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INSIGHTS IN AGING AND PUBLIC HEALTH: 2021

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EDITORIAL
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Editorial: Insights in Aging and Public Health: 2021

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Editorial on the Research Topic

Insights in Aging and Public Health: 2021

INTRODUCTION

Our global society is changing. Now in the third decade of the twenty-first century, the achievements made by scientists have led to major advancements in the fast-growing field of Aging and Public Health. As indicated by the United Nations Declaration of the Decade of Healthy Aging (2021–2030), there is global interest in understanding determinants of healthy aging and strategies to improve the lives of older people, their families, and the communities in which they live (1, 2). As such, the field of public health and aging must constantly evolve and adapt alongside the ongoing changes in population growth and demographics, social and physical environments, and policy and other drivers of health-related costs (3). Further, the indicators of risk and markers of success have assumed new meaning as new societal needs/challenges have emerged and our initiatives have targeted new populations and health behaviors (4).

This inaugural "*Insights in Aging and Public Health: 2021*" Research Topic includes forward-looking contributions focused on new insights, novel developments, current challenges, latest discoveries, recent advances, and future perspectives in the field of Aging and Public Health. Taking an inclusive view of different article types for advancing knowledge and practice, this Research Topic includes original research, brief research reports, systematic and mini-reviews, perspective and opinion pieces, and community case studies. It also reflects the geographic diversity of aging and public health researchers with contributors from Asia, Europe, the Middle East, Oceania, and the Americas. We briefly overview the selected articles, which we have organized around four main themes: (1) new ways of looking at aging; (2) resilience and social connectedness/isolation; (3) the power of intergenerational relationships; and (4) physical activity and built environment.

THEMES

Theme 1

The Research Topic begins with new ways of looking at aging and its implications for clinical practice. The heterogeneity of the older population is a classic aging principle (5). In their insightful perspective, Jaul and Barron propose a four-stage system for characterizing aging in terms of chronological age, functional status/disease burden, and life expectancy. The value of this system is its use in clinical decision-making to improve clinical care, provide personalized anticipatory guidance, and better understand the impact of functional status on the quality of life of geriatric patients. A related review by Adja et al. emphasizes the importance of taking a patient-centered, community-based approach to preventing and managing frailty. Specifically, they call for a stronger alliance between public health and primary care to view frailty as a multidimensional

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construct and understand clinical perspectives within the broader societal context.

Theme 2

Resilience and social connectedness have become major themes in understanding how older adults have managed throughout the COVID-19 pandemic (6–9). Even before the pandemic began, Madsen et al. foreshadowed the value of resilience for individuals and communities in the face of disaster. Their contribution is reframing the dialogue from a deficit view of aging to one that recognizes personal-level capacities that, in turn, promote community resilience. Their review provides valuable insights into everyday strategies to increase personal capacities, collective capacities, and/or community resources that can help buffer the range of adversities older adults encountered during the COVID-19 pandemic and are likely to encounter into the future.

There is a growing literature on the association of social isolation with a myriad of poor health outcomes, especially among the older population (10–12). Lynch et al. examined rates of social isolation by geographic location among a cohort of older drivers across the United States. Their brief research report revealed higher rates of social isolation in non-urban areas, although not significantly different. While this study was limited in the diversity of its sample, a major contribution was the use of a standard social isolation measure for improved measurement precision and recommendation for measurement standardization in future research.

Theme 3

Attention to social connectedness has led to a renewed interest in intergenerational research (13). In their opinion piece, Wong et al. make the argument that the involvement of younger people is essential to achieving healthy aging for all. They advocate for innovative intergenerational programs, education about aging to disrupt aging stereotypes, and participatory involvement of youth. This new vision will help create a new social contract between young and old to better address the Decade of Healthy aging's four action areas to change perceptions of age and aging, foster age-friendly environments, deliver age-responsive care, and provide quality long-term care (1, 2). A related analytical narrative review by Vaccaro et al. focuses on intergenerational communication and/or intergenerational social support to improve health, disease management, and/or participation in health research. Of special interest is the understanding about how such intergenerational models can better engage low-income minority populations in their healthcare. This study proposed a model to improve family intergenerational communication among Black and Hispanic older adults through additional qualitative research that addresses enablers and barriers to improved medical care, health behaviors, and health outcomes.

Novel approaches are needed to support intergenerational programs during the COVID-19 pandemic. In their case study, Kennedy-Behr et al. described the creation of an impactful intergenerational program model, its adaptation to community needs, and the employment of new online delivery models. A key success was co-designing the program with key stakeholder involvement, which included aged care providers, university staff and students, childcare staff, and aged care residents. The findings around their five themes (i.e., connection, skilled facilitators, exploration of past and present roles, a wish for continuity, and online challenges) provide evidence about the success of intergenerational programming, even with a pivot to virtual delivery.

Theme 4

Lifestyle factors and the built environment have been key factors associated with healthy aging, especially physical activity (14, 15). Physical inactivity has been associated with a myriad of poor health and functional outcomes, especially among older adults who are characteristically less physically active than other age groups. González-Ravé et al. examined the effects of a 10-week multicomponent exercise program among older women. The major strength of this original research was delineating different exercise protocols and comparing them on standardized functional and clinical outcomes. A unique aspect was its detraining period, enabling an assessment of intervention sustainability. The training program's confirmed benefits on some strength- and clinically-related outcomes is consistent with prior research about the value of physical activity regimens, even among older adults. However, due to sample sizes, it was not possible to assess the relative value of the different training protocols. Hence, further research is recommended to identify the relative advantage of different training programs on various functional and clinical outcomes over time.

Fogaça et al. conducted a systematic review to better understand the benefits of traditional Chinese mind-body therapies, which combine physical movements with relaxation and breathing techniques. This study resulted in an evidence map that provides an at-a-glance visualization of the positive effects of combining mind-body approaches (e.g., Tai Chi, Qigong, Yoga). Evidence maps are important for advancing current knowledge and practice about complementary therapies and can offer new options for older adults around the world to engage in health-promoting lifestyles.

While walking is known to promote health and functioning in old age, the built environment can act as a facilitator or barrier to walking frequency (16–18). Wu et al. conducted original research to identify the relationship between the built environment and walking and whether threshold characteristics of the built environment were associated with different walking levels. This research revealed non-linear relationships and concluded that the relationship is more complex than previously acknowledged. For example, low and medium population density may support walking frequency, but high population density may have only a small effect on utilitarian walking. Such in-depth analyses of different built environment characteristics can inform community/city planners and policymakers about strategies to support active-aging environments.

CONCLUSION

This Research Topic of 10 articles broadly encompasses a variety of health-related issues across the socioecological spectrum that impact older adults and the communities in which they live.

As such, this Research Topic highlights the progress made in the past decade as well as existing and future challenges still needing to be addressed. Findings from this Research Topics are intended to inspire, inform, and provide direction to researchers and practitioners in the field of aging and public health.

AUTHOR CONTRIBUTIONS

Both authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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REVIEW
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Enhancing Resilience in Community-Dwelling Older Adults: A Rapid Review of the Evidence and Implications for Public Health Practitioners

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Background: Resilience is a valuable platform for strengthening individuals and communities in the face of disaster. This review sought to evaluate the current literature related to individual and community resilience in community-dwelling older adults to understand the status of resilience in this population, identify gaps, and make recommendations about effective interventions that promote improved individual and community level capacity. Recognizing the concept of resilience is contested, the review conceptualized resilience as a collective concept that is multi-level and interdependent across those levels, cumulative, and contingent on context.

Methods: The rapid review located 29 relevant peer review journal articles and industry reports related to research or evaluations of interventions aimed at increasing resilience at either a personal or community level. The results of these papers were thematically analyzed.

Results: This review found personal resilience relates to those personal capacities and resources one has and uses to deal with individual stresses and change. We identified several recurring themes within those studies focused on personal resilience, including: (1) positive reframing and agency; (2) personal meaning and purpose; (3) acceptance and belonging. At a community level, we identified the following themes influence collective capacity and resources: (1) empowerment and shared decision making; (2) collective agency; and (3) collective leadership and engagement.

Conclusions: The review highlighted the need to reframe how communities view older adults and shift the narrative away from focusing on age-related deficits toward acknowledging the economic and social contribution older adults make to the community through activities such as volunteering and the sharing of knowledge of history, culture and skills. Demonstrating the interdependence across levels, these activities illustrate personal-level capacities promoting collective action and participation as important for increasing community resilience. The review argues resilience is developed in everyday circumstances, therefore active involvement within communities needs to be encouraged

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within community-dwelling older adults. Developing active involvement will not only contribute to both personal and community level resilience but will enable communities to prosper and flourish through adversity.

Keywords: resilience, community, adversity, aging, volunteering, resources

INTRODUCTION

Rationale

Australia has a long history of being impacted by natural disasters which can have a devastating impact on individuals and communities. Resilience is emerging as a valuable platform for strengthening individuals and communities in the face of disaster and change (1). Resilience is conceptualized here as the ability to withstand, adapt and transform capacities and resources in the context of uncertainty, change, unpredictability and surprise (1, 2). This conceptualization of resilience moves beyond the individual notion of bouncing-back, to a collective concept that is determined by interdependent factors such as community resources, social and economic capital, and governance (1). In addition to facilitating resilience within the wider community, resilience in older adults can be an important determinant of healthy aging (1).

Resilience is a term that has been used by a variety of disciplines over a number of decades. As such, resilience has come to have different meanings, and is a highly contested concept within the literature. Thus, there are numerous literature reviews defining and conceptualizing resilience, for example, Castleden et al. (3), Norris et al. (4), and Reid and Courtenay Botterill (5). Skerratt (6) outlined a typology of resilience from the 1940s to 2010, indicating three main areas of focus: physical systems (including maths, ecological systems, and psychological research); social-ecological systems; and human agency systems. The first two areas of focus conceptualized resilience as a way of bouncing-back from external shock or disaster, while the third focus took a different approach to conceptualize resilience in terms of proactive agency in a context of constant change, mechanisms, resources and vulnerabilities. While there has been some convergence in resilience thinking over the past decade (7), a number of authors suggest reaching consensus is not necessary, and that it is resilience's fuzziness and versatility that has the potential to establish it as a "shared, multi-sectoral framework for building flourishing communities" [(8), p. 363]. This means it is important that each study of resilience clarify the particular conceptualization of resilience used.

The points of convergence regarding resilience include an understanding that resilience is:

- Multi-level (includes individual, community, and regional levels) and interdependent across these levels;
- Cumulative (built over time through repeated mechanisms and pathways); and
- Contingent on context (social, cultural and material resources and ways of doing, being, and knowing) (6, 9, 10).

Some salient points that continue to be contested include whether resilience is a trait, process, outcome or the source of an outcome (6, 9, 11). This lack of agreement has particular political implications when resilience is applied as a policy to encourage local communities to address their own challenges. Steiner and Markantoni (10) urge researchers and practitioners to take a critical perspective of government policies that aim to "empower" local communities under the banner of building resilience while at the same time withdrawing resources and services.

In outlining the conceptualization of resilience for public health, Seaman et al. (1) highlight the need for resilience thinking across culture, economics, governance, and infrastructure at both individual and community levels. For the purposes of this paper, Magis' (2) definition of community resilience has been drawn on as it incorporates: (1) both individual and community levels; (2) process, resource, and outcome aspects; and (3) acknowledges the importance of context. It is a proactive agency perspective rather than a neutral conceptualization that places value on resilience as a common "good." This coincides with health promotion objectives of wellbeing and flourishing (1).

> *Community resilience is the existence, development, and engagement of community resources by community members to thrive in an environment characterised by change, uncertainty, unpredictability, and surprise. Members of resilient communities intentionally develop personal and collective capacity that they engage to respond to and influence change, to sustain and renew the community, and to develop new trajectories for the communities' future* [(2), p. 402].

Magis' (2) definition falls within Skerratt's (6) typology at the human agency systems end of the spectrum. It has also remained relevant; as concepts of resilience have developed in recent years Magis' (2) definition has been the basis of several resilience studies, including those identified for this rapid review (12–14). This definition is also broad enough to cater to a variety of circumstances including rapid and slow-moving natural disasters such as tropical cyclones and drought, as well as change and uncertainty that is influenced by human systems such as economic crises and food or water insecurity.

Magis' (2) definition of resilience, in conjunction with the work undertaken on resilience for public health by Seaman et al. (1), provides the conceptual framework for this rapid review (illustrated in **Figure 1**). This conceptual framework facilitated the focus on aspects of resilience amenable to community interventions that can be undertaken either as part of a natural disaster recovery program or general community development activities. Specifically, interventions aimed at developing personal capacity, collective capacity, or tangible and/or intangible community resources that allow communities or groups within communities to adapt successfully to change or to transform the context itself in some way to sustain human wellbeing are supported within the framework. In addition, understanding the material and social inequalities that may

characterize any particular community or context must be taken into account when considering the people living in that context: their educational and economic opportunities; their cultural connections and practices; their social and historical sense of belonging; and their social connections within and beyond the community. All of these factors will directly or indirectly impact on personal and community resilience.

While considerable attention has been paid to personal resilience, particularly within children and youth, there is an emerging interest in resilience and older adults (1, 15). Janssen et al. (16) point out that this focus on personal and community resilience within older adults is a counter-narrative to the deficit view of aging; that is, resilience shifts the focus toward the positive effects on health and life satisfaction. However, Wild et al. (15) warn this perspective should never be used as a means of transferring responsibility or blaming victims for deficits or declining abilities that may occur with aging. Janssen et al. (16) understanding of resilience in older adults is consistent with the conceptual framework used here, as a multi-leveled interdependence between personal resources (such as psychological traits) and processes, collective resources and processes, and the context within which these interactions play out. This multi-level understanding is important in guarding against transferring responsibility or victim blaming (15).

Wild et al. (15) note a number of researchers believe resilience is cumulative and that this has important implications for older adults. If there is a cumulative aspect to resilience—a process honed by a lifetime of adaptation to hardship—then how we approach resilience and older adults may provide us with an opportunity to review our understanding of the vulnerabilities of older adults during times of adversity such as natural disasters. This presents two implications. First, older adults often have a deep understanding and sense of connection to place. They have stories of how the community has responded to adversity in the past and how the community has rallied. This can be an important source of encouragement and hope. Second, rather than seeing older adults as vulnerable human-beings in need of assistance, the resilience literature emphasizes "the *experience of* rather than the *avoidance of* vulnerability" [(15), p. 142]; that adversity can provide an opportunity to learn and thrive, and that older members of our communities can contribute to this. This is not to suggest that older adults should not be supported by agencies, services, and other community members as needed during periods of crises. Rather, it suggests that if we look at resilience from a broader perspective, older adults have much to offer each other, themselves and the community in encouraging resilience. For example, Skinner et al. (17) outline how the volunteering of older adults in rural communities in Canada has on occasion led to the retention of local services and contributed to economic initiatives. Thus, older adults contribute to their own resilience and that of their communities through their stories, interactions and relationships, and provide leadership and economic benefits through activities such as volunteering.

TABLE 1 | Search terms.

Personal resilience search terms	Community resilience search terms
1. Resilien*	1. Community resilien*
2. AND personal capacit* OR hope OR agency OR motivation OR optimism OR self-efficacy OR positive emotion	2. AND collective capacit* OR social empowerment OR social capital OR sense of community OR collective efficacy OR network
3. AND intervention OR program OR strateg* OR project	3. AND intervention OR program OR strateg* OR project
4. AND communit* dwelling OR independen*	4. AND communit* dwelling OR independen*
5. AND senior OR aged OR older adult OR older OR elderly OR 50 years	5. AND senior OR aged OR older adult OR older OR elderly OR 50 years
6. AND regional OR rural OR remote	6. AND regional OR rural OR remote

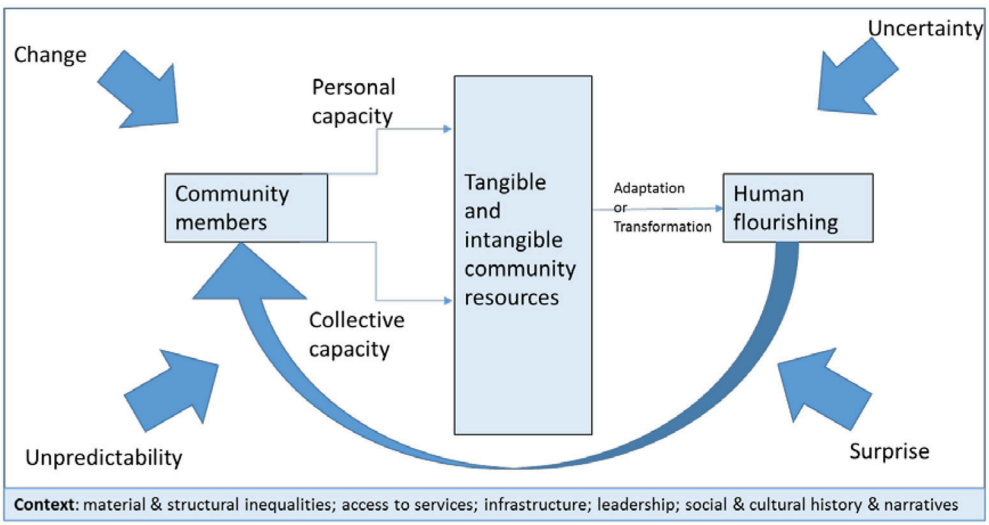

FIGURE 1 | Conceptual framework of resilience.

While they may make disproportionate use of various services within communities, older adults are simultaneously ensuring these services are available to all within the community. This latter aspect is particularly important in rural and regional areas that risk having services withdrawn.

Research Question

This rapid review focuses on community-dwelling older adults, who have traditionally been perceived as vulnerable in times of disaster and change. Therefore, this rapid review seeks to understand the current status of the evidence related to individual and community resilience within community-dwelling older adults by reviewing studies that effectively enhance individual and community resilience in community-dwelling older adults.

Objectives

The objective of this review was to examine the current body of knowledge to identify and evaluate the effectiveness of resilience-enhancing approaches, and use these findings to inform policy and program development. The review identifies commonalities across resilience-enhancing approaches that have evidence of effectiveness. Such evidence should enable service organizations, agencies, and governments to enhance the effectiveness of their programs and services.

METHODS

Study Design

This rapid review undertook a review of the peer-reviewed and gray literature to identify evaluation and research studies that capture resilience within regional, rural or remote areas of Australia and internationally, particularly interventions designed to enhance personal and community resilience within community-dwelling adults who are semi-retired or retired and living in good health with no major cognitive, psychological, physical, or clinical conditions.

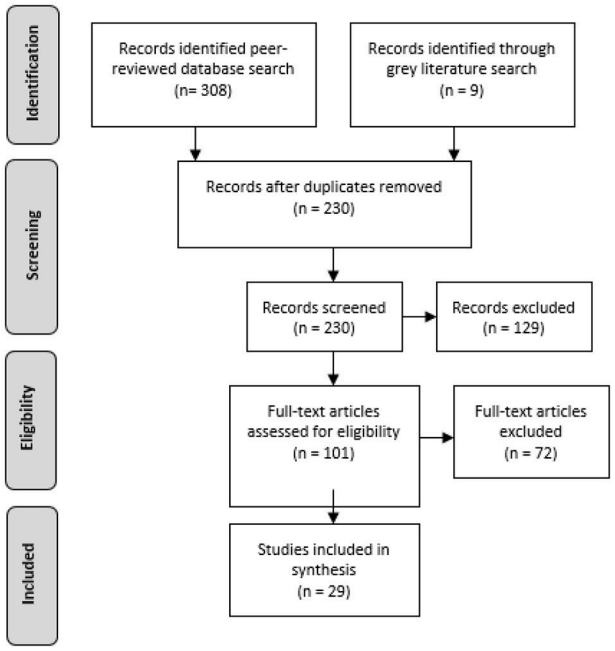

FIGURE 2 | Literature screening matrix.

Review Protocol

Before commencing this rapid review, a research protocol was developed to ensure our searching parameters were relevant, accurate and methodical. The research question, aims and objectives, study design, definitions and boundaries, inclusion/exclusion criteria and search strategies were clearly outlined within the protocol. This guided the research process and was an effective collaboration tool for reviewers to discuss findings and ensure consistency throughout the process. As new findings were presented, the scope of the project did evolve which was continuously reflected within the protocol. Thus, the protocol identified the inclusion criteria that guided the search strategy and data extraction processes. These inclusion criteria were:

- Original research;
- Primary research or evaluation study;
- Published after 2013;
- Written in the English language;
- Peer-reviewed journal article OR gray literature available from .gov or .org domains;
- Identify interventions which aim to enhance resilience;
- Report outcomes of personal resilience among community-dwelling adults aged $\geq$50 years of age with moderately good health (see aims/objectives) OR report outcomes of collective resilience across community groups including older adults.

Search Strategy

To ensure all peer-reviewed research on resilience was located, a comprehensive search of the following databases was undertaken: CINAHL, PubMed, Medline, PsychInfo, PsychArticles, The Cochrane Library, Science Direct, Sociology Source Ultimate, JBI, Scopus, Prospero, Public Health, Academic Search Ultimate, Health Business Elite, Health Management. In addition, to satisfy an exhaustive search, the gray literature websites with .gov and .org domains were searched.

Initially, preliminary searches were conducted to test search term accuracy. Boolean logic was applied where possible to enable breadth across searches. Once key terms were finalized, two independent searches were performed to explore both personal and community concepts of resilience within the target group. The search term strategies are identified in **Table 1**.

Data Sources, Studies Sections, Data Extraction

In total, 308 peer-reviewed articles were retrieved from the database searches and 9 studies retrieved from gray literature searches in accordance with study title relevance (see **Figure 2**). Once duplicates were removed, the abstracts of 230 studies were screened and 129 articles were excluded based on not meeting the

inclusion criteria (for example, focused on children or a cohort with significant mental health issues). A screening tool template was then developed so that the full text of 101 articles could be assessed for eligibility. Based on the inclusion criteria set out in the screening tool, 29 resilience-focused studies were identified for inclusion.

Data Analysis

Together, three reviewers used data extraction tables to explore the key concepts of each study, including their sample size, target groups, country of focus, study quality, and main outcomes/findings (See **Tables 2**, **3**). The main outcomes and findings were thematically analyzed.

RESULTS

Synthesized Findings

The final 29 articles were further categorized into two groups, either: (1) personal resilience; or (2) community resilience. Magis (2) distinguishes between personal and collective capacities and community resources as key components of community resilience. As such, for simplicity, we present the findings along the rupture lines of personal and collective capacities and resources, yet within the studies we reviewed, such distinctions were not always clear, reflecting the multi-level nature of resilience.

Personal Resilience

Personal resilience relates to those personal capacities and resources one has and uses to deal with individual stresses and change. We found a number of recurring themes within those studies focused on personal resilience, including: (1) positive reframing and agency; (2) personal meaning and purpose; (3) acceptance and belonging. Each of these will be explored separately.

Positive reframing and agency

While Bei et al. (24) suggest unexpected life events can lead to maladaptive coping and are closely associated with poor mental health, they also note positive reframing and humor are ways to improve an individual's personal capacity to deal with change, including supporting transformative change. Traditionally, age and aging have been viewed adversely and considered an undesirable process of unpreventable physical and cognitive decline. However, positive reframing can be a protective factor and contribute to human flourishing as older adults re-story their lives as part of the aging process. This process requires a level of acceptance of oneself that is aided by a healthy dose of humor. It also requires a certain level of agency. Bellamy et al. (25) contend older adults who develop the agency to draw on their age and life experiences are able to cope with expected and unexpected life events. Developing such agency is empowering in itself. Developing spiritual coping strategies may also contribute to empowerment and reframing the aging process (21, 22).

Personal meaning and purpose

A number of the studies identify the importance of maintaining relationships with others as the basis of personal meaning and purpose. Cohabitating adults, healthcare providers, family and friends, and others help older adults find meaning and purpose in life. Supporting this, Baldacchino et al. (22) suggest that older adults value a connectedness with others over a relationship with self. Moylan et al. (28) identify tangible community resources such as infrastructure and facilities which provide a place for interaction and help to facilitate inter-personal reflection which is essential for fostering meaning and purpose, whilst enhancing the ability for community members to connect with the moment, to self, to others, and to their environment. This engenders a sense of belonging in those who live in the community, which is acknowledged by Gibb (26) as necessary for sustaining resilience.

Acceptance and belonging

This sense of acceptance and belonging is highlighted as important by several authors. Research by Nitschke et al. (18) and Williams (44) indicate that during a heat event, the adaptive capacity of older adults is hampered by a lack of belonging and acceptance, with many older adults reporting feelings of isolation and a loss of confidence in their ability to call friends or neighbors. Such actions are seen to intensify their health risks. Nitschke et al. (18) concludes that social connectedness reduces mortality during a heat wave. Supporting this, Severinsen et al. (19) and Gibb (26) contend older adults value friendships and social connections with the community, neighbors, and family along with the sense of feeling in place. In fact, this sense of belonging and acceptance not only improves the well-being of older adults but enhances their independence and can reduce the health costs associated with aging (19, 23). Banbury et al. (23) argue a sense of belonging and acceptance derived from social support makes older adults feel more engaged with life. Inder et al. (27) suggest social isolation increases feelings of personal hopelessness, psychological distress and lower perceived prosperity among older adults. Annear et al. (20) explore how tangible community resources such as age-friendly policies and funding, in conjunction with appropriate community facilities and support provided through health agencies and social networks, are critical in providing a sense of acceptance and community cohesiveness. This allows older adults to remain in their homes and stay connected to their community as they age and to draw on intangible community resources such as history, personal and collective memories, and a collective sense of belonging and attachment that in-turn fosters adaptation and human flourishing.

Community Resilience

The following describes the commonalities identified that influence collective capacity and resources. We identified a number of recurring ideas: empowerment and shared decision making; collective agency; and collective leadership and engagement present in the literature. As with personal resilience, there is some overlap across the themes, but each will be explored separately.

Empowerment and shared decision making

Empowerment and shared decision making have been inextricably linked within the community development

TABLE 2 | Summary of reviewed papers—personal resilience.

Paper and Country/Target group	Years	Aim	Population	Data collection and analysis	Results
Nitschke et al. (18) *Australia*	2013	Explore resilience, behaviors, health risk factors and health outcomes during heat waves independently living residents	$N = 499$ (aged >65 years; $n =$ 341 from metro, $n =$ 158 rural)	Random telephone survey	75% of older adults undertook adaptive behavior during heatwaves, although were not informed or did not see themselves at risk. Notes importance of social connectedness in reducing risk of mortality during a heat wave.
Severinsen et al. (19) *New Zealand*	2016	Examine the narratives older people use to describe their housing preferences in later life	$N = 143$ (aged 65–93 years)	In-depth interviews Narrative analysis	Acknowledged older adults have a preference to remain in own homes as they age, although housing and/or location may become unsuitable for their changing needs Attachments to home and local community and feeling "in-place" improves well-being.
Annear et al. (20) *New Zealand*	2014	Develop community-generated recommendations to inform urban environmental remediation following earthquakes suitable for independently living older adults	$N = 38$ (aged ≥65 years; $n =$ 30 volunteers; $n = 8$ knowledgeable advisers)	Focus group discussions to critique mixed-methods and multiphase results	Developed 6 recommendations and associated actions: 1. Remediation of earthquake damaged areas 2. Transport and mobility needs 3. Age-friendly rebuilding 4. Safer communities 5. Resilient support agencies 6. Social and cultural venues.
Baldacchino et al. (21) *Australia and Malta*	2014	Detect any significant differences in spiritual coping strategies of older people related to their personal characteristics	$N = 137$ (mean age = 72.8 years; $n = 103$ men, $n = 34$ women; *Australia*, private homes $n = 30$; *Malta*, private homes, $n = 43$; Malta, residential, $n = 64$)	Descriptive sequential explanatory study Phase I: self-administered questionnaire and the Spiritual Coping Strategies (SCS) scale	Maintaining relationships with friends, family, room-mates, God and nature lessened anxiety and depression, and helped older adults adapt to their current situation. Spiritual coping is higher in those living in private homes in both Malta and Australia, although culture plays an important role in spiritual coping.
Baldacchino et al. (22) *Australia and Malta*	2014	Explain the impact of the use of spiritual coping strategies on institutionalized older persons	$N = 137$ (mean age = 72.8 years; $n = 103$ men, $n = 34$ women; *Australia*, private homes $n = 30$ *Malta*, private homes, $n = 43$; Malta, residential, $n = 64$)	Descriptive sequential explanatory study Phase 2: audiotaped face-to-face interviews ($n = 42$) Phase 3: three focus groups ($n = 23$)	Three main themes: 1. self-empowerment through connectedness with God, self, others and nature; 2. belongingness to the residence/institution; 3. the finding of meaning and purpose in life or the perceived after-life.
Banbury et al. (23) *Australia*	2017	Examined the relationship between changes in social support networks for older people living in a regional area following weekly videoconference groups delivered to the home	$N = 52$ (Mean age = 73 years; $n = 25$ female; $n = 27$ male)	Semi-structured interviews and focus groups	As people age in their homes, there is a greater risk of social isolation, which can be ameliorated by support networks with health professionals, family and friends. Videoconference education groups delivered into the home can provide social support and enhance self-management for older people with chronic conditions.
Bei et al. (24) *Australia*	2013	Examine the impact of floods on the mental and physical health of older adults and explore the risk and protective factors	$N = 274$ (Age >60 years; 147 were lost to follow up/dropped out)	Longitudinal prospective design Pre- and post-surveys (a flood event)	Floods did have an adverse impact, especially amongst individuals with greater flood exposure and inadequate social support. Includes higher PTSD and anxiety symptoms, but not higher rates of depression. Acceptance, positive re-framing and humor found to be protective factors.

(Continued)

TABLE 2 | Continued.

Paper and Country/Target group	Years	Aim	Population	Data collection and analysis	Results
Bellamy et al. (25) *New Zealand*	2014	Explore older adult's views, experiences and sources of bereavement support following the death of a spouse, family member or other significant individual	*N* =28 (aged ≥75 years; 65+ for Māori participants)	Telephone interviews Grounded Theory	Four main themes were identified: 1. Equanimity and resilience; 2. Older peoples' views and experiences of formal bereavement support services; 3. The pivotal role of family and friends in the provision of bereavement support; 4. The value of harnessing support from existing community and religious organizations in ensuring adequate support for older bereaved adults.
Gibb et al. (26) *Australia*	2018	Investigate how people managed to stay resilient as they aged in remote places	*N* = 14 (Age 61–80 years)	Individual interviews Follow-up focus groups	Highlights the importance of place as a set of conditions for sustaining resilience, psychological integration and belonging. Volunteering supplemented gaps in aged support services. Material sustainability and personal care support also noted as important.
Inder et al. (27) *Australia*	2015	Explore relationship between demographic, socioeconomic and mental health factors and personal hopefulness, including the influence of locality and remoteness	2,774 participants (53% female, mean age 69.1 years, 36% living outside metropolitan areas)	Data from two community-based longitudinal cohorts from New South Wales—one urban and one rural	Five factors were independently associated with lower personal hopefulness: being older, having lower perceived prosperity, less frequent socialization, experiencing high psychological distress or psychological impairment. Hopefulness was not associated with geographical location.
Moylan et al. (28) *Australia*	2015	Explore individual and community contribution of Community Men's Sheds (CMS) in terms of health, well-being and spirituality	*N* = 21 men (Varying ages)	Participant observation over a 6-month period and semi-structured in-depth interviews	Benefits provided by CMS: 1. Increased self-esteem and empowerment; 2. Respite from families; 3. A sense of belonging in the community; 4. Opportunity to exchange ideas relating to personal, family, communal, and public health issues; 5. Spiritual support.

literature for some time, so it is not surprising these are strongly identified in studies that consider community resilience (45). Fois and Forino (40) suggest shared decision making and collective leadership that focuses on the long-term impacts of decisions for a community and engendered autonomy, enhances community resilience through local empowerment, participation and transparency. Furthermore, McCrea et al. (35) argue community decision making and trust is a key dimension of community resilience. Communities that foster shared decision making and empowerment are more likely to view adversity as an opportunity for transformation. They are able to draw on intangible community resources such as community cohesiveness, collective history, memories and narratives to support local cultural and social practices, and equip individuals within the community to transform and flourish (29, 36). Shared decision making and leadership is a departure from the common discourse seen with top-down approaches that typically isolate members of the community. Fois and Forino (40) claim shared decision making and leadership leads to re-using community resources and re-storying connection to place.

Collective agency

Steiner (14) contends agency is the ability to collectively mobilize leading to increased individual and collective capacity and transformation. Research by Roberts and Townsend (12) and Steiner (14) suggest tangible community resources such as infrastructure and community facilities influence the adaptive capacity of those individuals living in the community. Poor physical infrastructure can inhibit individuals and the community by limiting social and cultural capital and impeding creativity and agency. This, in turn, can limit intangible community resources and threaten the collective capacity of the community (12, 14). While collective decision-making and leadership are important factors in community resilience, a sense of collective agency underpins any community initiative. Roberts and Townsend (12) argue such agency could have its origins in the development of cultural activity such as the influx into a community of cultural and artistic practitioners, which can have a spill-over effect fostering more diverse employment and economic outlets as well as bringing the community closer together.

TABLE 3 | Summary of reviewed papers—community resilience.

