

Navigating Challenges and Opportunities in Community-Based Interventions for Promoting Active Aging: A Systematic Review of the Roles of Technology

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Abstract

Background and Objectives: Researchers from different fields are increasingly interested in incorporating technology into community-based interventions that promote active aging. Yet, there lacks a comprehensive understanding of technology roles, posing challenges for designers seeking to maximize the intended impacts of such interventions. This systematic review aims to fill the gap by examining existing community-based interventions that integrate digital technologies to promote active aging.

Research Design and Methods: Thirteen studies were screened, with a total of 14 interventions examined, following the PRISMA Guideline.

Results: The challenges in designing and operating community-based interventions, the roles of technology in the interventions, and the caveats of utilizing technology during the process were identified. The review emphasizes the importance of overcoming challenges in community-based interventions and leveraging technology to enhance the intended impacts.

Discussion and Implications: The findings underscore the need to understand technology's nuanced roles in community-based interventions for active aging. The article provides a starting point for accumulating knowledge and practice in utilizing technology to navigate the challenges and opportunities encountered in such interventions. It also sheds light on a notable gap: the lack of innovative and strategic approaches that harness digital interventions appropriately in community-based interventions. This emphasizes a crucial requirement for guidelines to assist designers, policymakers, and community staff in integrating technology appropriately into community-based interventions or implementing interventions that incorporate digital technologies at the community level.

Keywords: Communities, Community-based care, Intervention, Older adults, Technology integration

Translational Significance: The study examines community-based interventions for active aging, specifically focusing on the integration of technology. The systematic review includes 13 studies, identifies key challenges, explores technology's roles in active aging, and provides design considerations, enhancing the intended impacts of interventions. This research informs the strategic use of technology in community-based interventions, fostering improved conditions for aging individuals. The findings offer actionable insights for designing interventions that positively affect societal well-being and promote active aging.

In recent years, the topic of aging has gradually shifted some attention from individuals to communities when engaging in research, design, and system development (Guan et al., 2021; Nicholson et al., 2021). This transformation has been driven by the recognition that individuals are not isolated entities but are embedded within social contexts and communities (Guo, Zhang, et al., 2023; Seering et al., 2020). Along with the shift, studies have started to develop online communities, or fuse traditional community-based interventions and digital technologies. This involves harnessing technological tools to empower group-based activities in public space. Although the latter form of intervention has received limited

attention in existing studies, recent literature has highlighted its potential to achieve target behavioral changes (Bol et al., 2018; Tomasini Giannini & Mulder, 2022). Specifically, this kind of fusion highlights the tangible support of traditional community-based interventions and the accessibility, connectivity, and knowledge-sharing potential of digital technologies (O'Leary et al., 2022). This leads to more comprehensive, inclusive interventions that can enhance community capacity (Bray et al., 2022; Karkera et al., 2023), promote equity (Klerks et al., 2020; Maye et al., 2020), and improve overall well-being in the interconnected world (Cooper et al., 2022; Dai & Moffatt, 2020; Maye et al., 2020).

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Against the backdrop, community-based interventions, paired with the integration of digital technologies, have been seen as promising approaches to promoting active aging. Active aging, defined as “the process of optimizing opportunities for health, participation and security to enhance the quality of life as people age,” is crucial for ensuring the well-being and vitality of older adults (Mao et al., 2020; Nassir et al., 2015; Robbins et al., 2018). Although there is a growing acknowledgment that technology can be effectively utilized in community-based interventions to foster active aging, scholars highlight the necessity of appropriately integrating digital technologies into community-based interventions aimed at fostering active aging (Harrington et al., 2022; Karkera et al., 2023). Nevertheless, a knowledge gap exists in understanding how technology has been and can be deployed in this context to maximize the intended impacts of such interventions. Despite the general consensus on the importance of active aging (Batsis et al., 2020; Jovanovic et al., 2021; Xiaobing & Meng, 2022), our understanding of the precise role that technology can play in this form of community-based interventions remains relatively incomplete (Mao et al., 2020). This poses substantial challenges for researchers and practitioners who are designing and implementing these interventions (Kapuire et al., 2015; Mantzavinou et al., 2018; Taylor et al., 2017). Therefore, there is an urgent need for further research to elucidate the role of technology in promoting active aging within community settings, ensuring that interventions are tailored to meet the diverse needs of older adults and enhance their overall well-being.

To address this gap, this paper presents a systematic review that aims to answer the question of how to integrate technology to navigate challenges and opportunities in community-based interventions to promote active aging. The study focuses on three key objectives:

- Identifying the challenges faced by community-based interventions for promoting active aging.
- Investigating the supportive roles of technology in these interventions to overcome the challenges identified.
- Examining the caveats associated with utilizing technology in such interventions.

Related Work

The Growing Attention on Communities and Digital Technologies

Recent research has shifted focus from individual users to the communities they inhabit, driven by recognition of the pivotal role communities play in shaping behaviors and well-being (Claisse et al., 2022; Dillahunt et al., 2022; Guan et al., 2021; Righi et al., 2017; White & Foale, 2020). These communities take various forms, including geographic (Talmage et al., 2021), interest-based (Rudnik et al., 2020), and cohesive units addressing challenges collectively (Guo et al., 2023; Marchesoni et al., 2012).

A number of researchers focus on the formation of online communities by harnessing digital technologies to catalyze the establishment and maturation of virtual communities, and transcending geographical and temporal constraints (Embarak et al., 2021; Peng et al., 2020; Seering et al., 2020). These online communities can be centered around a myriad of interests, hobbies, or shared experiences. They

allow individuals to connect, collaborate, and exchange information with like-minded individuals from around the world.

