*Paper Type: Review*

# *Emotional and Social Well-Being in Older Adults: A Scoping Review of Virtual Reality-Based Interventions*

Henrique Lopes[1], Pedro Cardoso[2], Eva Oliveira[3], Nuno Rodrigues[3]

[1]Faculty of Engineering, University of Porto (FEUP), Porto, Portugal
[2]i2ADS / Faculty of Fine Arts of the University of Porto, Porto, Portugal
[3]INESC-TEC, Porto, Portugal

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*Abstract*

*Background:* Loneliness, social isolation, and diminished emotional well-being are increasingly recognized as pressing concerns in later life, often linked to increased risks of depression, cognitive decline, and reduced quality of life. Traditional psychosocial interventions often encounter practical barriers, such as limited mobility and geographic dispersion. In response, Virtual Reality (VR) has gained traction as a potentially valuable medium to improve emotional and social well-being in older populations. However, a comprehensive overview of how VR is being deployed in this context is lacking in its formats, objectives, and implementation settings.
*Objective:* This scoping review aimed to systematically map the current empirical landscape of VR-based interventions that aim to improve emotional and social well-being in older adults. Specifically, it sought to identify common modalities, thematic trends, reported outcomes, and contextual factors that shape the design and delivery of these interventions.
*Methods:* Twenty-five peer-reviewed empirical studies published between 2017 and 2025 were selected based on predefined inclusion criteria. Eligible studies included participants 60 years or older, used VR as a central component of the intervention, and reported outcomes related to loneliness, emotional well-being, or social connection. Data were extracted and descriptively synthesized to capture intervention characteristics, delivery formats, and user experiences.
*Results:* Evidence indicates that VR interventions enhance emotional well-being, social connection, and engagement among older adults. Passive experiences, such as 360° videos, often elicit short-term relaxation and enjoyment, while more participatory or symbolic formats, such as co-creative environments or reminiscence-based scenarios, support deeper psychological benefits, including self-expression, identity reinforcement, and emotional connection. Socially interactive VR, particularly through avatar-mediated communication, shows strong potential to reduce loneliness and foster authentic interpersonal engagement. Effectiveness is closely tied to usability, accessibility, and cultural relevance. Although qualitative approaches offer insight into user experience and emotional mechanisms, quantitative research provides measurable outcomes; both contribute complementary perspectives. Assessments suggest that studies with greater methodological rigor tend to report a higher perceived impact, although the variability of the outcomes and the complexity of the interpretation remain. Creative and hybrid VR formats appear especially promising for balancing emotional depth with accessibility. In general, the findings highlight the importance of inclusive, user-centered design and context-sensitive implementation to maximize the psychosocial benefits of VR in later life.
*Conclusions:* VR interventions can support emotional and social well-being in older adults, particularly when they involve multi-user environments, culturally meaningful content, co-design, and trained facilitators. Passive formats offer short-term mood benefits but have limited lasting impact. Future research should emphasize inclusive design, long-term engagement assessment, and integration into existing care models to ensure sustainable and meaningful implementation.

*Keywords:* Virtual Reality; Aged; Quality of Life; Loneliness; Social Support

## *1 Introduction*

Loneliness and social isolation are increasingly recognized as pressing public health concerns among older adults. In Portugal, recent data indicate that 91% of people 65 years of age or older who are followed in primary care services report experiencing some degree of loneliness, with nearly one-third describing it as severe [1]. In addition, the prevalence of loneliness increases significantly with age, affecting 26.8% of those 85 years of age and over [2]. These phenomena are not only social problems, but are closely related to a wide range of negative health outcomes, including increased risks of depression, anxiety, cognitive impairment, sleep disturbances, functional decline, and premature mortality [3, 4].

Beyond the absence of social interaction, loneliness can affect the perception of meaning, self-worth, and psychological resilience of older adults. Social isolation, often caused by reduced mobility, chronic illness, bereavement, or geographic dispersion, further limits the opportunities for meaningful relationships. Both factors can undermine emotional and social well-being, which are critical components of overall quality of life in later life.

Well-being in older adults is a multidimensional construct that includes emotional, psychological, and social dimensions. It includes feelings of satisfaction with life, autonomy, belonging, positive affect, participation in meaningful activities, and the ability to maintain social roles. According to the WHO, well-being is not simply the absence of disease but the presence of positive experiences, functionality, and fulfillment [5]. Promoting well-being in aging populations requires interventions that foster social connection, emotional regulation, identity continuity, and cognitive vitality.

Traditional strategies to mitigate loneliness, such as support groups, community activities, and home visits, often face logistical challenges, particularly for those with mobility impairments or limited access to transportation. Furthermore, while communication tools based on the Internet and smartphone are widespread, many older adults experience difficulties with usability, accessibility, and emotional disconnect in digital interactions.

In this context, Virtual Reality (VR) has emerged as a promising alternative. VR technologies enable the creation of immersive, engaging environments that simulate real-life experiences, facilitate interaction, and provide opportunities for reminiscence, play, exploration, and co-presence. Preliminary research suggests that VR can improve mood, reduce feelings of isolation, and stimulate cognitive and emotional engagement. Social VR in particular, where users interact with others in shared virtual spaces, shows the potential to strengthen interpersonal bonds and foster a sense of community [6].

Despite this promise, empirical evidence on the long-term effectiveness of VR interventions remains limited and fragmented. Important knowledge gaps remain regarding which types of VR content and interaction formats are most conducive to positive outcomes, how individual and contextual factors shape user experiences, and the extent to which facilitation and design personalization contribute to engagement. There is also a lack of consensus on how to measure well-being outcomes consistently across studies.

This review synthesizes the findings of 25 empirical studies that explore the use of VR interventions to enhance emotional and social well-being among older adults. By examining technological formats, intervention structures, and reported outcomes, the review aims to identify effective practice patterns, highlight methodological strengths and limitations, and offer insight into how VR can be used more effectively to support well-being in aging populations.

## 2 Methods

This scoping review followed the methodological framework proposed by Arksey and O'Malley [7] and further refined by the Joanna Briggs Institute [8] following a five-stage model comprising: 1) Problem Identification; 2) Literature Search; 3) Data Evaluation; 4) Data Analysis; 5) Presentation of Findings.

The literature search was performed on five electronic databases: Scopus, PubMed, Web of Science, IEEE Xplore, and Google Scholar.

The search strategy combined terms related to virtual reality and older adults with emotional and social well-being outcomes, using the following string: ("virtual reality" OR "VR") AND ("older adults" OR "elderly") AND ("loneliness" OR "social isolation" OR "well-being"). This approach was designed to capture empirical studies investigating the use of VR interventions to promote emotional or social well-being in later life.

The primary review question guiding this process was: *What types of virtual reality interventions have been most frequently associated with positive emotional and social outcomes among older adults?*

Relevant records were identified through database searches and citation tracking. All references were exported to reference management software and duplicates were removed. The selection was carried out in two phases: an initial review of the titles and abstracts, followed by a full-text analysis of potentially eligible studies. Data were extracted on study design, sample characteristics, VR systems used, intervention formats, outcome measures, and reported results.

## 3 Ethical Considerations

This study is a review of published literature and did not involve human participants or the collection of primary data. Therefore, ethics approval was not required.

## 4 Results

### 4.1 Study selection

The selection process followed the PRISMA guidelines and was conducted in two phases: an initial screening of titles and abstracts, followed by full-text analysis based on predefined eligibility criteria.

Studies were included if they met all the following conditions: (i) the population consisted of older adults (60 years or older), (ii) virtual reality (VR) was used as a central component of the intervention, and (iii) the study reported results related to emotional or social well-being. Only original empirical studies were considered; reviews, opinion papers, and theoretical discussions were excluded. Both immersive and semi-immersive VR modalities were deemed eligible.

Studies were excluded if they did not meet any of these three core criteria, namely, if they did not focus on older adults, did not use VR as a central intervention component, or did not assess emotional or social well-being outcomes. In addition, studies were excluded if the full text was not available or if the article was not published in English.

During the full-text screening phase, several records were excluded on these grounds, most commonly due to insufficient outcome relevance, VR being used only as a supplementary tool, or lack of full-text access.

A total of 25 studies met the inclusion criteria and were retained for descriptive mapping and thematic synthesis. The selection process is detailed in Figure 1.