Paper and country	Years	Aim	Population	Data collection and analysis	Results
Wood et al. (29) *Australia*	2015	Document and reclaim stories of survival and resilience to enable people to speak of future hopes and dreams	Kalumburu (indigenous) community	Narrative Inquiry using an online outsider witness practice	Strong Women's Group used re-authoring, remembering, outsider witness process and definitional ceremonies to re-frame problems within the community and plan for collective action around: youth crime and detention, lack of child education, alcohol abuse, chronic disease (diabetes and heart disease), neglect, violence and families fighting, suicide of young people.
Cinderby et al. (30) *United Kingdom*	2016	Examine experience to build community resilience, where facilitators supported residents to take ownership of their own agendas	$N = 249$	Participatory Action Research	Highlights importance of improving quality of life and capacity of neighborhoods build resilience and how the community manages its environment. This includes: 1. Transforming social relationships; 2. Strengthening institutions; 3. Influencing local power balances.
Congues (31) *Australia*	2014	Examine the impact of drought on a farming community and success of attempts to promote and empower resilience and social connectedness	Whole community (size not specified)	Interpretive document analysis of range of evaluation reports and minutes	*Strong women, strong families* program identified as very successful (event for rural women to develop sense of friendship, ownership, education on mental health, enable empowerment), although criticized by some as led to belief women were responsible for welfare of husbands. Recommendation similar program be developed for men.
de Schweinitz et al. (32) *Alaska*	2017	Explore perceptions of causes and prevention of suicide and the functioning of Village Wellness Teams within rural Alaska Native community	$N = 54$ ($n = 43$ women; $n = 11$ men)	Focus groups	Participants were willing to directly confront the topic of suicide and its prevention, including the community's capacity to respond to emergencies and the creation of safe, alcohol- and drug-free events. Believed suicide partly attributed to loss of culture, language, and subsistence activities, as well as limited local economic opportunities and services. Recognized different needs for men and women.
Madsen and O'Mullen (33) *Australia*	2014	Evaluation of locally devised and delivered rural leadership programme	$N = 16$	Interpretative case study using semi-structured interviews	Two key themes illustrate how leadership programmes can contribute to the development of community resilience were identified: 1. Self-development (awareness of strengths and weaknesses of self and others, gaining of self-confidence, and emotional intelligence, increased understanding of leadership); 2. Building social capital (interaction between community members, ability to draw from other people's experiences, share knowledge, strengthens bond of community).
Madsen and O'Mullen (34) *Australia*	2016	Residents' perception of community resilience and how community resilience can be enhanced	First workshop, $N = 18$ ($n = 17$ female, $n = 1$ male) Second workshop, $N = 14$ ($n = 13$, female, $n = 1$ male)	Participatory research approach using photo-voice and surveys	Five themes identified as important factors in community resilience: 1. Social connectedness and belonging; 2. Optimistic acceptance of circumstances; 3. Learning tolerance and patience; 4. Learning from the past for the future.
McCrea et al. (35) *Australia*	2016	Test predictability of measures and concepts of community wellbeing and community resilience	$N = 389$	Computer Assisted Telephone Interviews. Path analysis to test model of community wellbeing and resilience	Community wellbeing predicted by community spirit and cohesion; services and facilities; community and social interaction; environmental loading; built environment; personal safety. Community resilience.

(Continued)

TABLE 3 | Continued.

Paper and country	Years	Aim	Population	Data Collection and Analysis	Results
					predicted by community decision making and trust; trust in industry decision making. Place attachment found to be separate construct and not a part of either community wellbeing or community resilience
Roberts and Townsend (12) *Scotland*	2016	Develop an understanding of cultural and digital capital to evaluate the contribution of creative practitioners to rural community resilience	$N = 15$	Semi-structured interviews based resilience framework themes	Creative practitioners developed adaptive capacities to compensate for slow and unreliable internet. Their contribution to cultural capital depended on connection to local community. Cultural activity seen as having spillover effects: economic benefits; bringing community together; employment/training; diversity.
Sangha et al. (36) *Australia*	2017	Community perceptions of resilience undertaken in two Northern Australian communities	$N = 188$	Survey, focus groups, semi-structured key interviews Desktop studies	Understanding of natural hazards interpreted in context of other hazards, including colonization and government intervention. There is a mismatch between the expectations of government emergency agencies and local communities related to: feelings of safety; recognition of cultural norms, practices and ceremonies; effect of disasters on physical, spiritual and economic conditions in communities; knowledge and accessibility of emergency plans; recognition of local Aboriginal organizations, local social networks and knowledges; ongoing need to strengthen local capacity; need for economic independence.
Smith and Lawrence (13) *Australia*	2014	Investigate food insecurity during and immediately after a major flood event	$N = 13$	Grounded Theory Semi-structured interviews Policy analysis Media and government literature review	Reliance on supermarkets with little food in supply chains, and limited alternative local food supply avenues. During a flood, there is a focus on supplying food to most vulnerable relying on community resources. Despite many examples of positive "collective community capacity" during the flood event (e.g., flexible and innovative use of personal "networking" to move food from one location to another), numerous challenges related to formal decision making and information-sharing processes.
Steiner (14) *Scotland*	2016	Explore whether facilitated community interventions can empower and develop community resilience	$N = 30$	Semi-structured interviews	Six rural communities were facilitated and provided with funding to undertake a community project: 3 completed; 3 did not in the timeframe. Facilitating factors included: funding availability; facilitator; increasing confidence and networking. Challenges included: lack of sufficient information; consistency of facilitator; insufficient communication; need for more flexibility in timelines; danger of dividing communities.
Tudor et al. (37) *New Zealand*	2015	Understand the role of craft and crafting groups in disaster recovery to help build connection to place and provide avenue for growth	$N = 32$ ($n = 9$ interviews $n = 5$ focus groups)	Semi-structured interviews and focus groups	Five themes identified related to role local organically formed groups of crafters played in providing opportunity for adaptation after a natural disaster: 1. Crafting for recovery and healing; 2. Social connection; 3. Learning and meaning making; 4. Giving to others; 5. A vision for the future.

(Continued)

TABLE 3 | Continued.

Paper and country	Years	Aim	Population	Data Collection and Analysis	Results
Williams (44) *Australia*	2013	Understand impact of extreme heat events on services and "at-risk" populations, including older community dwelling adults	$N = 13$ health service providers from 11 rural and remote communities	Semi-structured interviews	Increased use of health services but not as refuges from heat (air conditioned). Noted community members moderated own activities to restrict going outside during middle of day. Potential for older people to restrict social access, and to stay in a single air-conditioned room. Need to check elderly if have air conditioning, able to use it or willing to use it, and if have lack of sensitivity to heat. Noted safety issues related to locking doors and windows reducing housing ventilation.
Linnell et al. (39) *Sweden*	2015	Explore two key areas in crisis management: (a) the role of local communities in crisis preparedness and response, and (b) how to involve the citizens in this task	$N = 33$	In-depth interviews	Seven main themes related to enhanced public resilience: 1. Collaboration: Formal and informal practices; 2. Specific competences and general abilities; 3. Collective efforts and individual self-help; 4. Education and empowerment; 5. Traditional communication vs. digital media; 6. Individual motivation and involvement; 7. Generation and age.
Fois and Forino (40) *Italy*	2014	Understand community resilience processes in ecovillage and analyse how disaster served as window of opportunity for sustainability	$N = 8$	In-depth interviews	Critical of paternalistic, top-down approaches to disaster recovery that focus only on immediate housing needs. Longer term solutions created through local empowerment, participation, transparency, long-term visions and sustainability. Disasters can be an opportunity to transform.
Lyon and Parkins (41) *Canada*	2013	Account for deeper social phenomena such as agency, structure, culture and power in social resilience	$N = 59$	Focused ethnographies: key informants interviews; observations; photographs; secondary sources	Margaret Archer's sociocultural theory helps to better understand panarchy of social ecological resilience theory and adaptive cycles from a social and cultural perspective. Provides a richer and more nuanced understanding of community resilience that is not normative.
Stebbing et al. (42) *Australia*	2013	Describe perceived health effects of water insecurity and understand vulnerability, resilience and adaptive capacity in rural towns experiencing drought	$N = 13$	Focus groups and interviews	Adaptive capacity is enhanced when community takes a bottom-up approach to solving its own problems.
Wickes et al. (43) *Australia*	2015	Identify extent to which pre-flood context influences community resilience in post-disaster context	$N = 4{,}403$ (wave 3) $N = 4{,}132$ (wave 4)	Longitudinal survey and census data analysis	No major differences in social capital identified across flooded and non-flooded communities. City, state and federal actions may play a role in generating community resilience, as do community competence and actions.
Williams and Shepherd (38) *Haiti*	2016	Explore ventures initiated by local people in aftermath of earthquake: how they acquired and used resources to facilitate community resilience	$N = 55$	In-depth interviews, observations and secondary sources	Two pathways of alleviating suffering were identified: (1) staged resourcefulness that related more to obligation; and (2) deviant resourcefulness that related more to power and social status.

Steiner (14) reasons the initiation may also be provided from an external body, but that the community needs to be ready to undertake collective action. Linnell et al. (39) highlight community safety and security stem from a collective responsibility born by individuals within the community feeling they belong.

Collective leadership and engagement

Tudor et al. (37) elaborate on the role of creative skills in building community capacity through collective action. They outline the contribution of local groups of crafters in engaging and bringing together community members in the aftermath of the earthquakes in Christchurch, New Zealand, and in doing so provide an avenue for regaining control, improving economic and personal value, and developing connections with others and self (37). Congues (31) and Cinderby et al. (30) also explore the importance of skills as an avenue of engagement and in building collective capacity. Through skill-based activities the community can engage isolated community members, bridge gaps, and build and strengthen community cohesion. Programs that utilize tangible and intangible community resources to provide spaces, a sense of belonging and networks to run activities enable a more sustainable community that improves the collective leadership of the community, creates shared visions, and develops neighborhood assets for building resilience (30).

Likewise, de Schweinitz et al. (32) suggest programs that focus on the transfer of skills and knowledge and are activity-based provide opportunities for engagement and collective leadership. Action-based and outdoor activities provide key opportunities for at-risk groups to engage with others in the community. They also provide the opportunity for elders to mentor and exchange cross-generational dialogue with younger people, which provides support and purpose and builds collective capacity across generations within the community (32). Madsen et al. (33, 34) advocate leadership programs provide important skills that enable social connections and community cohesiveness, especially for isolated individuals or those who have not previously connected with the community. Madsen et al. (33) suggest collective leadership creates engagement through bridging social capital between members of the community, which is necessary for building resilience and human flourishing.

DISCUSSION

Summary of Main Findings

Understanding the various types of "resilience" apparent in the literature, terms related to natural disasters were deliberately not included within the search strategy. Instead, the focus was on personal and community resilience more generally. Interestingly, more than 50 per-cent of the papers included in the review related to fast-moving (earthquakes and cyclones) or slow-moving (droughts and climate change) weather events. This may indicate a tendency to focus on resilience during adversity. In fact, funding for personal and community resilience is often easiest to obtain as part of disaster recovery programs. However, this focus can be somewhat misleading. Although adversity such as a natural disaster can offer opportunities for individuals and communities to adapt and transform, for the most part, resilience is generally developed in everyday circumstances. This holds for all members of a community, including older adults. While we will focus as much as possible on resilience relating to community-dwelling older adults, due to the paucity of research that targets this particular cohort, throughout this discussion we bring together the two strands of personal and community resilience outlined above and will draw on more general studies to explore: (1) actions that have demonstrated a strong association with growing resilience at both personal and community levels; (2) the circumstances in which transformation through adversity may occur; and (3) the caveat that local resilience may not be sufficient to change structural inequities but that certain actions can form the foundation for further advocacy and policy work. Overall, we will argue the re-framing of community-dwelling older adults as assets and sources of resilience within our communities. This does not take away from the need to meet specific needs for older adults during crises, but it does shift the narrative away from focusing on age-related deficits toward recognizing: (1) the extent to which older adults are already contributing to their own resilience as well as their communities' resilience; and (2) how these efforts could be enhanced through external facilitation.

Growing Resilience Through the Everyday

Keeping in mind the conceptual framework outlined in **Figure 1**, there are a number of personal and collective capacities and community resources that consistently appear in the literature as foundational to resilience. This review has identified self-esteem (21, 28) having a sense of meaning and purpose (21), having a sense of belonging (18, 19, 28) as well as developing well connected social networks and support (13, 18, 20, 22, 23, 25, 30, 33, 34). In addition, for certain groups such as First Nations Peoples, acknowledging the importance of community knowledge and cultural norms and practices is also important for resilience (29, 36). Community resources include facilities such as churches, videoconferencing facilities (such as those available in public libraries), Men's Sheds, and community meeting places (23, 28). Funding can also be considered as a community resource (14). Importantly, in order to truly appreciate the breadth of available resources, it is important to undertake a mapping of assets (39).

As such, interventions to increase resilience can be aimed across a number of levels toward increasing personal capacities, collective capacities, and/or community resources. While there has been considerable targeting of personal capacities within personal resilience research, particularly toward those who have psychological issues or disease, it does appear that interventions targeting general community resilience also spill over to increase personal resilience (9, 10). Those activities consistently cited as contributing to community resilience include:

- Volunteering (26);
- Collective action and participation (29–31);
- Collaborative decision making (36, 40);
- Community learning through collaborative action (33, 34).

Community-dwelling older adults play an important role in communities through their volunteering efforts. Seaman et al. (1) highlight volunteering's economic contribution to resilience, while Gibb (26) suggests volunteering helps older people to supplement gaps in aged support services. In many instances, volunteering provides older adults with additional social support and networks beyond their family, and an increased sense of

belonging, meaning and purpose in life (22). Thus, increasing both personal and community resilience.

Activities that promote collective action and participation are important for increasing community resilience and act through a number of mechanisms. First, these activities necessitate mixing with other people, increasing social networks and support (1). Second, these activities help to build or consolidate community and cultural knowledge. Older adults are especially important resources of such knowledge in both Indigenous and non-Indigenous communities (1, 29, 36). Many of these activities require members to participate in collaborative decision making and the development of flat leadership governance structures which is important in developing group ownership and empowerment (1, 42). Collective activities also provide opportunities for collective learning as members negotiate everyday barriers and issues in undertaking their activities.

Whether these activities are related to crafting, making wooden tools, organizing indoor bowls, running adult education sessions or volunteering with a local charity, bringing community-dwelling older adults together on a regular basis to undertake everyday skill-based or social activities provides an opportunity to develop personal and community resilience that contributes to the level of general resilience apparent within the community. This is especially important in times of adversity. Thus, such activities are strongly reflected in the practice and policy recommendations we have put forward from this review (see **Table 4**). Participation, through volunteering, or in skills-based or social activities, that are accessible and affordable is fundamental to personal and community resilience in community-dwelling older adults.

Reframing Adversity and Resilience

Adversity such as a natural disaster can provide an opportunity for growth by adapting or transforming the context in which the event took place (38). However, this is only likely to occur if there is already a high level of resilience within the community before the event (10, 25, 30, 43, 46) (Refer to the positive feedback loop in **Figure 1**). Fois and Forino (40) outline an example of transformation within an Italian village after a massive earthquake in 2009. Older adults worked with younger adults to develop an eco-village for temporary accommodation which led to the revitalization of other community facilities and assets. Yet, as Cinderby et al. (30), and Wilson (46) point out, adversity can also be the catalyst for a community ending up in a more stressed state which can lead to the withdrawal of services and depopulation. While the availability of economic and support services are important, it appears that the culture of the local community plays a significant role in how a community will respond to a crisis. Lyon and Parkins (41) compared two rural Canadian communities in the wake of mill closures and found that local culture was the key to how the community will transform. Seaman et al. (1) support this point. Here again, older adults can play an active role, particularly in First Nations Peoples communities where the elders are revered as keepers of cultural knowledge and ways (29, 36). This is where social narratives and the recalling of history, particularly in how the community has responded to difficulties in the past—stories that are held by older members of our communities—can contribute to community resilience (1). In effect, they can help reframe the disaster experience.

Counter-narratives to mainstream perceptions can also be useful in supporting resilience. Wood et al. (29) highlight the need for Aboriginal older women to counter the historical stories of deficit through stories of strength. Likewise, Seaman et al. (1) suggest older adults need to re-shape narratives of aging, acknowledging that they have often overcome many difficulties over their lifetime and have accumulated considerable personal resilience, as well as being able to contribute to community resilience. Attention should, therefore, be paid to the narratives surrounding older adults and their contributions to personal and community resilience, and consider these narratives in policy and research endeavors (see **Table 4**).

Caveat Regarding Local Resilience and Structural Inequalities

While the types of activities outlined above have been shown to increase resilience at a local level, it is important to emphasize this may not be sufficient to overcome structural inequities evident within the context. However, as argued by Ledwith (45), increased community activity that enhances participation and shared decision making can contribute by empowering local communities who may go on to advocate at broader political and social levels to eventually bring about structural change. Such action takes a long time but is at the heart of the settings approach within health promotion and community development (45, 47). Older adults can, and do, play important roles in such advocacy. Indeed, as our population ages and more "Baby Boomers" enter retirement, it is likely "gray advocacy" will become much more prevalent as a social movement.

Instigating the initial co-operative activity may occur organically through one or two people identifying an issue that is able to generate local support and eventually lead to broader action (45). Outside facilitation may also be necessary. For example, Steiner (14) outlines a project in Scotland whereby external facilitators worked with rural communities who were not taking advantage of funding to provide community facilities. Not all communities completed the projects, but this type of facilitation seemed to provide the impetus for some communities to start and then gather their own momentum, moving from a "stressed community" to a more vibrant one through a process of engagement, participation and empowerment (31).

LIMITATIONS

There are a number of limitations associated with this rapid review. Due to time restraints, it was necessary to restrict the study parameters, and as such it is possible there are relevant studies that have not been included that are in languages other than English, published prior to 2013 or located in databases outside those searched. Furthermore, it was not always possible to identify the ages of participants in studies leading to the exclusion of potentially relevant studies. We also acknowledge the inherent limitations associated with the methodology, and that thematic

TABLE 4 | Practice, policy implications and areas for future research based on identified themes.

Theme	Practice/Policy implications	Areas for future research
Personal resilience	Encourage opportunities for community-dwelling older adults to volunteer	Establish the statistical relationship between volunteering, personal resilience and wellbeing Investigate factors that influence older adults volunteering
	Encourage opportunities for community-dwelling older adults to participate in community-based activities	Establish the personal benefits of participating in community-based activities Investigate factors that influence older adults participating in community-based activities
	Ensure community-dwelling older adults are aware of the opportunities available to them in the community	Investigate media avenues community-dwelling older adults use to find out about local community-based activities
Community resilience	Ensure community facilities are affordable to encourage community organizations and community-based activities for older adults	Undertake a cost-benefit analysis of community-based activities for older adults
	Should external facilitation be required to instigate community-based activity among older adults, ensure it is designed on an engagement-participation-empowerment basis to encourage ownership and collaborative leadership by community members	Investigate the role of external facilitation of community-based activity in rural communities and its short, medium and long-term impact on developing community resilience Explore the effectiveness of the engagement-participation-empowerment model in a variety of contexts
	Support and facilitate grassroots advocacy among community-dwelling older adults directed toward reducing inequities	Explore the effectiveness of grassroots advocacy in reducing structural inequities Investigate factors that influence older adult participation in grassroots advocacy
	Re-frame language and policies to reflect a strengths-based approach to resilience in community-dwelling older adults, recognizing the contribution older adults are making to the resilience of their communities	Evaluate the impact of re-framing language and policies related to community-dwelling adults to reflect a strengths-based approach to resilience within local government and non-government agencies

analysis is useful for exploring the "what" and "how" however, does not provide insight into the strength of relationships.

As such, it is within the context of these limitations that we outline a number of potential practice and policy implications, and potential areas for future research (See **Table 4**). These primarily relate to: (1) encouraging community-dwelling adults to participate in community activities in order to collaborate with others; (2) promoting positive and healthy aging narratives by older adults, and about older adults; and (3) developing the evidence-base associated with such activities and resilience.

CONCLUSIONS

This rapid review evaluated the current literature related to individual and community resilience in community-dwelling older adults to understand the status of resilience in this population, identify gaps, and make recommendations about effective interventions that promote improved individual and community level capacity. The review found personal resilience was based on positive reframing and agency, personal meaning and purpose, and acceptance and belonging. While at a community level, resilience was nourished by social empowerment, shared decision-making, agency, and collective leadership and engagement. The review highlighted the need to reframe how communities view older adults and shift the narrative away from focusing on age-related deficits toward acknowledging the economic and social contribution older adults make to the community through activities such as volunteering and the sharing of knowledge of history, culture, and skills. At a community level, activities that draw on these personal-level capacities to promote collective action and participation are important for increasing community resilience. The review also established that resilience is generally developed in everyday circumstances, therefore active involvement within communities needs to be encouraged within community-dwelling older adults. Developing active involvement will not only contribute to both personal and community level resilience, but will enable communities to prosper and flourish through adversity.

AUTHOR CONTRIBUTIONS

WM, MA, and MO designed the study, read and critiqued the articles, and wrote the paper. In addition, MO undertook the searches and MA undertook the thematic analysis.

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Strength Improvements of Different 10-Week Multicomponent Exercise Programs in Elderly Women

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The purpose of this study was to analyze and compare the effects of various muscle strength sessions performed during 10 weeks physical conditioning programs and 4 weeks of detraining on the physical conditioning, body composition and hematology of elderly women. 48 women were randomly distributed in four groups: a physical conditioning group (PCG; $n = 12$) with two sessions per week; a PCG with an extra-session focus on hypertrophy (PCGH; $n = 12$), a PCG with an extra-session in a shallow pool (PCGP; $n = 12$); and a control group (CG; $n = 12$). PCGH achieved a significant increase in Abalakov. Significant differences between the CG and the other groups were found in Countermovement Jump. There were significant improvements in the chair-stand test in the PCG and PCGH. The training programs suspected improvements in HDL, LDL, baseline glucose and glycated hemoglobin. In conclusion, a training program with an extra-session focus on hypertrophy achieved a greater improvement in strength in elderly women.

Keywords: strength, training, female, physical programs, jumps

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INTRODUCTION

The physiological and anatomical characteristics of elderly adults deteriorate over the years. Their functional capacity decreases and changes occur at the respiratory, cardiovascular, renal, nervous and muscle-skeletal level (1). In women, especially after menopause, various physical abilities (strength, flexibility, equilibrium, resistance, and agility) follow a natural evolution of loss with age (2).

Over the last 10 years, there have been numerous and varied physical conditioning programs aimed at adults older than 60 years. These programs have sought to improve physical characteristics and body composition, optimizing and improving the quality of life of these individuals (3–6).

One of the most common programs that has proliferated it's self in social/cultural centers and in municipal sports programs is the general physical conditioning or multicomponent program This sort of exercise plan has had positive effects on the health in women older than 60 years (6, 7).

However, most scientific literature has focused on strength training in elderly adults. Most studies that are focused on increasing the muscle strength and functional strength of elderly adults using hypertrophy or neural adaptation methods were implemented in a period varying between 6 and 16 weeks, with a weekly frequency of two to three sessions, obtaining strength gains in upper and lower limbs (8–13).

Additionally, all of these programs caused changes, which if not performed periodically can lead to losses in strength, functional performance and body composition after the end of the training periods (12, 14). The clinical relevance of the neuromuscular adaptations induced by strength training is its impact on the daily living activities, especially when the strength training performed for several weeks led to greater improvements in strength in the arms and legs.

Therefore, Considering the importance of physical exercise in women older than 60 years, particularly strength training, it is essential to continue analyzing different physical conditioning programs in order to determine the best protocols for improving physical fitness in this population.

The aim of this study was to analyze and compare the effects of various muscle strength sessions implemented in 10-week physical conditioning programs, with a 4 weeks detraining, on the physical conditioning, body composition and hematology of elderly women.

MATERIALS AND METHODS

Design

In an interventional controlled trial, a general conditioning program alone, the same program with a focus on hypertrophy, or the same program with an extra pool session was used to analyze the effects of different training sessions and deconditioning after completing the program in elderly women. The program implemented lasted 10 weeks, followed by a 4 weeks detraining period.

Subjects

Forty-eight women (mean age, 65.7, $s = 4.5$ years; mean weight, 75.3, $s = 11.1$ kg) voluntarily participated in this study. The sample size was calculated by estimating a large effect size, α of 0.05, and power of 0.8. The sample was divided into four groups and four measurement moments were established (pre-post 1 (after the training program), post 2 and post 3 (two and 4 weeks after finishing the training program). Participants had performed in 3–5 years of controlled physical exercise.

Participants were randomly selected from people involved in the senior activity program of the Community Center of Madridejos (Toledo, Spain). All tests and training programs were carried out at the Sport city center which belongs to the Municipality of Madridejos. The participants were assessed between February and June of 2016. They were checked thoroughly during all medical procedures by medical staff (doctor and nurse). To be included in the study participants had to be aged 60 and 80 years old, and live within 50 km of a metropolitan area.

The inclusion criteria were the following: women between the ages of 60 and 80 years participating for more than 3 years in elderly physical exercise programs in the Municipality of Madridejos (Toledo, Spain) The exclusion criteria were a history of cardiac, respiratory or joint movement problems, problems with dizziness during exertion, propensity for infections, use of drugs that could endanger the participant during the implementation of the program and participation in a physical conditioning program aimed at developing strength in the past 6 months.

A parallel group design was performed. The participants were randomly distributed to four groups: a general physical conditioning group (PCG; $n = 12$), a general physical conditioning group with hypertrophy development (PCGH; $n = 12$), a general physical conditioning group with strength development in a swimming pool (PCGP; $n = 12$) and a control group (CG; $n = 12$).

The participants were informed of the benefits and risks prior to signing the informed consent document to participate in the research. The study was approved by the Clinical Research Ethics Committee of the University of Castilla-La Mancha and conducted in accordance with the Helsinki Declaration.

Procedures

Training Program

The training programs were conducted for 10 weeks from February to April, 2016. Previously, all groups had performed two familiarization sessions with the assessment tests, and the training groups were also familiarized with the exercises to be performed. All study groups had several training elements in common (**Table 1**). The participants were asked not to participate in other physical activities during the study period.

The training was differentiated as follows:

- PCG: performed the previous program exclusively.
- PCGH: the extra session performed per week can be seen in (**Table 2**). In the familiarization sessions, we determined the work intensity, calculating the 12 repetition maximum (RM) of the exercises to be performed during the program (except in the abdominal and dorsal-lumbar extension exercises). We used variable resistance machines. Work was performed with the following exercise circuit, according to (**Table 2**).
    - Circuit 1: 1-Leg extension in pulley. 2- Rectus abdominis (Extended leg crunch) (25 reps). 3- Low pulley row. 4- Abductors seated on machine (Gluteus maximus). 5- Dorsal-lumbar extension in lying prone position (25 reps). 6- Alternating biceps curl with supination (seated). 7- Lifting the heels in the machine. 8- Alternating frontal liftings with low pulley.
    - Circuit 2: 1- Leg curl lying down (hamstrings). 2- Oblique abdominals (25 reps). 3- Bench press in machine (Pectoralis major). 4- Abductors seated on machine. 5- Triceps extension in high pulley. 6- Unilateral dorsal-lumbar extension in lying prone position (25 reps). 7- Leg press inclined. 8. Pulldown with pulley to chest.
    - Circuit 3: 1-Pull over with high pulley (latissimus dorsi). 2- Semi-squat in multipower. 3- Anterior deltoids in machine (shoulder press). 4- Gluteus medius (hip abduction standing in machine). 5- Abdominal crunches with legs (25 reps). 6- Butterfly chest contractions. 7- Unilateral dorsal-lumbar extension in lying prone position (25 reps). 8- Lateral lunges with dumbbells.
- PCGP: performed a training similar to that of the previous group in terms of muscles involved but different in terms of

TABLE 1 | Exercise program performed by training groups.

Frequency	Intensity	Time	Type
Once a week.	60–70% Estimated heart rate (HR), combined with 70–80% (speech test).	40 min	Mean aerobic (cardiovascular exercises with musical base) combined with intermittent exertions.
Once a week.	60–70% 1RM; Character of exertion (12–15 of 20 repetitions) with moderate execution speed.	8–10 exercises × 3 × 12–15/30"	Strength-resistance (use of auxiliary material and calisthenics with the body itself.
Twice a week.	Joint range of movement (ROM) (Progressive reach of the maximum).	(5 exercises × 1–3 × 20"/10")/ session	Flexibility (Joint ROM improvement). Stretching.
Once a week.	Progression in the difficulty level (no. of supports, equilibrium base, distribution of supports).	5 exercises × 2'/30"	Static and dynamic equilibrium.
Once a week.	Progression in the difficulty level (from hand-eye coordination to foot-eye coordination; from intraindividual to interindividual coordination; stable environments to unstable environments).	3 exercises × 3'/30"	Coordination and agility.

TABLE 2 | Programming of the specific training group with an extra strength session (PCGH).

Week	Volume	Intensity	Exercises
1	8 exercises × (2 × 12/1')/3'	• 70% 1RM	CIRCUIT 1
2	8 exercises × (2 × 12/1')/3'	• 70% 1RM	CIRCUIT 2
3	8 exercises × (2 × 12/1')/3'	• 70% 1RM	CIRCUIT 3
4	8 exercises × (3 × 12/1')/3'	• 70% 1RM	CIRCUIT 1
5	8 exercises × (3 × 12/1')/3'	• 70% 1RM	CIRCUIT 2
6	8 exercises × (3 × 12/1')/3'	• 70% 1RM	CIRCUIT 3
7	8 exercises × (3 × 8/2')/3'	• 80% 1RM.	CIRCUIT 1
8	8 exercises × (3 × 8/2')/3'	• 80% 1RM	CIRCUIT 2
9	8 exercises × (3 × 8/1'30")/3'	• 80% 1RM	CIRCUIT 3
10	8 exercises × (3 × 8/1'30")/3'	• 80% 1RM	CIRCUIT 1

1RM, 1 repetition maximum.

TABLE 3 | Factors for the programming of the specific block in the PCGP training group.

Week	Volume	Intensity	Exercises
1	8 exercises × (2 × 20/30")/2' (active rest).	• RPE (Borg): 7 • Bpm: 120	CIRCUIT 1
2	8 exercises × (2 × 20/30")/2' (active rest).	• RPE (Borg): 7 • Bpm: 120	CIRCUIT 2
3	8 exercises × (2 × 20/30")/2' (active rest).	• RPE (Borg): 7 • Bpm: 120	CIRCUIT 3
4	8 exercises × (3 × 20/30")/2' (active rest).	• RPE (Borg): 7 • Bpm: 120	CIRCUIT 1
5	8 exercises × (3 × 20/30")/2' (active rest).	• RPE (Borg): 7 • Bpm: 120	CIRCUIT 2
6	8 exercises × (3 × 20/30")/2' (active rest).	• RPE (Borg): 7 • Bpm: 120	CIRCUIT 3
7	8 exercises × (3 × 20/30")/2' (active rest).	• RPE (Borg): 8 • Bpm: 130	CIRCUIT 1
8	8 exercises × (3 × 20/30")/2' (active rest).	• RPE (Borg): 8 • Bpm: 130	CIRCUIT 2
9	8 exercises × (3 × 20/30")/2' (active rest).	• RPE (Borg): 8 • Bpm: 130	CIRCUIT 3
10	8 exercises × (3 × 20/30")/2' (active rest).	• RPE (Borg): 8 • Bpm: 130	CIRCUIT 1

Bpm, beats per minute; RPE, Rating of Perceived Exertion.

intensity and speed of execution (**Table 3**). This session was performed in a heated swimming pool and with the use of various auxiliary materials (boards, pull-buoys, pool noodles, and paddles). A musical base was employed to increase the participants' motivation.

The exercise circuits performed were as follows:

Circuit 1

1- Jumping Jack (opening and closing of the legs) with extension/flexion of the elbow. 2- Rectus abdominis (V with legs bent). 3- Traction with board in the water. 4- Knee extensions with lateral inclination (Lateral kicking). 5- Ventral to dorsal flotation. 6- Bicep supination with paddles. 7- Multiple tip-toe hops. 8- Shoulder adduction with pull-buoys.

Circuit 2

1- Femoral (heel to buttock). 2- Oblique abdominals (unilateral inclination with elbow extension). 3- Pushing with boards. 4- Pendulum to 1 leg with pool noodle (hip adduction). 5- Elbow extensions with paddles. 6- Ventral to dorsal flotation. 7- Alternating knee extension (in suspension). 8- Frontal shoulder adduction with pull-buoys.

Circuit 3

1- Tractions with pull-buoys. 2- Hops with semi-squat. 3- Deltoids with board (vertical elbow extension). 4- Hip extensions. 5- Rectus abdominis. 6- Unilateral push with elbow extension and with pull-buoys. 7- Lateral turns using the elbows in flexion. 8- Lateral lunge with elbow extension and board facing forward.

After completing the training programs (POST1), the assessment tests were repeated 2 (POST2) and 4 (POST3) weeks later (except for the blood analysis, which was performed only once [POST1] after the intervention).

Testing procedures

Prior to applying the training programs, the following measurements were performed, scheduling each group on a different day:

- Blood analysis, recording the cholesterol (total, HDL and LDL), hemoglobin (Hb), HB (HbA1c), hematocrit (HCT) and glucose.
- Body composition analysis through bioimpedance (Inbody 230, Biospace Co. Ltd., Seoul, South Korea).
- Countermovement jump test (CMJ) and Abalakov (ABK) using the Optojump contact barriers (Microgate, Italy), performing two attempts of each jump, separated by 2 min, and selecting the highest jump.
- Test for standing and sitting in a chair the highest number of times possible in 30 s. This test is part of the battery of tests known as the Senior Fitness Test (STF) (15). The test consists of sitting down and standing up as many times as possible in 30 s, without using the hands. This test was performed using a chair without armrests, with a height of 40 cm. The chair was placed against a wall to prevent it from moving during the implementation of the test. The test began with the individual seated in the chair, with the back straight and supported on the backrest, the feet parallel and placed on the floor in a straight line with the knees to maintain balance during the test. The arms are crossed at the chest.
- Biceps curl test with 2.5 kg for 30 s (15). To start the test, the individual must sit down in a chair without armrests with the back straight and the feet completely placed on the floor. The participants took the dumbbell with their dominant hand and placed it perpendicular to the floor, with their elbow against the body and the palm of the hand upwards. The participants lifted the dumbbell to the shoulder and then returned it to the starting position, performing as many repetitions as possible within 30 s.
- The 6-min walking test covering the longest distance possible, covering a rectangular circuit (29 × 0.5 m). The short walking test has been shown to correlate well with cardiopulmonary resistance in elderly adults with differing health conditions (16, 17).