Others concentrate on enhancing physical-world communities by integrating digital technologies into community-based group activities such as fitness classes (Harrington et al., 2018; Marcus & Forsyth, 2003; Pappas & Pappas, 2014), workshops (Pradhan et al., 2020; Villalba et al., 2021), volunteer initiatives (Klerks et al., 2020), and social gatherings (Gui et al., 2022; Lin & Chen, 2016). This integration aims to alleviate challenges faced by traditional community-based interventions, such as geographical constraints, resource limitations, sustainability failures, and low acceptance rate among participants (Israel et al., 1998; Lin & Chen, 2016; Wang et al., 2022).

Integrating digital technologies in community-based interventions seeks to overcome the limitations of online communities, fostering in-person interactions, building tangible support networks, and providing immediate physical assistance. Notable examples include the ActiStairs system, which encourages stair-climbing in public spaces, promoting physical fitness and overall well-being (Meyer et al., 2018). Furthermore, Renswouw and colleagues developed an interactive public installation called Fontana (Renswouw et al., 2022). Fontana incorporated game-like elements and encouraged residents to engage in regular exercise while connecting with others in the community. Moreover, Greevenbroek and colleagues developed a multisensory public display game to raise awareness of human impact on the environment, engaging community members in discussions about sustainability and environmental responsibility (Van Greevenbroek et al., 2020).

Active Aging and Technology Design

The World Health Organization (2002) defines active aging as “the process of optimizing opportunities for health, participation, and security to enhance the quality of life as people age.” This concept aligns closely with other terms such as healthy aging and successful aging, emphasizing action across multiple sectors to enable older individuals to remain valuable resources to their families, communities, and economies. In the framework of active aging, the term “active” denotes involvement in a range of activities spanning physical, social, economic, and cultural domains. Similarly, “aging” encompasses the entire life-course, highlighting that active aging begins in early life and continues throughout one’s lifespan (Mao et al., 2020; Robbins et al., 2018).

Technology has been recognized as a key approach to addressing challenges associated with the aging trend. A variety of systems have been proposed, ranging from monitoring systems to games for maintaining engagement in preventive exercises. Alongside this trend, designing technologies that compensate for “the downside of aging” (Rogers et al., 2014) becomes the primary design criterion, aiming to facilitate older adults in managing various activities of daily living. Multiple assistive technologies exemplify this approach (Saborowski & Kollak, 2015). Older adults are perceived as individuals requiring support due to age-related declines in functional capabilities that affect their daily lives, often with minimal or no familiarity with technology (Bannon, 2011). The analysis of these studies mirrors similar attempts to understand practices and rhetoric shaping the design of active aging technology (Chang et al., 2023; Mace et al., 2022). This work brings

forward an ageism perspective, exposing the intrinsic bias of computer science research toward deficit models of aging.

Conversely, an increasing body of research seeks to encourage a more optimistic view of aging (Robbins et al., 2018). Scholars advocate for digital technologies designed to prevent decline and promote health rather than simply fixing problems. Older adults are depicted as capable individuals who, despite their age, can utilize technologies and significantly contribute to their families and society (Marston & van Hoof, 2019; Yu et al., 2020). Consequently, the focus shifts from providing assistance to designing systems that enhance experiences, appeal to the human need for independence, and affirm a positive identity. This approach to technology design considers social relationships, personal interests and goals, and age-related functional declines, with significant attention placed on older adults themselves (Righi et al., 2017).

Community-Based Interventions for Active Aging

In contrast to interventions designed for individuals to promote active aging, recent studies focus on examining the impacts of interventions from a communal perspective. Researchers explore the potential of leveraging technology to enhance community-based interventions within the context of active aging (Gooch et al., 2020; Hill et al., 2021; Ollevier et al., 2020; Rocha et al., 2019). By incorporating digital elements into community-based settings, traditional interventions may harness technology's power to address specific needs (Brandt et al., 2020; Mao et al., 2020), amplify engagement (Jung et al., 2022; Smith & Iversen, 2018), and foster personalized support for older adults (Gerling, Ray, Abeele, et al., 2020; Hanrahan et al., 2019). However, not all older adults are comfortable with technology and the outcomes of intervention implementation are conflict (Frei et al., 2018; Park et al., 2019; Pol et al., 2019). There is a danger that the excitement over these community-based interventions that integrate technology will result in a misplaced focus on the technology, to the neglect of what must be the central focus: the older adults with complex needs who require being heard in community settings (Holthe et al., 2018; Merriman et al., 2018; Tsertsidis et al., 2019).

Recognizing this, a portion of the literature review emerges, with a particular focus on methods for engaging older adults in intervention design (Ma et al., 2022; Robbins et al., 2018), comparing older adults' perceptions of new and traditional interventions (D'Amore et al., 2021; Kong et al., 2022) and factors influencing intervention acceptance (Israel et al., 1998; Tan et al., 2021; Wister et al., 2021). These findings contribute to an in-depth understanding of designing and operating interventions among older adults, posing a gap in knowledge of how interventions that combine traditional and digital approaches can effectively harness their respective strengths and mitigate weaknesses. This study aims to fulfill the gap by systematically reviewing this form of community-based intervention and providing insights into the challenges faced by such interventions, the roles of technology to enhance these interventions, and the caveats of utilizing technology in this context.

Method

Search Strategy

Our methodology is inspired by the PRISMA 2020 statement (Page et al., 2021). That is, we followed commonly

accepted recommendations for conducting systematic literature reviews in line with specified search strategies, eligibility criteria, data extraction guidelines, and analysis methods.