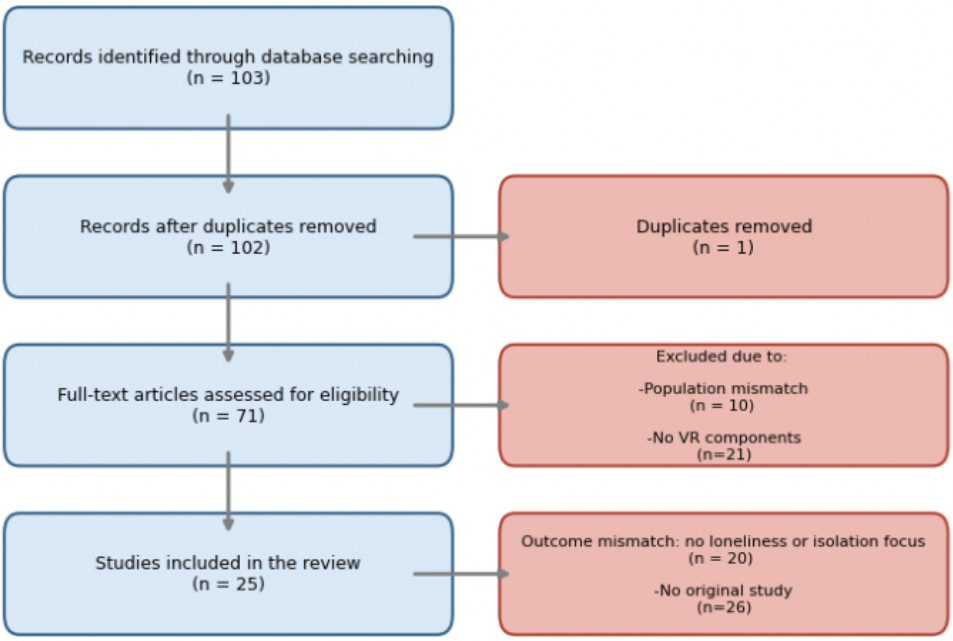


Figure 1: Flow Diagram of Study Selection Process.

### *4.2 Study characteristics*

This section provides an overview of the selected characteristics of the studies included in the review. A summarized version is presented in Table 1, while a more detailed version, featuring full descriptions of interventions, durations, and outcome measures.

| Title | Authors | Year | Population (Age, n) |
|---|---|---|---|
| Using Immersive Virtual Reality to Enhance Social Interaction Among Older Adults: A Cross-Site Investigation | Kalantari et al. | 2023 | 36 older adults (60+) |
| Impact of Virtual Reality (VR) Experience on Older Adults' Well-Being | Lin et al. | 2018 | 52 participants (68+), assisted living |
| Metaverse Virtual Social Center for Elderly Communication in Time of Social Distancing | Liang et al. | 2023 | 60 older adults (60–80) |
| VR in Nursing Facilities: A Randomized Controlled Multicenter Pilot Study | Gruber et al. | 2022 | 17 older adults (62–94) |
| Exploring the Design of Social VR Experiences with Older Adults | Baker et al. | 2019 | 22 older adults (70–81) |
| Playing in Virtual Nature: Improving Mood of Elderly People Using VR Technology | Graf, Liszio & Masuch | 2020 | 14 older adults (66–84) |
| Evaluating the Use of Interactive Virtual Reality Technology with Older Adults Living in Residential Aged Care | Baker et al. | 2020 | 5 aged care residents (74–88) |
| Eating Together While Being Apart: A Pilot Study on the Effects of Mixed-Reality Conversations and Virtual Environments on Older Eaters' Solitary Meal Experience and Food Intake | Korsgaard et al. | 2020 | 30 older adults (Mean age = 71.2) |
| Interrogating Social Virtual Reality as a Communication Medium for Older Adults | Baker et al. | 2019 | 25 older adults (70–81) |
| Avatar-Mediated Communication in Social VR: An In-depth Exploration of Older Adult Interaction in an Emerging Communication Platform | Baker et al. | 2021 | 16 older adults (70–81) |
| Virtual reality and well-being in older adults: Results from a pilot implementation of virtual reality in long-term care | Chaze et al. | 2022 | 32 older adults in LTC |
| Being There: Exploring Virtual Symphonic Experience as a Salutogenic Design Intervention for Older Adults | Faw, Buley & Malinin | 2021 | 16 older adults (76–90), incl. 3 with dementia |
| Connecting the Elderly Using VR: A Novel Art-Driven Methodology | Kosti et al. | 2024 | 10 older adults (60–85) |

Continued on next page

| Title | Authors | Year | Population (Age, n) |
|---|---|---|---|
| Older Adults With Cognitive and/or Physical Impairments Can Benefit From Immersive Virtual Reality Experiences: A Feasibility Study | Appel et al. | 2020 | 66 older adults (mean = 80.5) |
| School's Back: Scaffolding Reminiscence in Social Virtual Reality with Older Adults | Baker et al. | 2020 | 16 older adults (70–81) |
| Impact of Virtual Reality–Based Group Activities on Activity Level and Well-Being Among Older Adults in Nursing Homes | Li et al. | 2024 | 84 older adults (60–97) |
| Designing Virtual Reality (VR) Experience for Older Adults and Determine Its Impact on Their Overall Well-Being | Lin et al. | 2017 | 63 older adults (67–97) |
| Older Adults' Experiences of Social Isolation and Loneliness: Can Virtual Touring Increase Social Connectedness? A Pilot Study | Oppert, O'Keeffe & Duong | 2023 | 10 older adults (65+) |
| Application of Virtual Reality to Enhance Therapeutic Tai Chi for Depression in Elderly People | Qiu et al. | 2024 | 300 older adults (60–66 years) |
| Breaking Social Isolation With Technology: A Mixed-Methods Study on Virtual Reality for Older Adults Living Alone | Dinet et al. | 2024 | 65 older adults (63–93 years) |
| RemoteChess: Enhancing Older Adults' Social Connectedness via Designing a Virtual Reality Chinese Chess (Xiangqi) Community | Wei et al. | 2025 | 18 older Chinese adults |
| Designing Virtual Environments for Social Engagement in Older Adults: A Qualitative Multi-site Study | Xu et al. | 2022 | $\geq$60 years, n = 36 |
| The Effects of a Combination of 3D Virtual Reality and Hands-on Horticultural Activities on Mastery, Achievement Motives, Self-Esteem, Isolation and Depression: A Quasi-Experimental Study | Fan et al. | 2022 | $\geq$65 years, n = 62 |
| Effects of Semi-Immersive Virtual Reality Exercise on the Quality of Life of Community-Dwelling Older Adults: Three-Month Follow-Up of a Randomized Controlled Trial | Wang | 2024 | $\geq$65 years, n = 98 |

Continued on next page

| Title | Authors | Year | Population (Age, n) |
|---|---|---|---|
| Effect of Virtual Reality Sessions on the Mental Health of Institutionalized Older Adults | Restout et al. | 2025 | 42 institutionalized older adults (mean age ≈85) |

Table 1: Simplified summary of included studies.

### *4.3 Types of VR interventions*

The included studies in this review present a diverse and nuanced range of VR applications, reflecting a wide landscape of intervention formats tailored to older adult populations. To facilitate a structured understanding, the VR modalities adopted across these studies are organized into thematic categories: social and multiplayer VR, co-designed and participatory VR, passive immersive VR, interactive and cognitive VR, physical-exercise VR, and hybrid or artistic formats. Each category is discussed in depth, with an emphasis on structure, duration, participant interaction format, and therapeutic goals.

A major focus of multiple studies was the use of VR as a social platform to foster interpersonal interaction and emotional connection. Kalantari et al. [9] implemented a cross-site multiplayer intervention in which older adults participated in shared VR experiences at different geographic locations. Short and frequent sessions supported verbal and nonverbal communication in immersive environments, improving perceived social presence. Similarly, Liang et al. [10] introduced a virtual social center designed within a metaverse context, enabling participants to interact in shared virtual spaces that mimicked communal activities. Wei et al. [11] developed a culturally anchored multiplayer experience through a virtual Chinese chess community, improving social connectivity through familiar cultural practices.

Xu et al. [12] contributed a detailed qualitative exploration of one-on-one social VR, where older adults interacted using realistic avatars. The study emphasized the impact of interpersonal compatibility and the potential of avatar-based communication to build rapport. Li et al. [13] also applied group-based VR in a rustic virtual cottage setting to promote integration, initiative, and shared activity among institutionalized older adults. Baker et al. [14] explored the use of commercial social VR platforms in a controlled session, reporting positive feedback on avatar expressiveness and communication capabilities.

The participatory development of virtual reality environments was the hallmark of several studies led by Baker and collaborators. Baker et al. [15] conducted co-design workshops exploring how older adults imagine social VR. The results informed future interventions by incorporating

user preferences into system design. In another study, Baker et al. [16] developed a VR school environment based on reminiscence, tailored with participation of the participants to trigger shared memories and social bonds. The sessions lasted five months and allowed deep emotional reflection. Baker et al. [17] further conducted a longitudinal study exploring avatar-mediated interaction over multiple months, noting increased comfort, natural communication, and avatar personalization.