Statistical Analyses

The SPSS v.22 program was employed for the data analysis. The normality of the variables was analyzed with the Shapiro-Wilk test. Homoscedasticity was checked with Levene's test. To analyze the differences between groups for each of the variables, we applied an ANOVA of repeated measures (group × moment) with a Bonferroni *post hoc* test. Statistical significance was established at $p < 0.05$. We calculated the size of the effect using the partial eta squared (η^2) in the ANOVA analysis and through Cohen's d in the comparisons by pairs.

RESULTS

The results of all parameters are showed in (**Tables 4–11**). There were no significant differences in the changes between the groups or between the various assessments performed for the body weight, body fat percentage and muscle mass variables.

In terms of the variables obtained with the blood tests, we saw differences between the resulting changes between the groups. In the cholesterol-related variables, these differences were primarily observed in total cholesterol ($p = 0.02$; $\eta = 0.2$), mainly by

TABLE 4 | Results of Abalakov jump (cm) test (mean ± SD).

	CG (*n* = 12)	PCG (*n* = 12)	PCGH (*n* = 12)	PCGP (*n* = 12)
Pre-training	6.71 ± 3.73	10.18 ± 3.99	8.53 ± 1.93	7.17 ± 3.25
Post-training1	7.22 ± 3.88	10.68 ± 3.23	10.20 ± 2.39**	7.87 ± 2.77
Post-training2	6.05 ± 3.19	9.97 ± 3.54	10.83 ± 3.34**	8.42 ± 2.79
Post-training3	6.55 ± 3.46	9.78 ± 3.75	10.15 ± 3.25**	8.07 ± 3.03

***Difference ($p < 0.01$) with pre-training.*

TABLE 5 | Results of CMJ (cm) test (mean ± SD).

	CG (*n* = 12)	PCG (*n* = 12)	PCGH (*n* = 12)	PCGP (*n* = 12)
Pre-training	6.51 ± 3.03	8.76 ± 2.86	8.08 ± 1.91	6.16 ± 2.57
Post-training1	5.61 ± 2.87	9.17 ± 3.34#	8.85 ± 1.66	7.07 ± 2.82
Post-training2	5.49 ± 2.83	9.18 ± 3.38#	9.87 ± 2.15##**&	7.29 ± 2.29*
Post-training3	5.87 ± 3.02	9.38 ± 2.89#	9.51 ± 2.56#*	7.47 ± 2.15*

#Difference ($p < 0.05$) with CG.
Difference ($p < 0.01$) with CG.
**Difference ($p < 0.05$) with pre-training.*
***Difference ($p < 0.01$) with pre-training.*
& Difference ($p < 0.05$) with post-training1.

TABLE 6 | Results of Biceps curl in 30 s (repetitions) test (mean ± SD).

	CG (*n* = 12)	PCG (*n* = 12)	PCGH (*n* = 12)	PCGP (*n* = 12)
Pre-training	10.37 ± 3.25	13.92 ± 2.60	13.25 ± 3.05	12.17 ± 2.92
Post-training1	12.62 ± 3.70	15.77 ± 2.59	16.17 ± 1.75**	14.25 ± 3.05*
Post-training2	14.00 ± 3.62**	16.23 ± 2.65**	16.58 ± 1.83**	14.92 ± 2.43**
Post-training3	14.12 ± 3.48**	16.92 ± 2.22**	16.25 ± 1.76**	14.83 ± 2.25**

**Difference ($p < 0.05$) with pre-training.*
***Difference ($p < 0.01$) with pre-training.*

TABLE 7 | Results of Stand Chair (repetitions) test (mean ± SD).

	CG (*n* = 12)	PCG (*n* = 12)	PCGH (*n* = 12)	PCGP (*n* = 12)
Pre-training	14.00 ± 1.41	15.85 ± 2.15	16.33 ± 1.56	14.25 ± 2.14
Post-training1	14.12 ± 2.85	17.08 ± 2.36#*	18.00 ± 1.71##**	14.67 ± 2.50##&
Post-training2	13.00 ± 1.93	16.92 ± 2.22##	17.08 ± 1.93##	14.75 ± 2.60
Post-training3	13.25 ± 2.05	17.46 ± 2.96##@**	17.17 ± 1.40##@	14.33 ± 2.42

 # Difference ($p < 0.05$) with CG.
##Difference ($p < 0.01$) with CG.
& Difference ($p < 0.01$) with PCGH.
@ Difference ($p < 0.05$) with PCGP.
**Difference ($p < 0.05$) with pre-training.*
***Difference ($p < 0.01$) with pre-training.*

TABLE 8 | Results of 6-min walking (m) test (mean ± SD).

	CG ($n = 12$)	PCG ($n = 12$)	PCGH ($n = 12$)	PCGP ($n = 12$)
Pre-training	474.37 ± 55.90	533.08 ± 60.30	501.67 ± 87.32	484.58 ± 61.62
Post-training1	465.62 ± 65.16	541.92 ± 28.25	537.92 ± 33.13	508.33 ± 38.45
Post-training2	450.00 ± 56.38	540.00 ± 31.22	525.83 ± 31.83	514.58 ± 29.88
Post-training3	468.75 ± 50.20	541.15 ± 35.72	525.83 ± 35.73	513.75 ± 39.03

TABLE 9 | Results of body fat (%) and muscle mass (kg) analysis (mean ± SD).

	GC ($n = 12$)	PCG ($n = 12$)	PCGH ($n = 12$)	PCGP ($n = 12$)
Body fat (%)				
Pre-training	46.44 ± 7.42	45.09 ± 4.19	45.82 ± 4.15	45.49 ± 3.00
Post-training1	47.47 ± 7.36	45.02 ± 4.20	45.97 ± 4.54	46.02 ± 3.32
Post-training2	46.85 ± 6.91	45.12 ± 3.67	45.52 ± 4.82	45.70 ± 3.20
Post-training3	47.34 ± 7.38	44.48 ± 4.49	45.68 ± 4.56	45.59 ± 3.44
Muscle mass (Kg)				
Pre-training	22.99 ± 2.76	22.33 ± 2.87	22.26 ± 3.22	21.37 ± 3.05
Post-training1	21.70 ± 2.60	22.40 ± 2.69	22.01 ± 3.17	21.19 ± 3.56
Post-training2	22.00 ± 2.82	22.27 ± 2.52	22.00 ± 3.11	21.31 ± 3.21
Post-training3	21.86 ± 2.45	22.71 ± 2.98	21.96 ± 3.35	21.37 ± 3.08

TABLE 10 | Results of total cholesterol. LDL and HDL (mg/dl) analysis (mean ± SD).

	CG ($n = 12$)	PCG ($n = 12$)	PCGH ($n = 12$)	PCGP ($n = 12$)
Total cholesterol (mg/dl)				
Pre-training	194.25 ± 22.82	201.23 ± 23.53	208.58 ± 27.63	203.00 ± 22.37
Post-training1	207.25 ± 11.45**	200.31 ± 11.87	203.25 ± 25.37	202.13 ± 17.62
LDL (mg/dl)				
Pre-training	120.49 ± 25.01	117.41 ± 14.99	128.36 ± 18.92	113.94 ± 13.04
Post-training1	123.19 ± 17.77	114.49 ± 10.37	123.36 ± 16.83*	110.28 ± 13.32
HDL (mg/dl)				
Pre-training	56.50 ± 5.24	53.92 ± 8.20	51.75 ± 5.59	54.25 ± 4.97
Post-training1	58.38 ± 7.48	56.77 ± 5.57*	54.33 ± 4.07	56.17 ± 6.10

**Difference ($p < 0.05$) with pre-training.*
***Difference ($p < 0.01$) with pre-training.*

TABLE 11 | Results of Hemoglobin (g/dl), Hematocrit (%), Glucose (mg/dl) and Glycated Hemoglobin (%) analysis (mean ± SD).

	CG ($n = 12$)	PCG ($n = 12$)	PCGH ($n = 12$)	PCGP ($n = 12$)
Hemoglobin (g/dl)				
Pre-training	13.94 ± 0.81	13.97 ± 0.78	13.87 ± 0.66	13.92 ± 0.67
Post-training1	13.99 ± 0.79	14.25 ± 0.69	13.71 ± 0.69	14.07 ± 0.71
Hematocrit (%)				
Pre-training	40.06 ± 2.90	41.00 ± 3.38	40.30 ± 2.27	40.47 ± 2.39
Post-training1	39.87 ± 2.81	41.28 ± 2.97	39.72 ± 2.47	41.02 ± 2.30
Glucose (mg/dl)				
Pre-training	97.63 ± 10.07	98.85 ± 7.64	99.08 ± 9.59	102.17 ± 9.65
Post-training1	98.88 ± 12.26	97.77 ± 8.68	91.42 ± 7.24**	99.75 ± 10.70
Glycated hemoglobin (%)				
Pre-training	5.54 ± 0.29	5.58 ± 0.32	5.61 ± 0.28	5.78 ± 0.25
Post-training1	5.70 ± 0.29*	5.46 ± 0.29*	5.47 ± 0.24*	5.68 ± 0.35

**Difference ($p < 0.05$) with pre-training.*
***Difference ($p < 0.01$) with pre-training.*
CG, control group; PCG, general physical conditioning group; PCGH, general physical conditioning group (hypertrophy); PCGP, general physical conditioning group (pool).

the difference in LDL (n.s.; $\eta = 0.1$). In the Hb, we mainly saw a difference in the glycated Hb (p=0.005; $\eta = 0.3$; for the Hb n.s.; $\eta = 0.08$). There were no significant differences in the hematocrit (n.s.; $\eta = 0.06$). In terms of glucose, the PCGH showed a significant reduction ($p = 0.001$; $d = 1.1$) after the 10 weeks of training.

The results of the jump height in ABK showed no significant differences among groups or when analyzing only the 10 weeks of training or when considering the entire study period. However, we observed that the PCGH achieved an increase ($p < 0.01$, $d = 0.7$) with the training program, without changes among Post training 1, 2, and 3, although these changes are not significant (ns; $d = 0.2$), the values are still greater than the PRE value ($p < 0.01$, $d = 0.7$, for the PRE-POST2 difference, $d = 0.5$, for the PRE-POST3 difference). Therefore, no significant differences between-group were found on the ABK measure, but there was a significant within-group difference in the PCGH group.

The results of the ANOVA showed that there were differences ($p < 0.01$; $\eta = 0.20$) in the changes produced among all the groups in jump height in CMJ, although these differences were not observed right after the completion of the program but rather subsequently. Differences were found between the CG and the other groups ($p < 0.01$; $\eta = 0.61$, with the PCGH; $p < 0.01$; $\eta = 0.25$, with the PCGP; $p < 0.05$; $\eta = 0.12$, with the PCG). Both the PCGH and PCGP obtained higher values in POST2 and POST3 compared with the PRE value ($p < 0.01$; $d = 0.8$, $d = 0.5$, in the PCGH between PRE and POST2 and between PRE and POST3, respectively; $p < 0.01$; $d = 0.5$, $d = 0.6$, in the PCGP between PRE and POST2 and between PRE and POST3, respectively).

In the number of repetitions in biceps curl within 30 s, no significant differences were found in the changes between groups.

Although we did not find significant differences in the changes experienced in the chair standing repetitions between the groups, both the PCG ($p < 0.01$, $d = 0.5$) and PCGH ($p < 0.01$, $d = 1$) showed an increase after the training program.

Similarly, we found no significant differences, either after the 10 weeks of training or in the entire study period, between the groups in the distance traveled in the 6-minute walking test, although the 3 training groups increased their distance while the control group decreased their distance. The most relevant increase was that of the PCGH ($d = 1.1$) followed by the PCGP ($d = 0.6$).

DISCUSSION

The aim of this study was to analyze and compare the effects of various muscle strength sessions implemented in 10-week physical conditioning programs and 4 weeks of detraining on the physical condition, body composition and hematology of elderly women. Recent studies have shown that elderly women improved their physical fitness following multicomponent exercise (6, 7). Toto et al. (6) analyzed the effects of a 10-week multicomponent program and they observed a improving physical performance and activities of daily living. Kang et al. (7) affirmed that multicomponent training programs that consist of "balance, strengthening, and stretching exercises are a relevant intervention for the improvement of the level of physical fitness of older women."

No significant differences between programs were found in body composition. A possible explanation for these results is the fact that although a number of the subjects had some significant improvements in physical fitness, they did not decrease fat mass. This fact suggests that changes in body composition should not be the only indicator of the benefits of exercise in overweight postmenopausal women, as shown by Myette-Côté et al. (18) in their study. Halverstadt et al. (19) found no changes in body composition after 24 weeks of endurance exercise training. In addition, Amarante et al. (20) suggested that a 12-week resistance-training program (3 times a week) improved muscle strength without changes in body composition in elderly women under dietary intake maintenance.

Differences between the groups were found in some of the blood parameters after 10 weeks of the training program, which agrees with Ribeiro et al. (21). Halverstadt et al. (19) observed improvements in plasma lipoprotein and lipid profile with independence of diet and baseline levels after 24 weeks of endurance exercise training. Tomeleri et al. (22) performed a resistance training program consisting of 8 whole-body exercises for 3 sets of 10–15 repetition maximum (RM) performed three times per week with obese elderly women. The program improved inflammatory levels and the lipid and glycemic profiles. Our results agree with those of Martins et al. (23) who concluded that "training programs produced significant benefits in metabolic health indicators of sedentary elderly women and men."

There were no significant differences between the groups after 10 weeks of the physical conditioning program and 4 weeks of detraining in the jump height in ABK. However, the PCGH achieved an increase ($p < 0.01$, $d = 0.7$) between PRETEST and POST1 and between POST1 and POST2. After 4 weeks of training, a significant reduction was produced in POST3. These results agree with those of Delshad et al. (9) who found decreases after 4 weeks of detraining in 50-year-old women. According to the American College of Sports Medicine reports, "strength training is important for improving quality of life and physical function in older adults." Raj et al. (24) obtained improvements in the jump with a strength training program at 75% of 1RM for 16 weeks of training in older adults. The results of this study also agree with those of González-Ravé et al. (25) who observed improvements in the vertical jump after 16 weeks of strength training in elderly adults. The results of the CMJ confirm how significant improvements were produced in the jump in the PCGH and PCGP between PRETEST and POST2. Differences were also observed between the experimental groups and the control group.

In terms of performance in muscle resistance in the arms and legs, there were no differences in the 30-s biceps curl test between the groups after the training, although the experimental groups showed improvements on the number of repetitions with the various training programs. Amarante et al. (20) obtained similar results after a 12-week resistance-training program (3 times a week) in improving arm muscle strength, without altering the body composition in elderly women. Similar results were found by Daly et al. (8) after arm strength training for 6 weeks. The chair stand results in this study showed significant improvements in the PCG and PCGH. Jones et al. (26) concluded that the 30-s chair stand test was a good indicator of lower body strength in active older adults. Similar results were found by Taguchi et al. (5) but in elderly adults with a mean age of 84 years.

Finally, although the improvements observed in the 6-min walking test were not significant, the groups who performed the training improved their distance traveled in this test. The improvements in cardiovascular resistance in this type of individual can be greater than those observed in this study, given that in our study 40 min a week were dedicated specifically to improving the cardiovascular system, an amount of exercise lower than that recommended by the American College of Sport Medicine (27). This can be observed in other studies, such as the one by Hallage et al. (28), where weekly exercise of more than 150 min aimed at cardiovascular resistance was performed. The study obtained significant improvements after 12 weeks of training, although these improvements decreased significantly after 1 month of detraining.

Finally, the main finding of our study was that physically active older women, at least within in the PCGH, improved their muscle power, endurance and local muscular endurance without improvements in body composition and blood tests.

A particular strength of our study lies in the possibility to compare different conditioning programs for elderly women and the follow-up period that allowed us to measure the maintenance of the changes after the training sessions. However, several limitations should be taken into consideration. The small sample size of the study, specifically the control group with fewer participants than the other groups, or the lack of randomization of the sample did not allow us to show more significant results.

In accordance with González-Ravé et al. (25), any training proposal required to put on special attention and individual experimentation in elderly people. A well-planned

multicomponent training program does not entail an additional overload in the development of skeletal muscle in elderly women, as evidenced by an adaptive response without acute fatigue or overtraining, and by biochemical parameters. This is an important finding due to the demonstrated benefits of strength and power improvement for the function and quality of life of elderly people.

CONCLUSIONS

After 10 weeks of training with various conditioning programs for elderly women than 60 years, we observed that the program with an extra strength training session aimed at muscle mass gains resulted in greater improvements in strength in the arms and legs.

The multicomponent exercise programs supposed improvements in various hematological variables (HDL cholesterol, LDL cholesterol, baseline glucose and glycated hemoglobin).

The 4 week detraining period resulted in no significant changes in body composition, physical condition and hematological variables compared with post-training levels. Due to the changes observed after the extra strength training session, in future studies, it would be beneficial to deepen the intensity, frequency, or to analyze the effects of a longer detraining period on this population.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The study was approved by the Clinical Research Ethics Committee of the University of Castilla-La Mancha and conducted in accordance with the Helsinki Declaration. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RC-C, JG-R, TG-P, and DS-G conceptualized, designed and performed the experiments and analyzed and interpreted the data. RC-C, JG-R, TG-P, and DS-G edited and critically reviewed the manuscript. JG-R and DS-G wrote the manuscript.

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REVIEW
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The Importance of Taking a Patient-Centered, Community-Based Approach to Preventing and Managing Frailty: A Public Health Perspective

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Across the world, life expectancy is increasing. However, the years of life gained do not always correspond to healthy life years, potentially leading to an increase in frailty. Given the extent of population aging, the association between frailty and age and the impact of frailty on adverse outcomes for older people, frailty is increasingly being recognized to be a significant public health concern. Early identification of the condition is important to help older adults regain function and to prevent the negative outcomes associated with the syndrome. Despite the importance of diagnosing frailty, there is no definitive evidence or consensus of whether screening should be routinely implemented. A broad range of screening and assessment instruments have been developed taking a biopsychosocial approach, characterizing frailty as a dynamic state resulting from deficits in any of the physical, psychological and social domains, which contribute to health. All these aspects of frailty should be identified and addressed using an integrated and holistic approach to care. To achieve this goal, public health and primary health care (PHC) need to become the fulcrum through which care is offered, not only to older people and those that are frail, but to all individuals, favoring a life-course and patient-centered approach centered around integrated, community-based care. Public health personnel should be trained to address frailty not merely from a clinical perspective, but also in a societal context. Interventions should be delivered in the individuals' environment and within their social networks. Furthermore, public health professionals should contribute to education and training on frailty at a community level, fostering community-based interventions to support older adults and their caregivers to prevent and manage frailty. The purpose of this paper is to offer an overview of the concept of frailty for a public health audience in order to raise awareness of the multidimensional aspects of frailty and on how these should be addressed using an integrated and holistic approach to care.

Keywords: public health, primary care, frailty, biopsychosocial (BPS) model multidisciplinary, holistic care course

INTRODUCTION

The world is rapidly aging. According to the United Nations Department of Economic and Social Affairs "*World Population Aging 2019*" report, there are currently 703 million people aged ≥65. This is projected to reach 1.5 billion, representing one in every six people, by 2050, up from one in every 11 in 2019 (1). Similarly, the number of people aged ≥80 years will triple in the next 30 years and life expectancy after 65 years of age is predicted to increase by 19 years (1). However, the years of life gained do not always correspond to healthy life years. The latest figures, published for 2020 by Eurostat, reveal that in the European Union (EU) the proportion of healthy life years represents approximately 76.7 and 81.4% of the total life expectancy for women and for men, respectively (2). The reduction in healthy life years is characterized by an increase in frailty, multimorbidity and disability (3), which results in frequent use of healthcare services by older adults (4). All the above-mentioned conditions can impair several domains of health (i.e., physical, psychological, cognitive, and social), requiring holistic care for complex needs that are the consequence of multiple determinants of health.

The purpose of this paper is to offer an overview of the concept of frailty for a public health audience, in order to provide a better understanding of the condition and its prevention and management. Specifically, this paper aims to raise awareness of the multidimensional aspects of frailty and how these should be addressed using an integrated and holistic approach to care. To achieve this goal, public health and primary health care (PHC) need to become the fulcrum through which care is offered, not only to older people and those that are frail, but to all individuals, favoring a life-course and patient-centered approach focused on integrated community-based care.

FRAILTY AS A MULTIDIMENSIONAL CONSTRUCT

Frailty is a complex age-associated syndrome without a universally accepted definition (5–7). It results from a decrease in multiple physiological systems that leads to a state of increased vulnerability to stressor events with impaired ability to achieve homeostasis (8–10). Such triggers can include worsening of a chronic condition (11), environmental factors (12), change in therapies (3), and adverse life events (13). In older adults a progressive loss of physiological reserve is characteristic of frailty (14). Frailty is also associated with an increasing risk of adverse outcomes (3, 15–17), which includes falls (18, 19), fractures (20), disability (18, 19), delirium (21), depression (22), cognitive impairment (21), hospitalizations (18, 23, 24), need for long-term care (19), poor quality of life (25–27), limited life expectancy (28), and premature death (29, 30). Although research into frailty is continuously developing, some pillars of the condition have been established: it is an age-related condition (25, 31), though it is not an inevitable consequence of the process of aging (3, 32, 33). It is multidimensional, that is, it affects multiple aspects of health, namely physical, psychological, cognitive, social, emotional, spiritual, economic (32, 34–36), and nutritional domains (37). It is a dynamic and reversible state, at least in its initial stages (38), that is, persons can fluctuate from a robust state to a state of frailty, until the reduction in their physiological reserve prevents recovery to their baseline status (39). In addition, transitioning to more severe levels of frailty is more common than reversing frailty (3). As frailty mirrors biological rather than chronological age (40, 41), identifying biomarkers of this condition is important. However, to date, biomarkers that reflect biological age better than chronological age are as yet unavailable (42). These could also help identify frailty objectively and could contribute to further understanding its pathophysiology.

THE EPIDEMIOLOGY OF FRAILTY

The prevalence of frailty is higher (up to two-fold) in women, compared to men (18). Among community-dwelling older adults (≥65 years), the prevalence of frailty ranges between 5 and 16% (40, 43, 44), depending on the definition used and population examined; this percentage is known to be higher in clinical settings (38), reaching 85% in nursing home residents (40, 45, 46). Age is strongly associated with frailty; the American Medical Association reported that 40% of people aged ≥80-year-old are frail (47). Similarly, centenarian studies report rates over 50% (48). Given the extent of population aging, the association between frailty and age and the impact of frailty on adverse outcomes for older people, it is increasingly being recognized to be a significant public health concern (6, 7).

FRAILTY MODELS

The two most widely-used approaches to classify frailty are the physical frailty and deficit accumulation models of frailty. The Frailty Physical Phenotype was initially proposed by Fried et al. (18) who used the Cardiovascular Health Study to define the "frailty phenotype," identifying five physical components, specifically exhaustion (self-reported), low physical activity, weakness (low grip strength), slow gait speed, and shrinking (unintentional weight loss ≥5% in prior year), whose presence in number ≥3 establish physical frailty. If only 1 or 2 criteria are met, persons are defined prefrail, while when no components are present, persons are deemed robust. Rockwood and Mitnitski (49) and Mitnitski et al. (50) validated the cumulative deficit model using data from the Canadian Study of Health and Aging to create a Frailty Index, which originally included a total of 70 deficits including signs, symptoms, disabilities, diseases, and laboratory investigations (21). The cumulative number of disorders present in a person is divided by the total items explored: the more deficits are present, the higher the possibility that the individual is frail (51). Different items, consisting of activities of daily living, diseases, impairments, can be present in the frailty index, since not all of the deficits need to be necessarily considered, and a subset can be used (52). While these two operational models are the most commonly applied frailty constructs, they are different and should be considered

complementary, rather than alternatives (52). It is worth pointing out that neither capture all aspects of frailty; the frailty phenotype almost exclusively assesses physical frailty, while the frailty index captures multi-morbidity but does not clearly distinguish frailty from disability (52). Frailty is more complex than the presence of multiple deficits, limitations in activities of daily living or physical deficits alone. It also incorporates elements relating to the functional reserve, psychology and social environment of the individual. More recently, a broad range of screening and assessment instruments such as the Comprehensive Frailty Assessment Instrument (53) and the Tilburg Frailty Index (54) have been developed taking a more biopsychosocial approach (55). This characterizes frailty as a dynamic state resulting from deficits in any of the physical, psychological and social domains, which contribute to health. This conceptual model along with the physical and deficit accumulation models of frailty also lacks a specific operational definition.

FRAILTY AND SARCOPENIA

Many of the pathophysiological changes resulting in frailty remain unclear (32). In the late 1980s, Rosenberg invented the term sarcopenia to describe the loss of lean body mass experienced with aging (56). One of the first theories linking frailty and sarcopenia dates back to 1994, when Fiatarone et al. hypothesized a connection between frailty and decline in muscle mass, suggesting that improvement in muscle mass may be beneficial for people experiencing frailty (57). While an association between sarcopenia and frailty has been established, the pathophysiology of frailty appears to be more complex than the effect of sarcopenia alone (58–60). For example, it is still not clear whether sarcopenia causes frailty or whether it is a manifestation of it. Like frailty, sarcopenia is more prevalent among older adults, is associated with adverse outcomes and is potentially reversible (61). Both conditions can lead to functional decline and disability; thus, the early detection of both is recommended (61). To further study this connection, the ongoing study by Calvani et al. "BIOmarkers associated with Sarcopenia and PHysical frailty in ElderRly pErsons" (BIOSPHERE) proposes to identify biological markers for sarcopenia and physical frailty through blood sample analysis and may help shed some light on the connections between frailty and sarcopenia (6, 62). A better understanding of the two conditions and the connection between them could help in their prevention and management.

FRAILTY AND MULTIMORBIDITY

The epidemiological transition has led to prolonged life expectancy. This has resulted in chronic rather than acute conditions becoming the leading cause of morbidity and mortality (63). As a result, older adults are increasingly facing multimorbidity and chronic illnesses, such as diabetes, hypertension, and dementia as they age (64). Multimorbidity is defined as the presence of two or more chronic diseases (65, 66). Its impact on the health status is dependent on the interaction between the specific illnesses that affect the individual simultaneously (67), which is higher than the sum of the single effects expected from each disease (68). Frailty and multimorbidity are two overlapping but distinct conditions (19, 58, 69) and therefore require different management (69, 70) and prevention strategies. Although, the presence of multiple chronic conditions is associated with the development of frailty (6, 18), it is not necessarily the consequence of chronic disease. Frailty can be present even in the absence of chronic conditions, suggesting that there are different pathways leading to its development (71). Evidence showing how multimorbidity can lead to frailty is still lacking (72, 73) and more research on this is needed. The prevalence of both conditions increases with age, even if they do not affect only older persons (40, 74). However, multimorbidity is more ubiquitous than frailty, with up to three out of four people aged $\geq$75 years, fulfilling the criteria for multi-morbid (75–77). Furthermore, chronic diseases and frailty predict disability (16), and are associated with adverse outcomes and worse prognosis when they are both present (78).

As identifying frailty is considered a more reliable predictor of adverse outcomes than multimorbidity (79), the National Institute for Health and Care Excellence and the British Geriatric Society underline the importance of recognizing frailty in older adults with multimorbidity as these are at greater risk of adverse outcomes (80, 81). This could help target and rationalize appropriate treatment of multimorbidity, given that evidence suggests that intensive or over-treatment of chronic diseases may increase negative health outcomes in frail people (67, 82). Furthermore, when caring for persons with frailty and multimorbidity, it is important to take into account that frailty could hinder adherence to both pharmacological and physical therapies (83).

FRAILTY AND COGNITIVE IMPAIRMENT

Within the biopsychosocial model of frailty, research exploring the cognitive and psychological aspects of the syndrome have highlighted the relationship between physical frailty and cognitive impairment, leading to the conceptualization and operationalization of cognitive frailty (84). Experts from the International Academy of Nutrition and Aging found consensus on the definition of cognitive frailty, identifying it as a state that requires the presence of physical pre-frailty or frailty [according to the Frailty Phenotype (18)], and mild cognitive impairment (MCI), diagnosed with questionable dementia on the Clinical Dementia Rating (CDR) (score 0.5), a state similar to MCI (85). More recently, using these criteria, two main subtypes of cognitive frailty have been proposed: reversible cognitive frailty representing subjective cognitive decline (i.e., pre-MCI, a CDR score $= 0$) and potentially reversible cognitive frailty, equivalent to MCI (a CDR score $= 0.5$) (86–88). Both subtypes require the co-occurrence of physical pre/frailty and studies have shown that gait speed or grip strength are the physical characteristics most frequently associated with cognitive frailty (89). Different instruments other than the CDR have been used to detect cognitive impairment (90), leading to different

operational definitions of cognitive frailty (88). Hence as with general frailty, more research is needed to develop a shared operational definition. As for physical frailty, the onset of cognitive frailty can be delayed and reversed, at least in the first stages, and the condition can lead to a higher risk of adverse health outcomes (26), namely disability (91), worsened quality of life (92), hospitalization and mortality (93). Thus, public health professionals favor a life-course approach, intervening at a younger age with preventative strategies including physical activity and dietary modification, e.g., the Mediterranean diet (88). These may help prevent or delay onset of not only cognitive frailty but also sarcopenia and physical frailty (94), though further research is needed to confirm such findings.

FRAILTY AND THE SOCIAL DETERMINANTS OF HEALTH

In a broader sense, health reflects multiple factors beyond the medical, including social, economic, political, and environmental; individuals are affected by multiple environmental and social factors, which impact on their health (95), and contribute to social vulnerability (96). Furthermore, the social determinants of health, namely education, housing, job, nutrition, environmental protection (97), can decrease an individual's intrinsic and extrinsic capacity, rendering them frail. The ability of the individual and their social and caregiver network to manage frailty influences the risk of a broad range of adverse outcomes, including institutionalization and death, more so than their medical conditions or their ability to perform daily activities (98). Thus, as the manifestations of frailty are evident across not only the physical and the psychological, but also the social domain, it is important to explore the social consequences of frailty. Although patient-centered care is increasingly at the core of managing health, more research into the relationship between frailty and social vulnerability is needed so that an individual's social environment, perspective and desires are not overlooked. The work by Azzopardi et al. highlights how even within the biopsychosocial approach toward frailty, the social aspects and especially the environmental and personal factors (e.g., relationships) of the individual are not adequately considered by health and social care professionals (96). A recent scoping review examining the construct of social frailty (i.e., inadequate social resources to fulfill an individuals' social needs) found that the loss of social activities and self-management abilities are important components and must be supported to minimize adverse outcomes (99). Because public health professionals have a broader view of health determinants compared to clinicians, they are in a privileged position to address the social needs of people and to intervene in their home environment.

SCREENING AND ASSESSING FOR FRAILTY

At least in its initial stages, before the onset of functional impairment, frailty is often reversible (5, 38). Hence, early identification, usually at the pre-frail stage (100), is important to help individuals regain function and to prevent negative outcomes associated with the syndrome. Despite the importance of diagnosing frailty, there is no definitive evidence or consensus as to whether screening should be routinely implemented in different settings, whether a certain age threshold should be set (58, 101), nor which domains should be investigated (36, 102). Indeed, there is little evidence to support primary healthcare services for population-level screening, surveillance or monitoring of frailty (103). Nonetheless, the Royal College of Physicians, the French Society of Geriatrics and Gerontology (104, 105) and the British Geriatrics Society (80) all recommend opportunistic or targeted screening for frailty. Several short instruments to screen and assess frailty exist, although a standard approach to define frailty has yet to be agreed, hampering the ability to measure it (5, 31, 106). Given the multidimensional characteristics of the syndrome, various instruments with different features are validated and can be used depending on the clinical setting. Among these instruments, some are intended only to detect physical frailty while others are more multidimensional (**Table 1**). The main limitation of all these instruments is that they do not suggest any intervention on the basis of their score.

TABLE 1 | Selection of frailty screening and assessment instruments comparing uni and multidimensional scales.

Unidimensional	Multi-domain and multidimensional
Frailty Phenotype	Frailty Index
Gait Speed	Clinical Frailty Scale
Timed-Up-and-Go Test	Groningen Frailty Indicator
INTER-FRAIL	Edmonton Frail Scale
Short Physical Performance Battery	Gérontopôle Frailty Screening Tool
FRAIL scale	Frail Elderly Functional Assessment
	PRISMA-7 Questionnaire
	Kihon Checklist
	Tilburg Frailty Index
	Comprehensive Frailty Assessment Instrument

The "Frailty Phenotype" (18), the "Gait Speed" (131), the "Timed-Up-and-Go Test" (132), the "INTER-FRAIL" (133), the "Short Physical Performance Battery" (134), the "Frail Scale" (58) the "Frailty Index" (49, 50), the "Clinical Frailty Scale" (21), the "Groningen Frailty Indicator" (135), the "Edmonton Frail Scale" (136), the "Gérontopôle Frailty Screening Tool" (137), the "Frail Elderly Functional Assessment" (138), the "PRISMA-7 Questionnaire" (139), the "Kihon Checklist" (140), the "Tilburg Frailty Index" (54), and the Comprehensive Frailty Assessment Instrument (53).

To date, Comprehensive Geriatric Assessment (CGA) is considered to be the gold standard to assess frailty (3). However, it was not designed for this purpose and may not necessarily completely represent frailty, as it was originally intended to detect disability (69, 70). For this reason, a modified CGA might be more meaningful to use to identify frailty (80, 107). CGA is nevertheless important to create tailored interventions, though it can be time consuming and requires specialist input. PHC may be the best place to screen for frailty (80, 108, 109). To this end, it is worth stressing that PHC physicians and specialists should receive appropriate training on how to detect frailty (69), in

order to appropriately screen for the condition (58). There are an increasing number of examples of frailty education programs for healthcare professionals (110). These are supported by guidelines on interprofessional learning, which is central to frailty education (111). For example, in Ireland, the National Frailty Education Programme, which aims to provide education on the key fundamentals of frailty to a wide range of healthcare professionals in all healthcare settings, was successfully implemented (112). There is a need for a similar approach in other countries to provide the necessary skills to healthcare professionals and enhance their understanding of frailty and ensure early identification and appropriate management of this condition.

