housing Survey
6	Chudyk et al.	2015	Canada	Destinations matter: The association between where older adults live and their travel behavior	Research - quantitative	161	65+	Not stated	
7	Clarke	2014	USA	The role of the built environment and assistive devices for outdoor mobility in later life	Research - quantitative	8,245	65+	80.5% White non-Hispanic, 8.2% Black non-Hispanic, 4.6% Hispanic, 6.7% Other	National Health and Aging Trends Study (NHATS)
8	Crews	2005	USA	Artificial environments and an aging population: designing for age-related functional losses	Opinion (expert perspective)	N/A	N/A	N/A	
9	Engel et al.	2016	Canada	Older adults' quality of life - Exploring the role of the built environment and social cohesion in community-dwelling seniors on low income	Research - quantitative	160	65+	Not stated	
10	Etman et al.	2016	Netherlands	Residential area characteristics and disabilities among Dutch community-dwelling older adults	Research - quantitative	271	65+	Not stated	Elderly and their Neighborhood (ELANE) study
11	Ferreira et al.	2010	Brazil	Aging and urbanization: The neighborhood perception and functional performance of elderly persons in Belo Horizonte Metropolitan Area-Brazil	Research - quantitative	1,611	60+	Not stated	
12	Fogal et al.	2019	Brazil	Built urban environment and functional incapacity: Enabling healthy aging	Research - quantitative	410	60+	Not stated	
13	Henning-Smith	2017	USA	Where do community-dwelling older adults with disabilities live? Distribution of disability in the United States of America by household composition and housing type	Research - quantitative	504,371	65+	79.2% Non-Hispanic White, 7.4% Hispanic, 8.4% Non-Hispanic Asian/Hawaiian/Pacific Islander, 1.3% Non-Hispanic Other	American Community Survey
14	Ienca et al.	2021	Switzerland	Digital health interventions for healthy ageing: a qualitative user evaluation and ethical assessment	Research - qualitative	19	65+	Not stated	May have selection bias for people who are already used to using digital technology
15	Ivey et al.	2015	USA	Neighborhood characteristics and depressive symptoms in an older population	Research - quantitative	870	65+	Not stated	Healthy Aging Research Network – four study sites across the USA
16	Keysor et al.	2010	USA	Community environmental factors are associated with disability in older adults with functional limitations: the MOST study	Research - quantitative	435	65+	Not stated	Multicenter Osteoarthritis Study (MOST), looking at knee pain and disability
17	King et al.	2011	USA	Aging in neighborhoods differing in walkability and income: associations with physical activity and obesity in older adults	Research - quantitative	719	66+	Not stated	Population from two areas – Baltimore, Maryland/ Washington, DC; and Seattle-King County, Washington
18	Levasseur et al.	2015	Canada	Importance of proximity to resources, social support, transportation and neighborhood security for mobility and social participation in older adults: results from a scoping study	Literature Review	N/A	N/A	N/A	Most articles were from urban settings in the USA and Canada; few from Europe, Asia and South America
19	Levasseur et al.	2004	Canada	Relationships between environment and quality of life of older adults with physical disabilities	Research - quantitative	46	60+	Not stated	
20	Levasseur et al.	2008	Canada	Subjective quality-of-life predictors for older adults with physical disabilities	Research - quantitative	49	60+	Not stated	Longitudinal study
21	Lien et al.	2014	Taiwan	Relationship of perceived environmental barriers and disability in community-dwelling elderly in Taiwan - a population-based study	Research - quantitative	200	65+	Not stated	
22	Lu et al.	2021	Hong Kong, China	Neighborhood physical environment, intrinsic capacity, and 4-year late-life functional ability trajectories of low-income Chinese older population: A longitudinal study with the parallel process of latent growth curve modelling	Research - quantitative	2,081	65+	Not stated	Longitudinal study looking at functional ability trajectory
23	Mackenzie, Curryer and Byles	2015	Australia	Narratives of home and place: findings from the Housing and Independent Living Study	Research - qualitative	202	75-79	Not stated	Focused on aging in place