Baker et al. [18] also implemented interactive VR sessions for institutionalized older adults, emphasizing user agency and environmental exploration. Although these were single-user sessions, the focus was on understanding barriers to adoption and identifying strategies to support engagement. Kosti et al. [19] followed a similar participatory model by co-creating a culturally inspired virtual village for art-based engagement, promoting memory recall and creativity through aesthetic immersion and social interaction.

A significant number of studies used passive VR modalities, mainly focused on immersive 360° video. Gruber et al. [20] conducted a two-day intervention in nursing homes, presenting various 360° scenes, such as nature and people, to evaluate changes in happiness and mood. Appel et al. [21] used short single-session VR exposures featuring nature scenes, measuring engagement and relaxation in a large sample of frail older adults. Chaze et al. [22] allowed repeated viewing of Canadian landmarks during multiple sessions, showing increased cognitive and emotional stimulation.

Restout et al. [23] administered eight immersive VR video sessions based on nature over four weeks to institutionalized participants. The study demonstrated significant reductions in clinical symptoms of anxiety and depression. Oppert et al. [24] provided a single immersive tourism session and captured the comfort and emotional value reported by the participants. These studies most commonly used single-player exposure formats that focused on relaxation or affective outcomes.

Other studies explored interactive VR formats with a focus on cognitive stimulation and participation. Graf et al. [25] introduced a forest walk experience that incorporated elements of light interaction and virtual mood enhancing features. Lin et al. [26] compared a virtual travel scenario with television-based relaxation, reporting superior results in reducing loneliness and depressive states. Lin [27] assessed weekly VR sessions for two weeks, showing enhanced emotional well-being compared to a control group.

Fan et al. [28] combined virtual gardening with real-life horticulture, measuring gains in self-esteem, mastery, and achievement motivation. This quasi-experimental study linked immersive interaction with offline activities. These approaches emphasized engagement beyond passive observation and aimed to stimulate psychological activation, memory, and affect regulation.

VR was also used as a vehicle for physical activity with therapeutic objectives. Qiu et al. [29] conducted a 6-month RCT using VR-assisted Tai Chi exercises for depression treatment. Participants performed guided movements in single-user settings, with clinically significant reductions in symptoms. Wang [30] developed a semi-immersive group exercise intervention using weekly sessions over 12 weeks. Improvements in quality of life indicators such as autonomy, sensory function, and social participation, though effects diminished at follow-up.

Korsgaard et al. [31] examined virtual meals in a mixed reality setting, allowing participants to simulate social dining. Although food intake did not change, mood improved during shared virtual meals. These studies highlight the versatility of VR in delivering embodied and social therapeutic content.

Some studies explored hybrid or artistic uses of VR. Faw et al. [32] exposed participants to a VR symphonic concert experience, assessing immersion and aesthetic engagement. Participants reported emotional and social connection, particularly when placed virtually onstage. Dinet et al. [33] administered guided relaxation and walk-based VR interventions, structured to simulate

calming environments and assess effects on loneliness. Participants experienced measurable improvements in well-being and decreased isolation.

These hybrid interventions underscore the potential of virtual reality to bridge sensory, cognitive, and social dimensions through creative modalities that transcend conventional therapeutic boundaries.

The types of VR used varied in degree of immersion, interactivity, and personalization. Although some interventions leveraged avatar-based social interaction and co-creative participation, others focused on passive relaxation, physical activity, or aesthetic immersion. Most studies adopted structured sessions and validated outcome measures to assess emotional and social well-being, revealing a promising landscape of approaches. This thematic diversity underscores the adaptability of VR for different user profiles and intervention goals within older adult populations.

The articles employed a wide range of technological solutions to implement virtual reality (VR) interventions targeted at improving the emotional and social well-being of older adults. These technologies included head-mounted displays (HMDs), software platforms for individual and social experiences, tracking devices, audio enhancements, and custom-built environments adapted for elderly users. This technological diversity reflects both the rapid evolution of VR hardware and software in recent years and the experimental nature of many of the interventions designed for older populations.

A significant number of studies used immersive HMDs to deliver VR content, particularly those that aimed to induce a strong sense of presence or realism. The Oculus Rift was one of the most frequently adopted devices due to its robust tracking capabilities and immersive fidelity, appearing in the work of Baker et al. in several publications [14–18]. These studies explored avatar-mediated communication and co-designed social VR environments, utilizing the Oculus Rift in combination with platforms such as AltspaceVR and custom Unity-based applications to enable participant interaction. The same device was used in avatar interaction sessions lasting several months, offering participants a high level of embodiment and responsiveness through precise motion capture.

Oculus Quest 2 was another widely used headset, particularly favored in more recent studies for its wireless nature and relative ease of use. Kalantari et al. [9] used Oculus Quest 2 to allow geographically separated participants to connect in immersive environments, supported by integrated microphones and external audio devices such as Sony SRS-RA3000 speakers and Blue Yeti microphones for higher sound fidelity. This combination ensured better voice transmission and audio presence in multi-player settings. Qiu et al. [29] used the same device to perform a VR-assisted Tai Chi intervention over six months. The headset allowed participants to follow guided routines in a synchronized and embodied manner, combining visual feedback with body tracking to support therapeutic movement.

The Oculus Go, a standalone headset with simplified controls, was used in several studies that aimed to conduct more passive or observational VR interventions. Chaze et al. [22] selected this device for its lightweight design and user-friendly interface in a long-term care setting. Similarly, Graf et al. [25] used Oculus Go to deliver a forest walk simulation accompanied by a virtual dog and simple mini-games, aiming to improve mood through a naturalistic and low-interaction environment. The study by Appel et al. [21] also utilized this device to present 360° natural scenes in a feasibility study, demonstrating strong acceptance even among participants with cognitive impairments.

Samsung Gear VR, which uses Samsung smartphones as display and processing units, was used in earlier studies where cost-effectiveness and accessibility were critical. Lin et al. [26] compared Gear VR with traditional television viewing in a relaxation-based travel simulation, while Appel et al. [21] included it as part of a multi-device study setup. The ease of use of this headset

made it particularly suitable for passive viewing interventions focused on reminiscence or affective modulation. Gruber et al. [20] likely employed a similar configuration to deliver 360° video content in a randomized controlled trial in multiple nursing facilities.

HTC Vive was deployed in studies that required accurate positional tracking and interaction fidelity, such as in avatar-based social VR and co-creation tasks. Baker et al. [15, 17] used HTC Vive's room-scale tracking capabilities to allow participants to move and interact naturally with virtual elements. These studies integrated the headset with Final IK for inverse kinematics and OVRLipSync to provide synchronized lip movement during conversation, enhancing communication realism.

Leap motion sensors were used in some interventions to provide hand tracking without the need for handheld controllers. Liang et al. [10] incorporated this technology into a custom metaverse environment, allowing participants to interact with objects and avatars using natural hand gestures. Similarly, Kosti et al. [19] designed an art-driven VR village where gesture recognition was a key element to allow participants to express creativity and navigate virtual space. These environments were hosted on platforms compatible with the Unity and WebXR standards.

Several interventions used semi-immersive or non-HMD solutions. Wang [30] used the Uniigym semi-immersive VR system to deliver group-based physical exercise. This setup consisted of a large screen, motion tracking camera, and speaker system, which enabled participants to engage in full body movement exercises in a communal setting. The lack of HMD reduced accessibility barriers while still providing interactive feedback. Lin (2017) [27] also used a large screen setup in some conditions, comparing it with HMD-based experiences delivered via Rendever VR systems.

The study by Fan et al. [28] combined virtual 3D gardening experiences delivered on desktop VR systems with real-world horticultural tasks. The virtual component included a customizable gardening environment viewed from a desktop monitor and navigated with mouse and keyboard, offering lower immersion but greater control for participants unfamiliar with HMDs. This hybrid approach allowed cognitive stimulation through interaction while minimizing motion sickness and fatigue.

Some studies incorporated customized environments and content developed specifically for the intervention. Baker et al. (2020b) [16] created a virtual classroom 'School Days' using Unity3D, designed based on participant feedback to support reminiscence through environmental cues. Participants interacted via avatars in a multi-user setting. Kalantari et al. [9] developed a travel-based social VR environment with embedded mini-games and spatialized audio to encourage collaboration. The environment was accessible through Oculus Quest 2 and featured custom designed visual assets to mimic recognizable cultural landmarks.