FRAILTY AND COVID-19

In light of the pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), prognostic factors to allocate resources in case of limited medical supplies have been at the center of the discussion worldwide. Studies have shown that increasing age is associated with adverse outcomes for individuals with COVID-19 (113, 114). Given this, some have favored the use of age as a prognostic factor. However, recent evidence (115) suggests that age alone is insufficient, and that frailty may help guide in the evaluation of those most likely to benefit from critical care (116). For this reason, the National Institute for Health and Care Excellence (NICE) (117) recommends assessing frailty in all older adults with COVID-19 (except those with stable long-term disability such as cerebral palsy). The Clinical Frailty Scale (CFS) can be used with caution to support clinical decision-making for older adults with COVID-19 (116). The COVID-19 in Older PEople (COPE) study evaluated the utility of the CFS and showed that frailty predicts earlier death and longer time spent in hospital (118). This new evidence points to the central role that frailty assumes when caring for older persons with acute illness. Despite this, only limited data are available to support the use of frailty or any specific screening instrument at population-level in order to predict the severity of the clinical manifestations of COVID-19 in older people. As the pandemic continues, more data are required to help researchers, clinicians and public health officials to better understand how identifying frailty among older adults at a primary care level could help mitigate the most negative consequences of the pandemic for older populations.

DISCUSSION

This paper examines some of the key public health aspects of frailty. The need to understand the concept from a public health perspective is being increasingly recognized, such that frailty has been labeled as the "future core business of public health" (119) While several definitions of frailty are available these as yet, do not help operationalize the concept (5). This has limited the uptake of frailty as a research construct among public health professionals who have up to now focused more on risk factors for adverse aging including non-communicable chronic disease and socioeconomic inequalities. Involving international experts from different settings amongst health and social care professionals, academics and older people themselves could be the first step to reach a general agreement on a definition. Furthermore, consensus on the dimensions that must be examined for an operational definition has not been reached yet (102). Given the heterogeneity between definitions used to classify frailty and the varied features of frailty, the same person could be both frail and not frail, due to the different domains investigated. We suggest that reaching consensus on an operational definition might not necessarily mean finding a unique definition that fits for all health and social care settings, but rather having a common understanding and a multidimensional approach on ways to define and recognize the condition among all professionals including public health professionals is required. Contextual terms such as social frailty, nutritional frailty, physical frailty, and cognitive frailty may also be useful to improve uptake of the concept of vulnerability to adverse events that is at the core of frailty (34, 84).

At present, there is little data available for screening and assessing frailty at population-level (103). Furthermore, we suggest that implementing population-level screening would require upskilling the existing workforce and further research evaluating both the effectiveness and cost-effectiveness of this approach at a primary care and public health level. The role of secondary care (e.g., hospital-based Geriatricians) and how this could support community-based services also needs to be clarified. Identifying and labeling individuals as frail without clear benefit risks itself causing harm. Defining a concept influences how we identify it (34), and gives it a clear significance, with repercussions in everyday life. Labeling persons as frail might have consequences on how society relates to and engages with them (120). This could affect how people perceive themselves and their role in society as well as in the familial context. It is important that, even when recognized as frail, people are able to feel valuable and participate in everyday life to the fullest of their capabilities. To achieve this goal, as a society, we need to create environments that allow frail people to feel socially involved, minimizing social stigma. Hence, frailty does not only concern health-care services, but also social services and communities in their entirety as well. There is also a need to provide better communication to individuals with frailty and their supports in order to help people to contribute irrespective of their level of frailty in every aspect of life in so much as is possible. This an important approach to frailty that PHC and public health professionals should strive to achieve. Communication with the public regarding frailty is also needed. Public health campaigns explaining that this is a condition influenced by the life course is important. Therefore, as it is important to identify frailty at an early stage, we assert that more frailty research including people younger than 65 is required, as this would help identify frailty in its earliest, prodromal stage, usually referred to as pre-frailty (106, 121). Public health campaigns combined with interventions targeting pre-frail individuals may provide more positive outcomes, given that the reserve capacities at this stage are still sufficient to preserve functional abilities (122).

Population-level interventions taking a public health approach, centered on education are also appropriate. Again these should begin early and target younger individuals before the onset of frailty.

Although it is not yet clear how best to target frailty, the biopsychosocial model is the most appropriate to provide a holistic assessment of the patient. Recognizing which domains (i.e., physical, cognitive, nutritional, psychological, social, economic) contribute to the loss of function would serve as a proxy for health-care utilization and improve the quality of patient-centered care (123), favoring targeted strategies for prevention and management at population-level. Education is vital to ensuring that providers and older people themselves are well-placed to take advantage of these approaches. Evidence suggests knowledge about the prevention and reversibility, "malleability," of frailty is poor (123); hence, in the context of aging societies worldwide and high levels of frailty in all countries (124), there is a need to increase awareness at all levels (i.e., micro, meso, macro). In this sense, frailty should no longer be confined to geriatric medicine settings. For example, most healthcare specialties manage older people with complex needs that require a broader understanding of the overall health status of the patient (68), rather than a disease-specific approach. Furthermore, even if impairment is detected in a specific domain, the increased vulnerability associated with frailty places individuals at higher risk for rapid deterioration in other domains too. This requires proactivity rather than reactivity to prevent this from happening and the adoption of a person-centered, community-focused public health model. For this purpose, a holistic approach is needed when caring for frail older people. Thus, public health personnel should be first introduced to the multidimensional nature of frailty, then trained to identify frailty and consequently made aware of that it is not merely a clinical concept, but also a societal issue that can be addressed in the individuals' environment and within their social relationships. Moreover, public health professionals can contribute to education and training on frailty at a community level, fostering community-based interventions to support older adults and their caregivers to prevent and manage frailty. Similarly, policy-makers need to be more conscious of the role frailty plays and to shape policies that help foster seamless care for those with complex needs and to increase the ability of people to self-manage (125). The need to provide integrated care at population-health level is particularly important (126). Fragmentation of care hinders the possibility of properly addressing each aspect of frail individuals' complex needs.

The influence of socioeconomic inequalities on the development of frailty and outcomes amongst frail individuals cannot be underestimated. Frailty is usually associated with a lower socioeconomic status; frail individuals are usually less educated and have lower incomes (18, 40). This underlines how health is highly influenced by social factors. Furthermore, the lack of shared assessment of environmental and social factors, that are sparingly reported in currently multidomain frailty instruments, could influence a misleading approach to fulfill the real needs of frail individuals and populations (96). Services need to be able to intervene to address the social determinants of health, which too often, particularly in healthcare settings, are not considered as an integral part of the well-being of the person. Traditional health-care systems with their siloed structure and a strong hospital-centric and cure-first culture, need to be re-focused to adapt to the new complex and chronic care needs of populations. For this purpose, we need to put into action the framework for the redesign of healthcare centered around PHC set out in 1978 in the Alma-Ata Declaration and reaffirmed in 2018 in the Astana declaration (127). Public health, PHC and social services must be at the center of managing the care of frail older adults, promoting integrated care and a life-course approach to health. Intermediate care, which has been developed to foster the integration between acute and PHC and provides a wide range of both health and social services to bridge care for older and frail persons who have complex needs (128), could foster the management of complex needs of frail adults. It has been shown to influence healthcare outcomes including hospitalizations, though further study particularly at population-level is required (129). Hence, while it has been said that "complex problems require complex solutions" (130), we assert that complex needs require holistic and integrated care.

CONCLUSIONS

Further research is needed to address the challenging task of finding consensus on the conceptual and operational definition of frailty. This is important to support its use in public health. While physical frailty has been seen as the core feature of the condition, frailty is a more complex, and multidimensional syndrome influenced by the social determinants of health. Population aging is a worldwide trend that is no longer limited to more economically developed countries. Therefore, thorough study on the possible causes, role of socioeconomic factors, the high prevalence in low- and middle-income countries, and on possible prevention and management strategies that can be adopted in countries with less resources compared to developed countries, should be fostered. The orientation of the PHC vision outlined in the Alma-Ata declaration lays the foundation of what is known today as integrated care. Forty-two years later, it is time for public health and PHC to become the fulcrum of care through health promotion and prevention activities in the community, and through new models of care that foster the integration of health and social care professionals, guaranteeing a holistic person-centered approach to the complex needs of frail people.

AUTHOR CONTRIBUTIONS

The authors conceived and shared the idea of this manuscript and equally contributed to its content.

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Non-linear Relationships Between the Built Environment and Walking Frequency Among Older Adults in Zhongshan, China

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Aim: Promoting walking activity is an effective way to improve the health of older adults. Walking frequency is a critical component of walking behavior and an essential determinant of daily walking levels. To decipher the association between the built environment and walking frequency among older adults, this study's aims are as follows: (1) to empirically test whether non-linear relationships between the two exist, and (2) to identify the thresholds of the built environment characteristics that promote walking.

Methods: The walking frequency of old adults was derived from the Zhongshan Household Travel Survey (ZHTS) in 2012. The sample size of old adults aged 60 or over was 4784 from 274 urban and rural neighborhoods. A semi-parametric generalized additive model (GAMM) is used to analyze the non-linear or non-monotonic relationships between the built environment and the walking frequency among older adults.

Results: We found that non-linear relationships exist among five out of the six built environment characteristics. Within certain thresholds, the population density, sidewalk density, bus stop density, land use mixture, and the percentage of green space are positively related to older adults' walking trips. Furthermore, the land use mixture and the percentage of green space show an inverse "V"-shaped relationship.

Conclusions: Built environment features can either support or hinder the walking frequency among older adults. The findings in the current study contribute to effective land use and transport policies for promoting active travel among older adults.

Keywords: non-linear, built environment, walking frequency, older adults, thresholds

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INTRODUCTION

Physical activity (PA) brings numerous positive health outcomes for older adults by lowering the incidence of chronic diseases, disability, and bone fractures (1). As the most common PA for older adults, walking is low-cost and low-risk, and easy to incorporate into daily life (2, 3). All else being equal, walking over 120 minutes per week is positively associated with a more negligible risk of all-cause mortality (4). Older adults are, in general, the least physically active group of the population (5). Therefore, encouraging walking among older adults is a crucial intervention to improve the quality of life and healthy aging (6).

According to the United Nations' latest report, the global population of older adults aged 65 years or over is estimated at 727 million in 2020. The number is projected to more than double by 2050, reaching over 1.5 billion (7). Between 2020 and 2050, Eastern and South-Eastern Asia will experience the most significant percentage increases in the older population. As the most populated country in Eastern and South-Eastern Asia, China's aging population is expected to increase from 180 million in 2020 to 380 million in 2050 (8). However, in a review on the built environmental correlates of older adults' walking (9), only 15% of the studies focused on Eastern and South-Eastern Asia countries with ultra-high residential density. Therefore, the findings in the Western context are not necessarily translatable to the Chinese context. Furthermore, few interventions supporting walking among older adults have been implemented in China, as little is known about the barriers and facilitators of their walking (10). Therefore, it is of great significance to study the walking behavior of old adults in the Chinese context.

The investigation into the effects of the built environment on older adults' walking behaviors has encouraged evidence-based, health-oriented interventions to promote walking activity among older adults (11). Older adults are more susceptible to the built environment because they are more inclined to travel short distances. Therefore, they need safe facilities and spend more time in parks (12). Previous studies have indicated that a walking-friendly built environment, compact and mixed urban form, connective pedestrian infrastructure, accessible commercial and service opportunities, and green spaces and parks are essential determinants of older adults' walking (6, 13–15). However, most literature assumes that the relationships between the built environment and walking are linear or at least linear in variables. The linkages between the built environment and walking behavior remain ambiguous and mixed (16). The impact of a built environment variable on walking behavior may differ when it falls into different ranges of the variable, and its effect may be saturated when it reaches a certain level (17–19). Scholars of land use, transport, and public health called for studies to investigate the non-linear relationships between the built environment and travel behavior (20). Using generalized additive mixed models, the non-linear effects of the built environment on older adults' walking have been implied by Cerin et al. (21). Ding et al. used a gradient boosting decision trees (GBDT) method and found strong non-linearity between the built environment and driving distance in an empirical study in Oslo, Norway (18). Ding et al. applied a gradient boosting logit model to substantiate a non-linearity relationship of ridership, with Metrorail data collected in the Washington Metropolitan Area (19). Using a gradient boosting decision trees (GBDT) algorithm, Tao et al. (22) explored the non-linear associations between spatial attributes and walking distance to public transport (22). Their studies acknowledge the complexity of the effects of the built environment on older adults' walking. The results suggest the potential benefits of exploring threshold effects to inform more effective environmental interventions. However, relevant exploration of the non-linear associations between the built environment and walking among older adults is somewhat limited.

With data collected from the Zhongshan metropolitan area in China, this paper employed a semi-parametric generalized additive mixed model (GAMM) to explore the potential non-linear relationships between the built environment and walking frequency among older adults. The present study contributes twofold to the existing literature. First, it facilitates understanding of the relationships between the built environment and active travel in a developing country with rapid urbanization and motorization. Second, it challenges the linearity assumption and identifies the non-linear associations between various built environment characteristics and walking frequency among older adults. The threshold effects of the built environment observed in the study provide nuanced insights for policymakers and planners on efficient land use and transport planning strategies and policies to encourage walking among older adults.

MATERIALS AND METHODS

This study chose Zhongshan Metropolitan Area, Guangdong Province, China, as a case to examine the walking frequency among older adults in the Chinese context. Zhongshan is a medium-sized prefecture-level city with 24 districts and towns (**Figure 1**). In the three largest coastal urban agglomerations with the most competitive economies in China, there are about 20 medium-sized cities with similar urbanization and motorization level and urban transport characteristics to Zhongshan (6). The walking frequency of older adults in Zhongshan averages 1.42 trips per day, covering 55% of all utilitarian trips. Utilitarian walking refers to walking trips undertaken to fulfill common purposes (e.g., accomplishing errands or getting to work) (23, 24).

Data Collections

The walking activity data were obtained from the Zhongshan Household Travel Survey (ZHTS) in 2012. Selected by stratified random sampling, the sample size of older adults was 4,784 (2,905 male and 1,879 female) from 274 urban and rural neighborhoods, with a sample rate of 2%. The numbers of older adults aged 60–69, 70–79, and over 79 were 2,979, 1,078 and 272, respectively. The 2012 ZHTS provided a travel diary including self-reported walking activity, e.g., the frequency, duration, and purpose of walking trips, and the respondents' personal and household socio-demographics. The description of the population are shown in **Table 1**.

Variable Selection

Ewing and Cervero suggested that each D variable of the "five Ds" built environment contains several features commonly used in the built environment-travel behavior research (25). The "five Ds" are density, design, diversity, distance to transit, and destination accessibility. Additionally, the aesthetic is another built environment feature that influences walking frequency among older adults (14, 20). The meaning and represent variables (considering the best available data) of the five Ds and aesthetics are shown in **Table 2**.

This study carries out a Pearson correlation analysis to reduce the multicollinearity of independent variables and select the best

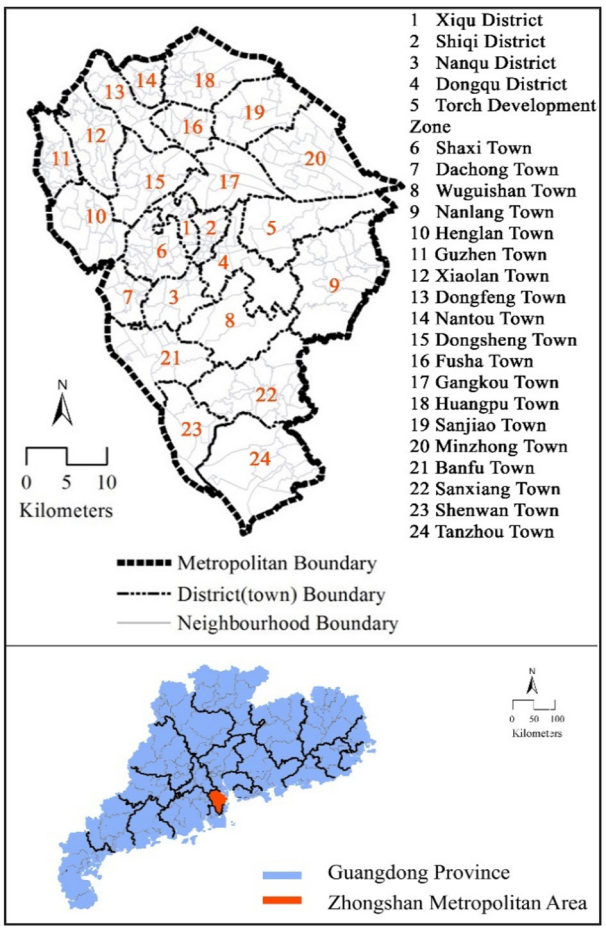

FIGURE 1 | Study area. The upper side of the figure shows the city boundary, district (town) boundary, and the neighborhood boundary of Zhongshan; while the bottom half shows the location of Zhongshan in Guangdong Province.

variables. Multicollinearity refers to the high correlation between the independent variables in the linear regression model. It makes the model estimation distorted or difficult to estimate accurately. The Pearson correlation coefficient between two independent variables can be used to determine the degree of correlation. If the correlation coefficient between the variables is large, there is usually strong collinearity between them. Therefore, only one of the variables is selected as the independent variable for modeling. In **Table 3**, the Pearson correlation coefficient between residential density and sidewalk density is 0.843, showing a significant correlation. The correlations of the distance to the city center with other variables were higher than commercial accessibility. Therefore, the built environment variables finally selected in this study are population density, sidewalk density, land-use mixture, bus stop density, commercial accessibility, and the percentage of green space.

Main Variables

The built environment data were collected based on neighborhoods, which are spatially equivalent to the traffic analysis zone (TAZ). As designed to be homogeneous concerning socio-demographic characteristics and living conditions, TAZs share boundaries with administrative divisions in most cases. According to the administrative divisions in Zhongshan, a total of 274 traffic analysis zones (neighborhoods) were selected in this study.

The population density, sidewalk density, bus stop density, and the percentage of green space are explained in **Table 4**. The land-use diversity represents the degree to which different land uses in a neighborhood are mixed. It is calculated by the Entropy Index (EI) (26), where 0 indicates single-use environments and 1 stands for the equalization of different land uses in area coverage. EI is defined by:

$$EI = \sum_{i=1}^{n} P_i \log(1/P_i) \ldots\ldots \quad (1)$$

where n = number of unique land uses, $n \geq 1$; P_i = percentage of land use i's coverage over total land use coverage (27). Commercial accessibility describes the ease of access to commercial attractions. The neighborhood-level commercial accessibility is defined by the area of coverage of commercial facilities within a one-kilometer distance from the centroid of a neighborhood. The 2012 ZHTS shows that a travel distance of one kilometer covers 70% of older adults' home-based commercial trips. For each neighborhood, we first defined the centroid of each neighborhood as the origin and distributed a one-kilometer travel distance as a buffer to the main roads from the origin. Then we formed an enclosed area with the endpoints of the acceptable travel distances in ArcGIS. Finally, we collected the data of the area covered by commercial facilities in the enclosed area in ArcGIS. The dependent variable

TABLE 1 | Description of the population.

Sample group	Range	Average	Median	STDEV
Male and Female	60–95	67.05	65	6.61
Male	60–95	66.95	65	6.53
Female	60–95	67.22	65	6.87

TABLE 2 | Dimensions of the built environment.

Dimensions	Meaning	Represent variables
Density	The variables of interest per unit of area	Population density, Residential density
Design	The characteristics of the street network inside an area	Sidewalk density, Road network density
Diversity	The number of different land uses in a fixed area and the represented degree	Land-use mixture
Distance to transit	The level of transit service at the residences or workplaces	Bus stop density
Destination accessibility	Ease of access to a certain location	Commercial accessibility, Distance to the city center
Aesthetic	Attractiveness and appeal of a place	The percentage of green space

TABLE 3 | Pearson correlation coefficient between explanatory variables.

	Population density	Residential density	Sidewalk density	Bus stop density	Commercial accessibility	Distance to center	Mixture	Green-space
Population density	1.000	1.000	0.500	0.488	−0.030	0.497	−0.352	0.112
Residential density	1.000	1.000	0.843	0.488	−0.030	0.600	−0.352	0.112
Sidewalk density	0.500	0.843	1.000	0.460	0.075	0.482	−0.132	0.126
Road network density	0.500	0.843	1.000	0.460	0.075	0.482	−0.132	0.126
Bus stop density	0.488	0.488	0.460	1.000	0.113	0.474	−0.008	0.100
Commercial accessibility	0.000	0.000	0.100	0.100	1.000	0.800	0.200	0.100
Distance to center	0.500	0.600	0.500	0.500	0.800	1.000	0.000	0.200
Mixture	−0.352	−0.352	−0.132	−0.008	0.238	−0.027	1.000	0.295
Greenspace	0.112	0.112	0.126	0.100	0.077	0.189	0.295	1.000

and independent variables (i.e., socio-demographics and built environment) used in this study are shown in **Table 4**.

Modeling Approach

The relationship between the built environment and walking trips of older adults is complex, uncertain, and probably non-linear (28). The semi-parametric GAMM as penalized generalized linear models can relax the pre-defined relationship (e.g., linear or log-linear) between the utility and explanatory variables (29). This study adopted a semi-parametric GAMM to disentangle the non-linear or non-monotonic relationships (17, 26). The model relating a univariate response variable μ to a set of explanatory variables $x_1, x_2, \ldots,$ has the general form:

$$g(\mu) = s_0 + \sum_{i=1}^{r} \beta_i X_i + \sum_{j=1}^{p} s_j(X_j) + \varepsilon \qquad (2)$$

where g is a smooth monotonic "link function" that allows a valuable degree of non-linearity into the model structure (27). s_0 is the intercept, μ is the dependent variable, which is the daily utilitarian walking trips (times/day) among older adults. X is the independent variable, X_i represents the household and personal socio-demographic variables (i.e., gender, age, household size, employment status, household income, ownership of bikes, e-bikes, motorcycles, cars), X_j stands for the built environment variables (i.e., population density, land use mix, sidewalk density, bus stop density, commercial, and percentage of green space). $s_j(X_j)$ are smooth functions of built environment variables. With the smooth term, it becomes a semi-parametric model with a parametric component and a non-parametric component. The parametric part is $\sum_{i=1}^{r} \beta_i X_i$, and the non-parametric part is $\sum_{j=1}^{p} s_j(X_j)$. ε is the residual of the model and $\varepsilon \sim N(0, \sigma^2)$. The details of the link function and smooth function estimation process were presented in **Appendix A**.

RESULTS

Employing the semi-parametric GAMM described in the section of the modeling approach, we developed a model to investigate significant correlates of utilitarian walking frequency among older adults and illustrate the non-linear effects of relationships with the built environment. Model estimation results are presented in **Table 5**.

The Associations Between Demographics and Utilitarian Walking Trips Among Older Adults

Table 5 presents the associations between personal and household socio-demographics and walking frequency among older adults. It is worth noting that the coefficients of parametric variables in a semi-parametric GAMM represent those in a traditional logit model. In general, socio-demographic variables are significantly correlated to walking frequency among older adults. The results show that the female walks more than the male, which is consistent with Kwan's "family responsibility hypothesis." In addition, women often participate in more daily family activities, generating more daily trips, including walking. Moreover, the employed older adults walk less than the pensioners. Presumably, walking is not a desirable option for commuting trips (6, 30). Unsurprisingly, being younger or having a positive attitude toward walking is associated with more walking trips (31, 32).

Owning private vehicle instruments, especially bikes, e-bikes, or motorcycles, shows a negative association with walking frequency. Walking frequency among older adults is especially negatively correlated to bikes, e-bikes, and motorcycles. It demonstrates that walking is an alternative to those modes in certain travel distances. Furthermore, e-bike ownership has more significant marginal effects than bike ownership and motorcycle ownership. That implies that e-bike is a stronger competitor for walking than conventional bikes and motorcycles (6, 17). One possible reason is that e-bike is easy to operate, safe, comfortable, and free of exhaust gas and noise pollution. It substitutes for conventional bikes, motorcycles, transit, and cars and meets the needs of the working class and middle-older-aged adult (17, 33).

Non-linear Relationships With Built Environment Variables

This study treated built environment features as non-parametric variables to disentangle their non-linear effects. In **Table 6**, the estimated degree of freedom (EDF) of commercial accessibility is 1.00, suggesting a stronger linear association, consistent with

TABLE 4 | Description of variables used in the analysis.

Variables	Description	Mean/ percentage (%)	St.Dev.
Dependent variables			
Frequency	Frequency of utilitarian walking trips of older adults, trips per day, count	1.42	1.43
Personal demographics			
Gender	Male	60.43	/
	Female	39.57	
Age	Age of the respondent in years, count	67.05	6.61
Employ	The respondent is employed	24.46	/
	The respondent is non-employed	75.54	
Prowalk	The respondent who favors walking over other modes	26.82	/
	The respondent who favors other modes over walking	73.18	
Household demographics			
HH-1	Household size is one person	26.82	/
HH-2	Household size is two persons	35.34	/
HH>2	Household size is over two persons	37.84	/
Highinc	Household income is high (>60,000 RMB/yr)	15.25	/
Midinc	Household income is medium (20,000–6,000 RMB/yr)	47.82	/
Lowinc	Household income is low (<20,000 RMB/yr)	36.93	/
Bikes	Number of bikes in a household, count	0.61	0.71
E-bikes	Number of electric bikes in a household, count	0.22	0.46
Motors	Number of motorcycles in a household, count	0.76	0.85
Cars	Number of private cars in a household, count	0.17	0.44
Built environment variables at the traffic analysis zone (TAZ) level (Explanatory variables)			
Popden	Population density,1000 persons/km^2, continuous	8.08	10.23
Mixture	Land use mixture, Entropy Index, continuous	0.7	0.18
Sidewalk	Sidewalk density, km/ km^2, continuous	4.65	3.31
Busstop	Bus stop density, number of bus stops per km^2, continuous	1.78	2.50
Comacc	Area coverage of commercial establishments within 1 km from the center of a neighborhood, in ha, continuous	33.19	33.08
Green	Percentage of green space land use among all land uses, continuous	0.07	0.08

Sample size = 4329.

TABLE 5 | Results of the semi-parametric generalized additive mixed model.

Parametric variables	Coefficients	T-statistic	*P*-value
Intercept	−0.18	−1.27	0.20
Personal demographics			
Gender	−0.13	−4.98	$p < 0.01$
Age	−0.01	−4.95	$p < 0.01$
Employ	−0.20	−4.89	$p < 0.01$
Prowalk	0.47	17.42	$p < 0.01$
Household demographics			
Hh.1	−0.10	−2.12	0.03
Hh.2	−0.07	−1.75	0.08
Highinc	0.08	1.75	0.08
Midinc	−0.03	−0.91	0.36
Bikes	−0.11	−4.98	$p < 0.01$
Ebikes	−0.20	−4.98	$p < 0.01$
Motors	−0.07	−3.13	$p < 0.01$
Cars	−0.06	−1.81	0.07
Non-parametric variables	**Estimated degree of freedom**	**F-statistic**	***p*-value**
Built environment variables			
Popden	3.15	3.42	$p < 0.01$
Mixture	2.25	4.12	0.02
Sidewalk	2.88	7.99	$p < 0.01$
Busstop	2.17	6.95	$p < 0.01$
Comacc	1.00	3.18	0.08
Green	2.83	13.20	$p < 0.01$
Model fit measurements			
Adjusted R^2	0.21		
Deviance explained (%)	21.2%		
Generalized Cross-Validation	1.60		
Scale est.	1.59		

After removing the invalid data, the final sample size in the study is 4329.

the plot in **Figure 2**. However, the EDFs of the other five built environment variables range from 1.38 to 3.15, indicating non-linearity.

When the population density is smaller than 7,000 persons/km^2, it was positively correlated with the walking frequency among older adults. This positive association is somewhat congruent with the literature (34, 35). As population density increases, walking may become a desirable option among older adults. Higher population density tends to support walking-friendly street space and infrastructure, and various services and shops, which has an indirect influence on walking (35). However, beyond 7,000 persons/km^2, the population density has a trivial marginal effect on walking frequency.

When the land use mix is smaller than 0.65, it was positively associated with the walking frequency among older adults, consistent with previous literature (36, 37). This relationship suggests that abundant commercial, service, and employment opportunities within walking distance promote older adults to walk more. By contrast, the land-use mixture seemed to affect the walking frequency negatively after the threshold of 0.65.

When the sidewalk density is below 6 km/km^2, it had a limited marginal effect on the walking frequency. However, above the threshold of 6 km/km^2, the sidewalk density showed a positive effect. This result makes sense because a denser sidewalk network indicates more walking-route choices, a

TABLE 6 | Comparison between semi-parametric GAMM and linear regression.

Variable	Semi-parametric GAMM Coefficients	Linear regression Coefficients
Personal demographics		
Gender	−0.13	0.04
Age	−0.01	0.00
Employ	−0.20	−0.01
Prowalk	0.47	0.28
Household demographics		
HH-1	−0.10	0.00
HH-2	−0.07	−0.00
Highinc	0.08	0.08
Midinc	−0.03	0.03
Bikes	−0.11	−0.05
E-Bikes	−0.20	−0.04
Motors	−0.07	0.01
Cars	−0.06	0.23
Built environment variables		
Popden	3.15	−0.01
Mixture	2.25	−0.36
Sidewalk	2.88	0.03
Busstop	2.17	0.01
Comacc	1.00	0.00
Green	2.83	0.31

walking-friendly environment, and better street connectivity, which increases older adults' willingness to walk (14, 38–40). These recommended values are significant to improving the cost-effectiveness of land use interventions.

When the bus stop density is within the range of six stops/km^2, it showed a positive association. Walking is a desirable and prevalent travel option to connect trip origins and destinations with bus stops. More accessible bus stops are potentially correlated to increasing transit use as well as walking trips. However, when the density exceeds six stops/km^2, the effect is saturated. The possible reason is that it may be hard to increase transit use by extra bus stops in neighborhoods with already high-level bus service provision. Hence, the increase in walking trips is minuscule.

The percentage of green space land use depicts an inverse U relationship with the walking frequency among older adults. In the range of 8–40%, the green space showed a positive association, consistent with the literature on green space and physical activity (6, 41, 42). Therefore, providing abundant green space in a neighborhood could be a desirable option to promote walking among older adults.

Model Comparison With Linear Regression

Zhang et al.'s study (6) is among the earliest attempts on the built environment and the walking behavior among older adults in the Chinese context. Zhang et al. (6) adopted a zero-inflated Poisson regression and assumed that all built environment variables have exponential correlations with walking frequency and duration among older adults. This study employed the same dataset and independent variables as Zhang et al.'s previous work. Therefore, we compared the coefficients of the variables between semi-parametric GAMM and linear regression (**Table 6**). The assumption of linearity in variables in the zero-inflated Poisson regression renders the non-linear relationship unobservable.

DISCUSSION

Major Findings

Using the 2012 Zhongshan Household Travel Survey (ZHTS) data, we examined the relationships between the built environment and walking frequency among older adults in Zhongshan, China. The walking frequency analyzed in the study is utilitarian walking trips per day. The older adults focus on adults aged 60 and over, in line with the definition of the aging population from the Law of the People's Republic of China on Protection of the Rights and Interests of Older Adults. Personal and household attributes related to gender, age, employment status, and attitudes toward walking are significantly connected to older adults' walking frequency. Specifically, being female or aged 60–69, or retired, or favoring walking over other modes is associated with more walking trips. The findings are consistent with previous literature (30, 31).

This study has shed light on the non-linear associations between the built environment and walking frequency among older adults. The non-linear patterns are demonstrated to be prevalent and vary among built environment attributes. The non-linear relationship shows that the impact of a built environment variable on walking behavior may differ when it falls into different ranges of the variable. Its effect may be saturated when it reaches a certain level (11, 17, 43). Specifically, in Zhongshan, the population density of 7000 persons/km^2 and the land use mixture index of 0.65 is sufficient to promote walking among old adults. However, the ultra-densely populated areas and excessively mixed land use may negatively impact the frequency of older adults walking. This finding is in line with Cerin et al.'s work (21) that additional residential density in highly compact areas would not increase but even decrease the odds of walking among older adults. Thus, the association between population density and walking frequency is non-linear and different from Zhang et al.'s study in 2014 (6). This difference indicates the limitations of the linear assumption widely used in previous studies.