Search terms

The literature search was performed in three electronic databases: ACM Library, Web of Science, and Scopus. An additional search was conducted using Google Scholar. ACM Library was chosen because it is the most comprehensive database for design research associated with technology. Web of Science is a multidisciplinary database and Scopus has the broadest coverage in the areas of scientific, technical, medical, and social sciences literature.

For the searches, initially, we included "active ag*ing" as a search term, yet we realized that many studies that address aspects of active aging (e.g., physical activity promotion and social activity participation) did not explicitly mention "active aging" in the article. Hence, we decided to broaden the search term and apply inclusion criteria to evaluate if a study addressed active aging during the screening phase. During the screening process, we also considered studies related to successful aging or healthy aging, recognizing their overlap with the concept of active aging, to ensure comprehensive coverage of relevant literature.

Based on the research objectives, there were three sets of search terms. The first set of search terms is related to older adults, which includes "older adult" and "elderly." We used 55+ as an age cutoff because, in many contexts, people aged 55 and older are eligible for certain age-related benefits and programs, making it a practical cutoff for studying populations that can access interventions promoting active aging. The second set of search terms pertains to the concept of community. For the purposes of this study, the term "community" is defined as "the people living in one particular area or people who are considered as a unit because they physically gather together for common interests." Hence, the set consists of "community," "public space," "physical space," and "ag*ing in place." The last set is related to technology. Considering the limited existing research specifically examining this intersection, we kept our search term "technology" broad to ensure we captured all relevant studies. The final search was conducted on June 19, 2023.

Eligibility criteria

The search covered all the studies published in the last 6 years up to June 2023. Given the absence of previous systematic studies on related topics, we opted for a broader year range to gain a comprehensive understanding of this type of intervention. We excluded studies published before 2017, as significant developments in community-based interventions that integrated physical, social, and digital elements emerged after this period. Study outcomes could be objective or subjective regarding behavioral changes after utilizing the intervention. There was no restriction on study design. The additional inclusion criteria were: (1) studies that developed or evaluated an intervention addressing aspects related to active aging, encompassing but not limited to the term "active aging"; (2) the intervention is based in a community; (3) the intervention

incorporates physical, social, and digital elements; and (4) studies that are written in English and published in a peer-reviewed channel.

Study Selection

The study selection consisted of five steps (Figure 1): (1) the two authors (F. Chang and G. Wang) conducted literature searches and merged all references into the Mendeley reference management database. The initial search identified 3,024 studies; (2) duplicates, records in other languages, in the wrong formats, or with the wrong target population were excluded, resulting in 2,773 records; (3) the two authors (F. Chang and G. Wang) examined titles and abstracts. To ensure consistency, a pretest screening was carried out on 80 randomly selected titles and abstracts, resulting in a Kappa k coefficient of 0.8512, indicating “excellent” interrater agreement. We then individually assessed the remaining titles and abstracts, discussing any studies with unclear inclusion/exclusion criteria. Any disagreements were resolved through discussion with a third author (Z. Gu). A further 2,688 records were removed through title and abstract screening against the inclusion criteria; (4) retrieval was then conducted, and 6 out of 85 records were excluded because full texts were absent; (5) all full texts were reviewed by the authors (F. Chang and G. Wang) and again discussed to check agreement that they met the preestablished inclusion and exclusion criteria. Uncertainties around paper inclusion and exclusion were again discussed with the third author (Z.

Gu) until a consensus was reached, leaving a set of 13 papers (Supplementary Table 1).

Data Extraction and Analysis

For the characteristics of the screened studies, the two authors (F. Chang and G. Wang) extracted data independently from eligible studies using a data extraction sheet. General characteristics of the included interventions (e.g., main focus, general descriptions, and included technologies) were extracted (Supplementary Table 2). Discrepancies between the reviewers were then resolved through discussions with the third author (Z. Gu). G. Wang has a background in community-based participatory research, with a focus on understanding social dynamics and community interactions. F. Chang specializes in welfare technological innovation, with a focus on developing and evaluating technology-driven solutions for enhancing well-being among older adults. Both authors have received formal training in the coding strategy used and approached the data extraction process with their unique perspectives and expertise, ensuring a comprehensive analysis that considers both community and technological aspects of the interventions.

For the synthesis of insights from the screened studies, the data extraction and analysis in this study employed an abductive thematic analysis approach (Fereday & Muir-Cochrane, 2006). The two authors (F. Chang and G. Wang) received formal training in the coding strategy and used Nvivo 12 for the data analysis. The analysis was guided by three primary research

