Social participation and risk of developing dementia

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The increasing number of people with dementia globally illustrates the urgent need to reduce dementia's scale and impact. Lifetime social participation may affect dementia risk by increasing cognitive reserve, and through brain maintenance by reducing stress and improving cerebrovascular health. It may therefore have important implications for individual behavior and public health policy aimed at reducing dementia burden. Observational study evidence indicates that greater social participation in midlife and late life is associated with 30–50% lower subsequent dementia risk, although some of this may not be causal. Social participation interventions have led to improved cognition but, partly due to short follow-up and small numbers of participants, no reduction in risk of dementia. We summarize the evidence linking social participation with dementia, discuss potential mechanisms by which social participation is likely to reduce and mitigate the impact of neuropathology in the brain, and consider the implications for future clinical and policy dementia prevention interventions.

Dementia is highly prevalent with 50 million people globally estimated to currently have dementia, and is forecast to grow markedly so that by 2050 there will be 152 million people living with dementia worldwide[1]. Dementia has a substantial impact on individuals and their families and is reported to be the most feared condition in older people[2]. Health and social care costs are estimated to be US $263 billion per year globally, with this figure forecast to rise to US $1.6 trillion by 2050, accounting for 11–17% of all health care spending[3]. The public health impact of dementia calls attention to the need to identify approaches to delay or prevent dementia. Projections indicate that delaying dementia onset by 5 years would halve prevalence[4], and a 3-year delay would reduce dementia cost by one-third[5].

There is suggestive evidence that changes in behaviors and improvements in health during the life course affect the risk of developing dementia. This is supported by studies of successive generations of older people showing that age-standardized dementia incidence and prevalence rates in several high-income countries have changed[6], attributed to better health and education[7]. For example, in the UK Cognitive Function and Ageing Studies, a 20% reduced incidence rate was observed between 1990 and 2010 (ref. [8]) and in the US Health and Retirement Study, the prevalence rate decreased by 13% between 2000 and 2012 (ref. [7]). These findings have been replicated in other settings, although the opposite trend has been found in Japan[9]. Dementia rates may have declined through adoption of a healthier lifestyle, such as reduced tobacco smoking[10] or alcohol intake, and earlier and more effective treatment of hypertension[11] and diabetes[12], or better access to education[7]. Conversely, an increasingly Western diet and physical inactivity leading to metabolic syndrome may account for Japan's increased dementia prevalence rate[13].

The overall evidence was summarized in the 2020 Lancet Commission for Dementia Prevention, Intervention and Care, which estimated that 12 potentially modifiable risk factors—lower education,

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hypertension, hearing impairment, smoking, obesity, depression, physical inactivity, diabetes, alcohol intake, poor sleep, air pollution and low social participation—may account for 40% of worldwide dementia risk[14]. The proportion may be higher in low-income and middle-income countries where these risk factors overall are more common, although there is variation between and within countries in the prevalence of individual risk factors[15,16].

Social participation has attracted interest as a potential factor influencing general health and well-being, as well as specifically cognitive health and risk of dementia; it may promote healthy lifestyles, reduce stress and build cognitive health. Furthermore, longstanding societal changes and those related to the coronavirus disease 2019 (COVID-19) pandemic have increased the focus on social isolation and loneliness[17,18]. The 2019 World Health Organization's (WHO) guidelines on risk reduction for cognitive decline and dementia[19] did not include social participation, but subsequent research findings in this area necessitate reexamination of the role of social participation.

Understanding the association between different aspects of social participation with dementia risk is important as it could guide measures to improve social participation behaviors at the individual and societal levels. While societal changes may contribute to social isolation and reducing social participation, there is little research evidence on social participation trends over past decades. Some studies show that formal social participation increased in older adults in the USA[20], and loneliness levels in Swedish older adults were stable between 1992 and 2014 (ref. [21]). The COVID-19 pandemic brought focus on social isolation and participation as measures to curb disease spread led to social distancing in most countries whereby reducing social participation was mandatory, with subsequent effects on mental health[22]. Social participation has not returned to pre-pandemic levels, and the effect of these changes on the health of older adults and on the risk of dementia remains unclear. However, some evidence suggests that people with dementia deteriorated more rapidly during the pandemic[23], emphasizing the importance of considering whether and how to target increasing social participation.

Social participation is defined as 'a person's involvement in activities providing interactions with others in community life and in important shared spaces … based on the societal context and what individuals want and is meaningful to them'[24]. We will use the term here to encompass engagement of individuals in sociable leisure activities (with focus on activities that are undertaken with other people), contact with social networks and their satisfaction with this participation. Definitions of this and related constructs are in Table 1.

In this Review, we aim to elucidate the links between social participation and dementia risk to inform current and future approaches to prevent dementia through clinical interventions and policy measures to increase social participation. We do so by examining the current observational and interventional evidence on social participation and the associated risk of dementia and the mechanisms underlying these links. We conclude this Review by summarizing the implications for future treatments and policy.