Wei et al. [11] developed a multiplayer virtual reality environment to play Chinese chess (Xiangqi), integrating a game engine with real-time voice communication and a culturally relevant design. The system was optimized for quick sessions on Oculus Quest devices, with audio-visual customization features to enhance participant comfort. The study by Xu et al. [12] also emphasized high-fidelity avatar design in a multi-site study, ensuring that avatars matched user characteristics and preserved identity cues, likely using Unity-based systems with support for advanced animation rigs.

Dinet et al. [33] used guided VR walks for relaxation and reflection, incorporating 360° video content accessed via Oculus Go and narrated scripts to provide structure. Similarly, Oppert et al. [24] delivered immersive virtual tours using single-player VR, likely using lightweight mobile VR headsets to ensure usability among older adults unfamiliar with technology.

Faw et al. [32] presented participants with virtual symphonic concert experiences, likely using

Oculus Go or similar HMDs for passive immersion. The VR experience included multi-angle virtual cameras placed onstage, combined with high-quality audio to simulate the experience of attending a live performance. Korsgaard et al. [31] conducted a mixed reality dining study, integrating VR visuals with real food and ambient sounds to simulate communal dining, using HMDs and video pass-through functions.

Chaze et al. [22] reported on the use of VR applications focused on Canadian landscapes, suggesting the use of preloaded content accessible through standalone HMDs. These devices allowed residents of long-term care facilities to experience familiar or meaningful places without physical travel. Li et al. [13] implemented a virtual cottage environment for group-based activities, likely using custom Unity-based multiplayer applications accessed via standalone VR headsets or projection-based systems depending on participant needs.

In general, technological implementations show a trajectory from stationary passive HMD systems to more interactive, social, and customized VR applications. Most interventions used off-the-shelf hardware adapted with tailored software, while several pushed the boundaries through co-design and cultural integration. This technological diversity reflects both the adaptability of VR and the importance of aligning hardware and software choices with user capacities, intervention goals, and research contexts.

### *4.4 Reported outcomes and measurements*

The 25 empirical studies included in this review used a variety of quantitative and qualitative methods to assess emotional and social well-being outcomes in older adults exposed to virtual reality (VR) interventions. Despite methodological heterogeneity, all selected studies provided data relevant to constructs such as loneliness, social connection, affect, mood, quality of life, and depression. These were typically measured through validated self-report instruments or researcher-designed protocols and, in some cases, supplemented with behavioral observations or physiological markers.

Kalantari et al. [9], who found high user engagement and intention to reuse VR ($M = 4.18/5$), and Lin et al. [26], whose intervention reduced loneliness and depression in assisted living residents. Gruber et al. [20] reported a one-point increase in subjective happiness ($SD = 1.62$) after two days of 360º video VR sessions. Korsgaard et al. [31] observed significant improvements in mood ($p < .05$) after mixed-reality social meals, while Appel et al. [21] recorded positive affect and relaxation using PANAS and usability metrics, with 76% of participants willing to reuse technology.

Qiu et al. [29] conducted a 6-month RCT in which VR-assisted Tai Chi significantly reduced depressive symptoms, as measured by the GDS. Wang [30] reported improvements in WHOQOL-OLD domains such as autonomy and social participation after semi-immersive VR exercise, although the effects were not sustained at 3 months of follow-up. Wei et al. [11] demonstrated increased social connectedness through multiplayer cultural gaming, while Lin [27] and Graf et al. [25] found increased emotional well-being and positive affect using PANAS scores before and after the sessions. Restout et al. [23] showed clinically significant reductions in depression ($p = .015$) and anxiety ($p < .001$) after eight immersive VR relaxation sessions, along with high satisfaction ($M = 8.7/10$).

Beyond this core group, other studies provided complementary findings. Liang et al. [10] implemented a metaverse-based social VR center and reported improved mental states through

qualitative feedback. Baker et al. [15] used participatory co-design sessions and noted that older adults valued social avatars and perceived VR as a tool for meaningful reminiscence. In [14], avatar customization and communication features were seen as critical for engagement. The longitudinal study by Baker et al. [17] found that over five months, participants became more expressive and emotionally connected through avatar-mediated VR, a finding also supported by [16], where the reminiscence environment of the "School Days" led to better reflection and connection.

Chaze et al. [22] reported that VR experiences offered cognitive stimulation and promoted social and emotional well-being. Oppert et al. [24] found that a single 30-minute 360° tour session improved comfort and reduced perceived isolation. Lin et al. [26] recorded higher satisfaction scores in VR than in TV conditions ($M = 6.13/10$). Faw et al. [32] used virtual symphonic concerts and observed positive emotional reactions and a strong sense of presence. Kosti et al. [19] emphasized cultural engagement, with participants appreciating the creative and social dimensions of their art-driven virtual village.

Li et al. [13] demonstrated significant improvements in flexibility ($\eta^2 = .109$), group integration ($\eta^2 = .141$), and proactivity ($\eta^2 = .104$) over four weeks of multiplayer VR activities in nursing homes. Fan et al. [28] combined VR 3D gardening with hands-on horticulture and found increased self-esteem ($\beta = 2.18$, $p = .005$) and mastery ($\beta = 1.23$, $p = .039$), using a generalized estimating equation (GEE) model. Xu et al. [12] showed that interpersonal compatibility in avatar-mediated interactions influenced social presence and engagement. Dinet et al. [33] reported significant qualitative improvements in perceived loneliness and mood after immersive guided walks and relaxation sessions.

The collected evidence points to several recurring themes in the literature. Multi-user social VR environments were more frequently associated with reports of increased emotional and social connection. Interventions that incorporated codesign methods or culturally relevant content (e.g. [11, 16, 19]) achieved stronger engagement and perceived meaningfulness. Aesthetic and leisure-oriented interventions (e.g. [20, 22, 32]) consistently improved mood, although typically with short-term effects. The presence of facilitators or staff was also crucial to implementation success, especially in institutional or long-term care settings (e.g. [13, 21, 23]).

The superior effectiveness of multi-user social VR environments in promoting emotional and social well-being was consistently demonstrated across several interventions. Kalantari et al. [9] implemented a partner matching design in geographically distant older adults, where social presence and shared activities led to high levels of engagement and positive feedback. Liang et al. [10] developed a metaverse-inspired virtual center, which allows elderly participants to socialize in group-based scenarios. The structured nature of this social VR setting, combined with the emphasis on interaction, contributed to improved mental states and positive usability evaluations. Similarly, Xu et al. [12] found that realistic avatar-mediated dyadic interactions enhanced perceptions of social presence and interpersonal engagement. Wei et al. [11] took advantage of culturally familiar content, Chinese chess, to create a social multiplayer VR space, resulting in increased perceived connectedness through meaningful and familiar gameplay. Baker et al. (2021) [17] further underscored the strength of prolonged social VR use, showing that regular engagement in avatar-based environments improved expressiveness and interpersonal communication over a period of five months.

Studies that incorporated co-design methodologies or culturally tailored content tended to yield higher engagement and perceived relevance. Baker et al. (2019a) [15] and (2020b) [16] developed interventions in which older adults were directly involved in the creation of virtual reality social environments and reminiscence scenarios. These participatory designs allowed users to shape

the virtual context to align with personal and cultural memories, promoting stronger emotional resonance and social connection. Kosti et al. [19] also adopted a co-creative framework, developing a culturally inspired virtual village through collaborative design sessions with older adults. The result was a highly appreciated and emotionally significant VR environment that supported artistic self-expression and cultural identity. Wei et al. [11], by embedding a traditional game in the social VR format, similarly capitalized on cultural familiarity to enhance participant motivation and comfort.

Short-term mood improvement was frequently observed in aesthetic and recreational VR interventions, particularly those using passive or semi-interactive experiences. Gruber et al. [20] reported increased happiness after only two short sessions of 360° video content, particularly when the scenes involved people or animals. Appel et al. [21] found that one-time VR exposure to natural scenes resulted in relaxation and enjoyment among frail institutionalized participants. Graf et al. [25] demonstrated a moderate improvement in positive affect after a single 30-minute interactive forest walk in VR. Restout et al. [23] implemented an immersive VR intervention of eight sessions using 360° nature videos in a nursing home context. The study reported a statistically significant reduction in anxiety ($p < .001$) and a more modest borderline effect on depression ($p = .067$), along with high participant satisfaction ($mean = 8.7/10$). Although anxiety outcomes improved clearly, caution is warranted when interpreting depression results due to weaker statistical support. The importance of trained facilitators was also evident, especially in institutional contexts. Lin [27] and Lin et al. [26] both conducted controlled trials comparing VR with television experiences, with facilitators guiding participants through the content. These studies noted better emotional outcomes in the VR groups, which may in part reflect the impact of structured delivery and technical support. Chaze et al. [22] conducted multiple sessions over two weeks in long-term care facilities, emphasizing emotional and cognitive stimulation, facilitated by staff supervision. Li et al. [13] implemented group-based VR activities with nursing home residents, where facilitators helped manage interaction and ensured accessibility. In all of these cases, trained personnel played a crucial role in supporting participant adaptation, troubleshooting technological issues, and enhancing the general sense of safety and confidence among users.

