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Social connections as determinants of cognitive health and as targets for social interventions in persons with or at risk of Alzheimer's disease and related disorders: a scoping review

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Abstract

Background: Social connections have a significant impact on health across age groups, including older adults. Loneliness and social isolation are known risk factors for Alzheimer's disease and related dementias (ADRD). Yet, we did not find a review focused on meta-analyses and systematic reviews of studies that had examined associations of social connections with cognitive decline and trials of technology-based and other social interventions to enhance social connections in people with ADRD.

Study design: We conducted a scoping review of 11 meta-analyses and systematic reviews of social connections as possible determinants of cognitive decline in older adults with or at risk

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Description of authors' roles

All the authors contributed to the conceptualization of the manuscript, searching the data, reviewing the data, and writing and updating of the manuscript as per the reviewers' comments.

Conflict of interest

None of the other authors have any conflicts of interest to disclose.

of developing ADRD. We also examined eight systematic reviews of technology-based and other social interventions in persons with ADRD.

Study results: The strongest evidence for an association of social connections with lower risk of cognitive decline was related to social engagement and social activities. There was also evidence linking social network size to cognitive function or cognitive decline, but it was not consistently significant. A number of, though not all, studies reported a significant association of marital status with risk of ADRD. Surprisingly, evidence showing that social support reduces the risk of ADRD was weak. To varying degrees, technology-based and other social interventions designed to reduce loneliness in people with ADRD improved social connections and activities as well as quality of life but had no significant impact on cognition. We discuss strengths and limitations of the studies included.

Conclusions: Social engagement and social activities seem to be the most consistent components of social connections for improving cognitive health among individuals with or at risk for ADRD. Socially focused technology-based and other social interventions aid in improving social activities and connections and deserve more research.

Keywords

aging; digital; robots; loneliness; pets; marital status

Introduction

Social determinants of health (SDoHs) are social and structural factors that affect incidence, prevalence, and course of diseases as well as health inequities and reportedly account for 30–55% of health outcomes, exceeding the contribution from medical factors (World Health Organization, 2008). SDoHs impact physical, mental, and cognitive function and longevity among all age groups including older adults (Jeste, 2022; Jester *et al.*, 2023). Over recent decades, the construct of social connections has acquired increasing attention as an SDoH. Social connection is a broad term that encompasses various structural, functional, and quality aspects of interpersonal relationships and interactions (National Academies of Sciences, Engineering and Medicine, 2020). Considerable scientific evidence shows that being embedded in close relationships and feeling socially connected to the people in one's life is associated with a significantly reduced risk for a range of disease morbidities and all-cause mortality (Holt-Lunstad *et al.*, 2017). In a meta-analysis of 148 studies with a total of 308,849 participants, the odds ratio (OR) for the strength of social relationships was 1.50 (95% confidence nterval 1.42–1.59), indicating a 50% [$CI_{95\%}$ 42%–59%] increased likelihood of survival among participants with stronger social relationships (Holt-Lunstad *et al.*, 2010). This finding remained consistent across a range of variables including age, sex, initial health status, cause of death, and follow-up period.

There is considerable literature on the relationship of social connections, isolation, and health (Jeste *et al.*, 2023a). Social disconnection has become a global behavioral pandemic (Na *et al.*, 2023). A National Academies of Sciences, Engineering, and Medicine Report highlighted how social isolation and loneliness are serious yet underappreciated public health risks that affect more than a quarter of the older adult population (National

Academies of Sciences, Engineering and Medicine, 2020). Social isolation is a major risk factor for several disabling and life-shortening disorders including dementia. This has led to research on interventions to enhance social support. A review (Hogan *et al.*, 2002) of 100 studies pointed to overall usefulness of social support interventions, although there was not enough evidence to conclude which interventions worked best for what problems. A more recent systematic review and meta-analysis of psychological interventions for loneliness, many of which involved cognitive behavioral therapy, found a significant reduction in loneliness compared to control groups, with a small to medium effect size ($g = 0.43$) (Hickin *et al.*, 2021).

Growing evidence suggests that SDoHs can help explain heterogeneity in outcomes in Alzheimer's disease and related dementias (ADRD). According to the World Health Organization (WHO), the number of individuals with ADRD worldwide is about 55 million today and will increase to 78 million by 2030 and 139 million by 2050 (World Health Organization, 2021). Recently, the national network of Alzheimer's Disease Research Centers presented a framework for assessing SDoHs in ADRD (Stites *et al.*, 2022). It proposed several specific SDoH domains that appear foundational to ADRD, and social support and social networks were prominent on that list. However, we found no published scholarly review that synthesized the findings of meta-analyses and systematic reviews focused on social connections as possible determinants of cognitive health in older adults with or at risk of developing ADRD. It will be useful to determine which components of social connections are more impactful than others. Similarly, there were no reviews synthesizing the findings of meta-analyses or systematic reviews on technology-based and other social interventions targeting social connections in people with ADRD. This review sought to address both those gaps in the literature and offer suggestions for interventions as well as future research. Scoping reviews aim at developing an overview of the published evidence when research objectives or review questions involve exploring, identifying, and discussing characteristics or concepts across a breadth of domains and sources (Munn *et al.*, 2018; Peters *et al.*, 2021). Given the heterogeneity of the published literature on SDoHs in ADRD, a scoping review was considered to be most appropriate.

Methods

We performed a scoping review of the literature on commonly listed social factors relevant to ADRD, as well as technology-based and other social interventions. Meta-analyses and systematic reviews were searched for inclusion, using the terms mentioned in Figure 1. This list was developed via consensus among the co-authors and was made to highlight potentially malleable major factors that could be assessed in a clinical setting (Figure 1). We used MeSH Trees to inform the specific search terms rather than searching for MeSH terms themselves. Many terms came directly from the following MeSH Tree: Anthropology, Education, Sociology and Social Phenomena Category -> Social Sciences -> Sociology -> Sociological Factors. After consulting this MeSH Tree, we found that many common terms were missing from the Nodes. Therefore, we sought additional guidance from a recently published review by Holt-Lunstad on how the many different facets of social connection may influence health in older age (e.g. social isolation vs. marital status vs. neighborhood and built environment) (Holt-Lunstad, 2022). We obtained a total of

2,513 articles from PubMED, PsycINFO, EMBASE, and CINAHL. After deleting 609 duplicates, we screened 1,904 articles based on the criteria of having all three elements in their title: (1) systematic review or meta-analysis, (2) Alzheimer's disease or dementia, and (3) one of the following terms: social connection, social isolation, social support, social network, socioeconomic, social activities, social engagement or disengagement, social skills, neighborhood, social contact, social belonging, social fragmentation, pets, social robot, marriage, social environment, couple relationship, social functioning, social behavior, loneliness, social participation, social interaction, intergenerational, community, social or community resources, social class, social drift, social determinant, social measure, social stressor, social disparity, social positioning, social identity, sociocultural factors, and social cohesion.

Articles were excluded if they had all three elements but referenced only caregivers or carers and not individuals with ADRD. A total of 1,872 records were excluded after title and abstract screening and 2 additional records were identified from other search methods and assessed for eligibility. Fifteen articles were excluded after full-text review. Nineteen studies (11 clinical outcomes studies and 8 intervention studies) were included in the final review (see Figure 1).

The data extracted included (1) author/year and study type, (2) number of studies included in the meta-analysis or systematic review, (3) sample size, (4) samples with or without ADRD at baseline, (5) study outcomes, (6) heterogeneity of findings, quality of study, publication bias, and sensitivity analysis, if provided, and (7) results of the meta-analysis with estimates and effect sizes when available – for example, OR (with 95% confidence intervals). Several articles also examined a few other potential risk factors for ADRD not related to social connectedness. These non-social factors are not discussed below.

Results

I. Associations of social connections with clinical outcomes

Table 1 lists main findings from 11 articles focused on meta-analyses and systematic reviews of the associations of various social connection-related factors, which included social engagement, social activities, social network, marital status, and social support, with clinical outcomes – primarily, change in cognitive function or risk of ADRD.

Below, we summarize overall results regarding reported associations of social connections with cognitive and other outcomes from studies included in Table 1.

Social Engagement and Social Activities: The strongest evidence for an association of social connections with lower risk of cognitive decline was related to social engagement and social activities. A meta-analysis (Jeste *et al.*, 2023b) found that poor social engagement was significantly associated with increased risk of ADRD (risk ratio = 1.41), whereas good social engagement was negatively associated with risk of ADRD (RR = 0.81), its main individual components being many social contacts (see below), and a high level of social activity (RR = 0.62), but not high social satisfaction. Martyr *et al.* (2018) reported that greater social engagement (weighted effect $r = 0.31$) and better quality of current

relationship with caregiver (weighted effect $r = 0.38$) had moderate associations with better quality of life (QoL) of persons with ADRD. Another (Samtani *et al.*, 2022) meta-analysis investigated the associations between social connection markers and the rate of annual change in cognition (global and domain-specific). It revealed that living with others was associated with slower global cognitive decline ($b = 0.007$). In terms of specific cognitive functions, living with others ($b = 0.017$), weekly interactions with family and friends ($b = 0.016$), and weekly community group engagement ($b = 0.030$) predicted slower decline in memory; and living with others also predicted slower decline in language skills ($b = 0.008$). On the other hand, relationship satisfaction and having a confidante were not predictive of decline in global cognition or memory, language, or executive function. Lenart-Bugla *et al.* (2022) reported that less participation in social activities, having unsatisfying social ties, low social engagement, and social isolation "can contribute to an elevated risk of ADRD" and that frequent social contact "may confer some protection against cognitive decline and ADRD by reducing the risk or delaying the onset," but no statistics were given.