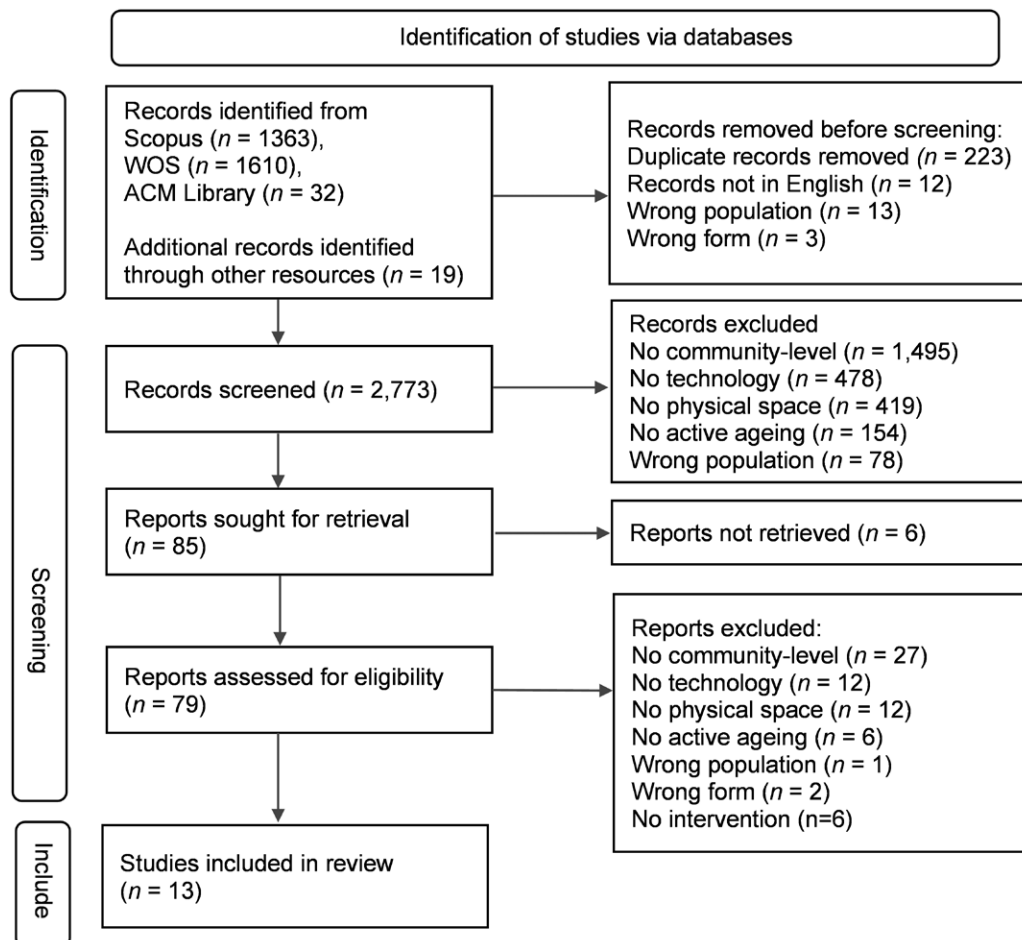


Figure 1. PRISMA flow diagram. ACM = Association for Computing Machinery; WOS = Web of Science.

questions, based on which a coding table that encompassed categories for “challenges,” “technology roles,” and “caveats” was created. This coding table served as an initial framework for organizing and categorizing the data extracted from the screened papers. Initially, all screened papers underwent thorough examination by F. Chang and G. Wang. Subsequently, the two authors generated initial codes. To ensure reliability and validity, the two authors analyzed five studies separately, followed by the comparison of the identified initial codes, and the discussion of discrepancies with the third author (Z. Gu). After achieving consensus, the two authors proceeded to analyze all screened studies. A number of initial codes regarding challenges, technology roles, and caveats were then filled into the coding table. As the analysis progressed, themes and subthemes were generated and refined. This iterative process involved moving back and forth between the initial codes and the evolving themes, ensuring that the analysis remained grounded in the research questions. As a result, three themes were identified, including community fitting and understanding, personalized engaging and motivating, as well as collective interacting and sustaining (Table 1). Each theme encompassed three subthemes related to challenges, technology roles, and corresponding caveats. Member checking was then used to ensure the validity and reliability of identified categories.

Quality Appraisal

The quality of studies was evaluated by the two authors (F. Chang and G. Wang) using the Mixed Methods Appraisal Tool (Hong et al., 2018; Supplementary Table 3). It is a validated checklist designed for assessing the quality of quantitative, qualitative, and mixed-methods studies that are included in systematic reviews. When evaluating quantitative descriptive studies, we considered sampling strategies, sample representativeness, appropriateness of measurements, and response rates. For qualitative studies, we assessed the relevance of the data sources, the analysis process, consideration of context, and researcher influence. In the case of mixed-methods studies, the quality of both the qualitative and quantitative components was examined. Any remaining doubts or disagreements in the appraisals were resolved through discussion between the two authors (F. Chang and G. Wang) and a third author (Z. Gu). Missing information was addressed by

searching the research project’s website (if available) or by contacting the authors directly.

Results

A total of 14 interventions were identified (Supplementary Table 2). Among the interventions, nine aimed to promote social participation among older adults, emphasizing technology-based social activities and initiatives that fostered social connectedness (Haan et al., 2021; Kosurko et al., 2022; Lazar et al., 2021; Lenstra, 2017; O’Brien et al., 2021; Pedell et al., 2021; Reuter & Liddle, 2020; Yang & John, 2020); four targeted the promotion of physical activity, utilizing personal or group exercise data and enhancing environmental safety to motivate older adults to engage in physical activities (Frei et al., 2019; Gooch et al., 2021; Pedell et al., 2021; Reuter et al., 2019). Additionally, there was one intervention focused on supporting healthcare management (Cao & Zhan, 2018). A range of technologies was employed. These included communication devices such as smartphones and radio station facilities (Cao & Zhan, 2018; Frei et al., 2019; Haan et al., 2021; Pedell et al., 2021), sensor devices such as healthcare tracking devices and monitoring devices (Cao & Zhan, 2018; Gooch et al., 2021; Pedell et al., 2021; Reuter et al., 2019), hardware such as 3D printers for creative workshop educational activities (Lazar et al., 2021), and software appliances such as WhatsApp to support events like group walking and social gatherings (Frei et al., 2019; Pedell et al., 2021; Reuter & Liddle, 2020). Besides, some researchers tailored a community display to promote physical activity in a community (Gooch et al., 2021), whereas some transformed a local game into a digital version to facilitate social connectedness (Yang & John, 2020). Additionally, unspecified technologies were mentioned in some interventions (Keirnan et al., 2019; Lenstra, 2017). Among the interventions, most technologies were off-the-shelf, whereas some technologies were self-developed.