Taken together, these findings suggest that social and co-created VR interventions are not only more engaging but also more effective in promoting meaningful interaction and emotional resonance. Passive or aesthetically focused experiences, while impactful in the short term, may benefit from repetition or integration into broader psychosocial programs. Finally, institutional interventions are most effective when accompanied by facilitation strategies that address the cognitive and physical needs of older adults, ensuring accessibility and maximizing potential benefits. In general, the outcome measures used in the studies, ranging from standardized psychometric tools (PANAS, GDS, WHOQOL-OLD) to customized usability metrics and qualitative reports, offered consistent evidence of the positive psychosocial potential of VR for aging populations. However, the heterogeneity in measurement instruments, intervention types, and reporting transparency highlights the limitations of drawing generalized conclusions in a scoping review context.

## *5 Discussion*

This review suggests that although VR research for older adults is rapidly expanding, the field remains fragmented and lacks a unified theoretical foundation for long-term psychosocial impact.

This growth is driven by the urgent need to address the challenges of the aging global population and the ongoing technological advancements. The ensuing discussion transcends a mere enumeration of findings; it constructs a critical narrative that cohesively connects studies, identifies emerging patterns, keenly examines methodological and conceptual disparities, and, most importantly, proposes a well-founded roadmap for future investigations.

The comprehensive analysis of 25 articles on Virtual Reality (VR) applications for the elderly reveals a dynamic and expanding research and intervention domain. To synthesize the main identified patterns, Table 2 summarizes these key themes and insights.

| *Theme* | *Key Findings* |
|---|---|
| *Mood and Emotional Well-being* | VR experiences consistently evoke positive emotional states such as relaxation, happiness, and enjoyment in older adults. |
| *Social Connection and Isolation Mitigation* | VR demonstrates significant potential to foster new social interactions and connections, particularly for older adults, by providing a supportive environment for community building. |
| *Usability and Accessibility in VR Adoption* | The intuitive design, ergonomic hardware, and adaptation to older adults' specific motor and cognitive capabilities are crucial for effective VR implementation and acceptance. |

Table 2: Key themes and findings.

There is consistent evidence that VR can affect older adults' emotional states, but the nature and depth of this impact vary considerably depending on the design of the experience. Passive content, particularly 360° videos of nature or familiar environments, has shown reliable effects in producing momentary relaxation, sensory pleasure, and psychological relief, especially in institutional settings where routine and sensory deprivation are common [20,23,25]. These effects are typically mediated by mechanisms such as attentional distraction, perceptual immersion, and temporary cognitive disengagement. Chaze et al. [22] reinforce this by demonstrating pain relief through VR, rooted in attentional redirection, while Lin et al. [26] and Fan et al. [28] expand emotional outcomes to include higher self-esteem and reduced depressive tendencies. However, while promising, these benefits can be shaped as much by novelty or contextual framing as by the content itself, as Appel et al. [21] cautioned.

More participatory or symbolic VR experiences appear to produce deeper and potentially more lasting emotional effects. Qiu et al. [29] showed that embodied engagement through movement-based practices such as Tai Chi led to reductions in depressive symptoms, suggesting that active participation enhances affective impact. Faw et al. [32] and Kosti et al. [19] emphasized the power of aesthetic and co-creative immersion to evoke complex emotional responses,nostalgia, self-expression, and transcendence, by activating personal and cultural memory. These studies point to a shift in the emotional mechanisms at play: from passive distraction to symbolic integration and emotional agency. Although passive VR offers a low threshold entry point with short-term mood benefits, more expressive and interactive formats may be necessary for long-lasting psychological gains.

Research increasingly supports VR's potential to mitigate social isolation among older adults, not simply by enabling contact, but by redefining how social connection is experienced in later

life. Unlike conventional communication tools, VR offers immersive and disinhibiting environments where older users can interact in ways that transcend physical limitations and social inhibitions. Studies such as Kalantari et al. [9] and Baker et al. [14] highlight the viability of VR as a communication medium, but also point to deeper dynamics: the capacity of immersive environments to foster affective copresence, encourage spontaneity, and reduce psychological barriers to self-expression. Avatars, as shown by Baker et al. [17], may function not only as proxies, but also as expressive extensions of identity, enabling users, especially those who are introverted or self-conscious, to interact more confidently and authentically. This suggests that social VR fosters a kind of relational flexibility that is rarely possible in real-world institutional settings.

In addition, interventions grounded in reminiscence, such as those designed by Baker et al. [15, 16], demonstrate how VR can create symbols-loaded spaces that trigger autobiographical memory and shared cultural reference points. These environments (e.g., old-style classrooms or familiar neighborhood scenes) do more than entertain; they scaffold connection through nostalgia and shared identity, reactivating dormant social scripts and relational roles. Similarly, shared activities such as virtual tours or Chinese chess [11, 24] serve not just as diversions, but as structured rituals that give meaning and rhythm to social contact. Xu et al. [12] and Dinet et al. [33] emphasize that carefully designed environments, with intuitive interaction, ambient social cues, and shared goals, can foster a sense of belonging even in remote or asynchronous settings.

However, this optimistic view warrants scrutiny. Although the affective and symbolic depth of social VR is promising, the risk of superficiality or performative interaction persists, especially when the content lacks cultural relevance or emotional resonance. Furthermore, the idealization of VR as inherently inclusive ignores critical issues of access, technological fluency, and individual readiness for embodied digital presence. Korsgaard et al. [31], for instance, found that even socially framed VR experiences (e.g., shared meals) may struggle to replicate the subtle social synchrony and emotional nuance of in-person interaction.

Together, the literature suggests that VR can indeed foster meaningful social connections, but only when designed with sensitivity to the psychological, cultural, and symbolic dimensions of aging. Its true strength may lie not in substituting face-to-face interaction but in creating new forms of mediated intimacy that feel authentic, emotionally resonant, and personally relevant. This demands a shift from viewing VR as a mere communication platform to understanding it as a relational ecology, where social presence emerges not from proximity alone, but from design choices that honor memory, identity, and emotional texture.

A central methodological divergence in VR interventions for older adults lies between single-user and multi-user formats, each offering distinct benefits and limitations. Single-user approaches, such as those employed by Gruber et al. [20], Chaze et al. [22], and Lin [26]—are often easier to implement, less demanding in terms of technical infrastructure, and highly effective in providing immediate emotional relief. These interventions typically rely on passive content (e.g., 360° nature videos) that can induce relaxation, reduce anxiety, and offer a temporary sense of escape, particularly valuable in institutional settings marked by monotony and limited stimulation. However, their inherently solitary nature and limited interactivity make them susceptible to habituation and reduced long-term engagement. Emotional gains may be driven more by novelty than by sustained connection, and without evolving content or personalization, these effects risk fading over time.

Multi-user or socially interactive VR such as in the work of Kalantari et al. [9], Wei et al. [11], and Baker et al. [16] offers a more robust foundation for enduring psychosocial benefits. These interventions leverage shared environments, avatar-mediated interaction, and culturally resonant scenarios (e.g., reminiscence-based virtual classrooms or games) to foster empathy, co-presence, and

a renewed sense of identity. Although technically more complex and dependent on user readiness, social VR tends to produce deeper engagement, particularly when users can actively contribute to the experience. It is especially well-suited to combating loneliness, as it creates opportunities for mutual recognition, conversation, and the formation of new relational routines. Importantly, several studies (e.g., Xu et al. [12], Baker et al. [18]) demonstrate that older adults can adapt to these environments over time, gradually building confidence and fluency in social interaction.

Hybrid designs, as explored by Fan et al. [28] and Oppert et al. [24], reveal that the line between individual and social engagement is not fixed. Passive experiences can act as gateways to more participatory use when scaffolded with human facilitation or contextualized within shared real-world activities. This adaptability is crucial: rather than prescribing a universal format, interventions must evolve with the user's emotional readiness, cognitive abilities, and social needs.

Although both approaches have merit, the evidence suggests that multi-user, socially oriented VR offers a more sustainable impact on the well-being of older adults. Its ability to foster belonging, reciprocity, and meaningful dialogue gives it a unique advantage in addressing not only transient mood states but also the deeper structural roots of loneliness and social disconnection. However, this potential can only be realized through thoughtful design, adequate support, and sensitivity to the evolving capacities of users. As such, the future of VR for older adults lies not in choosing between solitary or social formats, but in developing adaptive systems that prioritize social inclusion while accommodating diverse entry points.