A systematic review (Taniguchi and Ukawa, 2022) assessed the association between social participation in group activities and the risk of ADRD based on seven longitudinal cohort studies, five of which indicated that social participation in group activities was associated with slower cognitive decline. The investigators examined the association of the ADRD risk with three different types of activities: voluntary work, artistic activities, and participation in religious events. Older adults participating in voluntary work had a lower likelihood of having ADRD in two studies, with HR = 2.44 at 3-year follow-up and 2.46 at 5-year follow-up, while not participating in voluntary work increased the risk of ADRD at follow-up of <5 years (HR = 1.27), 5–10 years (HR = 1.10), and >10 years (HR: 0.96). Older adults participating in artistic activities had a lower likelihood of having ADRD at <10-year follow-up, and not participating in artistic activities was associated with an increased risk of ADRD at follow-up of <5 years (HR = 1.37) and 5–10 years (HR = 1.19), but not >10 years (HR = 1.04). Finally, in older adults without ADRD, those who attended religious events daily or almost daily were less likely to have ADRD at follow-up (HR = 0.66), and in adults aged 65–74 years, those regularly participating in community organizations/events were less likely to have ADRD at follow-up (HR = 0.75) as were those holding a leadership position the community (HR = 0.81).

Social Network: There was evidence linking social network to cognitive function or cognitive decline, but it was not consistently significant. Penninkilampi *et al.* (2018) noted that having a poor social network was significantly associated with increased risk of ADRD (RR = 1.59), and having many social contacts was negatively associated with risk of ADRD (RR = 0.85); however, extensive social network was not associated with reduced risk of ADRD. Evans *et al.* (2019) reported that larger social networks were associated with marginally better late-life cognitive function ($r = 0.054$; 95% CI 0.043, 0.065). Lenart-Bugla *et al.* (2022) found that having a small social network "can contribute to an elevated risk of ADRD" but no statistics were provided. In studies of Indigenous communities, Walker *et al.* (2020) found that feeling connected to their community was associated with lower risk of ADRD (OR = 0.61), though these results were not statistically significant. A systematic

review (Plassman *et al.*, 2010) reported no statistically significant associations between social network and cognitive decline.

Social Support: Evidence showing that social support reduces the risk of ADRD was weak. Two reviews (Penninkilampi *et al.*, 2018; Plassman *et al.*, 2010) found that strong social support was not associated with a reduced risk of ADRD or cognitive decline. Samtani *et al.*'s (2022) meta-analysis too found that the degree of social support was not predictive of decline in global cognition or in memory, language, or executive function. Lenart-Bugla *et al.* (2022) reported that greater social support "may confer some protection against cognitive decline and ADRD by reducing the risk or delaying the onset," but the findings from individual studies were inconsistent.

Marital status: Several studies reported a significant association of marital status with risk of ADRD. A meta-analysis (Samtani *et al.*, 2022) revealed that being married or in a relationship was associated with slower global cognitive decline ($b = 0.010$). Penninkilampi *et al.* (2018) found that being unmarried was significantly associated with increased risk of ADRD (RR = 1.41) and being married was associated with a lower risk of ADRD (RR = 0.68). Bougea *et al.* (2022) observed that widowhood and divorce were associated with increased risk of overall ADRD but not AD. Wu-Chung *et al.* (2022) reported that in 14 of 23 cross-sectional studies and 21 of 30 longitudinal studies examining bereavement status, widow(er)s exhibited significantly poorer cognitive function or were more likely to be diagnosed with mild cognitive impairment (MCI) ADRD or than non-widowed subjects, but no overall statistics were provided. Lenart-Bugla *et al.* (2022) found that being single, divorced, or widowed "can contribute to an elevated risk of ADRD" but did not provide statistics. On the other hand, some studies reported no significant relationship of marital status to risk of ADRD. Martyr *et al.* (2018) found that being married had a small association with better QoL (weighted effect $r = 08$). Walker *et al.* (2020) noted that among Indigenous people of East Malaysia never being married was associated with higher risk of ADRD (OR = 1.85) but failed to reach statistical significance. Plassman *et al.* (2010) reported no statistically significant association between marital status and cognitive decline in older adults.

Other Factors: Bougea *et al.* (2022) observed that a greater number of psychosocial stressors was related to a "progressively higher risk" of AD and other dementias. Wu-Chung *et al.* (2022) found that spousal caregivers had higher incidence of ADRD, higher risk for cognitive impairment, poorer cognitive function at follow-up, and more rapid decrease in cognitive function over time than non-caregivers in five longitudinal studies. Edwards *et al.* (2018) examined the association of the relationships between patient and caregiver and found a significant association between relationship with the family carer and global challenging behaviors (most p values <0.02), whereas caregiver relationship was not associated with QoL or with risk of institutionalization, hospitalization, or death. Martyr *et al.* (2018) reported that religious beliefs/spirituality (weighted effect $r = 0.35$) had moderate associations with better QoL, while living in the community showed small associations with better QoL (weighted effect $r = 0.12$). In Indigenous communities, Walker *et al.* (2020)

found that noting culture as a source of strength (OR = 0.514) was associated with lower risk of ADRD, though these results were not significant statistically.

II. Technology-based and other social interventions to enhance social connections in people with (or without) ADRD

Table 2 includes eight systematic reviews of social interventions in persons with ADRD. (There were no meta-analyses of such interventions.) Two papers also included persons with MCI (Neal *et al.*, 2021; Rai *et al.*, 2022), while one included older people without ADRD (Heins *et al.*, 2021). The eight articles are subdivided into (A) five on technology-based social interventions (Heins *et al.*, 2021; Hirt *et al.*, 2021; Neal *et al.*, 2021; Pinto-Bruno *et al.*, 2017; Rai *et al.*, 2022), (B) two on other social interventions (Marks and McVilly, 2020; Scott *et al.*, 2022), and (C) one on mixed technology-based and other social interventions (Han *et al.*, 2016).

Impact on Social Connections and Other Outcomes: Five of the included systematic reviews found that, to varying degrees, technology-based interventions designed to reduce or prevent social isolation or loneliness in people with ADRD improved social behavior and QoL, reduced loneliness and social exclusion, and enhanced social interaction. Pinto-Bruno *et al.* (2017) reported that Information and Communication Technology (ICT)-based interventions produced benefit for people with ADRD in maintaining, facilitating, and creating social networks. There were statistically significant improvements in increasing positive social activities and behaviors such as making more choices, spending less time asking direct questions, initiating conversation, and engaging in more singing. Rai *et al.* (2022) noted some improvements on measures of QoL in individuals with ADRD, including outcomes related to social connectedness, with technology-based interventions. A systematic review (Heins *et al.*, 2021) of studies of technological interventions targeting social participation or social isolation in older adults with and without ADRD found that participants with cognitive impairment showed initial improvement at 6 weeks with significantly higher social interaction, but it did not persist at 12 weeks. Older adults without cognitive impairment largely reported no statistically significant changes. Qualitative studies in older adults found that technological interventions promoted development or maintenance of social connections, companionship, social interactions, and communication, and decrease in loneliness. In mixed-method studies, a minority reported statistically significant positive effects on social participation. Hirt *et al.* (2021) obtained mixed results relating to behavioral outcomes, including neuropsychiatric symptoms, disturbing behavior, QoL, and activities of daily living in persons with ADRD. Neal *et al.* (2021) noted significant positive effect of technological intervention on social participation in ADRD in only one of the four studies reviewed.

Two other reviews (Marks and McVilly, 2020; Scott *et al.*, 2022) reported that other social interventions such as horticulture-based activities and pet-based interventions led to positive impacts on social engagement, social interactions, and mental and physical well-being for individuals with ADRD. Scott *et al.*, (2022) reviewed five studies of horticulture-based activities in community-dwelling people with ADRD. Four of those studies reported improved social interaction, including promotion of shared communication

about experiences living with ADRD, development of new social bonds, creation of a shared sense of identity, and development of intimate relationships. Another systematic review (Marks and McVilly, 2020) noted that the use of trained assistance dogs resulted in a statistically significant increase in social interaction in the experimental group in one study and a significant decrease in behavioral pathology in another. Qualitative studies reported enhanced communication with "volunteers", increased trust and self-determination, and the ability to reflect. Results were inconsistent regarding irritability and agitation, mood, daily activities, and QoL.

One review (Han *et al.*, 2016) of mixed technology-based and other social interventions included 32 studies investigating possible benefits of individualized social and leisure activities, particularly technology-based simulated presence therapy (SPT) and non-technology-based individualized reminiscence therapy (IRT), in people with ADRD. The SPT, which consists of individually tailored audio or video simulations of social contact with a family member, produced reduction in agitation and disruptive or withdrawn behaviors and increase in social interactions, compared to alternative interventions or standard care. However, one-on-one interactions had superior benefit in decreasing agitation than SPT, and audio SPT could be unsuitable for people with ADRD and a history of hallucinations. The IRT, consisting of facilitated activity where participants spoke with others about memories and life experiences to promote direct social interactions, improved overall QoL and depressive symptoms.

Impact on Cognition: In general, the intervention studies that assessed cognition did not find a significant improvement in cognition. Thus, Han *et al.* (2016) found that a randomized controlled trial (RCT) of IRT in people with ADRD showed no significant effect on cognition. Hirt *et al.* (2021) also reported no significant effect of social robots including pet robots, humanoid robots, and telepresence (social presence) robots on cognition in people with ADRD. While Marks and McVilly (2020) noted that the use of trained assistance dogs produced "generally positive results" on "cognitive impairment outcomes" in people with ADRD, the form and quality of the studies varied considerably, and no statistical analyses were presented.