Table 1. Papers Included in the Review *(continued)*

No.	Authors	Year	Country of origin	Title	Type of paper	No. of participants	Age of participants (in years)	Culture/ethnicity of participants	Comments
24	Marquez et al.	2016	USA	A qualitative exploration of factors associated with walking and physical activity in community-dwelling older Latino adults	Research - qualitative	20	60+	Hispanic; stratified by gender and preferred language (English and Spanish)	
25	Mendes de Leon et al.	2009	USA	Neighborhood Social Cohesion and Disorder in Relation to Walking in Community-Dwelling Older Adults	Research - quantitative	6,158	65+	73% Black	Chicago Neighborhood and Disability Study
26	Momosaki et al.	2019	Japan	Association between food store availability and the incidence of functional disability among community-dwelling older adults: results from the Japanese Gerontological Evaluation Cohort Study	Research - quantitative	31,273	65+	Not stated	Japan Gerontological Evaluation Study (JAGES)
27	Murayama et al.	2012	Japan	Contextual effect of neighborhood environment on homebound elderly in a Japanese community	Research - quantitative	572	65+	Not stated	
28	Nathan et al		USA	The role of the built environment on health across the life course: a call for CollaborACtiON	Literature review	N/A	N/A	N/A	Addresses promoting health of people of all ages across the lifecourse
29	Oyeyemi et al.	2019	Nigeria	Neighborhood environmental factors are related to health-enhancing physical activity and walking among community dwelling older adults in Nigeria	Research - quantitative	353	60+	Not stated	The only paper from Africa
30	Pearce et al.	2012	Australia	Robotics to enable older adults to remain living at home	Literature review	N/A	N/A	N/A	Papers from 1990-2012
31	Portegijs et al.	2017	Finland	Physical limitations, walkability, perceived environmental facilitators and physical activity of older adults in Finland	Research - quantitative	787	75-90	Not stated	
32	Rantakokko et al.	2013	Sweden	Environmental barriers, person-environment fit and mortality among community-dwelling very old people	Research - quantitative	397	80-89	Not stated	Mortality rate may be overestimated based on the age of the population studied
33	Samuel et al.	2015	USA	Household and neighborhood conditions partially account for associations between education and physical capacity in the National Health and Aging Trends Study	Research - quantitative	6,874	65+	80.5% White non-Hispanic, 8.2% Black non-Hispanic, 4.6% Hispanic, 6.7% Other	National Health and Aging Trends Study (NHATS)
34	Satariano et al.	2010	USA	Lower-body function, neighborhoods, and walking in an older population	Research - quantitative	885	65+	66.6% White, 23.8% African American, 6.2% Asian, 1.8% two or more races, 1.6% other race	Healthy Aging Research Network - four study sites across the USA
35	Stark	2004	Canada	Removing environmental barriers in the homes of older adults with disabilities improves occupational performance	Research - quantitative	29	67.3 (SD 9.9)	22 African American, 5 White, 1 Asian, 1 Other	Occupational Therapy study
36	Seo et al.	2021	Korea	Differences in the association of neighborhood environment with physical frailty between urban and rural older adults: the Korean Frailty and Aging Cohort Study (KFACS)	Research - quantitative	2,593	70-84	Not stated	
37	Shumway-Cook et al.	2002	USA	Environmental demands associated with community mobility in older adults with and without mobility disabilities	Research - quantitative	36	70+	Not stated	One of the earliest studies looking at environmental factors and mobility disability
38	Shumway-Cook et al.	2003	USA	Environmental components of mobility disability in community-living older persons	Research - quantitative	54	70+	Not stated	Stratified participants into elite (able to exercise and play competitive sport), physically able, and physically disabled
39	Smith et al.	2016	USA	Trajectories of outdoor mobility in vulnerable community-dwelling elderly: the role of individual and environmental factors	Research - quantitative	2,288	78.7 (SD 10)	78% African American	
40	Soma et al.	2017	Japan	Relationship between built environment attributes and physical function in Japanese community-dwelling older adults	Research - quantitative	509	65-86	Not stated	Rural region population
41	Tabbarah, Silverstein and Seeman	2000	USA	A health and demographic profile of noninstitutionalized older Americans residing in environments with home modifications	Research - quantitative	6551	70+	85% Caucasian, 10.9% African American, 4.1% Hispanic	Survey of Asset and Health Dynamics of the Oldest Old (AHEAD) study
42	Tomioka, Kurumatani and Hosoi	2018	Japan	Association between stairs in the home and instrumental activities of daily living among community-dwelling older adults	Research - quantitative	14,956	65+	Japanese	
43	Tong et al.	2020	Canada	These Few Blocks, These Are My Village": The physical activity and mobility of foreign-born older adults	Research - qualitative	18	66-81	44.5% Chinese, 55% South Asian	Facilitators of physical activity in foreign-born older adults
44	Van Holle et al.	2016	Belgium	Interactions between neighborhood social environment and walkability to explain Belgian older adults' physical activity and sedentary time	Research - quantitative	431	74.4 (SD 6.2)	Not stated	Only study that looks at physical activity and sedentary behavior
45	Wang and Shepley	2018	USA	Can aging-in-place be promoted by the built environment near home for physical activity: a case study of non-Hispanic White elderly in Texas	Research - quantitative	206	65+	89% Non-Hispanic White	May be subject to recall bias; involves a questionnaire about their previous home and neighborhood prior to moving to a senior living facility