For land-use mixture, recent studies indicate that in dense Eastern-Asian cities (e.g., Seoul, Hong Kong), when the mixture is beyond a certain level, a decrease in walking frequency is observed (21, 44). Presumably, due to higher proximity to services and destinations, people tend to have trip-chains of multiple trips in a single journey (38, 45). However, the in-depth reasons behind the negative association require further study. Strategies for designing street networks in Zhongshan or similar cities should also account for the non-linear relationships found in this research. Above the threshold of 6 km/km^2, sidewalk density shows a positive relationship with walking frequency. This finding is in line with the recommendations in China's Design Guidelines for the Pedestrian and Cycling Transportation System (46). The guideline recommended 6–10 km/km^2 of sidewalk density as the baseline for creating walkability in neighborhoods. Moreover, for neighborhoods where walking is highly intensive, the desirable sidewalk density is 10 to 20

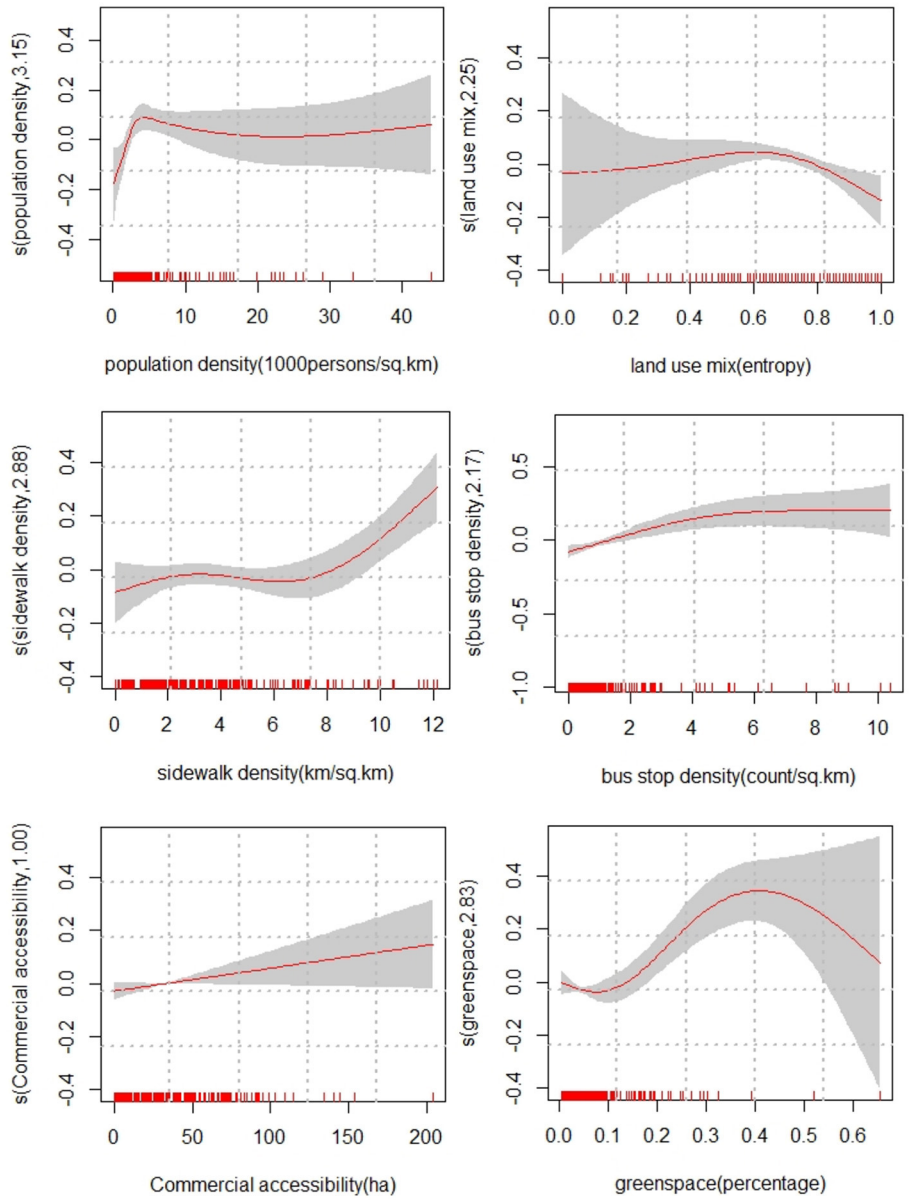

FIGURE 2 | The relationships between built environment variables and walking frequency among old adults. The numbers shown on the vertical axis in each plot indicate the estimated degrees of freedom. Solid lines represent the estimated effects of built environment variables. Shaded regions denote the 95% confidence intervals. The estimated curves are centered around zero because of the identifiability constraints.

km/km^2. Access to public transport fosters walking. Therefore, the density of bus stops has a significant impact on achieving regular engagement in walking among older adults. The bus stop density of six stops/km^2 is sufficient to optimize walking frequency, consistent with previous studies (6, 22).

Greenery, street trees, parks, and green corridors provide a more pleasant and safer walking environment, contributing to the increased walking trips among older adults (47, 48). In Zhongshan, the effective range of green space land use for increasing walking among older adults is between 8% and 40%. When the percentage of green space land use exceeds 40% (two out of 274 neighborhoods fall in the category), the walking frequency decreases, consistent with the literature of Christiansen L B et al. (48). The reason is that the two neighborhoods are located in the city parks and nearly 20 km away from downtown. Therefore, the commercial and service establishments in the two neighborhoods are scarce and beyond the suitable walking distance for older adults.

It is worth mentioning that the present study employed the same dataset and independent variable as in Zhang et al.'s work (6). However, the two studies are significantly different in modeling approach and contribution. Zhang et al. (6)

adopted a zero-inflated Poisson regression and assumed that all built environment variables have exponential correlations with walking frequency and duration among older adults. That research design is widely used in the existing literature. However, the present study employed a semi-parametric GAMM, hypothesizing that built environment variables have non-linear associations with the walking frequency among older adults. The results supported the hypotheses and challenged the conventional assumption used in Zhang et al.'s work (**Table 6**). Furthermore, it confirms that linear regression cannot reveal the complex non-linear associations between built environment variables and the walking frequency among older adults, as shown in **Figure 2**.

Limitations

The study has a few limitations. First, the cross-sectional data reveals more associations than casual effects. Future studies are suggested to employ panel data or attitudinal attributes to disentangle the causal influences of the built environment on walking behavior. Second, this study does not subdivide age groups, genders, and urban/rural areas. It would be useful to examine how different ages, genders, and urban/rural areas affect the walking behavior of older adults. Third, the thresholds found in Zhongshan may not be transferable for other regions with different sizes or built environment features. The GAMM model used in this study with such smooth functions relaxes the assumption of linear or known parametric functional forms for the relationships which can potentially capture (even complex) non-linear functional forms. However, the modification of just one of the assumptions might have easily led to different estimations. Therefore, there are several uncertainties when using in different cities. We encourage planners to identify specific thresholds in land use planning for older adults according to studies in different regions.

CONCLUSIONS

This study explores the non-linear relationships between the built environment and walking frequency among older adults with a semi-parametric generalized additive mixed model. The contributions of the study are threefold.

First, the findings suggest that the non-linear relationships between the built environment and walking frequency among older adults are prevalent. Based on the model results, the five built environment characteristics showing non-linearity are population density, land use mixture, sidewalk density, bus stop density, and the percentage of green space land use. The only linear built environment variable is commercial accessibility. The results are in line with recent literature (17, 22) and challenge the conventional linearity assumption in active travel studies. We also compared the present study with Zhang et al.'s work in 2014 using the same dataset but a zero-inflated Poisson regression (6). The assumption of linearity in variables in Zhang et al.'s work renders the non-linear relationship unobservable. Therefore, the linearity assumption of the regression model is flawed.

Second, the results underscore the critical role of the built environment in older adults' walking activity. Among the six built environment variables tested here, five were significantly associated with the walking frequency of older adults. In specific ranges, all else being equal, dense and mixed land use development, adequate pedestrian infrastructure, convenient bus service, and ample green land space are effective in encouraging older adults to opt for walking. Although the findings may not be directly used in other regions, the model developed in this study could be applied with their local data and facilitate strategies for land use and transport planning.

Third, the results suggest that built environment attributes have apparent threshold effects on the walking frequency among older adults. A built environment attribute may not have equivalent effects across the whole range of that attribute and thus finding the appropriate range would be cost-effective. In Zhongshan, the population density of 7,000 persons/km^2 is sufficient to optimize walking frequency among older adults. Therefore, it is important to develop neighborhoods with relatively balanced age structures and avoid overly aggregating the elderly population. Moreover, the sidewalk density of 6 km/km^2 should be the baseline in street network planning for creating walkability in neighborhoods. To promote walking activity among old adults, a bus stop density of 6 stops/km^2 and a land-use entropy index of 0.65 are suitable as built environment interventions. Furthermore, for the percentage of green space land use, the effective ranges for increasing walking among older adults are between 8% and 40%. These findings can inform planners of the most effective ranges for planning.

DATA AVAILABILITY STATEMENT

The dataset presented in this article are not readily available because it belongs to the Zhongshan Municipality Natural Resources and Planning Bureau and is a part of the ongoing projects (Grant No. 18BSH143 of the National Social Science Foundation of China, Grant No. 20692109900 of Shanghai Science and Technology Program, and Grant No. 2020-APTS-04 of APTSLAB). Therefore, the dataset is confidential during this period.

ETHICS STATEMENT

Ethical review and approval were not required for the study on human participants in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JW conceived of the study and participated in its design and coordination. CZ and YZ led the manuscript preparation. LW and CL contributed to data collection and analysis. TW and YZ contributed to data collection. All authors read, contributed to, and approved the final manuscript.

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APPENDIX A

The link function and smooth function estimation process

This section describes the estimation approach of the link function and smooth function of the semi-parametric model. The semi-parametric GAMM uses a link function to establish a relationship between the dependent variable and a smoothed function of the independent variables. The strength of these models is their ability to deal with highly non-linear and non-monotonic relationships between the dependent and the set of independent variables. The link function is defined by the distribution of the response variable (29). The relationship between them is shown in **Table A1**.

Misleading conclusions may be reached if an incorrect choice of the link is made (49). To avoid or, at least, mitigate the risks of such a wrong choice, predicting the dependent variable distribution is required. In this study, the dependent variable is walking trips, which is the continuous variable. Statistical literature has proposed that it is best to use the Kolmogorov-Smirnov (K-S) test to analyze whether a variable conforms to a certain distribution or compare whether there are significant differences between the two groups (50–52). Therefore, this study uses the K-S test to compare the actual frequency distribution with Gaussian, Uniform, Poisson, Exponential, etc. When assuming the response variable obeys gamma distribution, the results of the K-S test are $D = 0.824$, P-value $= 0.102 > 0.05$. The assumptions are established (53, 54). Finally, we selected the Log link for the link function.

In the semi-parametric GAMM model, it is necessary to consider both the goodness of fit and the smoothness of the curve. After experimental tests and research, we found that the spline-based smooth functions can automatically determine the optimal shape of the non-linearity. Therefore, this study uses the spline-based smoothing function, which has the following general form (27):

$$f(x) = \sum_{r=1}^{R} \lambda_r S_r(x) \tag{A1}$$

where S(x) is a basic function, r is the number of basic functions, λ is a smoothing parameter to be estimated (27).

The spline is a continuous function piecewise-defined by polynomials and is widely used to smooth observed data (28). Various functions (e.g., thin plate regression splines, cubic regression splines, and P-splines) can be used as the specified spline basis function. The smoothing parameters are chosen by Generalized Cross-Validation (GCV). The smaller the GCV value, the better fit the model (27). This study chose thin plate regression splines because the GCV value is smallest, 'knot locations' do not have to be selected and computation time is relatively efficient (17, 27).

In this study, the model estimation was implemented using the "mgcv" package in R (27).

TABLE A1 | Distribution of response variable and link functions.

Dependent variable distribution family	Link function
Normal distribution	Identity link: g(Z) = Z
Binomial distribution	Logit link: g(Z) = log Z/(1-Z)
Negative binomial distribution	Inverse link: g(Z) = 1/Z
Gamma distributions	Log link: g(Z) = log(Z)
Poisson distributions	Log link: g(Z) = log(Z)

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Characterizing the Heterogeneity of Aging: A Vision for a Staging System for Aging

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Introduction: Older adulthood encompasses several decades of change and heterogeneity. Primary care providers need a geriatric comprehensive vision for defining older adult subpopulations.

Methods: Using PubMed and Google searches, we reviewed the literature on epidemiology of age-related physiological changes, age-related diseases and geriatric syndromes, functional state, and emotional and social changes. We divided old age into strata based on chronological age and strata based on functional state, disease burden, and geriatric syndromes.

Results: We describe 4 chronological-age strata beginning at age 60, and 4 functional-age strata based on frailty according to a modified clinical frailty scale. We provide clinical considerations and anticipatory guidance topics for each of the age strata and functional strata.

Conclusion: Chronological age, functional status, chronic disease burden and geriatric syndromes, and life expectancy are all important domains that impact clinical care and appropriate anticipatory guidance for individual older adults. Better knowledge for differentiating subpopulations of older adults may improve clinical care, reduce medical overuse, improve personalized anticipatory guidance, and focus on the impact of functional state on the quality of life.

Keywords: chronologic age, aging, functional status, anticipatory guidance, life expectancy

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INTRODUCTION

In the coming decades, the proportion of older adults in the world will nearly double (1). Older adults are a heterogeneous population, with many people over the age of 80 continuing to work and travel, while others might be weak, chronically ill, or disabled. A traditional framework for describing different populations of older adults is "young-old," "old," "old-old," and/or "oldest old" (2). Fried's frailty phenotype (3) is a similar three-stage framework in which people are classified as non-frail, prefrail, or frail. Proteomic analysis finds large changes in gene expression at about the age of 40, 60, and 80 (4). However, these frameworks are not adequate to describe the different stages of aging and subpopulations of older adults. Older age is a risk factor not only for normative physiological changes with aging but also for cancer, heart disease, diabetes, dementia, and many

other chronic conditions. Genes, disease, and behaviors can pull on the chronological age of a person and make the person appear younger or older with the risk profile ("biological age") of someone younger or older (5).

The changes associated with aging can be divided into a few domains. First, there are normative physiological changes in every organ system as a person ages. Second, many diseases become more prevalent in older age. These physiological changes and diseases can contribute to functional limitations or disability. Third, aging is associated with some emotional and psychological changes. Finally, many social and environmental changes are common with advancing age.

Although adults age in different patterns and with different trajectories, generalizations about normal and typical aging might be helpful to inform patients, clinicians, and policymakers. When caring for older adults as a clinician or as a family caregiver, predicting the future and then planning for the most likely aging trajectories are the key steps. A primary care provider needs to consider life expectancy and time to benefit before ordering screening tests and before prescribing certain medications. Although many developed nations have an increasingly aging population, health care providers often display inadequate knowledge of geriatric medicine and low confidence in their ability to care for complex multimorbid older patients (6). Primary care providers and other physicians want to know when and how to treat older patients differently based on their age, comorbidities, and other factors (7). Primary care providers should be able to counsel older patients and their families on what to expect in the future and how to plan. Meanwhile, family caregivers who are helping to identify an appropriate placement (even at home) for older adults who are unable to live independently need to anticipate their future functional state and needs (8). Moreover, policymakers considering how to prepare for the "silver tsunami" (1) must appreciate the needs of different older adult subgroups.

At every stage during childhood, anticipatory guidance (9, 10) and a review for parents on what to expect and what to worry about it in the future, including evidence-based strategies for prevention, screening, counseling, and referrals were provided by the health care team. In contrast, in older age, which now spans 30 years rather than a few years, there is typically no anticipatory guidance plan to deal with age and its results.

This study presents a model for the division of older age into stages, which are characterized by chronological age, functional status, chronic disease burden, and geriatric syndromes. Dividing aging into stages and subpopulations can have two discrete benefits, such as improving the delivery of appropriate anticipatory guidance to patients and families, and improving clinical care by targeting interventions appropriately and avoiding inappropriate care [medical overuse (11)].

METHODS

The study began with a literature review using PubMed and Google. Literature reviews included search terms such as "age-related diseases, "normal aging," "physiological aging," "emotional changes with aging," "social changes with aging," "functional changes with aging," and for specific conditions or changes that were identified, the terms dementia, hyperlipidemia, and loneliness were paired with "epidemiology" and "aging." We then divided older age into four reasonable chronological age strata. For each chronological age strata, we described normative changes, age-related diseases, emotional, and social changes. Many of these changes are gradually progressive, and the designated age strata reflect an acceleration of change or the peak of a curve. Clinical considerations for the health care team based on these findings are suggested. We also divided aging into four functional strata and explored clinical considerations and anticipatory guidance topics that might be appropriate for each stratum. Tables were reviewed iteratively.

The stages of chronological aging in this study begin at age 60, but in fact, some body systems reach their peak performance well-before age 60. Age 60–69 was chosen because many physiological changes become clinically evident, and social and psychological changes are also noteworthy at this age.

We proposed an aging staging system using chronological age, functional status/disease burden, and life expectancy as three separate domains, comparable with the TNM oncology staging system (12) (tumor size, lymph nodes, and metastasis).

Functional status categories are based on compression of the Rockwood Clinical Frailty Scale (13). Life expectancy can be expressed as an expected age at death, or as the number of predicted additional years of life, or as the number of additional disability-free years (14), or as mortality risk (15) (1, 5, and 10 years). Life expectancy can be predicted based on age, functional status, disease burden, and geriatric syndromes.

RESULTS

Chronological age stages can be helpful in clinical care, particularly related to physiological and emotional changes, and prevalence of disease may vary with age. The four stages based on age (see **Table 1**) begin at age 60–69.

During this period, pulmonary (29) and renal (30) function, as well as some neurological (31) functions, start gradually declining, usually without clinical signs. Atherosclerosis (32) in men often progresses. During the second age stage, 70–79, hearing loss (20) becomes more common as well as osteoarthritis (33) and cardiac events (34) in men. Many working people transition toward retirement. Many women are caregivers (35) for ill husbands. During the third age stage, 80–84, cognitive aging (36) is more noticeable, and rate of falls (37) increases. The value of cancer screening (38) becomes more ambiguous due to lag time to benefit, detection of insignificant tumors, and burden of false-positive results. During the fourth stage of aging, 85+, most people are still in good health but problems such as dementia (39) and osteoporotic fractures (40) are increasingly common. An increasing majority of older adults are women and nearly half of these women live alone (41), many with risks for social isolation. Cardiac events in women increase to approximate the rate of men (42). Dementia and disability rates rise with advancing age.

TABLE 1 | Chronological age strata with appropriate clinical considerations and anticipatory guidance topics.

Stage 1 age 60–69	Clinical considerations
Normal aging	
	Aerobic exercise maintains fitness
	Avoid dehydration and nephrotoxins
	Social engagement and mentally challenging activities may help preserve cognition
	Reading glasses often needed (16) Night driving may be more challenging
	Counsel on menopausal treatment (17) Ask about sexual health
	Resistance exercise is helpful to minimize muscle loss
Disease	
	Check blood pressure at clinic visits (18)
	Lifestyle management and consider pharmacotherapy for hyperlipidemia according to guidelines
	Avoid anticholinergic medication to minimize burdensome adverse effects
Emotional	
	Older adults may not complain of symptoms that affect quality of life (19)
Social	
	Retirement planning
	Anticipatory guidance topics
	• Cardiac risk factor modification for men • Vision changes • Cancer screening
Stage 2 age 70–79	**Clinical considerations**
Normal aging	
	Hearing screening, counseling (20, 21), and referral
	Counseling on oral health (22), avoid anti-cholinergic medication
	Fast decline or very slow walking speed predicts mortality (23)
	Vaccines less effective (24)-consider HD Flu vaccine
Disease	
	Cardiac Risk factor management
	• Weight loss and exercise is helpful to reduce arthritis symptoms • Avoid non-selective NSAIDS for arthritis
Emotional changes	
	Opportunity for mentoring others in healthy behaviors (25)
Social changes	
	Counseling: goals, learning, spirituality, volunteerism
	Anticipatory guidance topics
	• Hearing assessment • Dental health • Cardiac risk factor modification for men and women • Changes in daily activities –work, volunteering • Vaccines for older adults • Bone health for women
Stage 3 age 80–84	**Clinical considerations**
Normal aging	
	Social engagement, physical activity, and cognitive stimulation are likely protective of cognitive decline
	Consider pharmacokinetics when prescribing
	Do not over treat abnormal urine cultures
Disease and geriatric syndromes	
	Bone density screening after age 65 for women Vitamin D screening Treatment/supplementation
	• BMI screening and weight management • Glucose screening for those at high risk
	• Falls Risk screening • Physical activity and multifactorial interventions
	• Fall prevention • Home safety screening by occupational therapist
	Screening and referral for assistive listening devices
	• Estimate life expectancy • Explain risks and benefits of screening tests
	Vision Evaluation and referral
	Ask about urinary incontinence. Counseling and referral
	For dementia patients: • Counsel on cognitive + neuropsychiatric symptoms • Maintain social and cognitive stimulation • Financial and legal planning
Emotional changes	
	Decision aids, particularly related to numeracy. Avoid offering too many choices (26)
	Depression screening and treatment
Social changes	
	PT/OT evaluation for identified mobility limitations (27)
	Encourage social engagement and physical activity
	Anticipatory guidance topics
	• Maintaining cognitive health • Cardiac risk factor modification for men and women • Joint health • Fall prevention • Pain • Depression • Financial exploitation
Stage 4 age 85+	**Clinical considerations**
Normal aging	
	Gait and nutritional evaluations
Disease and geriatric syndromes	
	Prevent iatrogenesis Optimize transitional care
Emotional changes	
	Screening and referral if suicide risk is identified (28)
Social changes	
	Consider risk of social isolation
	Care planning with patients and families
	Anticipatory guidance topics
	• Polypharmacy • Functional changes and functional assessment • Nutrition and nutritional Assessment • Dangers of social Isolation

The functional stage system (see **Table 2**) has four strata beginning with independent and lacking chronic illness and progressing to dependency and disability. The staging system is

TABLE 2 | Functional age stages with appropriate clinical considerations and suggested anticipatory guidance topics.

	Clinical considerations	Anticipatory guidance topics
Stage A Independence and minimal chronic illness burden (CFS 1-3)	1. Counsel on compliance with medication and lifestyle plan. 2. Regular medical visits and perhaps telehealth disease management for those with certain chronic illnesses.	1. Travel safety 2. Group physical activity opportunities 3. Work and Volunteer opportunities 4. Hot weather safety 5. Driving safety
Stage B Independent with some impairments (pain, balance, slower, etc.) due to worsening chronic illnesses (CFS 4)	Minimize polypharmacy and drug-disease interactions	1. Fall prevention 2. Avoiding polypharmacy 3. Financial planning for possible need for long term care 4. First discussions of assistive technologies 5. How to get the most out of medical visits
Stage C Mainly independent but some functional limitations and need for help (CFS 5)	1. Avoid medications that could increase risk of falls or cognitive impairment 2. High burden treatments are practical only with intensive social support.	1. Strategies for preventing hospitalizations such as medication compliance and good communication with primary care team 2. Advance directives 3. Home modifications, assistive technologies, and/or discussions of placement 4. Preventing social isolation
Stage D Disability and dependence on support of caregivers (CFS 6-9)	Cancer screening, intensive chemotherapy, and dialysis are probably inappropriate	1. Reassessment of advance directives and end of life care wishes 2. Caregiving plan 3. Elder abuse

similar to the ECOG performance status grading system used in oncology (43), but tilted to a more robust population.

In the first functional stage (A) of this model, corresponding to stages 1–3 of the Clinical Frailty Scale, older adults are active, independent, and without heavy burdens of chronic illness. They may take medicines regularly. Counseling during this stage will focus on the prevention of diseases (particularly cardiovascular), healthy lifestyle promotion, continuing work, and social engagement.

In the second functional stage (B), corresponding to Clinical Frailty Scale (CFS) stage 4, the old accumulate more chronic illnesses and display some functional impairments, but they still remain active and independent. They may be interested in technology device options to optimize independence. They may be considering a reduction in their driving.

In the third functional stage (C), corresponding to CFS stage 5, older adults display chronic illnesses of worsening severity, contributing to hospitalizations and impairments such as pain and fatigue. Polypharmacy and falls also begin to cause a decline in functional state and quality of life. People perform less physical activity. They may be interested in home modifications to ensure safety and promote independence. Some people might move to independent-living communities. As this stage progresses, many people become frail and may use assistive devices for mobility. Hospitalizations become more frequent and older adults may need more supervision from family caregivers. Mild cognitive impairment or mild dementia also can occur in this stage. Some people will move to assisted living communities.

In the fourth functional stage (E), corresponding to CFS 6–9, older adults need regular caregiving help due to disability (physical or cognitive). Without adequate support from caregivers, older adults may need placement in nursing care facilities. Support for caregivers is important. As this stage progresses, the responsibilities of caregivers grow and life expectancy becomes short. Hospitalizations are burdensome, and benefit from treatment is hard to predict.

Examples

Patient: M is a 73-year-old married part-time cashier with chronic obstructive pulmonary disease (COPD) and hypertension. She has not had any hospitalizations in the past year but has had several primary care and specialist visits as well as urgent care visits. She takes six medicines including her inhalers. She is not limited by shortness of breath with her daily activities.

Age Stage: 2A, 10% Risk of 5-Year-Mortality

Patient: S is an 87-year-old retired dentist with moderate dementia as well as coronary artery disease, congestive heart failure, knee osteoarthritis, and benign prostatic hypertrophy, who lives in the memory care section of an assisted-living facility. His wife visits daily. He was hospitalized this year once for a CHF exacerbation and once for complicated urinary tract infection (UTI). He takes eight medications regularly. He walks with a walker or with the assistance of another person.

Age Stage: 4D, Life Expectancy 3 Years

Anticipatory guidance based on age (see **Table 1**) reflects common age-related physiological and emotional/social changes. Anticipatory guidance based on functional state and burden of chronic illnesses (see **Table 2**) will include health promotion as well as the limitations that one might expect with a personal profile of chronic conditions, and might also include planning for future housing needs, assistive technologies, and caregiver support.

DISCUSSION

Aging can be viewed as a very slow step-wise decline from wellness and independence toward disability, reduced quality of life, and ultimately death. The rhythm of decline of an individual is very personal and depends on the genes, lifestyle, diseases, and geriatric syndromes such as dementia and falls. Social support and psychological factors like resilience and optimism also have a relevant effect. Not all age-related changes reflect functional decline and incident disease. In fact, migraine headaches and allergic rhinitis symptoms tend to decline with age. Meanwhile, wisdom and crystallized intelligence increase with age, and emotional situations are appraised more positively.

The biological causes for physiological changes with aging and for the prevalence of age-associated diseases continue to be explored and debated. Theories include accumulation of reactive oxygen species, telomere shortening, proinflammatory cytokines, apoptosis, and impaired repair systems (44).

Dividing the process of aging into phases, and characterization of these phases from various aspects can raise awareness and recognition that old age is not homogeneous or stereotypical as it is often considered. Healthy, active people in their 70's should not be treated like disabled people in their 90's, and active people in their 90's should not be treated like sick, disabled people in their 90's. Awareness of age-related physiological changes (such as reduced acuity of vision and hearing, slower reaction time, and impaired balance) will prepare patients and caregivers to prevent trauma, falls, and medication adverse effects.

Cumulative reports in the medical literature of longitudinal studies in older populations describe normative physiological signs/markers related to aging, which are predictive of future morbidity and mortality (gait speed, frailty, renal function, cardiorespiratory fitness, etc.). Recognition of these biological physiological markers helps to risk-stratify the older population with goals of slowing, delaying, and even preventing age-related changes.

Physiological changes in an older person occur not only from biological–physical causes, but also from social, emotional, and mental health circumstances. Awareness of these circumstances may improve or even prevent age-related deterioration, such as awareness and attention to depression and suicide in men during the 1st year after the loss of a spouse.

Adults in stages one and two of aging (age 60–79) typically remain in the first stage of the four-phase functional scale. The rate of decline to the next phases depends on vascular risk factors, genetics (family history), and social/environmental factors (such as education, career, physical activity, and social engagement or isolation). The goal of medicine is to compress morbidity, allowing old and old-old adults to spend more time in these earlier functional aging phases and less time in the disabled or burdened phase with bothersome symptoms.

Although telomere length and tools to calculate biological age have benefits over chronological age, they have not yet been adopted into clinical practice. Frailty scales are not sufficient for use in many settings, such as for the U.S. Preventive Services Task Force (USPSTF) recommendations. These scales and tools have particular uses in particular settings, and there is a risk of using them inappropriately (45). There are settings in which chronological age is appropriate to consider and settings in which frailty and life expectancy are appropriate. The settings in which biological age or telomere length are helpful need further clarification. The health care team should mainly consider the stage of the chronological age of a person when trying to make decisions about vaccines and low-burden screening tests. The health care team should mainly consider the stage of functional age of a person when trying to make decisions about home safety and about burdensome treatments like chemotherapy or hemodialysis. Finally, the health care team should consider the life expectancy of a person when making decisions about tests and treatments with a long lag time to benefit (46). Online tools like http://eprognosis.ucsf.edu can facilitate estimation of life expectancy.

Chronological age stratifications may not correlate with medical, functional, emotional, and social changes that an individual may be experiencing for multiple reasons. The chronological age strata used in this study are obviously inexact, but useful. As noted, older adults are heterogeneous and may develop problems earlier than average or later or never. The final chronological age strata in this proposed staging system are >85. In fact, there may be substantial differences between 87-year-olds and centenarians. However, at this time, there is insufficient data to describe organ system changes and disease epidemiology in subpopulations like centenarians.

Anticipatory guidance in **Tables 1**, **2** can help patients and families recognize and manage age-related changes. However, the most effective behavioral and pharmacological prevention strategies may need to begin decades before the advent of these adverse conditions. For example, preventing cardiovascular events or dementia may require management or avoidance of atherosclerotic risk factors starting in young adulthood.

With the advancement of modern medicine and with improved preventive care and lower rates of infectious disease, we more often witness an expanding gap between chronological age and biological age. Some people with advanced age have functional and cognitive abilities that are greater than those of younger people.

Just as the term "successful aging" suggests that some people are aging successfully and some are not, a staging system for aging may seem unkind and pejorative to people in the final stages. Many view the use of chronological age as a source of ageism. A large proportion of older adults experience ageism in the workplace and in their daily lives. The entire community has a responsibility to replace negative stereotypes of aging positive and nuanced portrayals. In fact, there is meaning and opportunity in every stage of life including every stage of aging. As people age, they continue to have a desire to be generative, which can include work, volunteering, grandparenting, and storytelling. Even people with very advanced illnesses can have dignity and be a source of inspiration as well as a motivator for kind acts.

Despite differences among individuals, aging can be divided into strata by chronological age, functional age, and disease burden, and by short or long life expectancy. These strata can be helpful to practitioners for the purpose of providing the required

anticipatory guidance and high-quality care. Chronological age itself is important to help predict risk for physiological and pathophysiological changes in organ function, but also stratifying by functional state and by life expectancy enable the health provider to provide guidance based on risk for future functional decline, health care utilization, and the likelihood of benefitting from particular tests and treatments.

It would be useful to describe the aging stages of older adults in a large observational study and describe their future functional and health outcomes. It would also be useful to explore the willingness of primary care providers to use a staging system to stratify their older patients.

DATA AVAILABILITY STATEMENT

The original contributions generated for the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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BRIEF RESEARCH REPORT
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Rate of Social Isolation by Geographic Location Among Older Adults: AAA LongROAD Study

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Introduction: Social isolation is a modifiable risk factor for negative health outcomes among older adults. This work assessed the relationship between geography (i.e., urban vs. non-urban residence) and social isolation in a cohort of older drivers.

Methods: The AAA LongROAD cohort with 2,989 older adult drivers from across the country were included. Social isolation was measured at baseline and at two subsequent annual follow-ups using PROMIS v2.0 Social Isolation 4a. The effect of geographic location with social isolation was assessed through with multivariable regression using a generalized estimating equation model.

Results: The rate of social isolation in urban areas was 21% lower (adjusted RR 0.79, 95% CI 0.46, 1.36) compared to non-urban areas after adjusting for covariates, though not significant.

Discussion: Social isolation is a predictor of poor health outcomes and geographic considerations have been lacking in the literature. The panel data in this analysis provides more evidence for causality though the under-representation of non-urban areas potentially reduces the power for the results.

Conclusions: It is important to understand the needs and risk of social isolation in various geographic settings to ensure resources and interventions are appropriately modified for a greater public health impact.

Keywords: geography, modifiable risk, driving, social isolation, older adults

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INTRODUCTION

The older adult population in the United States (US) is steadily growing, with adults over 65 projected to outnumber those under 18 for the first time in US history (1, 2). The rapidly growing older adult population is affected by age-related functional decline, increased prevalence of acute and chronic diseases, and the prospect of a loss of independence through driving cessation.

The latter is associated with significant health decline including worsening physical function and increased depression (1, 3–5). It was founded that a modifiable risk factor associated with mortality and increased medical costs is social isolation (6–8). A national assessment found that 24% of older adults in the United States are socially isolated (6). The construct of social isolation assesses social network, community connections and participation in society (5, 6, 8, 9).

We assessed if geography was associated with social isolation with a more precise measure of social isolation to build on this conversation in the literature. Social isolation is a more objective and comprehensive domain compared to loneliness. Along with mortality, social isolation is associated with increased medical costs (7, 8).

To date there has not been consensus on whether social isolation varies by geography. A study measuring prevalence of social isolation found no difference between urban and non-urban areas in the adjusted model where social isolation was measured as physical separation (6). A subsequent cross-sectional study more broadly defining social isolation by rurality found that urban residents had fewer close relatives and friends, and were less able to rely on them than residents of non-metropolitan areas (10). Interestingly, residents in the least populated and most isolated rural places had similar levels of loneliness to their urban counterparts, despite reporting more social connections.

Other research has shown that older adults utilize health care services more than younger patients, and particularly for older adults experiencing loneliness, interactions with the health system can be very important for social and physical health (11). Rural dwelling individuals also have been shown to have poorer access to healthcare, which may be exacerbated by the loss of the ability to drive with advanced age, particularly in settings with poor public transportation infrastructure more common in non-urban settings (12, 13). This creates a challenging situation for older drivers who may be experiencing loneliness or isolation but have a reduced ability to seek care.

Using the AAA Longitudinal Research on Aging Drivers (AAA LongROAD) cohort, we assessed the rate of social isolation among older adults using precise measures normed to the US average. The Patient-Reported Outcomes Measurement Information System (PROMIS) measure for social isolation is a concise and validated measure developed by the National Institutes of Health. It was derived from a loneliness scale which is more focused on the feeling of distress that is associated with social isolation vs. loneliness (14, 15). We hypothesized an increased rate of social isolation with a less pronounced change in more rural areas.

METHODS

The study population is from the AAA LongROAD prospective cohort study. Participants ranged from 65 to 79 years old at baseline and were recruited in one of five sites across the US: Ann Arbor, MI, Baltimore, MD, Cooperstown, NY, Denver, CO, and San Diego, CA. To be included in the study, participants had to reside in one of the above-referenced locations for 80% of the year, have a valid driver's license and have no major cognitive deficits. A total of 2,990 were enrolled in the cohort; more detailed methods are described in the LongROAD methods paper (2). Because we are assessing population averages, participants needed at least one measure of social isolation across the three time intervals (baseline 7/7/2015 to second year follow-up 6/8/2019); one participant did not meet this criterion and was excluded. The study population for this analysis was 2,989.