Discussion

In the US healthcare practice for older adults, healthy lifestyle including physical activity and better nutrition is emphasized along with adherence to prescribed medications for persons with hypertension, diabetes, heart disease, etc. Yet, little attention is paid to the assessment and interventions related to the single most important evidence-based determinant of health and longevity – *viz.*, social connections. Countless investigations have shown that social relationships are highly significant predictors of mental and physical well-being and reduce the risk of multiple illnesses including ADRD (Holt-Lunstad *et al.*, 2017). Yet, we did not find a review that synthesized the estimates and findings from meta-analyses and systematic reviews of studies on the association of social connections with cognitive decline, or of trials of technology-based and other social interventions seeking to enhance social connections in people with ADRD.

This scoping review examined the associations between social connections and outcomes primarily related to cognitive decline in older adults with or at risk for ADRD, as well as technology-based and other social interventions to promote social connections. Social connection is a broad construct, and it will be useful to determine which components are more impactful than others. The strongest evidence for an association of social connections with lower risk of cognitive decline was related to social engagement and social activities. There was also evidence linking social network size to cognitive function or cognitive decline, but it was not consistently significant. A number of, though not all, studies reported a significant association of being married or in a relationship with lower risk of ADRD. However, evidence showing that social support reduces the risk of ADRD was weak. Social support is known to improve well-being in people with mental and physical illnesses but may not delay the progression of cognitive decline because it is not associated with increased physical and psychosocial activities. To varying degrees, technology-based and other social interventions designed to reduce or prevent social isolation or loneliness in people with ADRD were found to improve social behavior and QoL and enhance social interaction and social activities; however, they had no significant impact on cognition.

This review has several limitations. Despite our best efforts, we might have missed a few relevant meta-analyses or systematic reviews on social connections in ADRD. Also, there are other social factors affecting individuals with ADRD that we did not include here (e.g. healthcare access, stigma, macroeconomic policies that affect access to resources, etc.), but our focus was on social connections as these have been shown to have some of the largest effects on health and longevity (Holt-Lunstad *et al.*, 2017). There are also a number of noteworthy limitations of the individual studies that were included in the meta-analyses and systematic reviews. For example, many investigations were cross-sectional and, therefore, do not show causality. There was also considerable heterogeneity in the measured constructs, some of which had not been validated in persons with ADRD, and in study samples of patients and comparison groups, restricting generalizability of the results. The definitions of terms such as social engagement were often lacking or variable across studies. The assessment of heterogeneity of study findings, scientific quality, publication bias, and sensitivity analysis varied across the meta-analyses and was usually not performed in systematic reviews, as can be seen from Table 1. A number of studies did not adjust for relevant confounders including overlapping SDoHs such as socioeconomic status and disadvantaged neighborhoods. Most studies were predominantly conducted in high-income countries. Future studies should expand the research to low- and middle-income countries and also include immigrants who face additional problems in connecting with their newly adopted society.

This scoping review was conducted to characterize the developing literature on social connections and ADRD through the lens of meta-analyses and systematic reviews. We found a variety of outcomes through 11 meta-analyses and systematic reviews of longitudinal, case–control, and cross-sectional studies (e.g. social engagement, social activities, social network, social support, social isolation, and marriage) and eight interventions seeking to improve social health and social connections. As a greater number of meta-analyses and systematic reviews will be published in the near future on each of these unique topics,

umbrella reviews will be needed to synthesize the effect sizes, examine the study quality, and determine future directions.

While we present findings in terms of social connections' impact on ADRD, it may also be that persons predisposed to cognitive decline and ADRD may have poorer social connections or may socially isolate themselves years before a clinical diagnosis. A majority of the studies included in this paper were cross-sectional, and therefore, limited in establishing a cause-and-effect relationship. Data from the US Health and Retirement Study showed that loneliness at baseline predicted accelerated cognitive decline, and poor baseline cognition predicted greater loneliness over time, pointing to the potential bidirectional relationship between aspects of social relations and cognitive function (Donovan *et al.*, 2017). Data from the National Health and Aging Trends Study 2011–2018 surveys showed different trajectories of social isolation and dementia risk (Xiang *et al.*, 2021). Two-thirds of the low-risk dementia group were in the rarely isolated group. The high-risk dementia group had the most overlap with the decreasing social isolation group, followed by the persistently isolated group. A study of 5,753 older dementia-free Americans over 8 years reported that social isolation was associated with subsequent cognitive functioning and lower cognitive functioning was associated with greater subsequent social isolation (Qi *et al.*, 2023). Sleep disturbance partially mediated the effect of social isolation on cognitive functioning. Shen *et al.* examined bidirectional relationships between social isolation/social interaction and AD using Mendelian randomization method for assessing potential causal inference (Shen *et al.*, 2021). Of the five types of social engagement examined, only one showed evidence of an association with the risk of AD. Attendance at a gym or sports club was inversely associated with the risk of AD, suggesting that gym/sports club attendance may lead to a reduced risk of AD. Thus, the overall evidence for a direct causal link between social participation and dementia is not definitive due to limitations in observational research but is somewhat consistent and biologically plausible. Further studies are warranted to elucidate potential mechanisms.

Another confounding factor related to the association between social connections and cognitive function among persons with ADRD is the well-being and functioning of the family caregivers on whom they rely (Jeste *et al.*, 2021). As stressed by Van Orden and Heffner, social connection is an understudied target of intervention for the health of ADRD patients' family caregivers, and there is an urgent need for developing mechanism-informed and principle-driven behavioral interventions to promote social connection in these individuals (Van Orden and Heffner, 2022). A systematic review (Jeste *et al.*, 2021) focused on social support interventions for caregivers of persons with ADRD concluded that while multicomponent social support interventions may improve caregiver well-being, there was insufficient evidence to conclude whether a change in social support was the underlying mediating factor. Another systematic review reported preliminary evidence to support the acceptability of psychosocial interventions by dementia caregivers, although the available supporting evidence was limited (Dam *et al.*, 2016). A third systematic review of dementia care programs commented on limitations of the literature, although there seemed to be some positive effect on providing support and improving outcomes for persons living with dementia and their caregivers (Demanes *et al.*, 2021).

Our review did not include studies of risk for MCI. The reason is the marked heterogeneity in the course of cognitive decline in persons with MCI, indicating that that the risk factors for MCI may be different from those for ADRD. According to Peterson, the annual rate at which MCI progresses to dementia varies between 8 and 15% per year (Petersen, 2016). In a study of 739 participants with MCI from the National Alzheimer's Coordinating Center Uniform Data Set, after 3 years, 238 participants (33.6%) progressed to dementia, while 90 (12.2%) reverted to normal cognition (McGirr *et al.*, 2022). Thus, a majority of the persons with MCI do not develop ADRD at least over a period of several years. Nonetheless, future studies should examine risk factors for MCI.

Notwithstanding the limitations, this review supports the critical role of specific types of social connections – that is, social engagement and social activities, in reducing the risk of cognitive decline in older adults. Furthermore, the availability of efficacious technology-based and other interventions that enhance social connections suggests that promotion of social connections is a feasible and promising strategy to reduce the risk of ADRD. Below, we offer a number of suggestions for research and interventions for older people with cognitive impairments of different severity.

Methodologically sound research on SDoHs related to cognitive decline in older adults is urgently warranted. It should include the development and testing of pragmatic, reliable, and valid measures of social connections both at individual and community levels (Sturm *et al.*, 2023). Other relevant measures and possible confounding factors such as socioeconomic characteristics should also be examined. Prospective longitudinal studies in randomly selected large and diverse samples are recommended. A further direction for future research is examining the neurobiological effects of social connections as well as those of prosocial interventions in people with ADRD that might improve brain function and alter biomarkers of cognition, aging, and stress (Jeste *et al.*, 2023a). Higher levels of social engagement in older adults are reportedly associated with increased total brain and gray matter volumes as well as greater gray matter integrity in regions relevant to social cognition (Krivanek *et al.*, 2021). Also, some interventions that enhanced social engagement seemed to have a potential to boost brain health and cognitive reserve. An RCT of an intergenerational social health promotion program labeled Experience Corps showed that, compared to the control group, the purposeful activity embedded within the intervention arm of that program halted in women, and reversed in men, declines in brain volume in regions vulnerable to ADRD (Carlson *et al.*, 2015). Thus, a comprehensive biopsychosocial perspective should be employed to carry out meaningful research projects on social connections.

With the rapid growth and dissemination of digital technology as well as artificial intelligence, there is an unquestionable need to develop and test new interventions to promote social connections in older adults including those with ADRD. Hirt *et al.* (2021) reported on studies evaluating pet robots which resulted in improvement in behavioral emotion-related well-being, QoL, and functioning. While the results of the technology-based interventions were mixed, they hold promise for robots and digital interventions to improve social connectedness in people with ADRD. Rigorous studies with larger sample sizes are needed to evaluate the long-term effects of such strategies. While the research on digital interventions is nascent, it does show the potential of scalable support. The predominance

of robot/animatronic-based interventions is likely related to their low cognitive load and a high degree of usability, which stands in contrast to most current smartphone apps, virtual reality systems, and wearables. Implementation of technology-based interventions in routine healthcare practice is challenging for several reasons including low usability of internet-based interventions. The System Usability Scale has been increasingly applied to measure usability of industrial products (Mol *et al.*, 2020). Similarly, the Technology Acceptance Model is the most widely employed theory to explain the user acceptance of a particular technology (Feng *et al.*, 2021). It is based on the hypothesis (Davis *et al.*, 1989) that both perceived usefulness and perceived ease of use form the users' beliefs and intent regarding technology use. Today very few studies in geriatric neuropsychiatry employ the System Usability Scale or the Technology Acceptance Model. New efforts to capture, quantify, and design around any barriers to technology-based interventions in older adults, utilizing these methods, will help advance the next generation of technology-informed approaches.