(PA) are linked to slowing down functional decline.[26-28] However, the authors point out that they do not suggest all older adults live in walk-up residences and therefore continue to advocate for barrier-free housing.

Clarke found that ramps facilitated outdoor mobility for any assistive device, while stairs pose a significant barrier to the ability to leave the house especially for people using walkers.[12] Unfortunately, her database of 6,000 Americans showed 75% had stairs to enter their house while only 10% had ramps, and 13% reported broken steps or uneven walking surfaces that can also increase the risk for falling. Similarly, a Swedish longitudinal study noted that a lack of handrails at stairs and entrances were associated with a high mortality risk in a cohort of individuals with functional limitations aged 80-89 years old,[29] although this data from this study must be interpreted with caution as older age and health status are possible confounders.

Digital Technology and Robotics

Digital health technologies can help maintain functional independence as part of healthy aging. These technologies have a role in improving quality of life and mitigating the socio-economic effects of aging. A literature review focusing on factors influencing acceptance of technology for aging in place by community-dwelling older adults found that technology was most commonly utilized for enhancing safety or providing social interaction. Some of the factors affecting acceptance included cost, usability, expected benefits, perceived need for technology, social influence, and the desire to age in place.[30]

A Swiss qualitative study with 19 community-dwelling older adults explored their views, needs, and perceptions regarding digital technologies for healthy aging.[31] Through interviews involving abstract reflections and hands-on practical demonstrations for a smartphone application (app), wearable device, and conversational robot, the researchers found that older adults viewed digital health technologies positively and were receptive to their use for promoting independent living, and ensuring safety and access. However, they also raised ethical concerns like privacy, safety, and surveillance. A selection bias may have limited the study since participants were already familiar with using smartphones and computers.

While robotic technology was available to assist with older adults' independence and social connectedness, limited evidence existed for its actual use.[32] A systematic review and critical evaluation of the literature found that most studies were conducted in hospitals and clinics instead of the home setting where robotic devices should eventually be utilized.

The Built Environment and Physical Activity

General Considerations

Wellbeing in older persons is influenced by the environment of the neighborhoods in which they live. A scoping review found mobility and social participation had positive associations with proximity to resources and recreational facilities, social support, having a car or driver's license, public transportation, and neighborhood security. Conversely, they were negatively associated with neighborhood insecurity and poor user-friendliness of the walking environment.[33]

Carlson et al. explored the interactions between psychosocial and environmental correlations with mobility-related moderate to vigorous physical activity (MVPA), showing that multilevel interventions may be more effective than targeting just one set of factors.[34] The authors used objective data from a wearable accelerometer and self-reported walking to measure physical activity (PA). They looked at the effects of psychosocial factors (*e.g.,* social support, barriers, and self-efficacy) and environmental factors (*e.g.,* neighborhood aesthetics, walking facilities, and access to parks and recreation facilities). Living in a supportive environment and having positive psychosocial attributes was related to 30-59 more minutes per week of MVPA; those in the same supportive environment but less positive psychosocial attributes only gained 0-28 more minutes per week.[34]

An American qualitative study among older Latino adults complemented the findings above, exploring socioecological factors associated with walking and PA through a series of focus groups addressing motivations and concerns underpinning PA.[35] Participants were aware of the health benefits of exercise and enjoyed walking but had concerns for neighborhood safety – both safety from crime and built environment obstacles like uneven sidewalks and fast vehicular traffic.