The self-reported PROMIS v2.0 Social Isolation 4a data was collected at baseline and annually (16). This measure for social isolation is derived from the following four questions: "I feel left out," "I feel that people barely know me," "I feel isolated from others" and "I feel that people are around me but not with me" (15, 17). Participants reported the degree to which they agreed with the statements, using Likert response categories which are summed and converted to a standardized T-score. The continuous T-score is normed to the US Census population with the mean being a T-score of 50 and a T-score of 40 being one standard deviation less isolated than the population mean.

Geography based on address of primary residence was dichotomized to urban and non-urban using Rural Urban Commuting Area (RUCA) codes. The original ten RUCA codes based on census tract, population density, and commuting were categorized into urban (1, 1.1), suburban (1.3, 2.2), and rural (>2.2) for the LongROAD study. For this analysis, the categories were dichotomized into urban and non-urban, the latter including the suburban population due to the small sample size. Potential confounders were age group, gender (male/female), race/ethnicity, marital status, education, measures of health and driving exposure (18). Marriage was categorized for the model and included as a dichotomous variable: married or live-in partner; divorced, separated, never married or widowed. Race/ethnicity was analyzed using the following categories: White Non-Hispanic (85.9%), Black Non-Hispanic, Asian, Hispanic and other non-Hispanic. Education categories were advanced degrees (41.6%), Bachelor's; some college, Associates' or vocational; and high school or less. Race/ethnicity, education and miles driven per week were included in the model as dummy variables. Physical status was measured with PROMIS SF v.1.0- Physical Function 4a dichotomized at the mean; scores <50 indicated worse than average physical function. Vision and hearing were dichotomized self-reported measures (Very Good to Excellent vs. Poor to Good) (10, 19). Social role (PROMIS Item Bank v2.0- Ability to Participate in Social Roles and Activities) and depressive symptoms (PROMIS Short Form v1 Depression 4a) both produce T-scores, with higher scores indicating increased depressive symptoms and increased ability to participate in social roles (20). Life satisfaction was measured on a scale from one to five with five representing the highest satisfaction (21). Driving frequency was self-reported miles driven per week. This variables was included because driving status is associated with social isolation (3, 8, 22).

Baseline characteristics were stratified by exposure status, i.e., urban or non-urban, and compared using χ^2 and *T*-tests. To account for correlation from repeated measures within individuals, a generalized estimating equation (GEE) was used

to assess the rate of social isolation using an identity link, Gaussian distribution and unstructured correlation structure. Life satisfaction and social role were highly correlated with one another and therefore excluded from modeling to increase the model's precision. Their collinearity approached 0.4. Time-varying covariates included in the model were age, race/ethnicity, marital status, education, depression, physical function, hearing and driving exposure.

TABLE 1 | Baseline characteristics by geographic status = 2,989.

Variables	Total	Urban *n*= 2,181	Non-urban *n*= 808	*p*-value
Age category, count (%)				0.04*^
65–69	1,243	937 (43.0)	306 (37.9)	
70–74	1,036	740 (33.9)	296 (36.6)	
75–79	710	504 (23.1)	206 (25.5)	
Gender, count (%)				0.87^
Female	1,587	1,156 (53.0)	431 (53.3)	
Race/ethnicity, count (%) *n*= 2,985				<0.01*^
White, non-hispanic	2,556	1,772 (81.4)	784 (97.0)	
Black, non-hispanic	212	208 (9.6)	4 (0.5)	
Hispanic	81	72 (3.3)	9 (1.1)	
Other, non-hispanic	70	62 (2.9)	8 (1.0)	
Asian	66	63 (2.9)	3 (0.4)	
Marital status, count (%) *n* = 2,961				<0.01*^
Married, live-in partner	1,974	1,403 (65.1)	571 (70.9)	
Divorced, separated, never married	609	497 (23.1)	112 (13.9)	
Widowed	378	256 (11.9)	122 (15.2)	
Education, count (%) *n* = 2,980				<0.01*^
High school or less	336	180 (8.3)	156 (19.4)	
Some college	725	496 (22.8)	229 (28.4)	
Bachelor's degree	698	528 (24.3)	170 (21.1)	
Advanced degree	1,221	970 (44.6)	251 (31.1)	
Depression PROMIS T-Score, count (%) *n* = 2,985				0.59^
>55 (increased depressive symptoms)	186	139 (6.4)	47 (5.8)	
≤55	2,799	2,041 (93.6)	758 (94.1)	
Self-reported vision, count (%)				0.79^
Very good—excellent	2,005	1,460 (66.9)	545 (67.5)	
Poor—good	984	721 (33.1)	263 (32.6)	
Self-reported hearing, count (%)				0.04*^
Good—excellent	2,640	1,942 (89.1)	698 (86.4)	
Poor—fair	348	238 (10.9)	110 (13.6)	
Physical function PROMIS T-Score, count (%)				0.56^
<50 (worse physical function)	1,369	1,006 (46.1)	363 (44.9)	
≥50	1,620	1,175 (53.9)	445 (55.1)	
Social isolation PROMIS T-Score, *n* = 2,970, mean (SD)	42.9 (6.9)	42.9 (6.9)	42.9 (7.1)	0.77~
Social role PROMIS T-score, *n* = 2,922, mean (SD)	57.4 (6.9)	57.4 (6.9)	57.6 (6.8)	0.51~
Life satisfaction, *n* = 2,986, mean (SD)	3.9 (0.6)	3.9 (0.6)	3.9 (0.6)	0.56~
Miles driven per week, count (%) *n* = 2,918				<0.01*^
0–49	696	550 (26.0)	146 (18.3)	
50–99	701	511 (24.1)	190 (23.8)	
100–150	794	539 (25.4)	255 (31.9)	
>150	727	519 (24.5)	208 (26.0)	

**Significant <0.05.*
^Chi-Squared.
~T-Test.
†Fishers exact.

TABLE 2 | Geography status and rate of being socially isolated.

	Unadjusted rate ratio (95% CI)	Adjusted rate ratio[a] (95% CI)
Urban	0.72 (0.43, 1.19)	0.79 (0.46, 1.36)

[a]*Adjusting for age, race/ethnicity, marital status, education, depression, hearing, physical function, miles driven per week.*

RESULTS

The population in this analysis was predominantly white (85.5%), married (66.0%) and held advanced degrees (40.8%) (**Table 1**). Below average depression (93.6%) and social isolation (mean 42.0, SD 6.9) were reported as well as higher levels of life satisfaction (mean 3.9, SD 0.6) (**Table 1**). Physically this cohort self-reported very good vision (67.1%) and hearing (88.3%) with 54.2% scoring better than average on physical function (**Table 1**).

Of the 2,989 participants 13.2% reported social isolation at baseline and the average T-score measures was 42.9, lower than average social isolation. A T-score of 50 is the mean and a T-score of 40 indicates one standard deviation below the mean corresponding with less social isolation. Variables from univariate testing as seen in **Table 1** that were statistically significantly different between urban and non-urban settings were included in the model. Those were age ($p = 0.04$), race and ethnicity ($p < 0.01$), marital status ($p < 0.01$), education ($p < 0.01$), hearing ($p = 0.04$) and miles driven per week ($p < 0.01$). Depression, vision and hearing were significantly related to social isolation and also included in the full model.

Participants in urban areas appeared to be 28% less likely to be socially isolated than participants in non-urban areas in the unadjusted model (unadjusted rate ratio 0.72, 95% CI 0.43, 1.19) (**Table 2**). That gap narrowed to 21% in the adjusted model (adjusted rate ratio 0.79, 95% CI 0.46, 1.36) (**Table 2**). Neither rate was statistically significant. The adjusted model was globally significant in being able to meaningfully assess the relationship between geography and social isolation ($\chi^2 = 384.7$, p-value < 0.01). Gender and vision were excluded as they did not contribute to the adjusted rate ratio.

DISCUSSION

Social isolation is gaining increased attention as a predictor of poor health outcomes, now associated with increased risk of death and increased Medicare expenses, although geographic considerations have been lacking in this literature (7, 23). Disparities in health outcomes and health care access by geographic location have been documented extensively, as have the associations between isolation and health care utilization, suggesting that these complex relationships require further examination (8, 11). Assuming that social isolation is a modifiable risk factor for poor outcomes, more detailed information can support more tailored interventions.

These results align with a larger cross-sectional study in that social isolation was not significantly different between urban and non-urban areas (6). Cudjoe et al. (6) had sufficient power for its conclusions; however, it was limited by the cross-sectional nature of the data. In this analysis, we similarly saw no significant difference in social isolation between urban and non-urban areas. A subsequent study assessing social isolation by geography found increased social isolation in urban areas and found an association in rural areas with the potential to buffer the effects of social isolation: friends that can be relied upon, number of close family members, number of living children and grandchildren, number of friends (10). A major limitation in social isolation research is a lack of consensus in construct operationalization.

A strength of this study is the increased precision of the PROMIS Social Isolation SFv2.0 short form which is normed to US census data allowing for increased comparability. Panel data from three time periods provided more evidence for causality. A limitation was that the sample is not demographically diverse, although it was not designed to be a nationally representative sample. Alternate transportation use was excluded in this analysis as it was not operationalized to include rideshare but could be a potential confounder when assessing geographic differences (24). The suburban and rural categories, combined to represent non-urban areas were under-represented in this study compared to urban areas, potentially reducing study power for these results.

CONCLUSIONS

The importance of social isolation is gaining more traction in research and it will be important to have a nuanced understanding of the experience in the geographically diverse areas of the US to ensure effective policies are implemented. Although geographic differences in social isolation were not statistically significant in this analysis, the evidence can build on the conversation in the literature regarding social isolation and rurality. This research was done prior to the COVID-19 pandemic; more research is needed to better understand the effect the pandemic may have had on social isolation, specifically older adults. Geographic location could potentially play a greater role in the setting of a pandemic and it needs further analysis.

DATA AVAILABILITY STATEMENT

Restrictions apply to the availability of these data. Data are available from the author with permission from the AAA Foundation for traffic safety and upon execution of a data use agreement.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by IRB of the Columbia University Medical Center (IRB-AAAN9950). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

TM and LL: conceptualization, formal analysis, and writing—original draft preparation. TM, LL, GL, and DS: methodology. TM, DS, CD, MB, LM, DE, VJ, LH, and GL: data curation. TM, LL, DS, CD, MB, LM, DE, VJ, LH, and GL: writing—review and editing. TM: supervision. All authors have read and agreed to the published version of the manuscript.

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Mind-Body Therapies From Traditional Chinese Medicine: Evidence Map

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Background: The mind-body therapies of traditional Chinese medicine include several intervention types and combine physical poses with conscious relaxation and breathing techniques. The purpose of this Evidence Map is to describe these different interventions and report related health outcomes.

Methods: This evidence map is based on the 3iE Evidence Gap Map methodology. We searched seven electronic databases (BVS, PUBMED, EMBASE, PEDro, ScienceDirect, Web of Sciences, and PschyInfo) from inception to November 2019 and included systematic reviews only. Systematic reviews were analyzed based on AMSTAR 2. We used Tableau to graphically display quality assessment, the number of reviews, outcomes, and effects.

Results: The map is based on 116 systematic reviews and 44 meta-analyses. Most of the reviews were published in the last 5 years. The most researched interventions were Tai Chi and Qi Gong. The reviews presented the following quality assessment: 80 high, 43 moderate, 23 low, and 14 critically low. Every 680 distinct outcome effect was classified: 421 as potential positive; 237 as positive; 21 as inconclusive/mixed; one potential negative and none no effect. Positive effects were related to chronic diseases; mental indicators and disorders; vitality, well-being, and quality of life. Potential positive effects were related to balance, mobility, Parkinson's disease, hypertension, joint pain, cognitive performance, and sleep quality. Inconclusive/mixed-effects justify further research, especially in the following areas: Acupressure as Shiatsu and Tuiná for nausea and vomiting; Tai Chi and Qi Gong for acute diseases, prevention of stroke, stroke risk factors, and schizophrenia.

Conclusions: The mind-body therapies from traditional Chinese medicine have been applied in different areas and this Evidence Map provides a visualization of valuable information for patients, professionals, and policymakers, to promote evidence-based complementary therapies.

Keywords: mind-body therapies, traditional Chinese medicine, Tai Chi, Qi Gong, evidence map, public health

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HIGHLIGHTS

- Mind-body therapies affects emotional, social, and health related outcomes.
- Evidence Map provides easy information for patients, professionals, and policy-makers.
- Positive effects include physiological indicators, mental health, and quality of life.
- Positive potential effects include metabolic indicators, pain, vitality, and well-being.

BACKGROUND

The WHO has been encouraging and strengthening the insertion, recognition, and use of traditional, complementary, and integrative medicines (TCIM), products, and their practitioners in national health systems at all levels of activity: Primary Care, Specialized Care, and Hospital Care, through the recommendations of the WHO Strategy on Traditional Medicine 2014-2023 (1).

Mind-body therapies (MBT) consider the interactions between brain, mind, body, and behavior and understand that emotional, mental, social, and spiritual factors can directly affect health (2). MBT includes Tai Chi, Qigong, Yoga, Meditation, and types of relaxation (e.g., breathing exercises, autogenic training, biofeedback, and neurofeedback) (3). Moreover, these therapies can be offered alone or together with conventional treatments, since self-efficacy by itself may produce physiological benefits (4).

Qi Gong covers several practices and it is important to describe their meaning. The "Qi" means the energy that gives rise to activities of human life and "Gong" concerns the regulation of Qi through practice. Qi Gong practices consist of two forms: Qi Gong dynamic (external) or Qi Gong meditative (internal). Qi Gong external involves movements of the whole body or limbs (e.g., Tai Chi and Baduanjin), while Qigong internal requires the maintenance of posture with subtle body movements when performing exercises involving breathing and the mind (e.g., Meditation and Mindfulness) (5).

Acupressure Shiatsu and Tuiná hold the same principles as Acupuncture, but are non-invasive and do not need sophisticated equipment, as they are technics that use pressure through the body itself, such as through fingers, at the Acupuncture meridians points, to activate the body's internal energy flow (Qi), contributing to the restoration of its internal balance (6). These practices are based on Traditional Chinese Medicine, with Tuiná (7) (Chinese massage therapy) being more developed in China, while Shiatsu is a form of Acupressure more developed in Japan, with reports since the 1920s by Tokujiro Namikoshi (8).

Since 2006, Mind-Body Therapies from Traditional Chinese Medicine (MBTTCM) are some of the 29 complementary therapies included in the Brazilian National Health System. MBTTCM are ancient and consist of skills used in mind-body exercises integrating controlled breathing, body posture, gentle, and synergistic movements with mind adjustments (9, 10).

Therefore, these practices may contribute to the psychological component of quality of life (11), self-care practices (12), hypertension, fall prevention, cognitive performance, osteoarthritis, depression, chronic obstructive pulmonary disease, pain, balance confidence, and muscle strength (13, 14). Because of the recent extension of the complementary therapies policy, the Brazilian Ministry of Health partner up with the Latin American and Caribbean Center on Health Sciences Information (BIREME - PAHO – WHO) and with the Brazilian Academic Consortium of Integrative Health (CABSIn) to develop complementary therapies evidence maps, including this one about Mind-Body Therapies from Traditional Chinese Medicine (MBTTCM). The objective of this Evidence Map is to describe these different interventions and report related health outcomes.

METHODS

The methodological steps of the evidence map are parallel to those involved in the initial stages of a systematic review. Although, systematic reviews look to collate a limited subset of the evidence base to answer a specific research question. However, the evidence map does not attempt to answer a specific research question instead guided by broader research objectives (15).

The Campbell Collaboration (16) suggests that any evidence and gap map are a systematic visual presentation of the availability of relevant evidence of effects for a policy domain. The map may be accompanied by a descriptive report to summarize the evidence for stakeholders such as researchers, research commissioners, policymakers, and practitioners.

This Evidence Map summarizes the interventions and health outcomes related to MBTTCM. These evidence maps considered six steps, each with a set of activities: (1) Search, (2) Selection, (3) Categorization, (4) Informetric, (5) Evidence map, and (6) Gaps (17). The method and results were reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (18) and the International Initiative for Impact Evaluation (3iE) Evidence Gap Methodology (19). This Evidence Map was supported by a technical expert panel of librarians, practitioners, policymakers, and researcher content experts.

Data Sources

Our search was conducted in several databases (BVS, PUBMED, EMBASE, PEDro, ScienceDirect, Web of Sciences, and PschyInfo), from each database inception to November 2019, looking for systematic reviews in English, Spanish, and Portuguese. The review question to guide the database search considered the following: (P) general population, (I) MBTTCM as intervention, (C) no comparator, and (O) health-related outcomes. We consulted topic experts and developed the search strategy together with Latin American and Caribbean Center on Health Sciences Information (BIREME), then entered the following expressions as shown in **Table 1**.

Inclusion Criteria

Systematic reviews about MBTTCM interventions and adequate descriptions of health outcomes were eligible for inclusion. We defined systematic reviews studies that self-identified as such. All participants of all ages, regardless of health status, were eligible

TABLE 1 | Search strategy.

Database	Search terms
BVS	"Lian Gong" OR Taiji OR "Tai Ji" OR "Tai-ji" OR "Tai-Chi" OR "Tai-Chi-Chuan" OR "Tai Chi Quan" OR Taijiquan OR "IQi Gong" OR "Xiang Gong" OR "Dao Yin Bao" OR "Jian Gong" OR "Tai Chi Pai Lin" OR "Tai Ji Qi Gong" OR Qigong OR "Chi Kung" OR Kunye OR "Lien Chi" OR MJ: "tai ji" OR MJ: Qigong
PUBMED	Lian Gong [tw] OR Taiji [tw] OR Tai Ji [tw] OR Tai-ji [tw] OR Tai-Chi [tw] OR Tai-Chi-Chuan [tw] OR Tai Chi Quan [tw] OR Taijiquan [tw] OR IQi Gong [tw] OR Xiang Gong [tw] OR Dao Yin Bao [tw] OR Jian Gong [tw] OR Tai Chi Pai Lin [tw] OR Tai Ji Qi Gong [tw] OR Qigong [tw] OR Chi Kung [tw] OR kunze [tw] OR lin ch i [tw] OR tai ji [mh] OR Qigong [mh]
EMBASE	('lian gong':ti OR taiji:ti OR 'tai ji':ti OR 'tai-ji':ti OR 'tai-chi':ti OR 'tai-chi-chuan':ti OR 'tai chi quan':ti OR taijiquan:ti OR 'iqi gong':ti OR 'xiang gong':ti OR 'dao yin bao':ti OR 'jian gong':ti OR 'tai chi pai lin':ti OR 'tai ji qi gong':ti OR qigong:ti OR 'chi kung':ti OR kunye:ti OR 'lien chi':ti OR 'tai ji'/exp OR 'qigong'/exp) AND [embase]/lim NOT ([embase]/lim AND [medline]/lim) AND ('meta-analysis' OR 'systematic review')
PEdro	Chinese Medicine, Tai Chi, Qi gong, Acupressure, Shiatsu
ScienceDirect	"Tai chi," "acupressure"
Web of Sciences	"Tai chi"
PschyInfo	"Tai chi"

for inclusion in the review. We excluded systematic reviews that did not focus on MBTTCM health outcomes. We included interventions on Tai Chi, Qi Gong, Traditional Chinese Exercise, Baduanjin, Acupressure techniques Shiatsu, and Tuiná of any duration and follow up.

Procedure

Two blinded independent literature reviewers screened the systematic review search output through the Rayyan software. Citations deemed potentially relevant by at least one reviewer and unclear citations were obtained as full text. The full-text publications were screened against the specified inclusion criteria by two independent reviewers; disagreements were resolved through discussion. This process is displayed at the PRISMA Flow Diagram (18) (**Figure 1**).

We did not calculate the effect sizes in a meta-analysis nor did we provide the risk of bias assessments, but *Assessing the Methodological Quality of Systematic Review* (AMSTAR 2) was applied to analyze the quality (high, moderate, low and, critically low) of the included systematic reviews. The AMSTAR 2 by 16 item quality assessment analysis indicates confidence in the results of each review and describes the sources of bias: selection, measurement, and confounding (20). From each included systematic review, the intervention Tai Chi, Qi Gong, Baduanjin, Traditional Chinese Exercise, Shiatsu, and Tuiná was extracted, along with the main health outcomes (e.g., depression, hypertension, balance, physical function, mobility, risk of falls, well-being, pain) that were summarized across the included studies. The data about population, treatment effect (positive, potentially positive, mixed findings, potential negative and negative), estimates for health outcomes, and systematic review characteristics were retrieved.

Data Synthesis

We developed a characterization matrix in Excel to synthesize the findings. This matrix included: Full-Text Citation; Interventions; Outcomes Group; Outcomes; Effect; Population (as described in each study); Database ID; Focus Country; Publication Country; Publication Year; Type of Review; Review Design; Study Design; Quality Assessment. The systematic review outcomes were drafted by one reviewer and discussed by the review team, and the matrix was discussed in two workshops organized by BIREME. We organized the Evidence Map considering the outcomes, effects, and quality assessment of the included systematic reviews. We use the interactive Tableau platform to graphically display all this information.

RESULTS

We identified 299 citations in the database search, 113 studies were excluded for not being systematic reviews, 172 were eligible for eligibility, 12 were excluded for being protocols, and 160 unique systematic reviews met the criteria for inclusion in the Evidence Map. Most of the reviews were published in 2017 and 2019. Tai Chi and Qi Gong were the most researched interventions.

The results found in the 160 systematic reviews were divided into eight major outcomes groups: cancer; acute diseases; chronic diseases; physiological and metabolic indicators and nutritional and metabolic diseases; pain; patient safety; mental indicators and mental disorders; vitality, well-being, and quality of life. This evidence map spanned wide health outcomes, effects, and populations. The outcome group, quality assessment, and effect by interventions are presented in **Figure 2**.

Interventions

The interventions were divided into two groups: Chinese bodily practices as Tai Chi, Qi Gong, Baduanjin, and Traditional Chinese Exercises; and manual stimulation of Acupuncture points (Acupressure) as Shiatsu and Tuiná. The Chinese bodily practices form was the most found in the reviews, highlighting the 313 Tai Chi and 107 Qi Gong interventions to distinct outcomes.

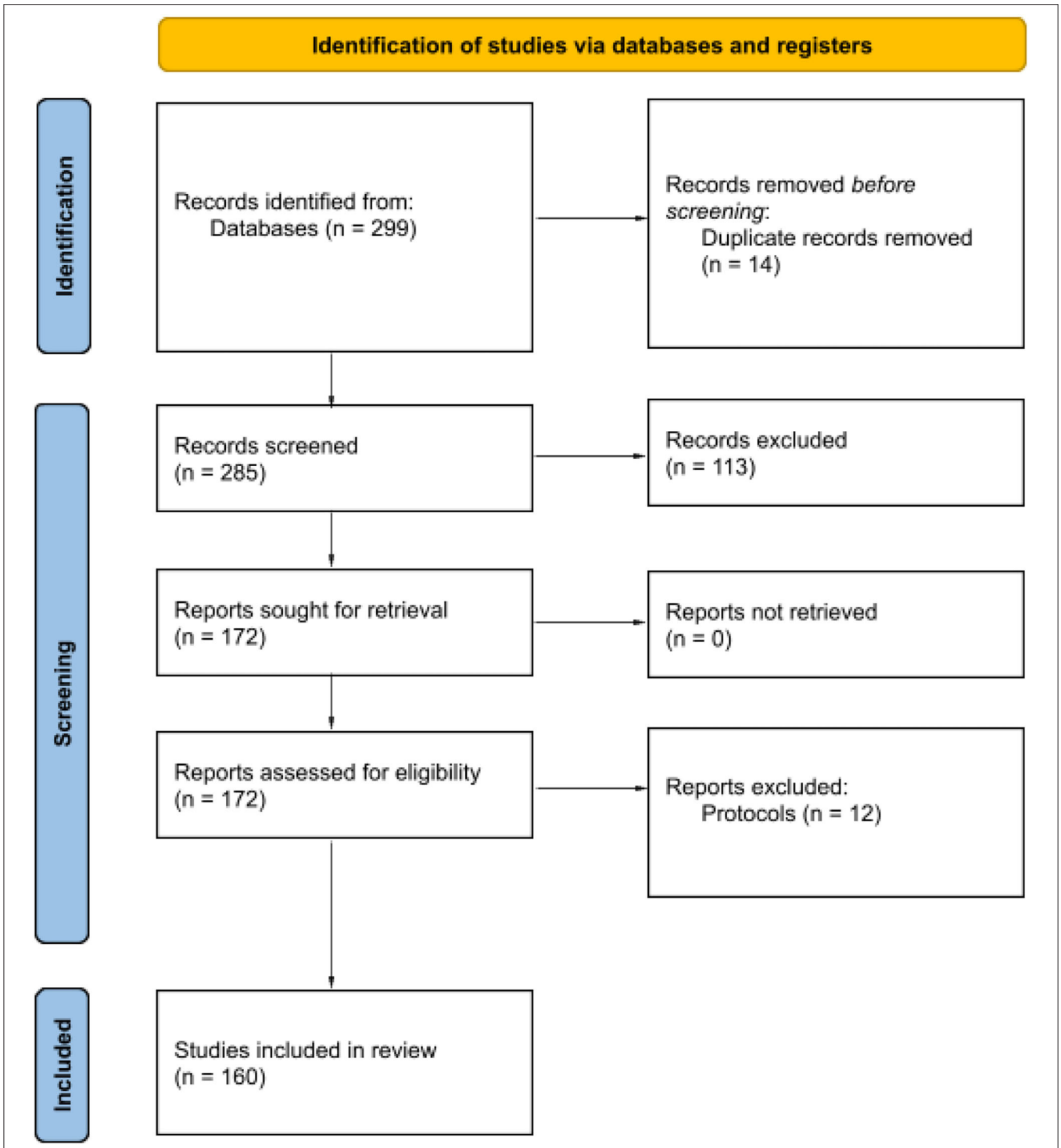

FIGURE 1 | Flow diagram for systematic reviews included in the Mind-Body Therapies from traditional Chinese Medicine Evidence Map. Flow diagram template adopted from the PRISMA approach to systematic reviews (18).

Population

This evidence map analyzed data from the following populations: people with chronic disease (38), older adults (38), people in general (18), people with heart disease (16), people with cancer (12), women (11). and diabetics (8). In addition, smaller representations with adults (5), people with hypertension (3), patients with stroke (3), and people with osteopenia (2). Patients with schizophrenia, graduation students, children with autism,

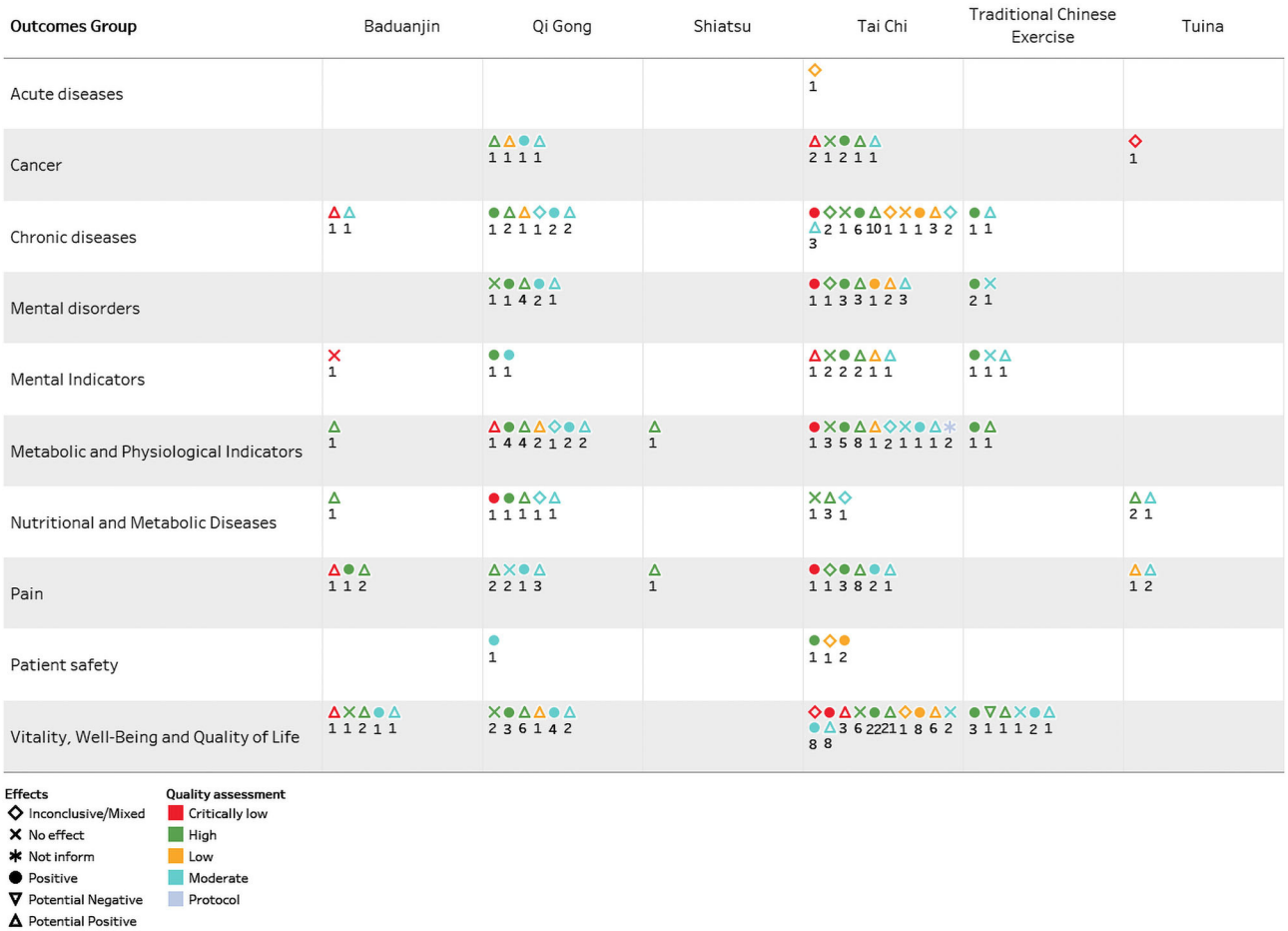

FIGURE 2 | Outcome group, quality assessment, and effect by interventions of systematic reviews included in the Mind-Body Therapies from Traditional Chinese Medicine Evidence Map.

and women with cancer, each with only one study. Two reviews had mixed populations of adults, women, and older adults.

Countries

The systematic reviews included analyzed data from the following countries: United States of America (50.3%), United Kingdom (23.7%), China (5.9%), Switzerland (5.1%), Singapore (2%), Germany (1.6%), Australia (1.4%), and England (1.25%).

Effects and Outcomes

Mind-Body Therapies from Traditional Chinese Medicine (MBTTCM) was evaluated as an intervention for 109 distinct health outcomes. Every outcome effect was classified as 421 positives; 237 potential positives; 21 inconclusive/mixed; one potentially negative, and none no effect, several reviews had more than one effect. Chronic diseases highlight positive effects for rheumatoid arthritis, hypertension, diabetes mellitus, coronary diseases, osteopenia, and rates of glycemia and high-density lipoprotein (HDL). Mental disorders target depression, anxiety, cognitive performance, humor, well-being, and dementia. Vitality, well-being and, quality of life outcomes emphasize results as balance, physical function, mobility, exercise capacity, quality of life and, risk of falling.

Figure 3 shows all these with more details as distinct ID counts divided by interventions vs. outcome list. Even as the colors show details about quality assessment and, the form shows details about the effects. Finally, the tags are labeled by distinct ID count and, the display is filtered on the effects of each intervention (**Figure 3**).

Cancer

The cancer group results in the included systematic reviews were breast cancer, general cancer symptoms, cancer pain, fatigue, nausea, and vomiting. Among these, the MBTTCM showed positive effects for breast cancer, fatigue, and general cancer symptoms (21–23). The systematic reviews showed potential positive effects for general cancer symptoms (24–26), as well as no effects for cancer pain and adjuvant cancer treatment (27–30). One systematic review showed mixed effects for nausea and vomiting (31).