Community Fitting and Understanding

One challenge identified in the findings is about localizing the intervention against complex local contexts. Encompassing the challenge, three technology roles were revealed: visualizing local dynamics, incorporating contextual information, and tapping into local resources and cultures. Besides, the

Table 1. An Overview of Identified Themes

Themes	Subthemes	Description
Community fitting and understanding	Challenges	Localizing the intervention against complex local context
	Technology roles	Visualizing local dynamics Incorporating contextual information Tapping into local resource and cultures
	Caveats	Scale and place of technology deployment limits participants
Personalized engaging and motivating	Challenges	Engaging individual older adults with varied needs and preference
	Technology roles	Motivating individuals Enhancing personalized user experience
	Caveats	Technology hinders skill-based participation.
Collective interacting and sustaining	Challenges	Enhancing collaboration among diverse stakeholders
	Technology roles	Connecting stakeholders Identifying shared values and matters of concern Balancing inner responsibilities
	Caveats	Social isolation emerges due to unsuitable communication styles

caveat of utilizing technology during the process is related to the scale and place of technology deployment.

Challenges

According to the screened studies, involving and engaging older adults meaningfully requires a deep understanding of their local context. The screened studies highlight that communities are dynamic and encompass divergent interests. Residents in a community have varying concerns, views, and backgrounds (Haan et al., 2021; Lenstra, 2017; O'Brien et al., 2021). Their routines (Gooch et al., 2021; Yang & John, 2020) and habits (Frei et al., 2019; Lazar et al., 2021; Lenstra, 2017; Reuter & Liddle, 2020; Reuter et al., 2019) vary. As such, it is a complex environment in which a multitude of small worlds can exist within a community. Besides, communities often have few financial and human means available (Gooch et al., 2021; Lenstra, 2017), or lack the required social capital and skills to maintain the intervention over time (Frei et al., 2019; Haan et al., 2021). A fundamental question thus emerges: How can interventions be effectively localized to navigate the intricacies of diverse local contexts? In this case, the challenge identified under this theme relates to localizing the developed intervention by applying it and subsequently working with older adults in their own community environment.

Technology roles

Technology can assist in visualizing local dynamics, allowing researchers and designers to grasp nuanced insights into the daily lives of older adults and related stakeholders, which is often challenging to obtain through traditional methods such as surveys and interviews. For example, by utilizing various technological tools such as digital mapping, community display, and monitoring systems (Frei et al., 2019; Gooch et al., 2021; Keirnan et al., 2019; Pedell et al., 2021), researchers can identify older adults' patterns in target physical activity (Pedell et al., 2021), preferred engagement platforms (Frei et al., 2019; Gooch et al., 2021), and suitable walking trails for older adults with different capabilities (Lazar et al., 2021). Additionally, technology enables the continuous monitoring of data from ongoing physical exercises (Frei et al., 2019; O'Brien et al., 2021; Pedell et al., 2021), digital games (Kosurko et al., 2022; Yang & John, 2020), or education sessions (Haan et al., 2021), allowing for iterative improvements to interventions based on evolving needs and interests (Frei et al., 2019).

Technology can also facilitate the integration of contextual information into the daily routines of older adults, fostering their understanding of and connection to their local communities. Digital displays and online platforms, for instance, provide older adults with valuable insights about their local communities, including news updates and activity classes (Gooch et al., 2021). Other examples include the presentation of the achievements and strengths of the community through a digital display (Gooch et al., 2021; Pedell et al., 2021), the stimulation of older adults to share their inspiring stories through radio stations (Reuter & Liddle, 2020; Reuter et al., 2019), and the provision of unique healthcare services information through a self-developed health system (Cao & Zhan, 2018). These actions through technology strengthened the connectedness between interventions and the target community environment by

triggering older adults' appreciation of their communities (Reuter et al., 2019).

In the process of connecting with the community, technology can empower interventions to tap into local resources and cultures that older adults are familiar with, thereby lowering the barriers to participation (Frei et al., 2019; Lazar et al., 2021; Lenstra, 2017; Yang & John, 2020). For example, recognizing the popularity of Bingo games in local environments, the transformation into a hybrid and group version was undertaken to bridge physical and digital realms (Yang & John, 2020). Moreover, some other studies show that technology integration into existing spaces may enhance comfort and affordability for older adults, including public libraries (Lenstra, 2017), senior centers (Frei et al., 2019), and creative workshop (Lazar et al., 2021). Connecting with local spaces can be achieved by creating connected devices, such as calling devices in a self-developed emergency healthcare system within communities (Cao & Zhan, 2018). These devices offer a tangible means of participation and link participating households (Gooch et al., 2021; Reuter & Liddle, 2020).

Caveats

Despite the promising roles of technology in matching the interventions to the local community environments, there are caveats about scale and place of technology deployment. According to the findings, physical scale and place of deployment highly influence who participates, as only a specific set of people will encounter the intervention when it is placed in a specific location in the neighborhood (Cao & Zhan, 2018; Gooch et al., 2021). For instance, if a community display or information kiosk is positioned in a specific neighborhood area, only those who frequent that location will encounter it (Cao & Zhan, 2018; Gooch et al., 2021). This can inadvertently exclude older adults who may not frequent that area due to mobility issues or other reasons. Such a limitation could lead to uneven participation and engagement, which goes against the goal of inclusive community-based interventions.

Personalized Engaging and Motivating

The second challenge identified from the screened studies is about personalization. The diverse nature of older adults' needs and preferences poses barriers to engaging and motivating this demographic effectively. Technology has proven to be instrumental in this regard by motivating individuals and enhancing personalized user experiences. Yet, we found that technology may hinder skill-based participation.