The Korean Frailty and Aging Cohort Study[36] involving older adults in urban and rural communities looked at the relationship between perceived neighborhood environments and physical frailty. In urban areas, frailty was associated with the absence of destinations (*e.g.*, banks or public facilities) and the lack of night-time safety from crime. In rural areas, frailty was associated with poor access to recreational facilities and no aesthetics (*i.e.*, no interesting places to see or pleasing scenery).

A review by Nathan and colleagues summarizes the influence of the built environment over the lifecourse. They point out that studies on the socioecological model of health behavior over the past 30 years have furnished robust evidence supporting its effects on PA and overall wellbeing.[10]

Transport-related Physical Activity: Walking and Cycling

Outdoor environments supportive of PA can promote aging in place for longer periods of time. Persons who could easily walk around their buildings, and those with at least one neighborhood destination within walking distance were able to stay at home at least 3 years longer than other individuals.[37] Chudyk and co-authors found a positive correlation between number of transportation-related walking trips per day and the most common destinations such as grocery stores, malls, and restaurants/cafes among community-dwelling

older adults.[27] A Japanese study specifically studied access to grocery stores, because the authors hypothesized that older adults' main reason for leaving the house is to shop for food, and thus food accessibility within the walkable neighborhood may influence an individual's functional disability.[38] After adjusting for multiple demographic and medical attributes like comorbidities and body mass index, the researchers found that early onset of disability was associated with low food store availability. Conversely, a community's neighborhood environment can be one of the factors in a person's decision to remain homebound. In a study that defined being homebound as going outdoors once a week or less, low accessibility to non-residential properties like restaurants and retail stores was associated with being homebound, even after adjusting for demographic information, physical, psychological, and social factors.[39]

Beyond increasing PA itself, walkable neighborhoods minimized overall functional disability in Dutch, Brazilian, American, and Nigerian older adults.[28,40-42] Notably, the Dutch[40] and American[28] studies included cycling in addition to walking as transport-related PA. Inhabitants of walkable neighborhoods had lower body mass indices. However, mobility-impaired older adults did less transport-related PA, regardless of neighborhood walkability and degree of impairment.[28]

Mobility and Muscle Strength

Other research has examined the relationship of the built environment with overall PA and specific measures representing PA, such as mobility and muscle strength. A longitudinal study from Finland regarding lower extremity physical limitations and self-reported PA showed that environmental facilitators for walking in the neighborhood (*e.g.*, appealing landscape, good lighting, near services or shops, even sidewalks, resting places by the walking route, no car traffic) were associated with higher odds for reporting moderate PA, but not with step counts.[43]

An American study determined whether the association between poor lower-body capacity and reduced mobility was moderated by characteristics of neighborhood environments.[44] Living in a residential area was associated with less time spent walking, compared to a living in a mixed-use or commercial area. Walking less than 150 minutes per week was also associated with less-compact areas; however, this association was only seen in people with poor lower body strength. Interestingly, residents of more compact areas were more likely to view their neighborhoods as unsafe, especially for those with poor lower body function. These compact areas may have more walking destinations, but greater pedestrian density, car traffic, and more streets to cross present more obstacles to persons who already have balance problems and a fear of falling.

While all the above studies looked at older adults' PA, a study from Belgium additionally measured the amount of sedentary behavior (SB) and explored the moderating effects of neighborhood walkability and neighborhood social factors on both. PA and SB were both self-reported measures.[45] Emphasizing the interaction between built and social environments, residents of highly walkable neighborhoods had a higher frequency of talking to neighbors, related to an increased amount of walking for transport, less television viewing, and less overall SB. These indicate that more frequent informal contacts and opportunities for social interaction encouraged older adults to get out and walk in their neighborhood.