In sum, empirical evidence supports the significant contribution of social engagement and social activities to reducing the risk of ADRD in older adults. As the number of people with ADRD will nearly double within a few decades (Jeste *et al.*, 2023b), innovative and scalable strategies are urgently needed to address this serious public health problem. Digital and other technology-based social interventions are likely to play an important role in this area.

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References

Bougea A, Anagnostouli M, Angelopoulou E, Spanou I and Chrousos G (2022). Psychosocial and trauma-related stress and risk of dementia: a meta-analytic systematic review of longitudinal studies. Journal of Geriatric Psychiatry and Neurology, 35, 24–37. 10.1177/0891988720973759. [PubMed: 33205677]

Carlson MC et al. (2015). Impact of the Baltimore Experience Corps Trial on cortical and hippocampal volumes. Alzheimer's & Dementia, 11, 1340–1348.

Dam AE, de Vugt ME, Klinkenberg IP, Verhey FR and van Boxtel MP (2016). A systematic review of social support interventions for caregivers of people with dementia: are they doing what they promise? Maturitas, 85, 117–130. 10.1016/j.maturitas.2015.12.008. [PubMed: 26857890]

Davis FD, Bagozzi RP and Warshaw PR (1989). User acceptance of computer technology: a comparison of two theoretical models. Management Science, 35, 982–1003. 10.1287/mnsc.35.8.982.

Demanes A, Ward KT, Wang AT and Hess M (2021). Systematic review of dementia support programs with multicultural and multilingual populations. Geriatrics (Basel), 7, 8. 10.3390/geriatrics7010008. [PubMed: 35076511]

Donovan NJ, Wu Q, Rentz DM, Sperling RA, Marshall GA and Glymour MM (2017). Loneliness, depression and cognitive function in older U.S. adults. International Journal of Geriatric Psychiatry, 32, 564–573. 10.1002/gps.4495. [PubMed: 27162047]

Edwards HB et al. (2018). Quality of family relationships and outcomes of dementia: a systematic review. BMJ Open, 8, e015538. 10.1136/bmjopen-2016-015538.

Evans IEM, Martyr A, Collins R, Brayne C and Clare L (2019). Social isolation and cognitive function in later life: a systematic review and meta-analysis. Journal of Alzheimer's Disease: JAD, 70, S119–S144. 10.3233/JAD-180501.

Feng GC et al. (2021). Determinants of technology acceptance: two model-based meta-analytic reviews. Journalism & Mass Communication Quarterly, 98, 83–104. 10.1177/1077699020952400.

Han A, Radel J, McDowd JM and Sabata D (2016). The benefits of individualized leisure and social activity interventions for people with dementia: a systematic review. Activities, Adaptation & Aging, 40, 219–265. 10.1080/01924788.2016.1199516.

Heins P et al. (2021). The effects of technological interventions on social participation of community-dwelling older adults with and without dementia: a systematic review. Journal of Clinical Medicine, 10, 2308. 10.3390/jcm10112308. [PubMed: 34070660]

Hickin N, Käll A, Shafran R, Sutcliffe S, Manzotti G and Langan D (2021). The effectiveness of psychological interventions for loneliness: a systematic review and meta-analysis. Clinical Psychology Review, 88, 102066. 10.1016/j.cpr.2021.102066. [PubMed: 34339939]

Hirt J et al. (2021). Social robot interventions for people with dementia: a systematic review on effects and quality of reporting. Journal of Alzheimer's Disease, 79, 773–792. 10.3233/JAD-200347.

Hogan BE, Linden W and Najarian B (2002). Social support interventions: do they work? Clinical Psychology Review, 22, 381–440. 10.1016/S0272-7358(01)00102-7.

Holt-Lunstad J (2022). Social connection as a public health issue: the evidence and a systemic framework for prioritizing the "social" in social determinants of health. Annual Review of Public, 43, 193–213.

Holt-Lunstad J, Robles TF and Sbarra DA (2017). Advancing social connection as a public health priority in the United States. American Psychologist, 72, 517–530. 10.1037/amp0000103. [PubMed: 28880099]

Holt-Lunstad J, Smith TB and Layton JB (2010). Social relationships and mortality risk: a meta-analytic review. PLOS Medicine, 7, e1000316. 10.1371/journal.pmed.1000316. [PubMed: 20668659]

Jeste DV et al. (2023a). Review of major social determinants of health in schizophrenia-spectrum psychotic disorders: III. Biology. Schizophrenia Bulletin, 49, 867–880. 10.1093/schbul/sbad031. [PubMed: 37023360]

Jeste DV (2022). Non-medical social determinants of health in older adults. International Psychogeriatrics, 34, 755–756. 10.1017/S1041610222000709. [PubMed: 36008366]

Jeste DV, Mausbach B and Lee EE (2021). Caring for caregivers / care partners of persons with dementia. International Psychogeriatrics, 33, 307–310. 10.1017/S1041610221000557. [PubMed: 33970060]

Jeste DV, Nguyen TT and Donovan NJ (2023b). Loneliness: Science and Practice. Washington, DC: American Psychiatric Publishing.

Jester DJ et al. (2023). Differences in social determinants of health underlie racial/ethnic disparities in psychological health and well-being: study of 11,143 older adults. The American Journal of Psychiatry, 180, 483–494. 10.1176/appi/ajp.20220158. [PubMed: 37038741]

Krivanek TJ, Gale SA, McFeeley BM, Nicastri CM and Daffner KR (2021). Promoting successful cognitive aging: a ten-year update. Journal of Alzheimer's Disease, 81, 871–920. 10.3233/JAD-201462.

Lenart-Bugla M et al. (2022). What do we know about social and non-social factors influencing the pathway from cognitive health to dementia? A systematic review of reviews. Brain Sciences, 12, 1214. 10.3390/brainsci12091214. [PubMed: 36138950]

Marks G and McVilly K (2020). Trained assistance dogs for people with dementia: a systematic review. Psychogeriatrics, 20, 510–521. 10.1111/psyg.12529. [PubMed: 32065698]

Martyr A et al. (2018). Living well with dementia: a systematic review and correlational meta-analysis of factors associated with quality of life, well-being and life satisfaction in people with dementia. Psychological Medicine, 48, 2130–2139. 10.1017/S0033291718000405. [PubMed: 29734962]

McGirr A, Nathan S, Ghahremani M, Gill S, Smith EE and Ismail Z (2022). Progression to dementia or reversion to normal cognition in mild cognitive impairment as a function of late-onset neuropsychiatric symptoms. Neurology, 98, e2132–e2139. [PubMed: 35351783]

Mol M et al. (2020). Dimensionality of the System Usability Scale among professionals using internet-based interventions for depression: a confirmatory factor analysis. BMC Psychiatry, 20, 218. 10.1186/s12888-020-02627-8. [PubMed: 32398111]

Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A and Aromataris E (2018 Nov). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Medical Research Methodology, 18, 143. [PubMed: 30453902]

Na P, Jeste DV and Pietrzak R (2023). Social disconnection as a global behavioral epidemic: a call to action to address social disconnection in health policy, education, research, and clinical practice. JAMA Psychiatry, 80, 101–102. 10.1001/jamapsychiatry.2022.4162. [PubMed: 36515940]

National Academies of Sciences, Engineering and Medicine (2020). Social Isolation and Loneliness in Older Adults: Opportunities for the Health Care System. Washington, D.C: The National Academies Press.

National Academies of Sciences, Engineering, and Medicine (2020). Social Isolation and Loneliness in Older Adults: Opportunities for the Health Care System. Washington, DC: The National Academies Press. 10.17226/25663

Neal D et al. (2021). Can use of digital technologies by people with dementia improve self-management and social participation? A systematic review of effect studies. Journal of Clinical Medicine, 10, 1–23. 10.3390/jcm10040604.

Penninkilampi R, Casey A-N, Singh MF and Brodaty H (2018). The association between social engagement, loneliness, and risk of dementia: a systematic review and meta-analysis. Journal of Alzheimer's Disease, 66, 1619–1633. 10.3233/JAD-180439.

Peters MDJ et al. (2021). Scoping reviews: reinforcing and advancing the methodology and application. Systematic Reviews, 10, 263. 10.1186/s13643-021-01821-3. [PubMed: 34625095]

Petersen RC (2016). Mild cognitive impairment. Continuum (Minneap Minn), 22, 404–418. 10.1212/CON.0000000000000313. [PubMed: 27042901]

Pinto-Bruno AC, García-Casal JA, Csipke E, Jenaro-Río C and Franco-Martín M (2017). ICT-based applications to improve social health and social participation in older adults with dementia: a systematic literature review. Aging & Mental Health, 21, 58–65. 10.1080/13607863.2016.1262818. [PubMed: 27936876]

Plassman BL, Williams JW, Burke JR, Holsinger T and Benjamin S (2010). Systematic review: factors associated with risk for and possible prevention of cognitive decline in later life. Annals of Internal Medicine, 153, 182–193. 10.7326/0003-4819-153-3-201008030-00258. [PubMed: 20547887]

Qi X, Pei Y, Malone SK and Wu B (2023). Social isolation, sleep disturbance, and cognitive functioning (HRS): a longitudinal mediation study. The Journals of Gerontology: Series A, 78, 1826–1833. 10.1093/gerona/glad004.

Rai HK, Kernaghan D, Schoonmade L, Egan KJ and Pot AM (2022). Digital technologies to prevent social isolation and loneliness in dementia: a systematic review. Journal of Alzheimer's Disease: JAD, 90, 513–528. 10.3233/JAD-220438.