Challenges

The diversity among older adults has been spontaneously mentioned in all screened studies, highlighting the difficulties of the intervention operation. Interventions take time to be implemented and integrated (Frei et al., 2019; Lazar et al., 2021), whereas not all older adults may be ready to engage simultaneously (Lenstra, 2017). Besides, when there is no clear motivation to participate, older adults won't participate in the program (Frei et al., 2019; Gooch et al., 2021; Lenstra, 2017) or will pretend to participate while silently believing the intervention concepts to be implausible (Haan et al., 2021a; Kosurko et al., 2022; Lazar et al., 2021; O'Brien et al., 2021). Consequently, it can be challenging to engage individual older adults with varied needs and preferences.

Technology roles

Technology can be helpful in motivating individuals. For some older adults who are open to new initiatives, the novelty of technology can trigger their motivations to participate and spark further interest in the interventions. For example, Reuter and colleagues described how older adults organized radio-related events, such as setting up the Older Voices radio station and hosting a radio festival (Reuter & Liddle, 2020; Reuter et al., 2019). Lazar and colleagues studied the formation of Makerspace, where older adults invented and prototyped simple technologies, increasing technology visibility in older adults' later lives (Lazar et al., 2021). However, for most other older adults, simply introducing advanced technology may not be enough, if they see no relevance and value of an intervention in their later life. Hence, technology has also been employed to make interventions more visibly valuable for those involved. For instance, Pedell and colleagues documented the information on older adults' mobility and physical activity levels measured by wearables and software applications, aiming to motivate participation through helping older adults understand themselves objectively (Lenstra, 2017; Pedell et al., 2021). Kosurko and colleagues developed a sharing dancing program that can share older adults' dancing data on multimodal streaming to motivate older adults through fostered sense of pride and enjoyment (Kosurko et al., 2022).

In the screened studies, technology also plays a role in enhancing personalized user experiences. Digital resources such as video guides, online tutorials, educational applications, and interactive modules were made available to cater to different learning styles, allowing older adults to learn at their own pace (Frei et al., 2019; Haan et al., 2021; Pedell et al., 2021; Reuter et al., 2019). Personalized reminders and notifications were made according to each person's preferences and schedules, helping to make the intervention adapt to older adults' personal routines (Frei et al., 2019; Haan et al., 2021; Kosurko et al., 2022). Moreover, technology like smartphone apps and wearable devices are utilized to enable individuals to set personalized goals related to physical activity and social participation, monitor personal progress and provide real-time feedback. For instance, O'Brien and colleagues utilized commercial activity trackers and a smartphone app. Older adults set daily step targets and tracked progress, leading to greater motivation due to notifications and virtual rewards upon goal completion (O'Brien et al., 2021). Moreover, as not all older adults are inclined toward competitive dynamics (Gooch et al., 2021), technology can balance collaboration and competition. For instance, a digital platform was designed to selectively highlight shared achievements and collective progress made by the community, encouraging members to work together toward common goals (Lazar et al., 2021).

Caveats

According to the findings, the choice of technology can hinder participation based on the skills required to use it. The more complex the skills needed, the less likely it is for older adults to participate meaningfully (Pedell et al., 2021). For instance, if an intervention relies on accessing information through smartphone apps or digital displays, older adults unfamiliar with these technologies might struggle to benefit from the intervention (Kosurko et al., 2022). Many of the

interventions studied address this issue by utilizing technologies that older adults already know.

Collective Interacting and Sustaining

For the last challenge, the smooth implementation of community-based interventions hinges on collaboration among stakeholders within a networked community. The findings underscore the importance of technology in connecting (to) stakeholders, identifying shared values and concerns, and balancing inner responsibilities. Digital platforms and tools have emerged as powerful communication and collective action facilitators. However, it is vital to recognize that technology alone cannot guarantee smooth collaboration. The willingness of stakeholders to express their needs, actively listen to others, and trust one another is equally crucial.

Challenges

The implementation of interventions, along with the innovations, changes, and new norms they bring, take place within a network of interconnected individuals and stakeholders, and the success of these interventions relies on effective collaboration among these actors within such a network (Keirnan et al., 2019). The literature suggests that involving all relevant actors and groups is essential to maximize the benefits of the intervention for community development (Pedell et al., 2021; Reuter et al., 2019). However, the more stakeholders involved, the more varied goals, needs, and agendas need to be considered. This can pose challenges to the feasibility of the interventions in local social environments, and hinder the progress of intervention operations (Frei et al., 2019; Gooch et al., 2021; Haan et al., 2021; Keirnan et al., 2019; Kosurko et al., 2022; Lazar et al., 2021; Lenstra, 2017; O'Brien et al., 2021; Pedell et al., 2021; Reuter & Liddle, 2020; Reuter et al., 2019; Yang & John, 2020). Therefore, more attention should be paid to enhancing collaborations among diverse stakeholders and strengthening the social network by facilitating communication and connecting the diverse set of stakeholders with each other.

Technology roles

Technology plays a crucial role in community-based interventions by fostering connections among stakeholders. Digital platforms such as messaging applications, social media, and online forums have become essential tools for facilitating communication and collaborations among stakeholders with diverse backgrounds and roles (Frei et al., 2019; Haan et al., 2021; Kosurko et al., 2022; Pedell et al., 2021). For instance, messaging apps like WhatsApp have been used to create groups that bring together older adults, intervention facilitators, community leaders, and other stakeholders (Frei et al., 2019), transforming the way stakeholders interact and collaborate. Additionally, technology can be critical in connecting older adults to their healthcare professionals in emergency situations within a community. Wearable devices with sensors can automatically trigger alerts to healthcare professionals in public spaces within the community, reducing response time and potentially saving lives (Cao & Zhan, 2018).