In contrast to the studies in urban areas, Soma and co-authors looked at community-dwelling older adults in rural Japan.[46] They looked at specific physical performance tests, correlating these with population density and the neighborhood destinations related to daily life. Similar to studies based in urban areas, lower population density and lower number of daily life-related destinations led to poorer performance in the physical measures.[46]

Two studies by Shumway-Cook and colleagues looked at how specific environmental factors contributed to mobility disability.[47,48] In the 2002 study, the authors compared adults 70 years and older with and without impaired mobility, defined as the inability to walk 0.8 km (0.5 mile) or climb stairs without assistance. Environmental factors observed in the study included temporal factors (*e.g.,* ability to cross a street within time allotted by traffic light, maintaining appropriate speed of walking), ambient conditions, physical load (*e.g.*, number of packages), terrain, attentional demands, postural transitions (*e.g.,* starting and stopping, or changing directions), distance and traffic density. Overall, persons with mobility deficits took fewer trips, had fewer activities per trip, more fatigue, more difficulty, and were less satisfied with their trips.[47]

The second study by the same group divided older adults based on their level of physical function: elite, physically able, and physically disabled.[48] They answered an Environmental Aspects of Mobility Questionnaire which asked questions about environmental features; in particular they were asked whether they encountered or avoided the environmental factors (*e.g.,* the terrain dimension listed flights of stairs, curbs, uneven surface, and escalators encountered or avoided, while the distance dimension asked about encountering walking distances greater than 10 blocks, vs. avoiding walking those blocks). While the elite group encountered the highest number of challenging physical environment factors, the disabled older adults avoided specific features within the environment posing a challenge to mobility which can lead to further reductions of social interactions and deterioration of physical status. The authors concluded disabled and nondisabled older adults travelled to equivalent locations but dealt with environmental factors differently.[48]

Activities of Daily Living

Aside from mobility, functional capacity also includes the ability to perform activities of daily living (ADLs). A

Taiwanese study explored categories of barriers influencing whether participants needed more assistance in basic ADLs and instrumented ADLs. Authors categorized barriers into services and assistance, attitudes and support, policy, and physical and structural barriers; of the four categories, having physical and structural barriers had the most influence on whether participants needed more assistance in basic ADLs and instrumented ADLs.[6] Keysor and colleagues found community factors such as mobility barriers (*e.g.*, uneven sidewalks, absence of safe parks or places to sit), and transportation facilitators (*e.g.*, public transportation close to home, presence of handicap parking spots) moderated disability. In their study, older adults with functional limitations living in restricted environments felt limited in doing daily activities, but did not perform these activities less frequently.[49]

The functional ability (FA) trajectories (*i.e.*, whether and how fast they declined in function) of over 2,000 older adults in Hongkong were followed over a four-year period. Declining FA trajectories over time were influenced by the participants' intrinsic capacity. FA trajectories were moderated by increased presence of residential green space, leisure, and public transport facilities.[50]

Older adults' functional performance, measured by the number of basic ADLs that they found difficult to perform independently, was found to be related to neighborhood characteristics in Brazil.[5] Out of 1,611 subjects, 47.1% reported needing help carrying out at least one ADL – a number that authors reported to be higher than other Brazilian studies. 84% were satisfied with the neighborhood but did not feel safe; only 18.4% trusted people around them, 78% feared being robbed, and 48.2% feared falling due to sidewalk defects. Among the older adults who had difficulty performing ADLs, modelling showed that having a fear of falling translated into 62% increase in the expected number of ADLs carried out with difficulty.

Neighborhoods and the Social Environment

Social Cohesion and Satisfaction

Social cohesion comprises mutual trust and solidarity among neighbors, along with their supportive social connections, exchange-based behavior, and interactions.[51] Socially cohesive neighborhoods also appear to be one of the factors encouraging older adults to age in place.[13] In a comparison of community-dwelling adults and those living in assisted-living facilities, neighborhood resources affected housing satisfaction more than physical functioning and environmental amenities.[11] Individuals who live in socially cohesive neighborhoods may be more attentive to the needs of their neighbors and participate more in outdoor activities.