Samtani S et al. (2022). Associations between social connections and cognition: a global collaborative individual participant data meta-analysis. The Lancet. Healthy Longevity, 3, e740–e753. 10.1016/S2666-7568(22)00199-4. [PubMed: 36273484]

Scott TL et al. (2022). Well-being benefits of horticulture-based activities for community dwelling people with dementia: a systematic review. International Journal of Environmental Research and Public Health, 19, 10523. 10.3390/ijerph191710523. [PubMed: 36078239]

Shen LX et al. (2021). Social isolation, social interaction, and Alzheimer's disease: a Mendelian randomization study. Journal of Alzheimer's Disease, 80, 665–672. 10.3233/JAD-201442.

Stites SD et al. (2022). Establishing a framework for gathering structural and social determinants of health in Alzheimer's disease research centers. Gerontologist, 62, 694–703. 10.1093/geront/gnab182. [PubMed: 34919705]

Sturm ET et al. (2023). Review of major social determinants of health in schizophrenia-spectrum psychotic disorders: II. Assessments. Schizophrenia Bulletin, 49, 851–866. 10.1093/schbul/sbad024. [PubMed: 37022911]

Taniguchi R and Ukawa S (2022). Participation in social group activities and risk of dementia: a systematic review. Open Public Health Journal, 15. 10.2174/18749445-v15-e2204141.

Valentí Soler M et al. (2015). Social robots in advanced dementia. Frontiers in Aging Neuroscience, 7, 133. 10.3389/fnagi.2015.00133. [PubMed: 26388764]

Van Orden KA and Heffner KL (2022). Promoting social connection in dementia caregivers: a call for empirical development of targeted interventions. The Gerontologist, 62, 1258–1265. 10.1093/geront/gnac032. [PubMed: 35235943]

Walker JD, Spiro G, Loewen K, Jacklin K (2020). Alzheimer's Disease and related dementia in indigenous populations: a systematic review of risk factors. Journal of Alzheimer's Disease, 78, 1439–1451. 10.3233/JAD-200704.

World Health Organization (2008). WHO Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health. Final report of the Commission on Social Determinants of Health. Geneva: World Health Organization.

World Health Organization. (2021). Fact sheets of dementia [Internet] [cited 2022 Apr 13]. Available from: https://www.who.int/news-room/fact-sheets/detail/dementia.

Wu-Chung EL, Leal SL, Denny BT, Cheng SL and Fagundes CP (2022). Spousal caregiving, widowhood, and cognition: a systematic review and a biopsychosocial framework for understanding the relationship between interpersonal losses and dementia risk in older adulthood. Neuroscience and Biobehavioral Reviews, 134, 104487. [PubMed: 34971701]

Xiang X et al. (2021). Dual trajectories of social isolation and dementia in older adults: a population-based longitudinal study. Journal of Aging and Health, 33, 63–74. 10.1177/0898264320953693. Epub. [PubMed: 32865104]

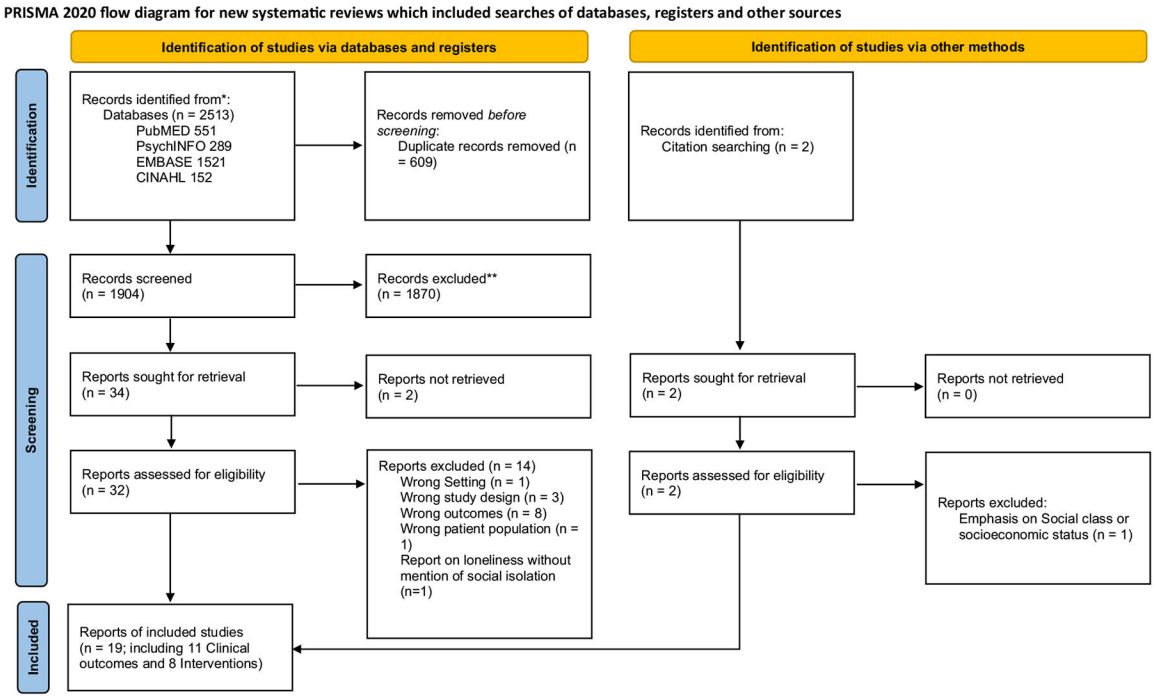

Figure 1.

Prisma flow chart.

*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

Table 1.

Meta-analyses and systematic reviews of studies on social connections related to cognitive decline and other clinical outcomes in Alzheimer's disease

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	SAMPLE SIZE	SOCIAL DETERMINANT(s) OF HEALTH	outcome(s)	META-ANALYSIS METHODS	FINDINGS
Bougea *et al.* (2022): Meta-analysis and Systematic review	13 studies; all longitudinal design; people with or without ADRD at baseline	N/A	Psychosocial stress: Work-related stress, SES inequalities, marital status, offspring status, PTSD, vital exhaustion or somatization of distress, and combined factors	Risk of ADRD (diagnosed by DSM-III,III-R, IV, V, NINCDS-ADRDA, NINDS-AIREN, or ICD–8,9,10) Results split into risk of AD vs. risk of dementia of any cause.	Heterogeneity: (1) forest plot visualization (2) null hypothesis of Cochrane's Q χ^2 test ($p < 0.1$) and (3) $I^2 = 82\%$ ($p < 0.01$) Publication bias: publication bias indicated given uneven distribution of studies shown in funnel plot. Egger's test was not performed. Quality Assessment: Quality of Prognosis Studies in Systematic Reviews (QUIPS): all but 7 included publications were rated as having adequate participation; all but 2 studies were noted to have 70% data on cognitive decline at follow-up, and all but 1 study were reported to have measured for potential cofounders. No studies met the quality statistics criterion for "no differences between participants and drop-outs" or "using sufficient methods" (though one study was listed as having insufficient information to judge this aspect). All but 2 studies failed to meet quality statistic criterion for "using sufficient methods." Sensitivity: No analyses reported.	• Marital status: In 5 studies, widowhood, divorce, and offspring death were associated with increased risk of overall ADRD but not specifically AD risk. • Combined stressors: In 5 studies, a greater number of psychosocial stressors was related to a "progressively higher risk" of dementia and AD. • No statistical analyses presented.
Edwards *et al.* (2018): Systematic Review	23 publications on 20 prospective and retrospective cohort studies in people with ADRD	N/A	Quality of relationship between a person with ADRD and their family carer	Incidence of institutionalization, hospitalization, QoL, death, behavioral, and psychotic symptoms of ADRD.	N/A	• Reported association between relationship factors and global challenging behavior, (most p values < .02) as authors note one study did not have effect sizes and another reported mean difference of 0.23 ($p < .05$) and the scale used had a large range of 1–144.

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	SAMPLE SIZE	SOCIAL DETERMINANT(s) OF HEALTH	outcome(s)	META-ANALYSIS METHODS	FINDINGS
						• Expressed emotion as a measure of "family environment" was associated with global challenging behaviors (mean difference: 1.9, 95% CI 0.77, 3.04; $p < 0.001$). • Risk of institutionalization, hospitalization, QoL, and death were not associated with caregiver relationship.
Evans *et al.* (2019): Meta-analysis and Systematic Review	65 articles with longitudinal design in persons without ADRD at baseline	102,035	Social isolation, assessed using measures of social network/contact, and social engagement/activity	Measures of global cognition (e.g. MMSE), episodic and semantic memory, and executive function.	Heterogeneity: Calculated using random effects model for (1) all social measures, (2) social activity, (3) social networks, and (4) measures that assess a combination of social activity and networks in relation to the cognitive measures assessed. All showed moderate or considerable heterogeneity other than combination of social activity and networks which had little heterogeneity. Publication bias: Egger's test: $b = 1.52$, 95% CI: 0.746, 2.285, $p < 0.001$, suggesting that results seemed to be overestimated due to publication bias. Quality Assessment: Critical Appraisal Skills Program checklist where higher scores indicate greater methodological quality (ranging from 14 to 42). The mean score of included articles was 38.1 (range 28–41). No articles had poor methodological quality. Sensitivity: No analyses reported.	• High engagement in social activity and larger social networks were associated with marginally better outcomes on cognitive measures with pooled correlation data (r = 0.054, 95% CI 0.043, 0.065).
Lenart-Bugla *et al.* (2022): Systematic Review	314 total studies; 17 SRs or MAs exploring 60 seperate"social factors"; people with or without ADRD at baseline	N/A	Social network (N = 13), social contacts (N = 12), social isolation, loneliness (N = 5), marital status (N = 9), social support (N = 6), participation in social activities (N = 5),	Various measures of cognitive health status including cognitive impairment and ADRD. Authors report the number of studies a given characteristic was	N/A	Associations based on reported results from individual articles without giving specific statistical analysis: • Less participation in social activities, having unsatisfying social ties, low social engagement, social isolation, being single, divorced, or widowed,

Int Psychogeriatr. Author manuscript; available in PMC 2024 April 29.