Another underexplored yet conceptually rich dimension of VR interventions lies in the transition from passive to active engagement and the creative affordances that facilitate this evolution. Although passive experiences, such as 360° videos or guided relaxation environments, are often used as initial entry points due to their low cognitive and motor demands, they risk remaining affectively shallow if not scaffolded toward more meaningful participation. Studies by Gruber et al. [20] and Restout et al. [23] show that passive VR content can induce immediate mood improvement and emotional comfort. However, without opportunities for expression, co-creation, or feedback, these experiences may offer limited psychosocial depth and are unlikely to sustain long-term engagement. In contrast, interventions such as those developed by Kosti et al. [19] and Faw et al. [32] illustrate how creative and artistic modalities can reconfigure older adults from passive observers to active participants and emotional agents. Kosti's co-creative workshops demonstrated that VR could awaken dormant expressive capacities and foster a sense of authorship and self-efficacy, particularly among participants with prior visual or artistic inclinations. Faw's exploration of aesthetic immersion revealed that symbolic and abstract environments, when thoughtfully designed, can evoke deeply personal emotional responses, such as nostalgia, transcendence, or connectedness to lost identities. These findings suggest that artistic engagement in VR is not a peripheral novelty but a central mechanism for emotional resonance and identity reinforcement, especially in later life.

However, despite their conceptual richness, such interventions raise important practical challenges. Artistic formats often resist standardization, complicating efforts to consistently evaluate impact between users or institutions. Their effectiveness may also depend heavily on individual expressiveness, cultural literacy, or prior exposure to creative practices that potentially exclude users with limited confidence, interest, or familiarity in such domains. Furthermore, emotional responses to symbolic content are highly subjective and context-dependent, posing difficulties for replication or scalability. As such, while artistic VR holds significant promise, its integration into broader care strategies requires careful attention to inclusivity, adaptability, and evaluative rigor.

Importantly, these artistic and co-creative approaches function as bridges—they gently ease users from consumption to participation, from solitude to connection. They also bypass traditional

barriers such as technological anxiety or lack of literacy in games by focusing on meaning, narrative, and emotional texture rather than performance. However, they pose challenges: artistic content is often more difficult to standardize, evaluate quantitatively, or scale across institutions. In addition, its impact can be deeply subjective and vary widely between users. Still, in light of the limitations of purely passive consumption and the practical demands of multi-user coordination, these creative formats emerge as a promising middle path. They enable emotionally rich, personally relevant, and semi-structured participation, making them ideal candidates for phased or adaptive VR strategies. Future work should explore how these modalities can be integrated more systematically into long-term care programs and whether their affective impact can be reliably measured over time. The available evidence suggests that moving beyond passivity, without demanding full interactivity, may represent a critical design sweet spot to engage older adults in immersive and meaningful ways.

The literature consistently emphasizes the critical importance of usability and accessibility for VR adoption and effectiveness. For VR to be successfully integrated into the lives of older adults and deliver potential benefits, software interfaces and hardware design must be intuitively accessible and meticulously adapted to their specific physical and cognitive capabilities. Research by Baker et al. [15], Baker et al. [18], and Xu et al. [12] consistently identifies challenges related to intuitive navigation, hardware ergonomics, and the need for designs that accommodate varying motor and cognitive abilities. These studies underscore that such design considerations are not secondary, but fundamental prerequisites for successful implementation. Appel et al. [21] explicitly noted that VR feasibility for older adults depends on addressing usability concerns, especially for those with cognitive or physical impairments. Kosti et al. [19] and Gruber et al. [20] further emphasize the critical need to rigorously evaluate the usability of the VR system and the overall user experience for older people, indicating that user-centered design is paramount. Implicitly, the positive outcomes reported by Lin et al. [26], Graf et al. [25], and Chaze et al. [22] regarding the enjoyment and engagement of older adults with VR strongly suggest that the underlying systems were sufficiently usable and accessible to facilitate these positive experiences. This collective emphasis on user-centered and participatory design approaches is presented as the cornerstone to overcome barriers and ensure widespread acceptance and efficacy of VR technology among older adults.

Beyond these three strongly supported findings, other relevant themes, although not consistently supported by eight or more articles in this specific review, also provide valuable insights. The broader concept of co-design with older adults, extending beyond mere usability to encompass creating highly relevant and emotionally engaging interventions, remains a crucial practice. The specific impact of sensory immersion for relaxation, particularly through passive or nature-based VR experiences, on emotional regulation and reduction of anxiety or depression symptoms is a distinct and promising area. Furthermore, VR's potential as a therapeutic or cognitive tool to enhance cognitive function, beyond its impact on mood and social participation, and to improve functional autonomy, particularly within structured physical or mental health programs, is also a developing research area. Lastly, the use of social VR for reminiscence and narrative engagement, allowing users to revisit autobiographical memories and explore cultural identities, thus enriching emotional expression and social connection, represents a significant and valuable application. Although these areas may require more extensive investigation to reach the same level of widespread support as the top three findings, they undoubtedly offer important avenues for future research and development in VR for older adults.

Beyond emotional and social well-being, VR is increasingly investigated as a valuable tool for cognitive and physical health. Although less emphasized in this specific collection of articles, the evidence is promising. Studies such as the randomized controlled trial by Wang et al. [30],

which examined the impact of VR exercise on quality of life, and the quasi-experimental study by Fan et al. [28], exploring VR combined with horticultural activities for psychological well-being, represent leading quantitative research with stronger methodological rigor. Wang et al. [30] report measurable improvements in quality of life, while Fan et al. [28] indicate benefits in domains such as self-esteem and mastery. These findings are encouraging, but the inherent heterogeneity of interventions (from structured physical exercise to therapeutic horticulture) impedes direct generalization and necessitates a more robust consolidation of evidence through systematic meta-analyses and additional randomized controlled trials focused on specific and clinically relevant outcomes. The capacity of VR to increase activity levels and engagement has also been noted in studies by Li et al., Chaze et al. and Baker et al. [13, 18, 22]. In particular, Li et al. [13] adopt a longitudinal and exploratory approach, investigating the impact of VR in nursing homes over time, suggesting that VR can be a sustainable strategy to promote long-term engagement. However, a persistent gap remains in direct comparisons between VR-mediated activities and traditional physical interventions regarding both clinical efficacy and cost-benefit, an area that requires more direct quantitative and comparative investigation.

A critical assessment of the implementation of VR for older adults reveals that technological sophistication alone is not sufficient to ensure effectiveness. Usability and accessibility are not peripheral concerns, but central determinants of adoption and impact. Participatory design studies and qualitative investigations by Baker et al. [15, 18] and Xu et al. [12] consistently emphasize the need for interfaces that accommodate the specific motor, cognitive and perceptual profiles of older users. Without intuitive and ergonomically adapted systems, even emotionally promising interventions risk rejection or superficial engagement. Moreover, as Chaze et al. [22] noted, while VR can reliably induce relaxation and distraction in structured settings, its long-term emotional efficacy remains uncertain. The fleeting nature of novelty-based effects points to the need for dynamic content, personalization, and graduated interactivity that evolves with user familiarity and interest.

This underscores a broader systemic implication: VR should not be deployed as a standalone tool, but as one component of an integrated psychosocial care model. Sustainable implementation requires infrastructural investment, staff training, and a supportive ecosystem that frames VR experiences within a continuum of care activities. In institutional contexts, where routine fatigue and under-stimulation are prevalent, embedding VR into regular therapeutic, recreational, or reminiscence practices, facilitated by caregivers or activity coordinators, may be crucial for sustained benefit. These findings call for a shift in focus: from isolated technological solutions to holistic, context-sensitive strategies that align with the lived realities and institutional constraints of older adult populations.

The acceptance of technology by older adults is an inherently multifaceted factor that extends beyond technical specifications. Baker et al. [18] underscore the paramount importance of perspectives from both residents and, crucially, nursing home staff. This reveals that VR acceptance is not only about hardware or software design, but also about its harmonious and sensitive integration into existing workflows and the institutional culture of care. The innovative 'new art-driven methodology' introduced by Kosti et al. [19] suggests that unconventional and creative approaches can unlock deeper and more authentic engagement, although their scalability and rigorous impact evaluation require further testing and validation. A significant gap in the current literature is the lack of systematic and in-depth investigation of adverse reactions, such as VR-induced dizziness or nausea (cybersickness). Although Gruber et al. [20] mention collecting data on 'side effects', the extent of discussion on proactive mitigation and actual prevalence in

older populations with varying sensitivities and comorbidities varies considerably. This critical area requires more systematic investigation, reporting, and integration into design guidelines and intervention protocols.