Buildings' architectural features were found to be correlated with psychological distress and perception of social support in an American study.[52] Porches, stoops and buildings built above grade (*i.e.*, at least 30 centimeters or 12 inches above sidewalk level) were positively associated with perceived social support. Researchers theorized that these features provided opportunities for person-to-person contact and interaction, encouraging older adults to go outside and facilitating social interactions. On the other hand, larger window areas and lower sill heights "may remove individuals from close person-to-person contact"[52] therefore resulting in reduced feelings of personal social support. Furthermore, the relationship between built environment variables and psychological distress was mediated by perceived social support, suggesting "a two-step process, in which features of the built environment impacted perceived social support, which subsequently impacted psychological distress."[52]

Walkable supportive physical and social environments positively impacted the physical activity and mobility of foreign-born older adults in Canada. The study authors found that physical activity was affected by access to public transport, culturally familiar shops, restaurants and community wellness centers, wellbeing and socialization, gendered identity, and personal biography.[53]

Neighborhood Disorder

Neighborhood disorder refers to "intimidating or threatening social conditions (*e.g.,* lack of safety, presence of strangers) and visible signs of neglect or decay (*e.g.,* trash and litter, crumbling sidewalks)"[51] that can discourage older persons from going out into the neighborhood. Living in a neighborhood with low socio-economic status was linked to increased odds of depressive symptoms.[54] Samuel et al. found that neighborhood and household conditions moderate the effect of education on physical capacity.[55]

A study of over four thousand participants in Chicago demonstrated neighborhood-level disorder was significantly associated with lower levels of self-reported walking, and disorder was also associated with individual-level neighborhood perceptions.[51] These results complement the findings from focus groups showing older adults enjoyed walking and recognize its health benefits, but expressed concerns about safety from crime, fast vehicular traffic, and uneven sidewalks.[35]

Quality of Life

The environment can also potentially shape older adults' quality of life (QOL), especially those with physical disabilities. A longitudinal study[56] examined the predictors of QOL with time points two years apart through the Quality of Life Index (QLI). QOL was favorable overall, in that 10 participants had decreased QOL, 14 with an increase, and 25 remained stable. According to the researchers, this lack of change may be explained by adaptation to physical disabilities and acceptance of disabilities as part of the aging process, which in turn reduce the subjects' expectations. The best predictors of QOL were participation in social roles and fewer obstacles in the physical environment; however, when baseline QLI scores were entered as an independent variable

into the multiple regression model, participation in social roles became the only predictor of QOL at the 2-year time point.

The associations between the built environment, social cohesion and QOL of 160 Canadian older adults were examined by Engel and colleagues.[9] Their findings demonstrate that older adults' capability wellbeing was positively associated with social cohesion, and negatively with street connectivity (*i.e.*, shorter distances between intersections and alternative routes). Authors did not expect the negative association as previous studies showed that better street connectivity facilitates neighborhood walking, shorter trips, increased travel by public transport, and more interactions among neighbors. They theorized that higher street connectivity negatively affects QOL via exposure to more traffic and an increased risk of injury because of declining vision, hearing, and mobility.

DISCUSSION

The articles in this review demonstrate that healthy aging does not occur in isolation. The socioecological model of health behavior takes into account the complex interactions and relationships between individual, social, and environmental factors that influence health behaviors, which in turn can be facilitators or barriers to the physical, mental, and emotional aspects of healthy aging.[10,42] Likewise, the social model of disability focuses on how the individual interacts with the environment – an accessible, inclusive environment benefits the entire population of able-bodied and differently-abled individuals.