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	SAMPLE SIZE	SOCIAL DETERMINANT(s) OF HEALTH	outcome(s)	META-ANALYSIS METHODS FINDINGS	
			satisfaction with social ties (N = 5), and social engagement (N = 5)	reported as a risk factor, a protective factor, if inconsistent results were reported or if no association was found. Individual statistical measures were not reported.		and having a small social network "can contribute to an elevated risk of ADRD." • Greater social support and frequent social contact "may confer some protection against cognitive decline" and ADRD by reducing the risk or delaying the onset" but report findings to be inconsistent.
Martyr *et al.,* (2018): Meta-analysis and Systematic Review	307 articles: 282 journal manuscripts, 16 conference abstracts, 3 health technology assessment reports, 1 book chapter, 5 PhD theses; includes longitudinal and cross-sectional studies of persons with ADRD	37,639	For systematic review: 159 factors related to persons with ADRD and 69 related to carers 43 factors for meta-analysis: 33 related to persons with ADRD and 10 related to carers Main factors: Social engagement, Marital status, Quality of current relationship with carer, religiosity, spirituality, Living in the community	QoL, well-being, or life satisfaction measures in persons with ADRD. QoL measured with self-rated (IE. QoL-AD), informant-rated or proxy-rated (DEMQOL-Proxy) scales. Well-being measures included (PWB-CIP). Life satisfaction measures varied but include Life Satisfaction Questionnaire weighted effect sizes </= to 0.09 considered negligible; 0.10–0.29 considered small; 0.30–0.49 considered moderate; and >/= to 0.5 considered large.	Heterogeneity: I^2 measurement of between-study heterogeneity moderate-to-large for most factors. Publication bias: No findings reported. Assessment: Measured using a study quality checklist adapted from existing measures. Authors labeled 16 studies as poor quality, while the remaining studies were labeled as satisfactory or good quality. Quality sensitivity analysis: through inserting correlation = 0 for p values deemed to be nonsignificant and then repeated meta-analysis. Additionally, 14 articles deemed to be of poor quality were removed from the analysis. Both measures reportedly had limited impact on overall results.	• Greater social engagement [weighted effect r value 95% CI 0.31 (0.12, 0.48) p value .0017], better quality of current relationship with carer [weighted effect r value r 95% 0.38 (0.15, 0.48) p value .0019], and religious beliefs/spirituality [weighted effect r value r 95% CI 0.35 (0.12, 0.55) p value .0035], had moderate associations with better QoL. • Living in the community showed informant ratings [weighted effect r value r 95% 0.12 (0.06, 0.18) p value .0001] had small associations with better QoL. • Being married self-rating [weighted effect r value r 95% 0.08 (0.05, 0.11) p value < .0001]; informant rating [weighted effect r value r 95% 0.10 (0.06, 0.14) p value < .0001] had small association with better QoL.
Penninkilampi *et al.* (2018): Meta-Analysis and Systematic Review	33 studies (31 cohort and 2 case–control) in persons without ADRD at baseline	2,370,452	Social engagement characterized by marital status, living situation, social network size, degree of social support, degree of social satisfaction, frequency of social contacts, and frequency of participation in social activities. Also assessed loneliness and social isolation.	Risk ratio of ADRD. (Meta-analysis showed significant heterogeneity among studies as well as potential publication bias.)	Heterogeneity: Substantial heterogeneity in association of dementia risk with poor social engagement (I^2 = 94.3) but not with good social engagement (I^2<75.00). Publication bias: Not for the association between poor social engagement and increased dementia risk (p = 0.13), but significant bias for the	• Poor social engagement (RR = 1.41, 95% CI 1.21–.65) was significantly associated with increased risk of ADRD with individual components showing the following RRs: being unmarried (RR = 1.63, 95% CI 1.37–1.94), and having a poor social network (RR = 1.59, 95% CI 1.31–1.93). • Good social engagement (RR = 0.81, 95% CI 0.74–0.88) was negatively associated with risk of ADRD with individual components showing the

Int Psychogeriatr. Author manuscript; available in PMC 2024 April 29.

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	SAMPLE SIZE	SOCIAL DETERMINANT(s) OF HEALTH	outcome(s)	META-ANALYSIS METHODS	FINDINGS
					relationship between good social engagement and risk of dementia ($p < 0.001$). Quality Assessment using Newcastle–Ottawa Scale (9-star rating scale): In studies related to good social engagement, 9 were characterized as excellent and 8 as poor or adequate to good. In studies related to poor social engagement, 4 were characterized as excellent and 11 as poor or adequate to good. Sensitivity: No analyses reported.	following RRs: Being married (RR = 0.68, 95% CI 0.47–0.99), having many social contacts (RR = 0.85, 95% CI 0.77–0.93), and having a high level of social activity (RR = 0.62, 95% CI 0.48–0.82). • Loneliness was not significantly associated with increased risk of ADRD (RR = 1.38, 95% CI 0.98–1.94), and extensive social network, strong social support, and high social satisfaction were not associated with reduced risk of ADRD.
Plassman *et al.* (2010): Systematic Review	250 articles (127 observational studies, 22 RCTs, and 16 systematic reviews). 15 observational studies looking specifically at SDoH	42,950 in studies assessing SDoH	Social engagement characterized by marital status (N = 16,565), social network (N = 10,926), and social support (N = 15,459)	Varied measures of cognitive decline, such as MMSE.	N/A	• Social engagement (defined by marital status, social network, and social support) was not associated with cognitive decline; low evidence quality. No statistical analyses presented.
Samtani *et al.* (2022): Meta-analysis	13 cohort studies in persons without ADRD at baseline	38,614	Social connections characterized by being in a relationship or married, living with others, weekly interactions with family and friends, weekly community group engagement, relationship satisfaction, having a confidante, degree of social support, and never feeling lonely	Annual rate of change in global cognition (usually with MMSE), and scores on some specific cognitive domains: memory, executive function, and language skills.	Heterogeneity: Assessed using I^2 and tau^2 statistics. Described as low for most statistically significant findings (I^2 0–15%) though relationship between slower memory decline and living with others (I^2 = 58.3%) and slower memory decline and community group engagement (I^2 = 37.5–72.2%) had greater heterogeneity. Publication bias: Assessed using Egger's test and funnel plot visualization. Individual statistics listed in supplementary material, but no overall results or summary statistics provided. Quality assessment: STROBE statement checklist used to assess	• Being in a relationship or married (b = 0 · 010, 95% CI 0 · 000–0 · 019), living with others (b = 0 · 007, 0 · 002–0 · 012), and never feeling lonely (b = 0 · 047, 95% CI 0 · 018–0 · 075) were associated with slower global cognitive decline. • Living with others (b = 0 · 017, 0 · 006–0 · 028), weekly interactions with family and friends (b = 0 · 016, 0 · 006–0 · 026), and weekly community group engagement (b = 0 · 030, 0 · 007–0 · 052) predicted slower decline in memory. • Never feeling lonely predicted slower decline in executive function (b = 0 · 047, 0 · 017–0 · 077). • Living with others predicted slower decline in language skills (b = 0 · 008, 0 · 000–0 · 015). • Relationship satisfaction, having a confidante, and degree of social support were not predictive of decline in global

Int Psychogeriatr. Author manuscript; available in PMC 2024 April 29.

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	SAMPLE SIZE	SOCIAL DETERMINANT(s) OF HEALTH	outcome(s)	META-ANALYSIS METHODS	FINDINGS
					quality of included cohort studies. Authors did not report summary statement or statistics regarding quality of included studies. Sensitivity Analyses: Using "complete cases", authors reported that the results pattern was replicated.	cognition or memory, language or executive function.
Taniguchi & Ukawa (2022): Systematic Review	7 longitudinal, cohort studies in persons without ADRD at baseline	N/A	Participation in social group activities, including voluntary work, artistic activities, attending religious activities, and participating in community organization or events	Individual study hazard ratios for ADRD at follow-up with different time intervals (<5 years, 5–10 years, >10 years).	N/A	• Older adults participating in voluntary work had lower likelihood of having ADRD in two studies: HR = 2.44, 95% CI: 1.86–3.21 (3 years of follow-up); HR: 2.46, 95% CI: 1.89–3.24 (5 years). • Not participating in voluntary work and ADRD: follow-up < 5 years (HR = 1.27, 99% CI: 0.99 − 1.62); follow-up 5–10 years (HR = 1.10, 99%CI: 1.00–1.22) Follow-up > 10 years (HR: 0.96, 99%CI: 0.92–1.00). • Older adults participating in artistic activities had lower likelihood of having ADRD but not at >10 year follow-up: not participating in artistic activities: follow-up < 5 years (HR = 1.37, 95% CI 1.01–1.85); follow-up 5–10 years (HR = 1.19, 95% CI 1.06–1.34); follow-up > 10 years (HR = 1.04, 99% CI 0.99–1.09). • In older adults without ADRD, those who attended religious events daily or almost daily were less likely to have ADRD at follow-up (HR = 0.66, $p < 0.05$). • In adults aged 65–74 years, those regularly participating in community organizations/events were less likely to have ADRD at follow-up (HR = 0.75, 95% CI 0.64, 0.88) as were those holding a leadership position the community (HR = 0.81, 95% CI = 0.65, 0.99).
Walker *et al.* (2020): Systematic Review	13 studies: 3 review articles, 6 cross-sectional studies, 4 cohort studies; people	N/A	Reports on associations and risk factors in Indigenous populations including cultural and community connections and marital status.	Measures of risk (OR, PAR) or prevalence of ADRD. Definition of how individual studies	N/A	• Aboriginal Australians: Noting culture being a source of strength (OR 0.514, 95% CI 0.24–1.08) and feeling connected to community (OR 0.61, 95% CI 0.19–1.95) were associated with ADRD, though this was not statistically

Int Psychogeriatr. Author manuscript; available in PMC 2024 April 29.