The dual presence of qualitative and quantitative approaches represents a methodological advantage in this emerging field, but one that remains under-leveraged. Although qualitative studies uncover the nuanced mechanisms behind user experience and engagement, and quantitative studies offer outcome validation, the two rarely inform each other in a truly integrated framework. Future research would benefit from prioritizing mixed method designs in which qualitative insights directly inform the development of quantitative measures, thereby supporting a more integrated and explanatory understanding of the impact of VR on older adults. Their complementarity is evident: qualitative studies provide the necessary depth to uncover the 'why' and 'how' VR experiences affect older adults, critically forming future intervention design. Quantitative studies offer the breadth and rigor to measure effects and compare interventions. For example, detailed insights from Baker et al. [14] on avatar design motivations can and should guide the development of more effective VR interventions, which can then be rigorously tested for outcomes like depression, as investigated by Qiu et al. [29]. However, the intrinsic limitations of individual studies persist. Qualitative studies, while rich in ecological validity and capable of generating an in-depth understanding, are inherently exploratory, and their often small samples limit the generalization of the results. Their conclusions focus on understanding potential rather than statistically proven efficacy. Randomized controlled trials [20,30] and quasi-experimental studies [28] are crucial to establish evidence for clinical efficacy. However, these often lack the depth to explain the underlying mechanisms or capture the rich subjective experiences of the participants. For example, Lin et al. [26] may demonstrate quantifiable benefits, but individual perception of these benefits is not the main focus. Their limitations often include relatively short intervention durations and inherent difficulty in controlling all outcomes-influencing variables. Korsgaard et al. [31]'s failure to find significant changes in energy intake highlights the complexity of measuring physiological outcomes in virtual environments and the need for more robust study protocols. A notable literature gap is the scarcity of truly integrated mixed-method studies, where qualitative and quantitative data are collected, analyzed, and crucially interpreted together for a holistic understanding. Currently, many articles are predominantly one type, and the other component serves only a secondary role.

It is important to clarify the methodological rationale that underpins the dual assessment of study quality and perceived benefit. Although this synthesis did not apply standardized critical evaluation tools, the quality evaluation of the study called the Strength of Evidence (SoE) was informed by widely recognized criteria, including methodological clarity, transparency in data collection and analysis, ethical conduct and general contribution of the study to knowledge. This approach is conceptually aligned with frameworks such as those proposed by the Global Spine Journal to define levels and the strength of evidence in applied health sciences [34]. Crucially, the SoE score was calculated independently of the benefit rating to preserve a clear distinction between methodological rigor and the magnitude of the impact of the intervention.

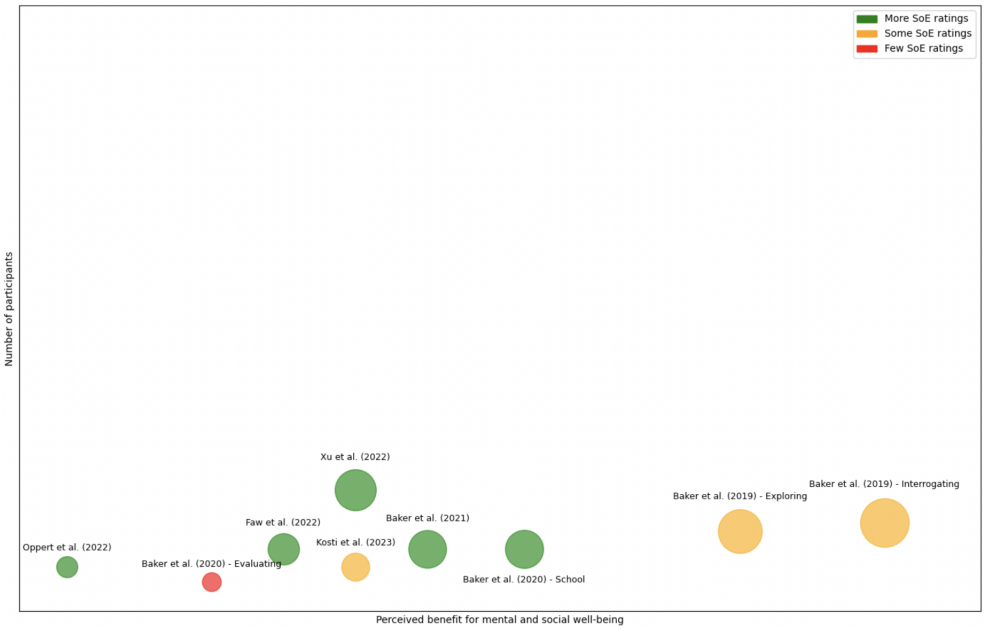


Figure 2: Perceived benefit in qualitative studies.

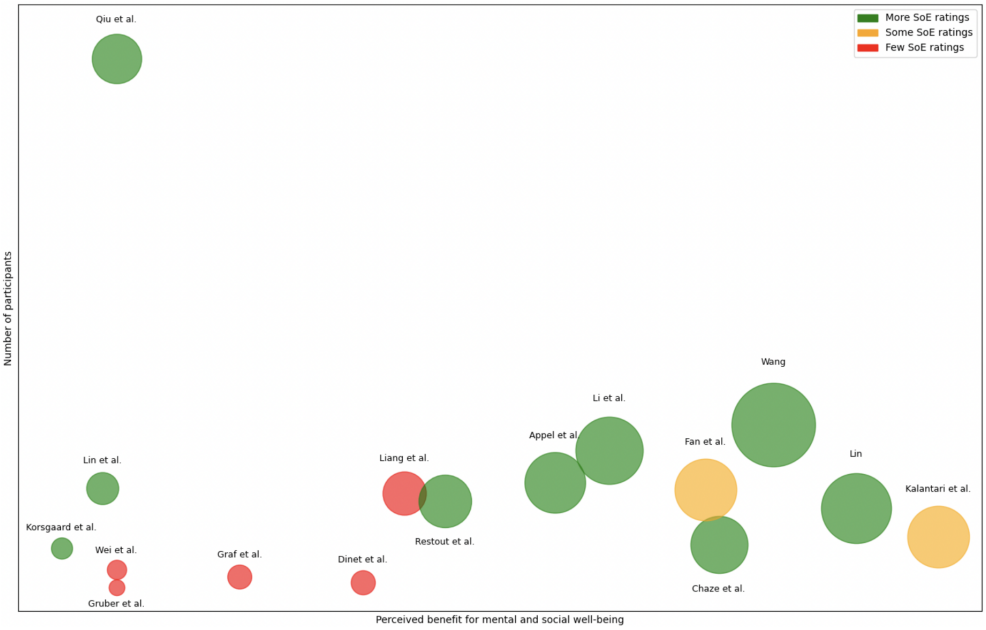


Figure 3: Perceived benefit in quantitative and mixed-methods studies.

In contrast, the estimation of perceived benefit, illustrated in Figures 2 and 3 is inherently more interpretative. There is no universal metric for quantifying the benefit of VR in heterogeneous designs. The reviewed studies employed diverse outcome measures, from thematic narratives and user satisfaction to standardized mood scales and physiological indicators. As such, benefit scores were derived through a structured synthesis of reported results, emphasizing the scope, depth, and clarity of perceived effects. Greater weight was given to interventions that demonstrated sustained emotional or social improvements, participant-reported transformation, or novel contributions, while short-lived, ambiguous, or narrowly framed outcomes were rated lower.

These figures are not intended as hierarchical rankings but as comparative heuristics. The position of each bubble reflects its reported benefit (x axis) and sample size (y-axis); the color encodes its methodological strength (SoE); and the size is proportionate to the combined influence of SoE, perceived benefit and participant count. This multidimensional representation allows for comparative insight while avoiding reductive scoring. Ultimately, this pluralistic framework underscores that meaningful contributions may arise from both qualitative richness and quantitative robustness, and that "benefit" should be understood contextually rather than universally quantified.

Although most studies cluster in the mid to high benefit range, particularly those rated as high quality, these scores should be interpreted with caution. Although the visual synthesis suggests broadly positive outcomes, it also risks obscuring critical differences in how the "benefit" is conceptualized and measured across diverse methodologies. Studies range from capturing subjective well-being and social connection to tracking cognitive stimulation or symbolic engagement. Thus, the appearance of clustering may flatten this heterogeneity.