The principles of universal design, for example, aim to level the playing field and make accessibility the norm. Level footpaths, sidewalks with ramp access, and automatic sliding doors for buildings enable accessibility not only for the wheelchair user but also the mother with a stroller, older adult with a walker and all individuals. One cannot truly separate the built environment from the other components of the environment as listed by the WHO: the people and their relationships, attitudes and values, health and social policies, and systems and services that affect older adults' intrinsic capacity and functional ability as they live in their communities and societies. In light of an aging population, adapting and designing the built environment to fit older adults' unique needs has become more important.[57] Older adults can feel more secure and independent in homes with adequate lighting, ramps, wide walking lanes formed by strategically placed furniture, and open spaces for free movement.[57] As the home environment can be an important part of an older person's identity, ideally its design characteristics should be facilitators rather than barriers to aging in place.

Individual characteristics, living arrangements, and disability status and their relationship with home accessibility can be viewed as an aspect of the person-environment fit theoretical model.[14,15] Living alone, with children or with other people, in an apartment building or mobile home were all associated with higher odds of having any disability.[58] Disability may predict living arrangements (*e.g.,* a person moving to a more accessible home in order to live alone), and living arrangements can also influence the disablement process, creating a vicious cycle. Similarly, barriers to the entry of the home, such as an unstable front porch or broken steps, were associated with being homebound. Homebound adults were more likely to be older, have more severe mobility impairment, and fearful of falling,[59] which creates another vicious cycle. Those who do not leave the house have poorer health outcomes, and the poorer health decreases their capacity to leave the home. Optimizing the built environment can therefore have a significant impact on older persons' health.

Wellbeing in older persons may also be influenced by the neighborhood in which they live. Identifying factors that may encourage or discourage PA and social participation can have widespread implications for older adults' health. In particular, regular participation in PA has been linked to healthy aging: for example, it prevents and helps manage the risk of chronic diseases like type 2 diabetes, coronary artery disease, some cancers, and age-related disabilities, while also addressing depression, cognitive impairment and social isolation in older adults.[26,27] At least 150 minutes of PA, or 75 minutes of moderate to vigorous physical activity (MVPA) per week is recommended for older adults.[44,60,61] Walking is the preferred and most prevalent PA among older adults: it is low risk, beneficial to health, and contributes substantially to daily energy expenditure.[26] In general, walkable neighborhoods have even footpaths and paved roads; access to destinations, services and public transport; adequate street lighting, traffic safety, and safety from crime; aesthetic elements like green spaces and urban afforestation (placing trees where none were present before); and land-use mix diversity.[26,40-42]

Environmental factors like good lighting, places to rest and low traffic flow increased the likelihood of older people reporting participation in exercise. However, while some studies suggest older people are more likely to be physically active in compact areas where there are good walking destinations, the same areas may also have higher traffic flow and greater risks to safety. Access to services like food shops and transport facilities also seem to support physical activity. "Walkable" areas with higher population density seem to increase opportunities for social interaction, which promotes overall wellbeing. Because there appears to be a difference in the way older people with and without disabilities engage with their environment, it is important for planners to consult with a range of stakeholders to encourage mobility across the elderly population.

A relationship also exists between the perceived quality of the neighborhood environment, functional capability, and frailty. Having more economic revenue in cities can lead to more areas like parks, green spaces, and walking courses, which in turn help prevent frailty by promoting PA and cognitive

stimulation.[36] Access to recreational facilities and safe, pleasant places to see and experience improves the capacity for older people to engage in safe physical activity, reducing the risks of social isolation and frailty. In addition, correlating the built environment with PA using a lifecourse approach is important because exposure to the built environment does not happen in one point in time; rather, exposure over time can have an influence on PA for many years. Nathan et al. suggest public health researchers and advocates, health policy makers, and health promotion practitioners should actively collaborate with stakeholders in order to provide optimal built environments to promote healthy living over the lifecourse and encourage healthy aging in place.[10]

The person-environment fit theoretical model can explain how the neighborhood influences the residential satisfaction of older adults.[15] Depressive symptoms are significantly associated with reports of neighborhood crime, unsafe traffic, and unwillingness of neighbors to help each other.[54] Older people who live in disordered neighborhoods with intimidating or unsafe social conditions are less likely to be physically active.[55] While socioeconomic resources such as educational achievement are not readily modifiable, changes to household and neighborhood conditions are more feasible. Infrastructural interventions like improving public sidewalks might influence more older adults to walk in the neighborhood more frequently, and could increase their social participation and use of services.[5] Interventions and policies supporting increasing physical capacity can target household- and street-level disorder, conversely facilitating aging in place.[55]