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	SAMPLE SIZE	SOCIAL DETERMINANT(s) OF HEALTH	outcome(s)	META-ANALYSIS METHODS	FINDINGS
	with or without ADRD at baseline		Authors do not clearly define terms	defined ADRD is not included.		significant, while older adults reporting being connected to their culture had a nonstatistically significant negative with ADRD. • Indigenous people of East Malaysia: Being never married was not associated with ADRD (OR 1.85, 95% CI 0.39–8.89).
Wu-Chung *et al.* (2022): Systematic Review	64 studies: including both cross-sectional and longitudinal studies; people with or without ADRD at baseline	N/A	Spousal caregiving (N = 11, including 5 longitudinal) and spousal bereavement (N = 53, including 30 longitudinal)	Cognitive function and risk of ADRD in widow(er)s and caregivers. Measures of cognitive impairment included studies using incident ADRD and subtype by clinician diagnoses or chart review and specific tests (MMSE, AVLT, AD8, LNST, CDR, word recall, serial 7s, etc.) reported as single score or as composite scores.	N/A	• Spousal caregivers had higher incidence of ADRD, higher risk for cognitive impairment, poorer cognitive function at follow-up, and more rapid decrease in cognitive function over time than non-caregivers in 5 longitudinal studies. • 14 of 23 cross-sectional studies and 21 of 30 longitudinal studies examining bereavement status found widow(er)s exhibited significantly poorer cognitive function or were more likely to be diagnosed with ADRD or mild cognitive impairment (MCI) than non-widowed subjects. No statistical analyses reported.

AD = Alzheimer's disease, AD8 = The Eight-item Informant Interview to Differentiate Aging and Dementia, ADRD = Alzheimer's disease and related disorders, AVLT = Auditory Verbal Learning Test, CDR = Clinical Dementia Rating Scale, DEMQOL-Proxy = Quality of Life in Dementia – Proxy Assessment, DSST = Digit Symbol Substitution Test, LNST = Letter-Number Sequencing Test, MCI = mild cognitive impairment, MMSE = Mini-Mental State Examination, OR = odds ratio, PAR = population attributable risk, PTSD = post-traumatic stress disorder, PWB-CIP = Psychological Well-being in Cognitively Impaired Persons Scale, QoL = quality of life, QoL-AD = Quality of Life in Alzheimer's Disease, RR = relative risk, SES = socioeconomic status, VaD = vascular dementia.

Table 2.

Systematic reviews of technology-based and other social interventions to enhance social connections

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	TYPE OF INTERVENTION	OUTCOME(S)	FINDINGS
Technology-based interventions				
Pinto-Bruno *et al.* (2017): Systematic Review	6 articles using 10 different interventions in people with ADRD	Information and Communication Technology (ICT)-based applications	Social health and social participation in older adults with ADRD.	• ICT-based reminiscence intervention, called CIRCA, compared with a non-ICT-based reminiscence intervention (traditional reminiscence sessions or TRAD): people with ADRD using CIRCA made more choices ($t(10) = 3.6717$, $p < .005$); spent less time asking direct questions ($t(10) = 3.13$, $p < .01$), had higher levels of initiating conversation ($z = 2.03$, $p < .05$), and engaged in more singing ($t(10) = 2.191$, $p < .05$). • "Chittchatters" (CC) game, a leisure technological intervention as a facilitator of social behavior compared with reminiscence program without technology (Question Game or QG): social verbal behaviors during CC intervention (CC mean = 5.09, SD = 3.31) was higher than during QG intervention • (QG mean = 7.41, SD = 4.03; $p < .15$). • Other interventions reported only qualitative data with results suggesting benefit for people with ADRD from ICT interventions in maintaining, facilitating, and creating social networks.
Rai *et al.* (2022): Systematic Review	10 studies in people with ADRD or MCI	Digital technologies	QoL, depression, emotional responses, agitation, anxiety, loneliness, sleep quality, and perceived social support. N varied for different outcome measures.	• An intervention in which a projector shows animations and games on a table that respond to touch improved scores on a Quality of Life scale in the domains of negative affect, restlessness, tense behavior, and positive self image ($p \leq 0.04$), and on Discomfort scale ($p < 0.001$). • The studies below did not present statistical analyses. – In one study, VR headset with handheld controllers resulted in increased participation in social activities. A "virtual pet" displayed on a tablet controlled by staff members following a script reduced depressive symptoms, increased Montreal Cognitive Assessment score, and improved social interactions. Some participants who reported feeling attached to the virtual pet had increased anxiety. – A robot "torso" with a tablet PC that displays apps was used to encourage participants to do reminiscence and social engagement tasks on their own. There was improvement in resilience but not in depression or perceived social support. – A device designed to hold an iPad on wheels that allowed patients to participate in facilitated group activities improved peer interactions within and across care homes, improved quality of social ties with fellow residents, and other findings including re-relating to others, inclusion, being able to share stories and overcoming situational loneliness. – Participants who completed "a routine" with a humanoid robot able to listen, speak, move, and gesture paired with a moderator showed improvements in mood, loneliness, and depression. Authors note that

Int Psychogeriatr. Author manuscript; available in PMC 2024 April 29.

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	TYPE OF INTERVENTION	OUTCOME(S)	FINDINGS
				improvements in persons with ADRD were slightly greater than in those without ADRD. – Interactive robot cat reported to improve QoL and agitated behaviors. – Telepresence "Giraff" robot with screen that family members could operate remotely aimed at enhancing communication between people with ADRD and their family reported to reduce social isolation and increase connection. – TV delivering live chat, home exercise, and advice related to COVID-19 virus implemented into participants homes. Participants were able to receive support for the device via telephone. Authors report the intervention to be "effective as a cognitive stimulation and telehealth tool especially where face to face meetings were not possible …" and that this type of technology "may" reduce feelings of isolation. – Intervention included automated sun blinds, lighting, alerts, pathway lighting, and life circles (authors report life circles are "designed to allow for residents to access different areas in the home …") implemented into care homes. The intervention showed improvement in quality of life, including individual scores on social isolation, having things to do, esthetics, and quality of life appreciation. – A "virtual pet" displayed on a tablet controlled by staff members following a script was found to reduce depressive symptoms, increase Montreal Cognitive Assessment score, and improve social interactions. Participants who reported feeling attached to the virtual pet based on the Comfort from Digital Companion Animals Scale had increased Generalized Anxiety Disorder Assessment scores at the end of the intervention.
Hirt *et al.* (2021): Systematic Review	15 articles on 16 studies included people with ADRD	Social robot interventions separated into Pet robot, Humanoid robot, and Telepresence (social presence) robot studies	Behavioral, emotion-related, well-being, and QoL, medication-related, functional, and cognitive outcomes in people with ADRD.	• Results reported as author's interpretation of individual studies without quantitative results or statistical analyses. • Pet robots: – Behavioral outcomes: Statistically significant reduction in apathy, agitation, and persons with ADRD whose severity was characterized as "mild/moderate/severe" or "non-severe" when compared to usual care. Though the same effects were not seen on neuropsychiatric symptoms, wandering, or when severity of ADRD was unspecified. Cognition did not improve in any study. – Emotion-related outcomes: Various statistically significant positive results reported without specific statistical analyses in some but not all studies including: improvement in mood, reduction in depressive symptoms, "improved" anger and pleasure, improved positive affect. Studies and results varied in whether they included people with ADRD and the disease severity. – QoL outcomes: three out of 5 studies were characterized as "beneficial results."

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	TYPE OF INTERVENTION	OUTCOME(S)	FINDINGS
				– Functional outcomes: One study reported statistically significant reduced step count and physical activity in people with ADRD participating in a non-facilitated PARO robot intervention. The same study found reduced step count and physical activity at night. “Beneficial” statistically significant differences reported for pulse oximetry, pulse rate, and galvanic skin response which authors report were measures of “stress and arousal.” “positive effect” reported for performing ADLs. Authors report no benefit seen for sleep patterns, weight, blood pressure, heart rate, or cortisol levels. – Medication outcomes: Studies differed in reporting whether statistically significant difference was seen in reduction of pain, behavioral, or psychotropic medication dosages. – Cognitive outcomes: No statistically significant change observed. • Humanoid robots: – Behavioral outcomes: One study showed statistically significant reductions in apathy and neuropsychiatric symptoms in one cohort of participants, but the opposite results were observed in a separate cohort (Valentí Soler *et al.*, 2015). – Emotion-related outcomes: Statistically significant improvement in positive affect reported in one study. – QoL outcomes: No statistically significant change observed. – Cognitive outcomes: One study showed statistically significant reduction in “cognitive inertia” post-intervention, but no difference or worsened cognition in other measures. • Social Presence (Telepresence) robots: Only one case study of two persons included in primary review. Mixed results without statistical analysis given with regard to neuropsychiatric symptoms, disturbing behavior, QoL, ADLs, and cognition. Authors mention in discussion, a review of four studies of telepresence robots reporting potential to improve social connectedness in people with ADRD and their caregivers.
Heins *et al.* (2021): Systematic Review	37 articles on 36 studies included people with or without ADRD	Technological interventions targeting social participation or social isolation in older adults with and without ADRD	Loneliness, perceived social support, social isolation, social network size, social integration, social connectedness, social interaction, and social participation Scales varied by study and included UCLA Loneliness Scale, De Jong Gierveld Loneliness Scale, Multidimensional Scale of Perceived Social Support, Duke Social Support Index, Interpersonal Support Evaluation List, Lubben Social	• A quantitative study of participants with cognitive impairment showed initial improvement at 6 weeks with significantly higher social interaction of the group receiving individualized one-on-one mobile reminiscing therapy via an app vs. the comparison group who took part in a group intervention (t = 2.38, $p = 0.017$) and the control group who were participants on a waitlist for the interventions (t = 2.84, $p = 0.005$) that was not seen at 12-week follow-up. • Quantitative studies in older adults without cognitive impairment largely reported no statistically significant changes, with mixed results regarding loneliness. • For qualitative studies, older adults (2 out of 14 total studies focused on older adults with ADRD specifically), technological interventions promoted development or maintenance of social relationships or connections, improvement in social connectedness, companionship, social interaction, and communication, and decrease in loneliness. No statistical analysis was provided.