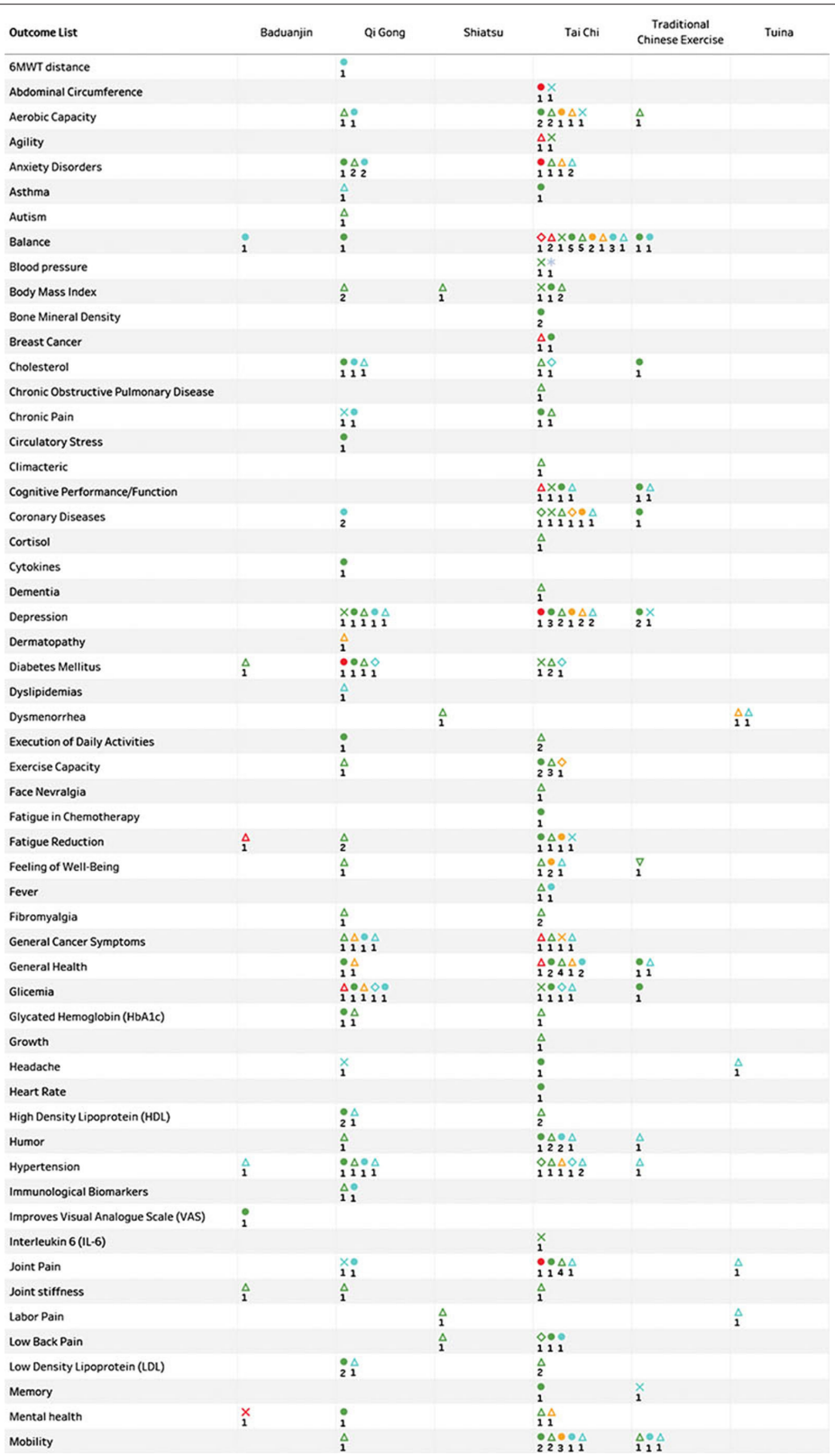

FIGURE 3 | Continued

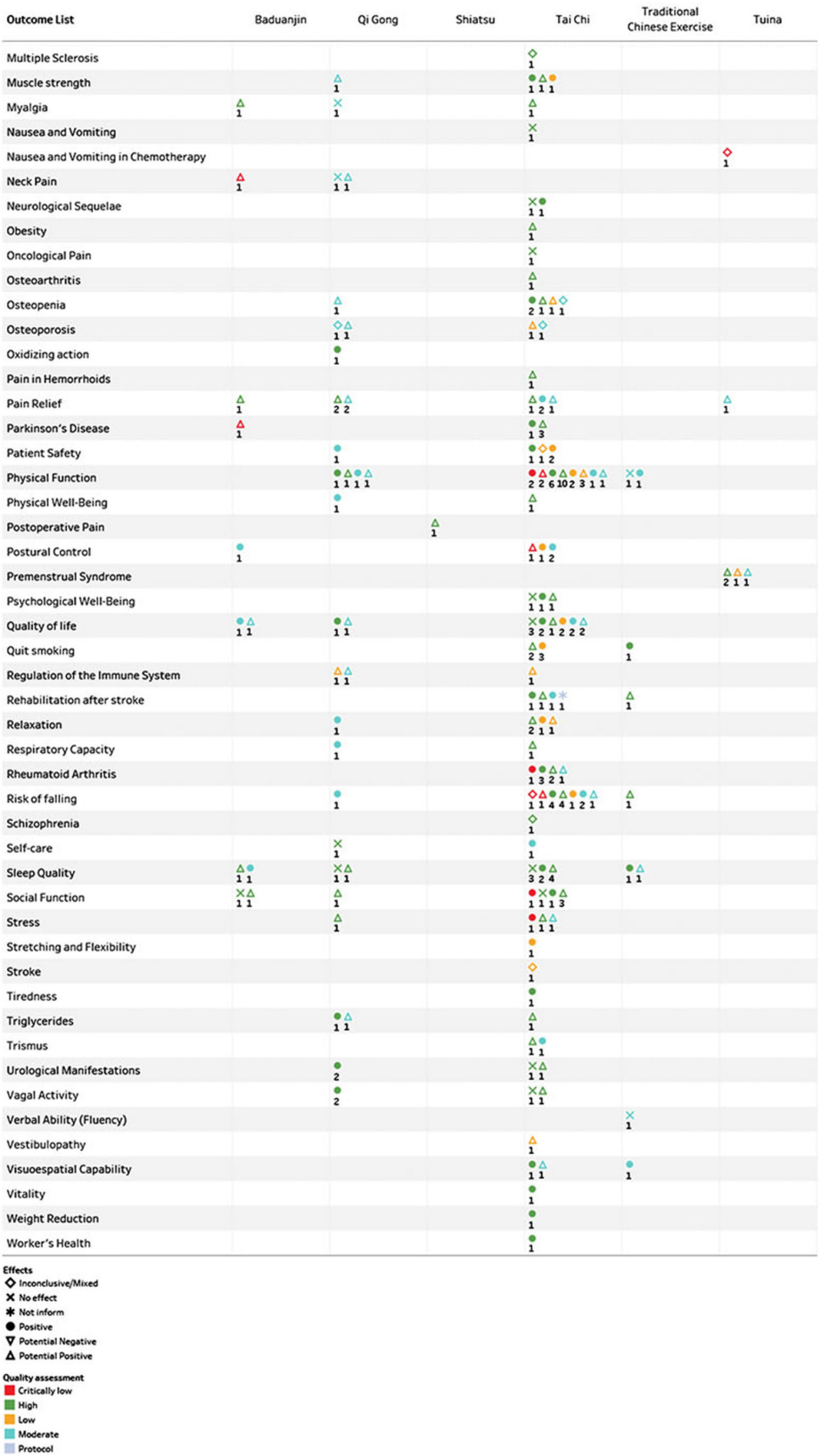

FIGURE 3 | Outcomes, quality assessment, and effects by interventions of systematic interviews included in the Mind-Body Therapies from Traditional Chinese Medicine Evidence Map.

Acute Diseases

The acute disease group results represent Tai Chi and Qi Gong interventions for stroke prevention. However, the effect of the single survey that related the results for stroke were inconclusive and mixed (32).

Chronic Diseases

The chronic diseases group results were rheumatoid arthritis, coronary disease, Parkinson's disease, hypertension, diabetes, osteopenia, osteoporosis, fibromyalgia, osteoarthritis, chronic obstructive pulmonary disease (COPD), asthma, multiple sclerosis, and vestibulopathy. The effects of MBTTCM were positive for osteoarthritis (33–35), coronary diseases (36–39), hypertension (40, 41), cardiovascular disease and risk factors (32, 42), and diabetes (43, 44). The MBTTCM presented a potentially positive effect for Parkinson's disease (45–47), fibromyalgia (48, 49), osteoarthritis (50), premenstrual syndrome (51–53), COPD (27, 54–57), and vestibulopathies (58).

Metabolic and Physiological Indicators and Nutritional and Metabolic Diseases

Mind-Body Therapies from Traditional Chinese Medicine (MBTTCM), as interventions for metabolic and physiological indicators and nutritional and metabolic diseases, showed positive effects for cholesterol, glycemia, and triglycerides (59, 60). Despite positive results, mixed-effects were also found in a study on cholesterol, glycemia, and no effect on blood pressure (36, 61–63).

Pain

Mind-Body Therapies from Traditional Chinese Medicine (MBTTCM), as interventions for pain conditions, showed positive effects for headache, joint pain, chronic pain, and low back pain (64–67) Also, potentially positive effects were related to general pain, dysmenorrhea, neck pain, hemorrhoid pain, labor pain, post-operative pain, myalgia, and facial neuralgia (48, 49, 52, 68–74).

Patient Safety

Mind-Body Therapies from Traditional Chinese Medicine (MBTTCM), as interventions—for patient safety, showed positive effects such as Tai Chi on the quality of life of patients with chronic disease, self-efficacy, psychological health conditions, and to prevent and manage cardiovascular disease (35, 75–79).

Mental Indicators and Mental Disorders

In the mental indicators and mental disorders group, Mind-Body Therapies from Traditional Chinese Medicine (especially Tai Chi and Qi Gong) had positive effects for cognitive performance, memory, physical and psychological well-being, depression, anxiety, dementia, stress (56, 80–83), and mixed effect to schizophrenia (84).

Vitality, Well-Being, and Quality of Life

Mind-Body Therapies from Traditional Chinese Medicine (MBTTCM) (especially Tai Chi and Qi Gong), as interventions in the vitality, well-being, and quality of life group, showed positive effects for balance, physical function, mobility (66, 82, 85–101), quality of life (102–104), and fall prevention (90, 97, 100, 105–107). There were also mixed effects for aerobic exercise, visuospatial capacity, fatigue-reducing, and cardiovascular disease (81, 108–110).

Quality Assessment

The systematic reviews included were analyzed based on AMSTAR 2, resulting in the following quality assessment: 80 High, 43 Moderate, 23 Low, and 14 critically low. The systematic review's authors indicated some methodological flaws, highlighting population heterogeneity in the practice groups, period, and time of intervention.

Limitations and Strengths

Even though Evidence Maps have several limitations, like the fact that we used only published reviews to provide an overview on the research on MBTTCM, more evidence, including qualitative studies, were not included. We did not calculate the effect sizes in a meta-analysis, nor provide the risk of bias assessments, but we tried to overcome these limitations by applying AMSTAR 2 to the quality assessment of the included systematic reviews.

In addition, the grouping of outcomes was review-content driven. Even though individual primary research studies would have more contributions to add to the analysis, this was not the focus of the Map. Besides, we were unable to avoid overlapping the included studies across reviews, but we did not repeat the results from updated reviews. We relied on the review author's skills in conducting systematic reviews, evaluation of primary studies quality, choice of outcomes, analysis of effects, susceptibility to publication, and outcome reporting bias.

Evidence maps are not designed to provide detailed and definitive information on the effectiveness of interventions. The implementation of the reviewed interventions in practice will require additional steps (e.g., identifying the optimal intervention format). Generally, evidence maps are a very broad overview of the evidence base, indicating areas in which research has been conducted, to help stakeholders interpret the state of the evidence to inform policy and clinical decision making.

Therefore, this evidence gap map can only provide a broad research overview, the findings showed more positive effects than potential negative or negative ones, including reviews of high, moderate, low, and critically low-quality assessments. The duration, period, and frequency of MBTTCM have not been analyzed and need more research.

The creation and publication of this evidence map consist in graphically representing the best evidence found, analyzed, and categorized, in addition to linking with the bibliographic records and full texts (when available) of the studies to facilitate access to information for all those interested.

Research Gaps

The systematic reviews included did not clearly report the time of practices, frequency, more details of each practice, and duration of interventions. Therefore, the heterogeneity of the studies regarding the included participants, intervention

characteristics, durations, and control groups may also limit the validity of the results. Furthermore, there have been no studies with pregnant women.

This Evidence Map will also not be able to answer more specific questions, such as the most appropriate method of applying Traditional Chinese Medicine Mind-Body Therapies, the difference between health services, adequate training of professionals, patient access, and self-application effects.

Future research, such as qualitative review surveys and evidence maps that only include systematic reviews of randomized clinical trials, are needed to answer refined questions, which are extremely important for the development of Traditional Chinese Medicine Mind-Body Therapies.

DISCUSSION

This evidence map for MBTTCM is based on 160 published systematic reviews and provides an available evidence broad overview of these interventions, related outcomes, and effects. It shows the volume of available research and highlights areas where the interventions showed positive effects.

The characteristics of the MBTTCM (e.g., Tai Chi, Qi Gong, Baduanjin, and Traditional Chinese Exercises) include low cost, moderate intensity, low technology, and low impact, and the possibility of practice by adults and older adults with chronic diseases (111). The movements are slow and rhythmic, linked together in a continuous sequence, and the body weight is shifted from one leg to another, challenging the balance control system to maintain its center within a changing support base (112).

Mind-Body Therapies from Traditional Chinese Medicine (MBTTCM) have been evaluated in different health conditions, including chronic diseases and mental disorders, and in vitality, well-being, and quality of life, assessed in a very broad population, from patients with chronic diseases to older adults.

This evidence map demonstrates that Tai Chi can significantly benefit adults and older adults with chronic diseases related to rheumatoid arthritis, hypertension, diabetes mellitus, coronary diseases, and osteopenia. Furthermore, significant improvements emphasize the results such as balance, physical function, mobility, exercise capacity, quality of life, and risk of falling. Highlighting beneficial effects for reductions in depression, disability falls, pain, and stiffness.

Tai Chi included significant improvements in cancers, chronic obstructive pulmonary disease, coronary heart disease, heart failure, hypertension, low back pain, osteoarthritis, osteoporosis, Parkinson's Disease, and stroke (113) as well as has favorable effects on depressive symptoms and quality of life of older adults (114), psychological well-being among persons with cardiovascular disease (115). Tai Chi can also improve strength, balance, balance confidence, mobility, gait, and executive function among older people (116, 117), reducing outcomes related to the extended frailty phenotype in older age adults (118).

The inconclusive/mixed-effects related to Tai Chi such as schizophrenia, aerobic exercise, visuospatial capacity, fatigue-reducing, and cardiovascular disease need more research.

The evidence map outcomes related Qi Gong to mental disorders scoped depression, anxiety, cognitive performance, mood, and feeling of well-being as well as chronic diseases such as diabetes, hypertension, metabolic syndrome, and cancer. Also, beneficial effects for reductions blood pressure, rates of glycemia, and HDL, pain, and improving risk factors metabolic syndrome were associated with Qi Gong.

Qi Gong may serve as a promising opportunity to improve psychological health domains such as the quality of life, depressive symptoms, fear of falling, and sleep quality in older adults (119), potentially having a beneficial effect on symptoms of anxiety (120), potentially effective to improve gait speed, balance, activities of daily living, and mobility to be a promising complementary therapy in Parkinson's Disease (121, 122), significant improvement in fatigue, and global distress in oncology patients (123).

Although this evidence map found positive effects of Qi Gong for diabetes, further research is suggested to debate these results. Also, Qi Gong applied to children with autism.

This evidence map involves 10 reviews of the Traditional Chinese Exercise (TCE) and only three reviews to present the Baduanjin results. The health outcomes for these interventions report positive and potentially positive effects related to chronic diseases such as diabetes, hypertension, coronary disease, osteoarthritis, and Parkinson's disease and the improvements emphasize results of fatigue, low back pain, neck pain, cognitive performance, psychological well-being and quality of sleep. The Baduanjin to osteoarthritis demonstrated a statistically significant improvement in pain, stiffness, and physical function (124), effective physical exercise intervention in patients with essential hypertension (125), is associated with statistically significant global cognitive function in patients post-stroke and the community of middle-aged and older adults. (126, 127). TCE can be potentially beneficial in alleviating cancer-related sleep disturbance (128), can effectively improve physical performance, balance, and muscle strength in the elderly population (129).

Although these studies include both high and moderate-quality assessments and could be considered for healthcare applications in these areas, further research with TCE and Baduanjin is needed.

Acupressure techniques such as Shiatsu and Tuiná are variants of Acupuncture and use hands and fingers to rub, knead or strike soft tissues and joints of the Acupuncture point regions in the body. They are non-invasive body practices and can be administered by the patients themselves (130).

This evidence map related to acupressure interventions showed potential positive effects involving dysmenorrhea, labor pain, nausea and vomit, low back pain, premenstrual syndrome, and pain relief. These effects appear in only seven reviews with high and moderate-quality assessment highlighting dysmenorrhea, nausea and vomit, and pain relief.

The Cochrane review demonstrates that acupressure probably has efficacy in reducing nausea and vomiting in women in labor, however, the stand-out evidence was generally low warranting further research (131). Acupressure may reduce pain intensity for pain management during labor (132, 133).

This Evidence Map demonstrated that acupressure could be considered for healthcare applications in these areas, nonetheless, further research is required.

Our map showed more positive effects and only one potential negative effect from a moderate quality review related to adverse effects and sense of well-being (134). The mixed effects justify further research and can help to guide different institutions' funding calls.

The outcomes and effects information of MBTTCM showed in these Maps will further advance our evidence-based knowledge of complementary therapies, such as that proposed by the complementary therapies policy in Brazil and promoted by the WHO MTCI 2014-2024 agenda.

CONCLUSIONS

Mind-Body Therapies from Traditional Chinese Medicine (MBTTCM) have been applied in different areas and this map indicates 421 positive and promising health outcomes that need further research. Despite the outlined limitations, this evidence map provides a visualization of valuable information for patients, health practitioners, and policymakers, in order to promote evidence-based complementary therapies.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

LF and MS drafted the manuscript. LF, MS, RG, CA, and CP designed the study and were involved in data acquisition and analysis. CA, MS, and LF designed and executed the search strategy. All authors were involved in the interpretation of the data, contributed to the final manuscript, read, and approved the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.659075/full#supplementary-material

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Review and Implications of Intergenerational Communication and Social Support in Chronic Disease Care and Participation in Health Research of Low-Income, Minority Older Adults in the United States

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Background: Health disparities disproportionally affect Black and Hispanic older US adults. Health research is needed to understand and eliminate these disparities; however, older adults, and particularly Black and Hispanic/Latino older adults are underrepresented in health research. Adult children have influenced health behavior and health outcomes of their older parents in several demographics in the US. Analysis of these studies can lead to a model for the development of interventions aimed at improving health and healthcare participation of older Black and Hispanic US adults.

Objectives: To review the role of intergenerational communication and social support in health behavior, health research, and health outcomes for older adults and to apply these findings toward a model for health interventions for Black and Hispanic US older adults.

Methods: An analytical narrative review and application toward an intervention model.

Results: Key topic areas were reviewed and analyzed by examining studies that applied forms of intergenerational communication and/or intergenerational social support with the goal of either improving health, disease management and/or participation in health research in populations world-wide. Next, a model for providing health interventions in older Black and Hispanic US adults was developed using strategies gleaned from the findings.

Conclusion: A model for health intervention for Black and Hispanic/Latino US older adults was presented based on an analytical review and intergenerational communication and/or social support. Qualitative data are necessary to understand the enablers and barriers of intergenerational communication and social support to improve health outcomes in these populations.

Keywords: intergenerational communication, social support, health decisions, health research, older African Americans, Hispanics/Latino, chronic disease, geriatric care

INTRODUCTION

Low-income minority populations, in particular older adults, are underrepresented in health research and have poor health outcomes according to the National Institute of Aging (NIA) (1). Increasing recruitment of older, minority adults in health research is an ongoing strategy of the NIA to reduce health disparities (1). Intergenerational communication and/or intergenerational social support has the potential to influence health behavior and health outcomes for older adults. Research on intergenerational communication of families and other social support from minority populations could uncover the enablers and barriers, and motivators for health behavior and participation in health research; however, studies are lacking for intergenerational influence (influencers) on health behaviors of older minority populations in the US. Furthermore, there are few studies aimed at improving adherence to chronic disease care or encouraging participating in health research for older adults that apply the strategy of intergenerational communication and/or intergenerational social support in the US.

METHODS

This study was an analytical narrative review examining studies that applied forms of intergenerational communication and/or intergenerational social support with the goal of either improving health, disease management, or participation in health research in older populations world-wide. Mendeley library, Elsevier publisher was used to import research papers, reviews, and dissertations not restricting dates. Mendeley reference manager imports papers from multiple resources. Additional searches were performed using the Google search engine for reference articles provided by reviews and with the same key terms entered in Mendeley. Key terms included various combinations of the following: *intergenerational communication and/or intergenerational social support/ and or family intergenerational communication, and/or intergenerational relationships with, health, healthcare, adult child and elderly parent, recruitment of minorities in health research, disease management, hypertension, diabetes, cancer, diet, nutrition, physical activity, exercise, Hispanic/Latino, African American/Black*. Articles were selected based on relevance to the following components: (1) defining intergenerational communication and social support with respect to an adult child and their older parent; (2) intergenerational communication/social support on psychological health and self-rated health of older adults; (3) recruitment of minorities in health research; (4) intergenerational communication/social support in disease management, diet, and physical activity of older adults. Intergenerational communication/social support *w*ere defined, and a model was proposed incorporating cultural sensitivity and cultural humility strategies to improve intergenerational communication in US minority populations with the objective of improving the health of older adults.

RESULTS

The results are summarized below as separate topics.

Origins and Trends of Intergenerational Communication and Family Social Support on Older Adults' Health

The degree of effectiveness of intergenerational communication on health and health behaviors of older adults is a subset of Family Communication Patterns Theory (FCPT). The premise of FCPT is that families share a social reality which influences their decisions, activities and interactions with others (2, 3). Thus, family communication is based upon the relationships and interactions of members within the family and the hierarchical relationship the family members may hold. Other theories have been used to study intergenerational communication such as social learning theory; however, the directionality observed has been from parent to child or grandparent to grandchild. This review investigated social support aspects of intergenerational communication on older adults' health and health behaviors with the caveat that relationships are often reciprocal.

Goals of intergenerational communication research proposed by O'Connor et al. (4) based on an Australia population were to: identify the enables of health common to both generations and those unique to each generation within a particular community; and, to develop, monitor, and evaluate specific approaches of intergenerational communication and available resources for effectivity of health improvement. In this study, community art therapy was used to bring younger and older adults to discuss health and well-being and how they can be brought together to enhance community strength. This study highlighted the respect and trust that are shared among generations and how this can be leveraged to strengthened community wellness.

In other studies, interrelationships among intergenerational communication, social support, and health of older adults have been studied primarily in Asian and Australian populations and sporadically in US populations. Key historical and geographical trends are represented in this paragraph. Intergenerational communication and social support of older adults and their adult children has been characterized as reciprocal in US populations in the 1980s (5). The patterns of communication and instrumental and emotional social support differ by living arrangement and physical proximity, frequency and quality of exchange, assistance, and support, and its contribution to psychological well-being. This study reported that well-educated, healthy, resourceful older adults were comfortable communicating with their adult children about their health and healthcare in the future (5).

The impact of modernization on intergenerational communication is complex yielding positive and negative consequences. Intergenerational communication of older adults from Thailand was shown to be augmented by technology despite the urbanization of their adult children and grandchildren (6). The authors reported use of the internet by older adults resulted in their effective communication contribution to their family which increased their sense of belonging, empowerment, and well-being (6). A US study suggested that moderated levels of support were psychologically beneficial and more accepted by widowed and unmarried parents compared to their counterparts; however too much support was counterproductive

(7). In a rural community in the US, older adults reported better communication satisfaction and resources as compared to the younger generation. This study was self-reported perceptions and gives insight into how family members perceived communication not how they actually communicate (8).

There are several studies that reported the communication and interaction between grandparent and their grandchildren in the US. Grandparents were found to influence the pattern of communication of their children and grandchildren in the southwestern, rural region of the United States (9). Zhang and Hummert (10) reported that Western younger adults' stereotype of older adults as weak, sick, dependent, and not worthy of respect and Eastern younger adults not seeing the older adult as caring, loving, and of a higher status of them resulted in both cultures patronizing their parents. The authors further suggested that Eastern and Western adult children's patronizing is a danger to the psychological and physical health of older adults (10).

Intergenerational Social Support on Psychological Health and Self-Rated Health of Older Adults

Intergenerational communication has been widely studied as a broad field; however, little is known about family intergenerational communication and its effect on health behavior and health outcomes in minority populations in the United States, such as Blacks and Hispanics. Family intergenerational studies of older adult's health have been studied primarily in Chinese and Australian populations with few on Chinese Americans, refugees and immigrant populations. Several studies demonstrated the psychological benefits for older adults who live in multigenerational households in China (11, 12), Thailand (6), and in California (13).

However, Silverstein and Bengtson (13) indicated that excess social support erodes confidence and causes psychological distress in a US population, which suggests that excessive support erodes independence and contributes to distress. Emotional support tends to reverse direction as parents age so that children are providing their older parents with intangible social support in a Northern European cohort (14). Intergenerational social support was positively associated with self-rated health for Chinese older adults (15) and Chinese American immigrants (16). A distinction should be considered between over-dependence on adult children's health advice and reciprocal and balanced relationships within the family when assessing the well-being, mental health, and community relationships of older adults (17).

Recruitment of Minorities in Health Research

Disadvantaged groups, such as US racial/ethnic minorities, need to be included in health research in order to understand the mechanisms behind health disparities (18). There is a plethora of literature on the challenges of recruitment and retention of ethnic-racial minorities into health research. Immigrants and African Americans have heard of or had negative experiences with the healthcare system, and some have shown a distrust of healthcare professionals (19, 20). African American males, across all age groups, reported a lack of trust as a primary reason for their unwillingness to participate in health research (21). Approximately half of a sample of African American women stated that research in the United States is unethical (22). African American cancer patients were more likely to decline participation in a cancer clinical trial as compared to their White counterparts with family pressure and feelings of being overwhelmed as reasons for declining even after adjusting for phase in clinical trial, type of cancer, sex, and insurance (23). Researchers targeting this population need to understand the concerns and issues of this population for successful recruitment and retention.

Intergeneration Communication and Social Support in Disease Management and Health Behavior

Communication is a dynamic and interactive process. There is focus in the literature on older adults as role models to encourage healthy eating for disease prevention for their adult children and grandchildren either with limited success (24) or a promise of a future strategy as with hypertension prevention in African American households (25, 26) but who do they consult for preventive health guidance? A number of studies focused on the effect of intergenerational communication and social support on health of older Chinese adults (27–29). Older Chinese adults were the respected elders to whom younger adult consulted for health guidance. Due to vastly different social systems and philosophies on elders, Asian intergenerational communication may have limited relevance to US cultures as half of US adult children live 10 or more miles from their older community-dwelling parents (30). Due to either living alone or having spouses with functional limitations, older, community-dwelling adults could prosper by social support of their adult children despite geographic barriers (30).

Intergenerational communication can be applied to enhance disease management in older adults through web-assisted technology. Younger adults (part of the family and/or community network) worked with community-dwelling older adults to develop a website to help African American older adults manage their diabetes (31). The barriers that emerged were technological skill and literacy. Enablers included having patience with older African Americans and small groups when teaching with web-based strategy to improve disease management (31).

Cornerstone of Disease Management: Diet and Exercise and Intergenerational Communication

Adult children have been found to encourage their parents to adopt health behaviors and lifestyles in an effort to manage their chronic disease for Hispanic and African American older adults (32, 33). Intergenerational communication about healthy eating varied by race/ethnicity in terms of health encouragement for disease management for Italian, Anglo, and Asian families in Australia regardless of chronic disease history

(34). Intergenerational exergaming improved intergenerational communication and motivation to exercise for older Chinese adults (35). Exergaming has been shown to be a viable motivator for exercise in older adults, while improving quality of life, empowerment, and intergenerational communication across populations (36); albeit, the role of intergenerational social support has yet to be investigated for underserved, low-income minority older adults as low socioeconomic status could be a barrier to access.

Cultural Sensitivity, Cultural Humility, and the Development of Strategies for Health Interventions in Black and Hispanic Older Adults

Both cultural sensitivity and cultural humility are part of overall cultural competency in the delivery of health interventions. Culturally sensitive in health care is defined by the Office of Minority Health as upholding the main standard of being "appropriately responsive to the attitudes, feelings, or circumstances of groups of people that share a common and distinctive racial, national, religious, linguistic, or cultural heritage" (37).

Cultural humility is an attitude that reflects the healthcare professional's ongoing process of critically incorporating life-long learning, self-reflection (38). As such, clinicians practice cultural humility by having an ongoing internal dialog whereby their collaboration and negotiation with each client is driven by listening, learning, and negotiating (38). Culturally sensitivity and cultural humility can be integrated into interventions targeting intergenerational communication and social support to enhance healthy aging of older Hispanic and African Americans. This is particularly important as the US population of older adults are expected to outnumber children by the year 2030 (39).

DISCUSSION

There were few studies that examined how older Hispanic and/or Black adults use advice from adult children for their health behavior, health outcomes, or participation in health research. Lack of trust of the healthcare system, fear of research being unethical, and feelings of being overwhelmed have prevented US minorities from participating in clinical trials. This review was timely and relevant since it investigated the role of intergenerational communication and social support in health behavior, health research, and health outcomes for older adults worldwide with an emphasis on Black and Hispanic populations was reviewed.

Intergenerational communication and social support were characterized as reciprocal in the US in the 1980's (5); however, this may have changed over 40 years. Older adults may not feel comfortable receiving guidance from their adult children since Zhang and Hummert (10) reported that many young US adults characterize older adults as weak, sick, and dependent and not worthy of respect. Moreover, young adults who have a negative stereotype about older adults could respond by providing excess social support. Psychological distress and eroded confidence

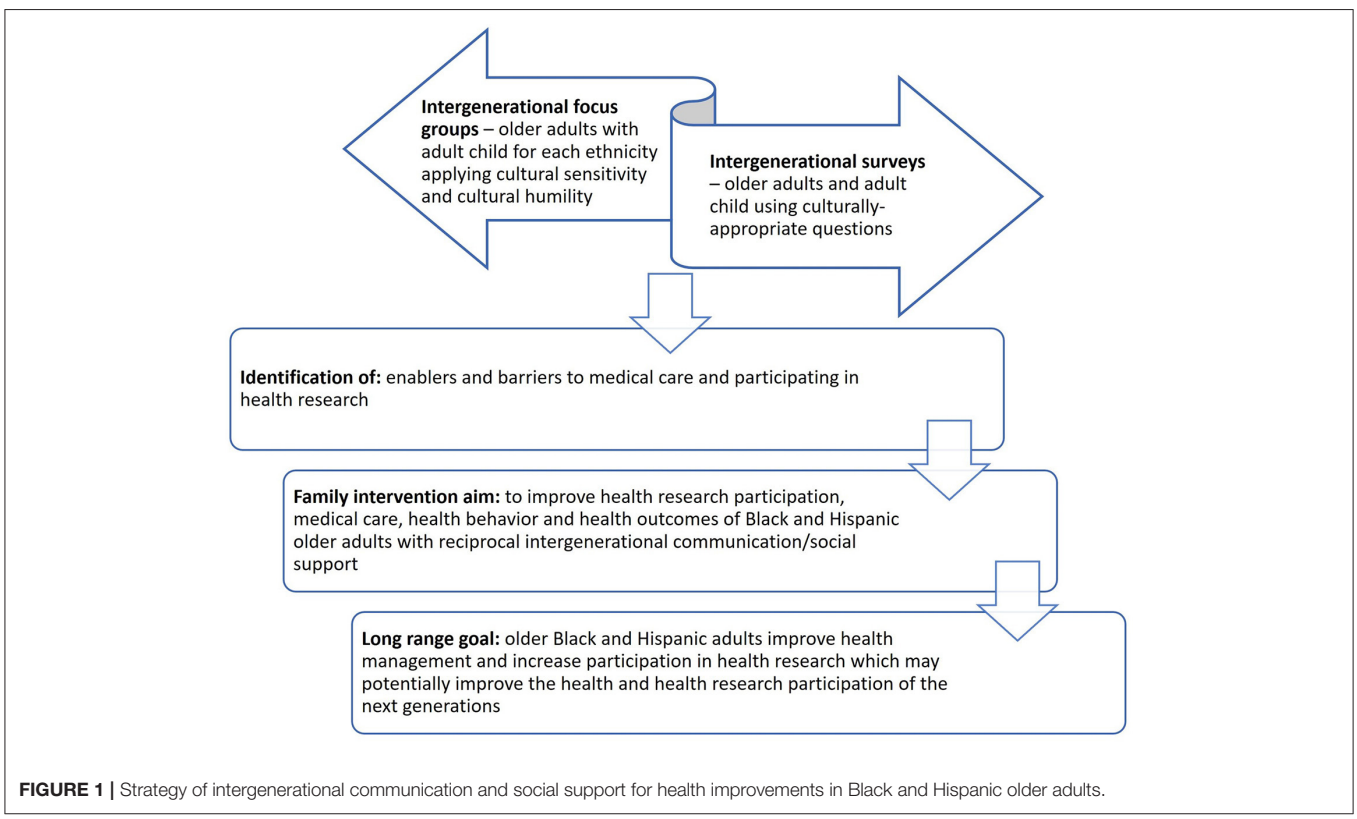

FIGURE 1 | Strategy of intergenerational communication and social support for health improvements in Black and Hispanic older adults.

were the outcomes of excess social support given to US older adults (11). Web-based intervention programs utilizing intergenerational communication in Western cultures have been shown to have some benefits to help older adults eat healthier (33), increase performance of safe exercise (33), and manage chronic disease (diabetes) (31) while uncovering barriers for participation. Of promise are several pinnacle studies where adult children helped their older parents manage their chronic diseases in Hispanic (32) and African American (31, 33) populations.

The findings of this review, together with cultural sensitivity and cultural humility were incorporated in the proposed model (**Figure 1**). The result is that strategies to improve family intergenerational communication of Black and Hispanic older adults require separate focus groups for each ethnicity within Black and Hispanic populations, to address their unique concerns. Induced enablers and barriers from qualitative research (focus groups) and resulting survey interpretation are proposed to improve medical care, health behaviors, and health outcomes. The overarching goal is to increase participation of minority older adults in healthcare and healthcare research and improve the health of the next generations.

This study had several limitations. First, subtle health behavior changes due to intergenerational communication and social support for older adults may have been missed due to focus of the subtopics. Second, the search terms used may not have exhausted all the possibilities of intergenerational communication and social support. Finally, the analysis is based on the education and experience of the authors in the field of health.