We have tools at our disposal to ensure a better person-environment fit which can enhance safety and optimize health. However, initiatives promoting built environment modification have not happened at the same pace throughout the world. It is still an unfortunate reality that these changes require material resources that may not be readily available, especially in the global South. Political will also plays a part: advocates can recommend changes, and governments can make regulations, but implementing and enforcing rules may be another ballgame. Most of the included studies were in urban settings located in developed countries; older adults in rural and developing countries are underrepresented despite general acknowledgment that the health of aging populations is a worldwide problem. A few studies from low- and middle-income countries were excluded because they included adults younger than 60 years old; however, even if these studies were included, studies were still predominantly from developed countries. Reflecting on this, the context of what age is considered 'old' or the age of retirement in each country may need to be taken into account so that appropriate evidence for specific populations can be obtained.

While general principles regarding the effects of the built environment on the health of older adults can be identified, the applicability of these principles to specific sociocultural environments may be limited because living conditions are unique to each locality. Furthermore, we should also note that older adults in these studies live in their own current environments. Older adults of the future will interact with a different built environment, likely one in which technology will play a larger role. As this review focused on peer-reviewed literature, only a few articles on digital technology and robotics emerged from the search. However, the growing role of technology in environmental modification is evident in the gray literature and our daily lives. For example, the internet has enabled people to readily access exercise videos and interactive workouts which enhance older adults' PA. Assistive devices that augment hearing, vision, and mobility through electronic means are continuously under development. Mobile phone apps can track the user's health status through a variety of indices. Robotic devices have the potential to enable safe and independent living at home for older adults. On the other hand, mobile phone apps and online commercial businesses have reduced the need for people to go out into the community to buy food and other essentials, because these can be easily delivered to the home. While the older adults in the studies included in this review may not readily adopt such technology, older adults of the future will certainly be more comfortable with these because this technology has already been integral to their lives. Conversely, technology may even diminish the significance of the built environment in the future. As the recent COVID-19 pandemic has shown us, people have become more comfortable with remote and online interactions, and face-to-face socialization may not be as important.

Limitations have been identified in conducting this review. Non-English language papers were excluded. Most studies in this review employed quantitative research methods while a few used either mixed methods or were purely qualitative, reflecting the overall character of published research in public health. Quantitative research studies were heterogenous and comparisons between them may not be possible. Conducting further qualitative research can provide more in-depth evidence regarding the relationships between the environment and older adults' health. As previously stated, the role of digital technology and robotics in the lives of community-dwelling older adults does not appear to be prominent in this review of the peer-reviewed literature; however, the gray literature and popular culture will attest to their influence in the daily lives of this population.

Ongoing research regarding enhancing older adults' physical activity and function may also alter their capacity to cope with the built environment. Programs addressing fall prevention,[62] frailty,[63] and sarcopenia,[64] if implemented broadly and effectively, can improve the overall health of older adults going forward. Much of the research examined PA in relation to the built environment, perhaps because it is more easily measured compared to psychosocial constructs and because the connection between PA with functional capacity is more intuitive. While there are studies regarding the built environment in relation to social participation and support as well as psychosocial factors like self-efficacy and

mastery or control, the majority of articles regarding older adults' psychosocial factors examine these separately from the built environment. Future research directions would include elucidating these factors using the socioecological model of health, exploring how to improve the ability to age in place, and enhance or maintain overall quality of life.

CONCLUSION

The existing peer-reviewed literature has clearly shown that the built environment can affect overall well-being, in which ensuring a better person-environment fit can promote safety and healthy aging. However, while the health needs of an aging population are recognized worldwide, the availability of resources as well as the existing sociocultural, political, and economic aspects of the environment also affect the extent to which the built environment can modify the function, physical activity, and overall health of community-dwelling older adults. A socioecological approach with adequate resources directed to older adults' health and healthcare is necessary in order to achieve the ultimate goal of healthy aging in this population.

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