Among qualitative studies, some with moderate SoE, such as Baker (2020) [18] and Baker (2021) [14], reported high benefit scores. Their success likely stems from immersive and socially engaging designs that resonated deeply with participants, despite not being the most methodologically rigorous in the sample. In contrast, Oppert et al. [24], despite a higher SoE rating, demonstrated minimal benefit, possibly due to the limited emotional activation provided by passive virtual tours.

In the quantitative and mixed methods subset, a wider spread in benefit scores is observed. A stronger correlation between SoE and benefit; however, several outliers challenge this trend. High-quality studies such as Korsgaard [31], Qiu [29], and Lin et al. [26] showed limited benefit, probably because their interventions targeted specific domains (e.g. eating habits, tai chi, exercise) without deeply engaging social or emotional dimensions.

In contrast, studies with only moderate SoE—Kalantari [9] and Fan et al. [28]—reported high benefits. These interventions emphasized emotionally rich, socially immersive experiences, such as interactive VR social spaces or horticulture-based VR, which produced a strong user-reported impact despite being less methodologically strict.

The largest bubble in the quantitative and mixed methods graph belongs to Wang [30], who combined semi-immersive VR exercise with longitudinal monitoring. Its high benefit reflects not only the sample size, but also the reach of the intervention in multiple outcome areas, including mood improvement, physical activation, and quality of life, highlighting its broad effectiveness.

However, the process of assigning a unitary benefit score in various epistemological paradigms invites reflection. Interventions focused on embodied affect or subjective experience are not always directly comparable to those centered on measurable change in behavior or symptoms. For example, transient mood improvements may reflect novelty effects or social desirability biases rather than lasting change. Meanwhile, deeper shifts in agency, identity, or belonging often captured in qualitative studies are difficult to quantify but highly relevant.

Moreover, the near absence of adverse outcomes (e.g. cyber-sickness, disengagement, or

perceived irrelevance) raises the possibility of selective reporting or institutional optimism. In particular in feasibility trials conducted within care settings, structural pressures can lead to under-reporting of neutral or negative effects, contributing to an overly favorable portrayal of VR interventions.

Although low-quality studies tend to produce low benefits, the relationship is not strictly linear. Substantial perceived impact can arise from moderately rated studies when the intervention is strongly aligned with the social, emotional, or experiential needs of the participants. These findings reinforce the importance of contextual sensitivity and user-centered design when interpreting and implementing VR in later life.

In this light, Figures 2 and 3 should not be read as definitive impact rankings, but rather as heuristic maps that highlight visible patterns and tensions in the literature. Their value lies not in prescribing a hierarchy of outcomes, but in prompting deeper reflection on how 'benefit' is conceptualized, measured and experienced among aging populations.

Furthermore, this review highlights several crucial practical implications and imperative future directions for VR research and application in older adults. First, VR design for this population must be intrinsically inclusive and older-adult-centered, necessitating the systematic adoption of participatory and co-design methodologies from early development stages. Meticulous attention to hardware ergonomics, intuitive interfaces, and culturally and personally relevant content remains paramount. Second, the context of VR application is diverse. Although showing particular promise in nursing homes, as demonstrated by Baker et al., Chaze et al., Li et al., and Restout et al. [13, 18, 22, 23], offering an escape from routines and new socialization opportunities, its potential for independently living older adults, as studied by Oppert et al., Wang et al., and Fan et al. [24,28,30], is equally vast, requiring solutions that integrate seamlessly into daily life. Third, successful VR introduction and implementation require adequate training and support for both older adult users and their caregivers. The challenge of overcoming barriers to digital literacy and ensuring safe, effective and autonomous use of technology is fundamental.

For future research, the following strategic directions are imperative. There is an undeniable need for more large-scale randomized controlled trials with heterogeneous and diverse samples to confirm the effectiveness of the VR intervention in specific health and well-being outcomes, ideally with longer durations to assess the sustainability of the effect. Developing VR content for older adults requires a grounded approach informed by empirical evidence, particularly qualitative insights into user preferences, values, and capabilities. Translating this understanding into design decisions, ranging from narrative structure to complexity of the interface, can significantly improve the psychosocial and cognitive relevance of VR interventions, improving both engagement and outcome sustainability. Evaluating long-term metrics and investigating the sustainability of VR engagement are crucial in order to understand how benefits are maintained over months or years. Furthermore, research should explore cost-efficient and scalable implementation models for healthcare systems and care institutions, ensuring a wider reach of VR. The impact of VR on family dynamics and caregiver well-being (formal and informal) is an underexplored area of immense practical and social importance. Addressing older adult population heterogeneity is vital; more studies are needed to investigate VR effectiveness in specific subgroups, considering, for example, varying cognitive impairment levels, pre-existing health conditions, and cultural contexts, to ensure truly personalized and equitable interventions.

Although the potential of VR to improve social, emotional, physical and cognitive well-being in older adults is increasingly recognized, the field now faces the more pressing challenge of translating this potential into scalable, inclusive, and sustainable implementations. Rather than reaffirming

its promise, future research must focus on overcoming persistent limitations: small samples, short intervention durations, and inconsistent methodological standards, by fostering convergence around robust mixed-method frameworks and longitudinal designs. Crucially, advancing this field depends not only on technological refinement, but on embedding VR within broader ecosystems of care that prioritize user-centered design, accessibility, and contextual integration. The objective is no longer to prove that VR works, but to ensure that it works meaningfully and equitably in real-world settings, contributing to aging experiences that are not only longer, but richer in dignity, connection, and personal agency.

## *6 Conclusion*

This review identified recurring patterns in the way virtual reality (VR) interventions have been applied to promote emotional and social well-being in older adults. As discussed in the section Reported Outcomes and Measurements, the most engaging and emotionally resonant experiences were those situated in multi-user virtual environments involving culturally meaningful activities. These contexts supported stronger emotional involvement, a sense of presence, and perceived connectedness.

The analyses in subsections within the types of VR interventions further highlighted the relevance of participatory approaches. Interventions that involved co-design processes or adapted content to user memories, routines, or cultural backgrounds were generally met with higher engagement and acceptance. This reinforces the importance of designing VR not only as a technological solution but as a medium shaped by lived experience and user agency.

Passive and aesthetic VR formats, such as immersive 360° nature or artistic videos, were frequently associated with mood regulation and short-term emotional relief. However, as detailed in the Discussion, these effects were often limited in duration and rarely extended beyond the intervention sessions. Their value, while real, appears to be bounded by context, frequency, and the degree of interaction offered.

A recurring implementation factor in different settings was the role of facilitation. As explored in the Discussion section, the presence of trained staff or facilitators was crucial to ensure accessibility, technical fluency and emotional support. However, few interventions examined how this facilitation could be integrated into routine care in a sustainable manner.

Despite the encouraging results, several methodological challenges remain. The heterogeneity of the outcome measures, the absence of medium- or long-term follow-up in most cases, and the underrepresentation of participants with cognitive or physical impairments are limitations that restrict the generalizability of current findings. Furthermore, the lack of consistent evaluation intervals complicates the assessment of sustained impact and limits cross-study comparisons.

Future research should prioritize longitudinal studies with standardized psychosocial outcome measures and scheduled follow-ups. Comparative approaches, such as those proposed in the Discussion, can help determine how specific modalities (e.g., interactive versus passive, social versus solitary) perform across different user groups and contexts. Adaptive intervention models that evolve from low-barrier formats to more immersive interactive experiences may offer promising pathways for gradual engagement and digital inclusion. In addition, a clearer understanding

of how to incorporate facilitation into existing care workflows is needed to support real-world implementation beyond experimental settings.

In conclusion, the findings synthesized in this research indicate that the value of VR in improving emotional and social well-being in older adults is strongly dependent on the social relevance of the experience, the degree of participatory design and the continuity of implementation. Rather than approaching VR as a standalone technological solution, the most effective interventions are those shaped by user needs, enriched with culturally meaningful content, and supported by integrated facilitation. These insights offer a structured foundation for advancing more context-sensitive and person-centered applications of immersive technologies in gerontological practice.

## *End sections*

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*Conflicts of Interest*

None declared.

*Data Availability*

In this study, no new data was generated or analyzed. The data sets used during the review are available from the corresponding author on a reasonable request.

*Authors' Contributions*

*Henrique Lopes*: Conceptualization, methodology, formal analysis, visualization, writing – original draft, review, and editing.

*Nuno Rodrigues*: Supervision, validation, review, and editing.

*Eva Oliveira*: Review, editing, and validation.

*Pedro Cardoso*: Review, editing, and validation.

*Abbreviations*

- HMD: Head-Mounted Display
- M: Mean
- PANAS: Positive and Negative Affect Schedule
- RCT: Randomized Controlled Trial
- SD: Standard Deviation
- TV: Television
- VR: Virtual Reality

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