CONCLUSION

An analytical review of the literature indicated promise in health participation and potential health improvements for older Black and Hispanic adults by seeking guidance from their adult children and grandchildren, particularly in areas where health is connected to the virtual world. A few promising studies of adult children encouraging their parents to adopt health behavior in an effort to manage their chronic diseases were found for Hispanic and African American older adults. This focused review builds upon the finding from other cultures due to a gap in the literature for US minorities. Qualitative research is necessary to direct future programs aimed at reducing health disparities due to the wide differences in intergenerational influences across the ethnic racial groups in the US. Effective intergenerational communication and social support could potential be beneficial in health improvement for older adults for each culture within Black (Caribbean-American, African American) and Hispanic (Cuban-American, Puerto Rican-American, Central-American, South-American) ethnicities. This is due to the wide differences in attitudes and behaviors across cultures.

AUTHOR CONTRIBUTIONS

TG and JV contributed equally to the literature search, literature analysis, data integration, and writing the manuscript. RM contributed to the literature search and critically reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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OPINION
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Involving Young People in Healthy Ageing: A Crucial Facet to Achieving the Decade of Healthy Ageing (2021–2030)

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INTRODUCTION

In response to a rapidly ageing world population, the World Health Organisation (WHO) has proposed a *Decade of Healthy Ageing 2021–30* (hereafter: *the Decade*) to promote the health of over a billion people aged 60 and older (1). The COVID-19 pandemic has exposed faults in healthcare, equity, and economic safety affecting all humanity. According to the WHO's baseline report for *the Decade*, more than 40% of COVID-19-related deaths (up to 80% in some high-income countries) during 2020 are linked to long-term care facilities (2). Moreover, certain pandemic response measures (e.g., lockdowns) have exacerbated existing issues experienced by older adults around the world, such as depression, loneliness, and social isolation. COVID-19 has also added to the concerns of many young people about the future of health, healthcare, and social protection in old age, who must ask "in what kind of world do we want to live?" and "how do we want to age? (3)"

Healthy ageing is defined by the WHO as "developing and maintaining the functional ability that enables well-being in older age" (1). Recent comments and reports have called for more youth engagement in global health issues, including those which will impact them later in life (e.g., health governance) (4). Young people and youth are herein considered to be individuals between 15 and 29 years, which is inclusive of most young adults actively receiving education, entering the workforce, or early in their career. This commentary hereby aspires to reflect the vision of young health researchers and medical students in the discussion of *the Decade*'s four action areas. We argue that youth engagement should extend to ageing care, as youth perspectives are an important determinant of well-being in old age, both of youth themselves (in terms of their future selves) and how their actions affect older people in their communities.

Youth contribute to the barriers and stigmas encountered by older adults, make up a substantial portion of the health workforce engaged in older adult care, and are critical to effectively plan for a better and healthier future to foster intergenerational partnerships and prevent people from being left behind in the era of Universal Health Coverage (5). Innovative solutions, particularly surrounding social support and care, are necessary to address the otherwise unmanageable health

needs of the ageing population (6). Meaningful engagement of young people in revolutionising ageing does not detract from the need to centre voices of older adults. Rather, it increases the scope of stakeholders involved and provides additional opportunities for positive actions to be realised. Younger and older adults are less visible and typically less represented in "all-age" initiatives. As such, bi-directional engagement and learning opportunities to promote such initiatives would be mutually beneficial.

CHANGING PERCEPTIONS OF AGE AND AGEING

The first action area of *the Decade* calls for governments to "change how we think, feel and act towards age and ageing" (1). The baseline report highlights how deeply rooted societies' negative perceptions are about older people. From a young age, children pick up cues from those around them about their culture's stereotypes and prejudices. Not only are these quickly internalised, but also build over time and develop into ageist stereotypes. These stereotypes are later employed to make inferences and guide one's feelings and behaviours towards people of different ages and towards oneself (7).

Immune system ageing has been a major contributor to older people dying at disproportionately high rates from COVID-19; the acceptance of disproportionately high deaths among the older population exemplifies the ageist principle of the expendability of older individuals. When trying to do something about ageism at individual, community, and institutional levels, governments should consider the body of evidence in favour of intergenerational programmes, in which individuals of varying ages collaborate, co-create, and engage in shared activities. The development of intergenerational social projects has been shown to advance the meaningful inclusion of the ageing population in communities, address negative attitudes towards ageing in youth and older adults, and model opportunities for youth to work across generations (8).

In an example of how intergenerational programmes can be mutually beneficial, medical students in Hong Kong accompanied older and terminally-ill patients in Grantham Hospital. By listening to the patients and leading a range of activities targeted at their emotional needs, students experienced development in terms of their empathy and communication skills (9). Participation in this programme enabled the students to better understand the patients' states of mind and more effectively alleviate the older patients' symptoms. Another example is Humanitas Deventer, an intergenerational care home in the Netherlands where students—in return for affordable housing—live alongside older neighbours and contribute to their social care (10). Students' attitudes and actions towards ageing shifted in response to their immersion in the care of older adults, and older individuals reported exiting the "sick role" often experienced in classic long-term care facilities (11). Other studies also support an association between informal intergenerational activities, such as occasional volunteering or friendships, and improved young people's attitudes towards working with older adults (8, 12).

The initiatives mentioned above often rely on students accessing formal education in health-related fields. Governments can support intergenerational initiatives by identifying additional young populations with the capacity to engage with older people as well as facilitating environments and opportunities to support these connections. In March 2021, the WHO released a guide on initiating conversations about ageism. This guide, which includes sections for children and adolescents, is a useful tool for facilitating discussions and acknowledgement surrounding ageism. To ensure the engagement of young people, adaptations should consider young people beyond adolescence (for example, university students, early career professionals) and include methods for them to encourage and start the conversation, not just be on the receiving end (13).

FOSTERING AGE-FRIENDLY ENVIRONMENTS

Second, *the Decade* asks governments to "ensure that communities foster the abilities of older people" (1). We encourage governments to foster youth engagement in near-term initiatives that promote the abilities of older people and their integration in the community. An example of this is intergenerational residential groups (10) and companionship schemes (14), in which older community members participate in mentorship and neighbourly roles. Such programmes have been shown to lead to positive quality of life outcomes in older individuals with dementia (15). In countries and cultures where intergenerational living is common, such as India, older people in intergenerational environments have been shown to have lower risks of short-term and chronic illness (16, 17).

We argue that fostering the intrinsic capacity and functional ability of older people will take longitudinal effort. To this end, intergenerational professional mentorship within health professional organisations, academia, and advocacy stakeholders is necessary to build the leadership capacities of a younger generation advocating for patient-centred care and healthy ageing. This mentorship should extend to the global health arena to ensure both the older and the younger generations progress in the global movement for a non-ageist world. We encourage the development of advocacy working groups for late-life health improvement, where older mentors liaise with youth participants to connect, cultivate leadership, and generate innovative intergenerationally-led solutions for ageing and health. These approaches are feasible for institutional actors to implement, and could take place within existing youth networks (e.g., the WHO's Global Health Workforce Network Youth Hub).

In the longer term, we encourage governments to devote resources towards training young researchers interested in inclusive age-related policy, mechanisms of ageing, ageing interventions, and/or functional improvements in later life. Over the past few decades, biogerontologists have made fundamental discoveries about the mechanisms of ageing (e.g., the relationship between metabolism, inflammation, and ageing). Devoting resources to early-career biogerontologists and implementation scientists will contribute to interest in translational projects

as well as enhance the implementation of the fundamental discoveries in real-world settings over the coming decades. Additional research should consider the built environment and opportunities to create spaces appealing and accessible to all ages. Governments should enact policies that make environments physically more ageing-friendly. In all research, it is important to ensure that the perspectives of older adults are integrated.

DELIVERING AGE-RESPONSIVE CARE

Third, *the Decade* calls for sufficient "delivery of person-centred integrated care and primary health services responsive to older people" (1). Our focus here is to promote the interest in and quality of care for older people. An inability to do so will contribute to the looming geriatrician shortage/geriatric care gap, and lead to care ignorant of evidence that links diseases of ageing to underlying aetiologies of ageing (18). Health professions schools should make clinical education on ageing and geriatrics mandatory, as called for by the International Federation of Medical Students' Associations, which represents the voice of 1.3 million medical students worldwide (19). This training should reflect developing scientific and social realities. Current clinical training on diseases of ageing is siloed into specialties with a single-disease focus, with trainees focusing on the treatment of diseases like cardiovascular disease, chronic obstructive pulmonary disease, and cancer, often not within the purview of geriatrics as currently configured. This weakens research and treatment capacity (20). Furthermore, clinical training about diseases of ageing needs to include training on the substantial links between patients' social realities and clinical outcomes.

Policymakers should meaningfully involve younger generations in discussions around how to strengthen primary health care and most effectively allocate resources to harness maximal economic potential. In addition to rethinking and reshaping health financing models to cover geriatric care at the primary care level, youth perspectives are crucial for the future planning of a health workforce which threatens to disappear if actions are not taken. For instance, medical students in Ireland led advocacy initiatives that called for increased funding for the ageing population and opposed the privatisation of nursing home care (21). Furthermore, these students orchestrated a day-long event in which local older people were able to share their concerns regarding healthcare and ageing with attending physicians and medical students. Such initiatives not only allow students to actively reflect on the type of systems in which they wish to work and age, but also provide a voice for older individuals who do not have direct access to communicating with the medical network. By uplifting their voices such that both older and younger people are advocating for change, there is increased amplification of the needs of older people.

PROVIDING LONG-TERM CARE

Fourth, *the Decade* asks governments to "provide access to long-term care for older people who need it" (1). This is a necessary action area, but one that will likely place the responsibility of care on younger generations without adequate support for those carers. We call on governments to invest in young carers and caregivers through financial support and education as well as encourage solutions that engage young carers in service design (22). The intergenerational living programmes proposed earlier may be particularly effective in this respect, demonstrating how potential solutions to individual action areas are likely to positively impact multiple key sectors. Moreover, the rising demand for long-term care for older people amidst growing workforce shortages has negatively impacted aged care quality and safety efforts. Governments could involve youth in the co-creation of strategies to enhance the retention of the aged care workforce and mitigate shortages.

DISCUSSION

The journey into older age is a shared, inevitable human experience. Our response to *the Decade* proposal centres on how innovative intergenerational programmes, comprehensive and mandatory broad education about ageing, and the participatory role of youth in the global conversation on healthy ageing can concurrently address the four action areas of *the Decade*.

The desire to achieve these ideals and adequately address ageism amidst the grand challenge of our ageing society introduces a myriad of questions. How do we transfer best practice examples to increase their scope? How do we address subconscious ageism and ensure our efforts are truly centring on the wants and needs of older people? Indeed, how do we go beyond a needs-based approach and acknowledge that a cultural paradigm shift is needed that allows older people to not only have basic needs met but to also have wants, passions, and a valued place in society? How do we design a new social contract that benefits everyone, regardless of age?

AUTHOR CONTRIBUTIONS

BLHW led the writing of the manuscript. OE-O and DS provided guidance on youth engagement in global public health issues. DD, NA-C, and DG provided geriatric and gerontology-specific technical guidance. All authors contributed to the writing of the manuscript.

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COMMUNITY CASE STUDY
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Intergenerational Virtual Program: Promoting Meaningful Connections Across the Lifespan During the COVID-19 Pandemic

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Intergenerational programs have long been identified as a way of promoting health and well-being for participants. Continuing such programs during pandemic restrictions is challenging and requires a novel approach. This community case study describes the use of co-design to create a high-level intergenerational program model, adapt it to specific community needs, and deliver it virtually with the aid of modern communication technology. Interviews conducted after the program had finished indicated that despite the challenges and limitations of the virtual environment, meaningful connections were achieved across three generations. The high-level program model may serve as a basis for other programs wanting to explore this area.

Keywords: active aging, intergenerational programs, children, older adult, technology, health and well-being

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INTRODUCTION

The existence and benefits of non-familial intergenerational programs for children and older adults are well-established (1–4). Emerging as a response to changing sociodemographic trends in the 1960's in the US, the scope and heterogeneity of inter-generational programs have proliferated (5, 6). Typically, intergenerational programs are defined as services that aim to increase sharing, interaction, or exchange between two generations, particularly when separated due to changes in social structures. These initiatives enable the strengths of each age group to enhance the experience or quality of life of the other (7). More simply, intergenerational programs include "activities that bring old and young together for their mutual benefit" (8). For older people there is evidence of self-reported improvements in health and depressive mood, self-esteem and confidence, enjoyment, satisfaction and happiness, improved interactions and relationships with others (1, 2, 6).

Reported benefits for children include supporting them to develop a positive attitude to and more knowledge of aging (6, 9), skill development and character building, mood and enjoyment, feeling helpful and having a friend (4).

Quality outcomes in intergenerational programs are achieved when implementation is theoretically sound and evidence based, and the high level of logistical, staffing and curricular work or training is addressed (6, 10). Evidence suggests the absence of these characteristics, with a concurrent assumption that "simply bringing younger and older people together will result in meaningful relationships" (11), is a "fatal flaw" of some

intergenerational programs resulting in them being only short-lived (10).

One form of service delivery involves the co-location of pre-school children and vulnerable seniors in fully integrated shared site intergenerational programs (SSIPs) to meet the diverse needs of families without duplication of services (10). The SSIP is a way to link young and old, eliminate transport issues and costs, schedule shared activity, create opportunity for informal activity and ensure sustainability (10). However, such day services for young and old are not yet a mainstream option in Australia, and as such most intergenerational programming involves the two cohorts meeting for shorter timeframes. When one of the participant groups includes people with dementia or frailty, it is more likely the child participants will travel to the older people. However, with the advent of the COVID-19 pandemic and the immediate physical distancing requirements, the option for face-to-face interaction was halted.

Using technology as a mode for delivering health programs is also well-established with telehealth being in existence for almost 60 years (12). However, the gaps in services and supports identified and the need to innovate during the COVID-19 pandemic accelerated the use of telehealth interventions in new ways with novel populations (13). A recent scoping review of 77 studies exploring technologies for fostering intergenerational connectivity and relationships found this is an early and emergent field, e.g., over half the studies were reported in conference proceedings (14). Only two studies were conducted in assisted living facilities and only one used technology, being an Apple iPad® mediated art class (15); no studies reported participants located in different environments or technology being used to connect participants for intergenerational programs activity.

This community case study reports on a pilot project using virtual conferencing to deliver a structured, co-designed intergenerational program with children located in an inner-city childcare center and residents of a suburban aged care facility.

CONTEXT

The Australian Government's Aging in Place policy has changed the way services are provided to its older citizens. Of the 1.3 million consumers of aged care services in 2019–2020, only one third were living in residential care (16) with the majority still living in their own homes. A corollary of this is that those who are in residential facilities tend to be high need and/or frail. The most recent figures indicated that 58% of residents were over 85 years of age (16) and 51.9% had a diagnosis of dementia.

The intergenerational program, which is the focus of this report, took place in Adelaide, South Australia, a city of 1.3 million, in an inner-city childcare center and a suburban aged care facility located 10 km away. This project fits in the context of South Australia's Plan For Aging Well 2020–25 (17), which identifies meaningful connections as a strategic priority to support older people to age well, both in the community and in residential facilities, and it proposes that challenging ageism is an important condition to achieve that.

The intergenerational program was the product of co-design between the aged care provider, university staff and students, childcare staff and aged care residents and had six phases: scoping, planning, co-design, pilot, evaluation, and reporting.

Co-design, also referred to as participatory design (18, 19), is relatively new in healthcare and focuses on empowering the participants most affected by the design (19), in this case, the residents and children. Participants are co-designers, involved at all stages of the design process rather than being passive recipients of the design or program. Co-design is suitable to be used with vulnerable participants. By necessity, co-design involves power-sharing, and giving a voice in decision-making to those who are often left unheard (18).

Older adults, living in residential care, and young children are both vulnerable groups. Bringing two vulnerable groups physically together can be logistically complex and was made more difficult by the COVID-19 pandemic. The safety of both groups needed to be ensured and appropriate compliance checks needed to be in place. Although the intergenerational program was originally planned for delivery face-to-face, COVID-19 restrictions throughout 2020 and much of 2021 excluded young children from visiting aged care facilities and so a virtual program was designed instead.

The co-design phase was conducted between August and December 2020 and aimed to involve all stakeholders in the development of a high-level program model. It was conceived as a three-level exercise starting from broad principles and concluding with the test of actual locally responsive intergenerational activities designed in partnership with participants. **Figure 1** summarizes the co-design approach.

In this phase, aged care residents, staff, children and their families and occupational therapy students were consulted in depth regarding their interest in an intergenerational program, their hopes and any concerns that they might have. These were incorporated into the original design with the key objectives of increasing social connectedness for both older people and young children. The project also aimed to explore and develop new opportunities for older people to actively shape services that support aging well.

Following this, the key stakeholders developed a broad program model that was feasible within the restrictions but also contained flexibility and ensured the needs of both children and aged care residents were represented. The basic structure of the model consisted of re-occurring "book-ends" to start and finish each session, a warm-up and a main activity. Staff with experience working in aged care and childcare proposed basic themes such as gardening, cooking, travel, going to the beach, which served as a starting point for customization with the participants (see **Figure 2**).

At the beginning of the pilot phase, two occupational therapy students took the basic structure and brought the ideas of the program to residents. The students spent time with the residents building relationships and explaining what would be involved. Of the fifteen people identified as possible participants, ten chose to participate and either they or their next of kin signed consent forms. Possible participants were identified by the aged care facility's lifestyle coordinator. Residents with behaviors of

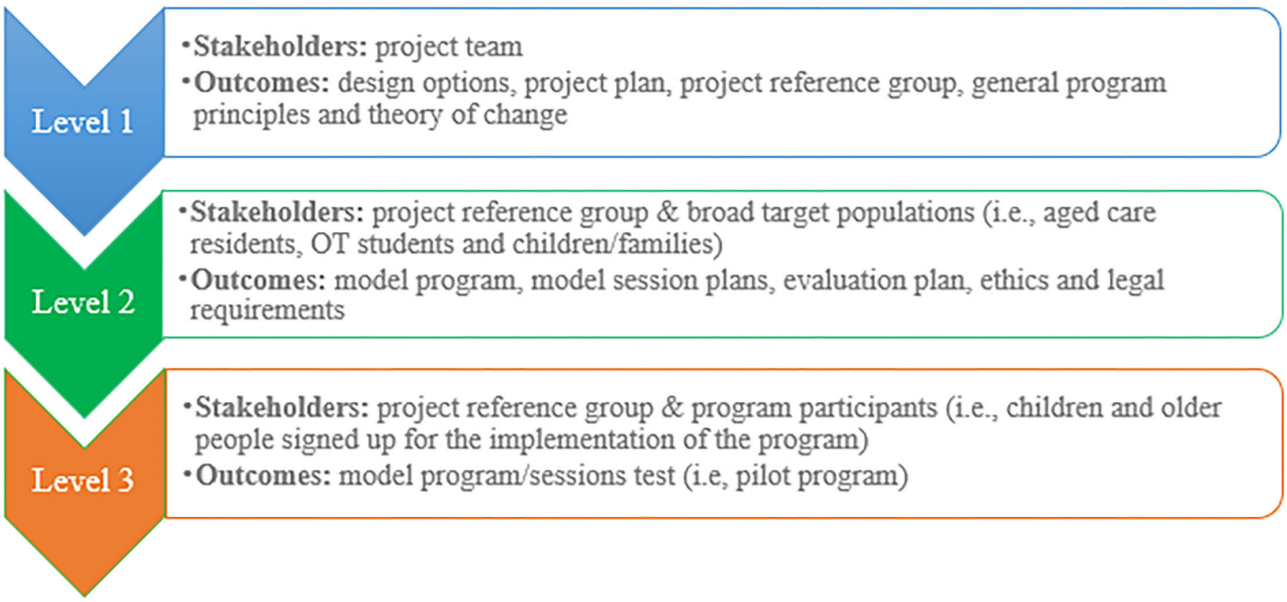

FIGURE 1 | The process of co-design.

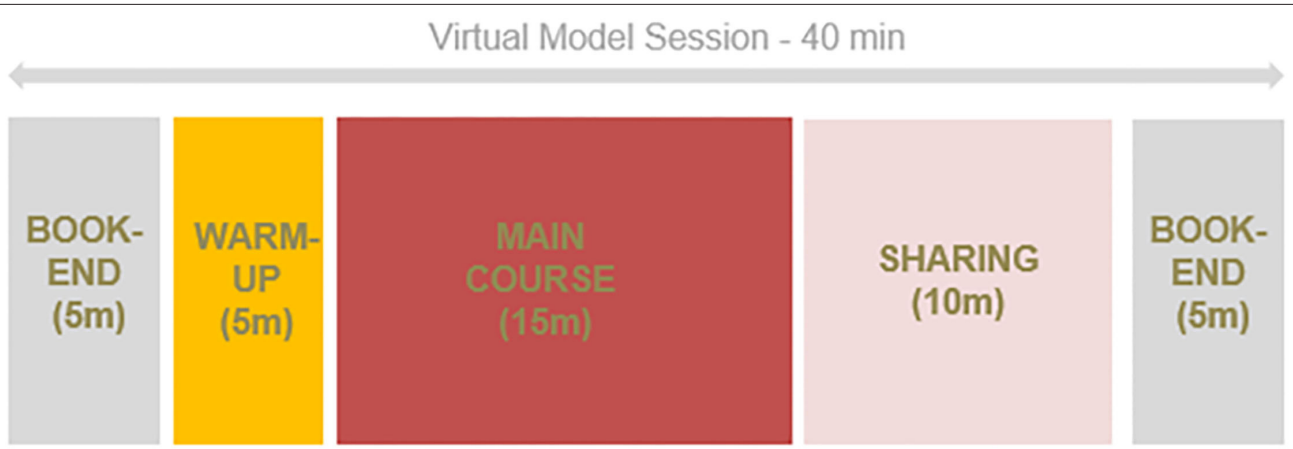

FIGURE 2 | High-level model of a virtual intergenerational session.

concern were excluded from the program. As this was a health promotion project, diagnoses were not recorded nor relevant. The common reason for participation was a desire to interact with children as many residents had grandchildren they did not see often. Residents also participated because they wanted to engage with other like-minded residents. Reasons given for parents enrolling their children in the program included their child not having grandparents and wanting to develop their child's connection to the wider community.

The two occupational therapy students, in partnership with staff of all three organizations involved, spent 3 weeks adapting the broad model program to the specific needs and interests of those who enrolled in the pilot. This involved fine-tuning all the proposed activities and overcoming logistic and coordination problems, including how to best introduce participants to the technology. This included repeated interactions with the aged care residents *via* informal conversation and *via* play with the children. The student facilitators spent one morning a week interacting with the children, and one morning a week interacting with the residents. The interactions allowed the facilitators to develop a relationship with the children and residents, and to learn about them as individuals. Further, the interactions guided the themes and activities of the weekly sessions, as they were based on the information gained from discussions and feedback from the participants. Ultimately, the interactions ensured the weekly sessions were client-centered, and based on tailored activities, interests, and themes. Following the program design, the pilot intergenerational program was run as described below.

Detail to Understand Key Programmatic Elements

The final program consisted of a 45-min session held once a week for 5 weeks. Children participated *via* Zoom Cloud Meetings from their childcare center, supported by their teachers and one occupational therapy student. The aged care residents met in the facility's clubrooms which had a large drop-down screen for the projection of the Zoom connection. They were supported each week by an occupational therapy student and university supervisor, the aged care facility lifestyle coordinator and a volunteer.

Older adult participants ranged in age from 77– 94 years and the children were aged between 3–5 years. Each session followed the same pattern, starting with a welcome song ("Wheels on the bus"), themed activities, a refreshment, time to chat and then a goodbye song ("You are my sunshine"). An additional component was added to the broad model developed in the planning phase. Due to concerns regarding establishing relationships and connections being minimized on a virtual platform, a sharing component was added to the plan to assist with individual interactions, knowledge sharing and relationship development.

In addition to the weekly Zoom session between the residents and children, an extra session was run with just the children a day prior to the intergenerational program. These sessions supported the children's ability to participate in the virtual sessions and were shorter but had the same theme with a different activity. The additional session allowed time to familiarize the children with the Zoom sessions and assisted with developing relationships with the children. The children sang the same "book-ends" and the facilitators discussed the weekly theme with the children and their "Grandfriends" (20). [1] The children-only sessions were also an opportunity for the children to create something for their Grandfriend, which could be given to them the next day and discussed in the session. This mimicked a relationship between a grandchild and their grandparent, wherein the grandchild would make something for their grandparent and give it to them. Examples of things made included musical instruments, painted a pot plant, "baked" cupcakes, and made an Easter card for their Grandfriends.

Time was spent interacting and establishing relationships with the participants to guide the themes used within the pilot. Interactive activities were chosen based on participants' interests, while ensuring the activities enabled inclusion of everyone involved and appropriateness for both generations. Themes included "Getting to Know You, Rhythm, Gardening, Farms, and Easter," as participants shared an interest in music and gardening, some residents had lived on farms and the children enjoyed farm animals, and Easter brought about mutual excitement among the participants. The participants' culture was considered in session planning, and the sessions provided them with the opportunity to share their culture (particularly within the Easter session), which supported knowledge sharing, learning and connection. At the conclusion of the pilot program, interviews were conducted with adult participants to involve them in the evaluation of the project and to gain an in-depth understanding of their perspectives. Six residents agreed to be interviewed and two staff members (see **Table 1**). Interviews were chosen to allow participants time to speak. All participants were familiar with the interviewer (an occupational therapist) and interviews gave participants the opportunity to express their opinions. The interviews were audio-recorded, transcribed and then analyzed using independent line by line coding (21) by two authors. These were then discussed and further developed into themes which are presented and discussed below.

[1] "Grandfriends" was chosen as the term to describe the relationship between the children and residents as it reflects the intergenerational component but does not assume kinship. This term was adopted from Low et al. (19).

TABLE 1 | Participants' demographics.

Name (pseudonym)	Age	Sex	Resident or staff member
Ruby	88	F	Resident
Eileen	88	F	Resident
John	90	M	Resident
Peggy	84	F	Resident
Vera	92	F	Resident
Bob	86	M	Resident
Rosa	77	F	Resident
Beryl	94	F	Resident
Flynn	–	M	Staff — 10 years' experience
Roger	–	M	Staff — 17 years' experience

RESULTS

Five key themes were identified from the interviews with participants and staff. These themes included: "connection, skilled facilitators, exploration of past and present roles, a wish for continuity, and online challenges."

Findings are evidenced by quotes in text, pseudonyms are used to differentiate between participants, and different groups are identified by abbreviations R (resident) and S (Staff).

Connection

The residents spoke of the connection they were able to develop with the children, even though the connection was developed and maintained over a virtual platform.

This connection was fostered through the use of shared occupation and experiences — which was reflected in the interview with Vera (R) "*I think the painting and that sort of thing was the best part… they were participating, and we were participating*". This was also reflected through Flynn's statement "*there is a purpose and activity and that's what they come for*" (S).

When discussing highlights of the group three of the five residents spoke of the shared occupations where the children completed part of the task (i.e., painting the pot) and the resident finished the task (i.e., planting a plant). The children also made cards for the residents for Easter which were mentioned in the interviews "*I shall treasure this because I can't believe the note*" (Ruby, R). In this statement Ruby was referring to a touching note from a child that expressed feelings of care and love toward her.

The connection formed between the participants was emphasized by Eileen (R), "*they gelled with us… they wanted to see us again… they wrote notes to us*". The residents also reflected on the level of connection with the younger people and the "genuine" nature of this connection. This sentiment was reflected by the children who embraced the title of "Grandfriends." The use of this terminology demonstrated a "language of connecting with older people" [Roger(S)].

The sense of connection was strengthened through the self-identified grouping of the younger and older generations to the exclusion of the facilitators' (who were not part of either generation). Based on the interviews it appeared there was an "us and them" mentality with the older adults and children being "us" and the facilitators being "them". This exclusive clique was reflected through the interviews; "*contact between [old and young] is very important in all walks of life, from when you start walking*" — Peggy (R), and "*I think everybody was really impressed, old and young*" Eileen (R). In fact, one of the older participants referred to the "adults" (facilitators) as being separate from the main group. This observation was supported through a staff member identifying that the "third generation [the student facilitators]" were important in bridging the age gap.

Skilled Facilitators

A key theme that was identified was the skill of the facilitators in running the group and managing the technology, group dynamics and the children's engagement.

The areas that were commended were the facilitators' use of shared activities, adapting to an online environment and supporting the children to stay engaged.

In particular, their ability to adapt to technology was mentioned by participants and staff, "*I did not think we'd be able to do a group with another group at the other end, but they made it work really well*" [Flynn (S)] and "*whoever you are, to generate energy through a screen, to connect people, it is almost impossible to do*" [Roger (S)].

The residents all identified being surprised and impressed by the children's levels of engagement and the role of the facilitators in enabling this, "*the control she had over those children for their ages… it was amazing*" (Ruby, R.) and "*She had the class right under her [control]*" (Eileen, R).

In terms of the program itself, the residents identified that the group had run well, and this was confirmed with examples of activities completed. One participant, Vera stated "*I thought it was very good the way it was done*" (R.), this was supported by Ruby (R.) who identified that despite the need to run the group online "*everything else flowed so well.*"

Exploration of Past and Future Roles

Each of the residents described their interaction with the group and the children through the lens of their own experience. This often led to an unprompted exploration of roles they had previously held in their families and/or the workplace. These roles were celebrated with a sense of achievement and pride.

For example, one participant reminisced on her previous experiences as a teacher and saw a relationship between this and her ability to easily engage with the children: "*It may have been that I have had a bit of training in that area*" (Ruby, R). Another spoke of her role as a mother "*I've been with children a lot, with six of our own*" (Eileen, R) and one shared his experience as a grandfather raising his grandson. Those who had less experience with children spoke of their upbringing and exposure to older adults when they themselves were a child "*I had a lot of contact with older people and that was, I don't know, just part of life*" (Peggy, R).

Participants were also able to be future focused, thinking about the children's future and the future of technology, and the modern world. Bob (R) shared a sense of wonderment at the children's future; "*I wonder what memories the kids will have.*" This finding portrayed the theme of hope for the future and a desire to be engaged in that future "*That's why I want to stick around for a few years, because I want to see what's going to happen*" (Ruby, R).

A Wish for Continuity

All participants and staff expressed their enjoyment in the program and a wish for the program to continue, but this theme was most strongly shared by all the residents. "*I think it should keep going*" (Peggy, R.), "*I did enjoy it very much actually*" (Vera, R.) "*I was sorry when it finished*" (Eileen, R.).

Some of the residents reported in the interviews that the group was still being raised for discussion in their communal dining room. Many residents also reported that the timeframe (5 weeks) went very quickly, and they were "saddened" when the program was due to end.

Online Challenges

Despite the positive outcomes and enjoyments of participants — both staff and residents expressed a desire for the program to run face to face — whilst acknowledging the merits of technology to enable it to happen during COVID-19 limitations.

In particular the staff reported disappointment at the program needing to move online "*I think we had our reservations about it being virtual*"- Flynn (S) and their hopes that it could have been run in person "*We were hoping for these sessions to be face to face*" – Roger (S).

Although the staff identified challenges with being online — the residents reported that the program ran well-despite the modifications, "*It is a shame they couldn't come here- but never mind*" (Vera, R). Residents were also surprised at the children's adaptability to the use of technology. When speaking about the use of technology, one resident discussed the children's ability to adapt to it *"[that was] the way that it worked, and they accepted it*" (John, R.).

DISCUSSION

This project tested an intergenerational program conducted virtually. Initially the project was anticipated to run face to face — however changes in COVID-19 restrictions forced the group into an online environment. To the best of our knowledge, this is the first study to report on the use of technology and occupation to facilitate the development of these connections.

Despite concerns that this shift would limit engagement and connection, the project was a success and this outcome opens

up the potential for more diverse and innovative approaches to intergenerational connection.

Based on the interviews with the participants, it was evident that a bond was able to be formed between the children and older adults over the course of the project. The children readily adopted the term "grandfriends" indicating a special relationship built on pillars of friendship rather than service delivery, obligation, or family ties. The importance of friendship for older people in terms of physical, social and mental well-being is well known (22) and there has been growing investigation into the importance of "befriending"(23, 24). Befriending refers to a relationship where a younger person becomes friends with an older person and interactions are based around topics that are meaningful to the older person (23). In previous studies, befriending is implemented by volunteers and the benefits to the older adult receiving the "befriending" are captured. However, there has been little focus on the concept of reciprocity and what benefit the older adult brings to the relationship (25).

Analysis of the interviews suggested that this bond was enabled through the use of shared occupations and enhanced through a shared commonality: vulnerability.

The use of meaningful occupation to enable engagement, participation and well-being forms the foundation of occupational therapy (26). Sharing occupations is known to support the development of connection between groups and individuals and has long been used as a therapeutic tool (27–29). This was reflected within the program where participants reminisced about the activities and how they were able to share them together, albeit online.

CONCLUSION

Intergenerational programs can facilitate connection even when conducted virtually. This innovative program demonstrated that while face to face is preferred, virtual interaction can still support a sense of belonging across generations. There was a unanimous response from residents and staff that the program should continue. It created meaning and connection and was a source of joy. More resources may be needed to deal with the technological challenges or ongoing technical advancements and the quality of the programming relies on careful attention to co-design and evaluation.

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This was a pilot program conducted over 5 weeks with two vulnerable populations, aged care residents and very young children. This placed constraints on what outcome measures could be used and who could be interviewed. Not all residents were able to be interviewed due to limited verbal capacity. The findings of this project cannot be generalized to all aged care facilities however, they do provide a starting point and initial evidence on which longer and more in-depth projects can be based.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of South Australia's Human Research Ethics Committee. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

AK-B: led the ethics application, supervised delivery of program, conducted all interviews, and co-wrote the manuscript. ER: led the Child Care in Aged Care project and contributed to the manuscript. SM-R: contributed to the development of the research protocol, data analysis, and manuscript. AB: contributed conceptually to the project and contributed the manuscript. AH and HB: facilitated the program and contributed to the manuscript. KB: contributed to the development of the research protocol and data analysis. DA and BJ: contributed conceptually to the co-design and delivery of the program. CM: contributed the development of the research protocol, the co-design process, data analysis, and manuscript. All authors contributed to the article and approved the submitted version.

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