Technology is also used to identify shared values and concerns among stakeholders, guiding project opportunities and stakeholder involvement. Gooch and colleagues, for example, describe how they revealed the shared matters of concern among different older adults when ideating a community display, which were then used as a starting point to identify

relevant parties to work with and discuss the relationship within the community (Gooch et al., 2021). Technologies were also used to promote transparency and openness, which help build trust among stakeholders and promote effective collaboration toward common goals (Haan et al., 2021; Keirnan et al., 2019; Pedell et al., 2021).

Projects often rely heavily on researchers' facilitation efforts, which can hinder intervention sustainability when researchers leave (Keirnan et al., 2019). As O'Brien and colleagues indicated in the study that despite communities seeing the value of working with location and step-count data in the context of physical activities, they experienced difficulties in accessing and understanding the data without relying on professionals (O'Brien et al., 2021). In this case, technology is used to balance inner responsibilities by promoting a more balanced role for researchers and encouraging ownership among participants. For example, in the intervention described by Pedell and colleagues, technology was used to give older adults access to their own activity data, allowing them to do self-management (Pedell et al., 2021). Similarly, in the intervention described by Frei et al. (2019), the researchers provided technical support and guidance but also allowed participants to take ownership of the process by encouraging them to elect one older adult to manage the whole project.

Caveats

Intervention participation can be hindered by using communication channels and styles unsuitable for the target group. Kosurko et al. (2022) provide an example of how using a digital platform unintentionally affected participation. Some participants either left or hesitated to participate in the intervention because they were unfamiliar with or preferred the digital solution provided. Moreover, the success of connecting stakeholders in interventions is not solely determined by the technology used for communication but also relies on the willingness of partners to express their needs and actively listen to others (Haan et al., 2021; Keirnan et al., 2019). Merely relying on technology is insufficient for ensuring smooth operation. For instance, Frei et al. (2019) developed an intervention targeting physical activity promotion among older adults in a community. The intervention decided to employ a mobile app to connect stakeholders and support participants (Frei et al., 2019). However, some older adults hesitated to use the app because they were unfamiliar with the other group members. To overcome this obstacle, the intervention team organized a kick-off event to facilitate familiarization among stakeholders. As a result, stakeholders became more willing to use the app and engage with other participants in the intervention.

Discussion

Enhancing Intervention Adaptability and Fitness for Local Communal Environments

According to the findings, communities are far from being homogenous entities. They are characterized by an intricate interplay of interests, daily routines, inner relationships among residents, and accessible resources. Our findings highlight the challenges faced by these interventions in seamlessly aligning with and effectively leveraging the unique affordances of each community they engage with. Understanding the dynamic nature of these communities is pivotal to the success of interventions. This understanding aligns with the existing literature, as scholars like Futcher and Domingos (Domingos et al., 2022;

Futcher et al., 2019) have advocated for community-centered approaches to developing interventions.

In this landscape, technology emerges as a key enabler, facilitating the enhancement of intervention adaptability and suitability within local communal environments. Researchers and practitioners in the screened studies harnessed technology as a versatile tool to craft and tailor interventions finely tuned to the specific and ever-evolving needs, interests, and resources that distinguish one community from another. Specifically, technology plays a pivotal role in visualizing local dynamics, incorporating contextual information, and tapping into local resources and culture to create interventions that resonate with the unique characteristics of each community.

Yet, the utilization of technology in such interventions necessitates thoughtful deliberation about physical accessibility. Our findings highlight a nuanced dimension of inequality—the physical divide—which complements the more widely recognized digital divide (Yuan et al., 2018). Although efforts to bridge the digital gap have gained traction in recent years, the physical barriers to technology access pose unique challenges that cannot be overlooked. Thus, future research and intervention initiatives need to address these disparities comprehensively, with focus not only on digital literacy and access but also on the physical infrastructure necessary to support equitable engagement.

Enhancing Intervention Personalization for Individual Older Adults

The variations in learning speed, adaptability, and preferences among older adults further complicate the design of interventions tailored to their needs (Pedell et al., 2021). Our findings underscore the importance of effectively engaging and motivating older adults while flexibly meeting their needs, highlighting the significance of user-centered design principles (Merriman et al., 2018) and personalization (Gomez-Portes et al., 2021; Yu et al., 2018).

In contrast to previous subsections focusing on intervention adaptability in local communities, technology here serves to attract, persuade, and support older adults in enhancing their participation. Our study confirmed that pleasure and enjoyment play a crucial role in motivating older people. This resonates with research on user experience design (Sames et al., 2019) and persuasive design (Klerks et al., 2020). This highlights the distinction between “need” and “want” in technology design. When designing technology perceived as “needed” by older adults, functionality often prevails over other factors, neglecting the role of pleasure in user engagement. In this case, age-related stereotypes that influence older adults' attitudes toward intervention adoption can manifest in various forms within the realm of technology design. Conversely, designing technology that aligns with the desires of older adults—what they truly “want”—recognizes them as active agents with unique needs (Jovanovic et al., 2021; Mannheim et al., 2019). Prioritizing user enjoyment in design holds potential for promoting active aging, enhancing quality of life, and fostering meaningful engagement. Therefore, considering both “need” and “want” in technology design for older adults at the community level is essential for creating interventions that resonate, promote active aging, and enhance overall satisfaction (Wang et al., 2023).