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	TYPE OF INTERVENTION	OUTCOME(S)	FINDINGS
			Network Index, and Medical Outcomes Study Social Support Survey.	• In mixed-method studies, 3 out of 10 reported statistically significant positive effects on social participation, while another reported statistically significant improvement in ability to use technology. One study reported a statistically significant decrease in total social isolation (t = 3.84, $p < 0.001$, $d = 0.74$) and loneliness (t = 7.53, $p < 0.001$, $d = 1.45$), but no statistically significant change in lack of social support after intergenerational technology tutorial sessions delivered by college students to noncognitively impaired older adults. Another study reported statistically significant decrease in loneliness in a group of older adults after interacting in a group using an "embodied conversational agent" ($F(1, 150) = 7.713$, $p < 0.01$). A third study which included a subset of participants who filled completed the R-UCLA Loneliness Scale before and after computer classes delivered by students reported a decrease in one item of the scale ("There is no one I can turn to") after the classes (p = 0.023). Remaining studies where statistical analyses were performed were not found to be statistically significant. Enhanced communication with loved ones through building technological skills, and decreased loneliness were reported as qualitative results.
Neal *et al.* (2021): Systematic Review	9 studies; 4 related to social participation; included people with ADRD or MCI	Technological interventions (virtual reality-based, wearable technology based, or software application based)	**Self-management** (measured by Instrumental Activities of Daily Living scale (LIADL), Adults and Older Adults Functional Assessment Inventory (IAFAI), among others); social participation (measured by self-reported satisfaction with social contacts, Dementia Quality of Life (DQoL), 36-Item Short-Form Health Survey (SF-36), Medical Outcome Social Support Survey (MOSS) among others) **Caregiver outcomes** (measured by Beck Depression Inventory (BDI-II), Care of Older People in Europe (COPE-index), or World Health Organization Quality of Life BREF (WHOQOLBREF)).	• Self-management outcomes: One study reported statistically significant improvement in LIADL scores in both experimental and control group comparison ($p < 0.001$, $\eta^2p = 0.87$) and "group by time interaction effects" ($p < 0.01$, $\eta^2p = 0.217$). Another stated improvements in this area were observed, though no statistical analyses were reported. A third evaluating effect of reviewing wearable camera footage twice weekly with a psychologist showed statistically significant improvement in Global IAGAI scores (visit effect: $F[2,43] = 16.26$, $p < 0.01$, $\eta^2p = 0.28$; group by visit interaction $F[2,43] = 8.71$, $p < 0.01$, $\eta^2p = 0.29$), and IADL familiar subscale: (visit effect: $F[2,43] = 5.31$, $p < 0.01$, $\eta^2p = 0.11$; group by visit interaction $F[2,43] = 5.40$, $p < 0.01$, $\eta^2p = 0.21$), IADL advanced subscale (visit effect: $F[2,43] = 11.74$, $p < 0.01$, $\eta^2p = 0.22$; group by visit interaction $F[2,43] = 4.83$, $p < 0.01$, $\eta^2p = 0.19$). Another reported statistically significant improvements on WHODAS 2.0 (measuring self-management and social participation, but subscale analysis not reported) (group effect $p < 0.01$, $\eta^2p = 0.341$; time effect $p < 0.05$, $\eta^2p = 0.128$; interaction effect $p < 0.01$, $\eta^2p = 0.191$). • Social participation outcomes: As reported above, one study reports statistically significant improvements on WHODAS 2.0 (measuring self-management and social participation, but subscale analysis not reported) (group effect $p < 0.01$, $\eta^2p = 0.341$; time effect $p < 0.05$, $\eta^2p = 0.128$; interaction effect $p < 0.01$, $\eta^2p = 0.191$). Another reports statistically significant "group by time" improvements for informational support ($p < 0.05$, $\eta^2p = 0.123$) and tangible support ($p < 0.01$, $\eta^2p = 0.186$) as measured by MOSS. The same study reported improvement in three-item loneliness scale with group effect ($p < 0.05$, $\eta^2p = 0.184$). • Caregiver outcomes: Statistically significant improvement in positive attitudes using COPE index ($p < 0.023$, effect size not reported).
Non-technology-based social interventions				
Scott *et al.* (2022): Systematic Review	8 articles (3 mixed methods studies, 2 qualitative	Horticulture-based activities	Social interactions or socialization, cognitive function, memory, physical function, well-being, and QoL	• Cognitive function: One study reported decline in MMSE scores pre- to post-intervention ($t(5) = 3.88$, $p = 0.012$) and reported improvement in well-being, though no statistical analysis was given. No statistically significant difference was reported in the only other study assessing cognitive outcomes.

Int Psychogeriatr. Author manuscript; available in PMC 2024 April 29.

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	TYPE OF INTERVENTION	OUTCOME(S)	FINDINGS
	studies, 2 quantitative studies, and 1 case study); 5 articles assessing social interactions, participants were people with ADRD living in the community		5 studies reported a standardized assessment tool (MMSE, Geriatric Depression Scale-15, Wechsler Memory Scale-Revised, Five-item Observed Emotion Rating Scale, dementia care mapping tool, Lubben Social Network Scale 6, etc.).	• Memory outcomes: No statistically significant difference reported. • Physical Function: No statistically significant difference reported. • Social interaction: Based on dementia care mapping tool, results from one intervention reported as " … observed working together toward certain goals and having common objectives and experiences, which promoted shared communication about the horticulture activity program and about their experience living with dementia." Another intervention was "helped to develop new social bonds …" One intervention reportedly "created a sense of identity and enabled a connection to others and the development of intimate relationships." A fourth study "appeared to support social interaction amongst participants." The one study using a structured assessment, Lubben Social Network Scale 6, found not statistically significant difference pre- and postintervention. • Well-being and QoL: One study reported "high levels of observed well-being for 77.42%" of time spent in intervention and reported care partners reported that this continued after the intervention. A single-blinded randomized control trial assessed pre- and post-intervention Short-Form Health Survey-12 scores and found no statistically significant improvement. This study as well as the rest of the studies looking at well-being and QoL reported subjective improvements reported by participants or reportedly observed, but none provided statistical analyses.
Marks and McVilly (2020): Systematic Review	24 articles in people with ADRD	Trained assistance dogs	Mood, prosocial behaviors, daily activity/quality of life, cognitive impairment, existential function measured using Scales (MMSE, Geriatric Depression Scale, Cornell Depression in Dementia Scale, etc.), physiologic measures of stress (change in cortisol levels, salivary chromogranin A (CgA), or subjective observation.	• Decrease in behavioral pathology (measured by Behave – AD scale) at 3-month follow-up from an average baseline score of 11.14 (± 4.85) to 7.29 (± 7.11) ($p < 0.05$) in the experimental group; no significant difference in the control group. • Reported themes of "enhanced communication with volunteers" and "increased trust" as evidenced by interviews with participants in an experimental group in one study. • "Statistically significant increase" in social interaction in experimental group, though specific measures or analyses were not reported. • Studies with outcomes related to existential function showed increased or sustained self-determination, ability to reflect and remember, and to place oneself in the world. • For cognitive impairment: One study reported mean MMSE increase of 4.5 ($p = 0.06$) in experimental group compared with 2 ($p = 0.0941$) for the control group. Another reported slowing of cognitive decline based on the Alzheimer's disease Assess Scale, though specific analyses were not reported. A third reported improvement in "mental function," but only between the 6- and 12-month interval during the intervention measured by Mental Function Impairment Scale with no specific analyses reported. • Inconsistent results with irritability and agitation, mood, daily activities, and QoL.
Mixed technology-based and other social interventions				
Han *et al.* (2016): Systematic Review	32 studies in people with ADRD	Individualized social and leisure activities in people with ADRD, simulated presence therapy (SPT), and individualized	Varied outcomes: agitation, disruptive or withdrawn behaviors, social interactions, overall QoL, depression, and cognition.	• SPT produced reduction in agitation and disruptive or withdrawn behaviors and increase in social interactions, compared to alternative interventions or standard of care; however, one-on-one interactions had superior benefit in decreasing agitation compared to SPT. • Audio SPT may be unsuitable for people with ADRD and history of hallucinations.

Int Psychogeriatr. Author manuscript; available in PMC 2024 April 29.

AUTHOR (YEAR) STUDY TYPE	# OF ARTICLES INCLUDED	TYPE OF INTERVENTION	OUTCOME(S)	FINDINGS
		reminiscence therapy (IRT) in people with ADRD		• IRT improved overall QoL and depression symptoms but did not have effect on cognition in the one reported RCT.

AD = Alzheimer's disease, ADRD= Alzheimer's disease and related disorders, MCI = mild cognitive impairment, MMSE = Mini-Mental State Examination, OR = odds ratio, QoL = quality of life; RCT = randomized controlled trial.