Despite efforts to engage more older adults, our research suggests that technology can either facilitate their active participation or hinder their engagement. This raises a

fundamental question: does technology determine outcomes for older adults, or is its impact shaped by design and implementation? The debate between technological determinism and technological constructivism is pertinent in understanding the question. Although determinism suggests technology inherently shapes behavior, constructivism argues for the role of social context and human agency in shaping the impact of technology (Chang et al., 2023; Peine & Neven, 2019). In the context of active aging, this debate highlights the importance of considering not only technology features but also its integration into older adults' lives and the broader sociocultural context. Future research should delve into how older adults engage with technology in community-based interventions to better understand adoption and use factors.

Enhancing Intervention Collaborativeness for Community Stakeholders

Our findings show that effective community-based interventions rely on collaboration among stakeholders. However, the diversity in their focus, needs, and habits poses a challenge. This underscores the critical need to prioritize the capacity of community-based interventions to facilitate communication and connections among these diverse stakeholders, in line with current literature (Cooper et al., 2022).

Technology plays a role in fostering these collaborations, serving as a bridge, connecting stakeholders who have varying backgrounds and roles, and facilitating communication and interaction among them (Nurain et al., 2021; Peek et al., 2016). Additionally, technology contributes to the identification of shared values and concerns, which are pivotal for effective community development. By enabling stakeholders to explore and understand these shared meanings, technology provides a foundation for collective action.

However, against a modern discourse that technology should replace certain divisions of labor (Nicholson et al., 2021; O'Leary et al., 2022), our findings call on a recognition that technology alone does not contribute to seamless collaboration. The heart of effective collaboration lies in the willingness of stakeholders to openly express their needs, actively listen to the perspectives of others, and trust one another. Our research serves as a poignant reminder that technology should complement and enhance these human interactions rather than replace them. Hence, there is a need for researchers to explore strategies for balancing digital and nondigital elements in collaboration. Moreover, our analysis highlights a potential pitfall—the overreliance on researchers for technical support and facilitation. When projects near their conclusion, this dependency on researchers can pose a significant threat to sustainability. To address this concern, more research is needed to explore strategies that reduce dependency on researchers for technical support and facilitation, ultimately promoting the long-term sustainability of community-based interventions.

Future Directions

Based on our findings and reflections, technology plays a crucial role in improving intervention adaptability and suitability for local communal environments, enhancing personalization for individuals and facilitating collaboration among community stakeholders. The wide array of technological solutions and various integration approaches in the findings raise the question: under what contexts should which kind of

technologies be utilized to achieve the target goal regarding active aging? We call for more studies that develop innovative and strategic approaches to systematically evaluate the appropriateness of different technological interventions in diverse sociocultural contexts.

Specifically, there is a need for empirical guidelines that not only consider the diverse characteristics of communities but also recognize the preferences and agency of older adults. This entails exploring evaluative frameworks that could be used to characterize communities, considering factors such as infrastructure availability, digital literacy, socioeconomic status, cultural preferences, and adoption attitudes among older adults.

Furthermore, it is crucial to enhance the inclusivity of technological interventions by addressing the needs of all community members, including those with mobility challenges or limited digital skills. This requires longitudinal studies that track intervention outcomes across different age groups and involve older adults from the outset in the co-design of interventions.

Effective engagement of diverse audiences within communities also requires innovative communication strategies. By trialing hybrid communication channels and formats, such as text messages, email, social media, videos, and infographics, future research is needed to better understand how to engage older participants across various contexts while recognizing their agency in selecting and utilizing these communication channels.

Moreover, the utilization of digital technologies should aim to create adjustable platforms that foster collaboration among diverse stakeholders within communities. There is a need to understand how age-related factors such as digital literacy and motivational factors such as comfort with technology affect participation in collaborative platforms.

Lastly, for interventions to be sustainable in the long term, it is crucial to develop operating models that incorporate the aspects of how a community operates, the people, culture, processes, governance, information, technology, infrastructure, and facilities and other aspects with the aim of enabling its sustainable running. For instance, future research could explore the impact of internal responsibilities within communities during intervention operation on long-term sustainability, with a recognition of older adults' agency in ensuring the sustainability of these interventions.

Limitations

We are aware of several limitations inherent in this study. Firstly, our literature search was confined to articles accessible through the ACM Library, Web of Science, and Scopus databases. We acknowledge that this selection may not encompass the full spectrum of approaches and technologies employed in community-based programs to promote active aging. However, although other databases might contain relevant materials, the collection of papers included in this review indeed offers a comprehensive and varied perspective on interventions documented in credible academic sources. Besides, our review is constrained by its reliance on English-language papers. Future reviews should explore whether research published in languages other than English aligns with or diverges from the trends observed here. Additionally, although we have defined older adults in the study as individuals aged 55 and above, this age cutoff may not capture the full spectrum of aging experiences and needs. Future studies

may need to explore the diverse ways in which individuals in different stages of later life engage with and benefit from related interventions.

Conclusion

This systematic review synthesizes findings from 13 studies that explore the development and implementation of community-based interventions that integrate technologies for promoting active aging. The article provides a starting point for accumulating knowledge and practice in harnessing technology to navigate challenges and opportunities faced by the interventions at the community level. Moreover, our findings highlight the gaps in current research: innovative and strategic approaches that leverage digital technologies in the community-based interventions for promoting active aging. To address related gaps, future research should focus on conducting case studies or pilot projects to evaluate these approaches in diverse community settings.

Supplementary Material

Supplementary data are available at *Innovation in Aging* online.

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Conflict of Interest

None.

Data Availability

The authors confirm that the data supporting the findings of this study are available within this article and the Supplementary Materials. The studies reported in the manuscript were not preregistered.

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