Association between social participation and dementia

There is growing epidemiological evidence for an association between aspects of social participation and risk of dementia. These observational studies have examined social participation in midlife or late life and followed participants to compare dementia incidence, usually ascertained from clinical examination using diagnostic criteria or health records, between those with more and less social participation. Diagnosis of the cause of dementia (for example, Alzheimer's disease or vascular dementia) is typically not ascertained with high-quality examination in these studies. Methods used to assess social participation have largely relied on self-report questionnaires completed by participants. These include validated scales such as the Berkman–Syme Index[25] for

Table 1 | Glossary of terms relating to social participation

Term	Definition
Social participation	Engagement of individuals in social leisure activities (focusing on activities undertaken with other people), contact with social networks and their satisfaction with this participation.
Social activity engagement	Taking part in leisure activities within the communities in which people live, including activities undertaken with other people that are social, physical and mentally stimulating[145,146].
Social contact	A quantitative measure relating to visiting or communicating with relatives, friends and acquaintances, usually but not necessarily as a recreational activity; and not encompassing qualitative aspects of satisfaction with social contact.
Social network	The web of social relationships that surround an individual and the characteristics of those ties[145,146].
Social isolation	The inadequate quality and quantity of social relations with other people at different levels of human interaction (individual, group, community and the larger social environment)[147].
Social interaction	The quality of the verbal and nonverbal behaviors that are exercised between an individual and others in their surroundings.
Loneliness	A subjective unpleasant experience that occurs when a person's network of social relationships is deficient in quality[148].
Social support	The exchange of resources is intended to enhance the well-being of the recipient, including emotional and instrumental support[149].

aspects of social network contact, and the UCLA scale[26] for assessing loneliness. Several unvalidated scales, created for the purposes of a study, have been used to assess participation in social activities.

Social activity engagement

Accumulating evidence suggests that having less engagement in social activities is associated with higher relative risk of dementia[27–30] (Fig. 1). Such studies generally combine activities into a composite activity scale regardless of how social these activities are; some involve other people (board games or group discussions), while others are solitary (crosswords and reading).

However, a major challenge of observational research of risk factors for dementia is the potential for reverse causation underpinning observed associations, so follow-up duration must be considered in this literature. Pathological changes develop decades before the diagnostic threshold for dementia is reached, and some symptoms of dementia precede diagnosis by many years during this preclinical phase[31,32]. Thus, establishing that a particular characteristic or behavior is present before dementia diagnosis does not confirm its status as a risk factor, as that characteristic may instead be an early consequence of dementia pathology arising during dementia development.

Many studies have a short follow-up; for example, five of the seven studies in one review of the effect of cognitive leisure activities had less than 6 years of an interval between activity measurement and dementia assessment, and all these studies found significant associations, whereas the remaining two studies, with 9 and 12 years of follow-up did not[27]. To reduce the risk of reverse causation, studies require a long interval between measurement of social participation and assessment for dementia and should exclude people with impaired cognitive status at baseline. Recent studies in the UK, Japan and China with 8–15 years of follow-up have linked more social engagement, participation in cognitive, intellectual and social activities,
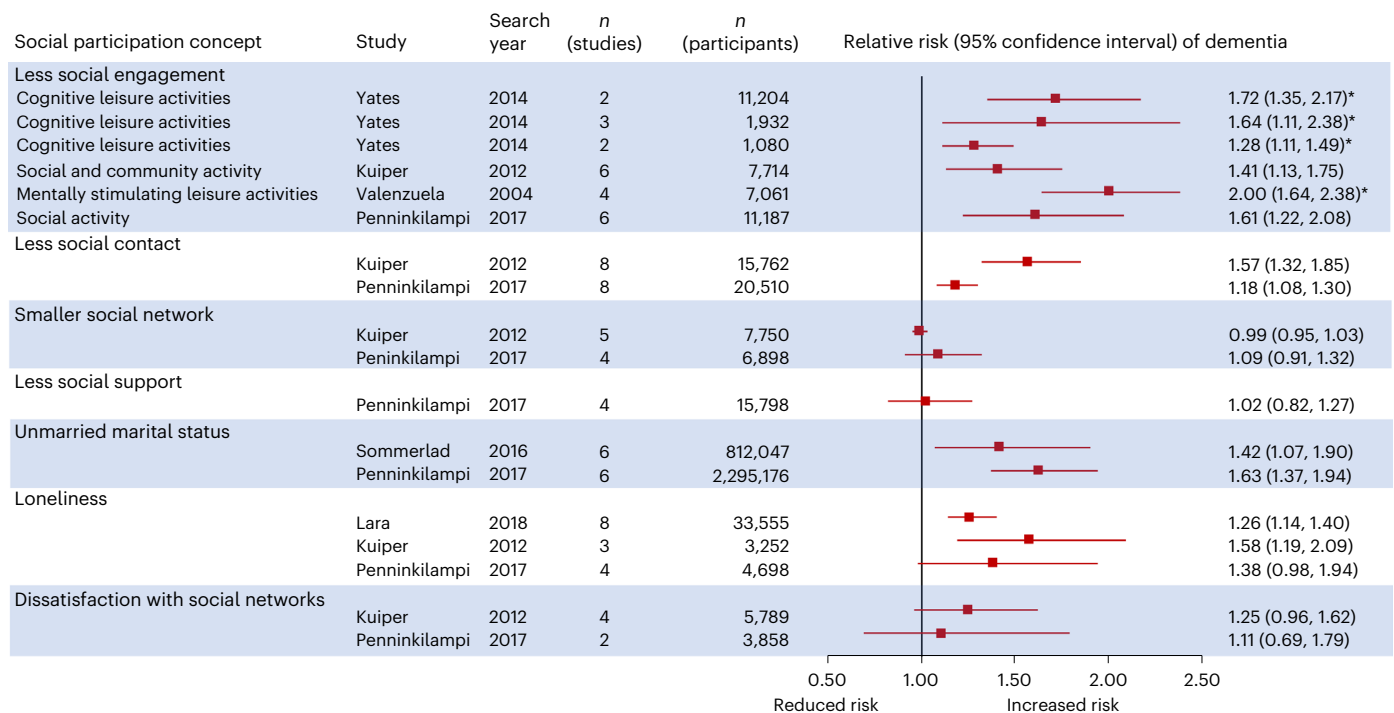
Social participation concept	Study	Search year	n (studies)	n (participants)	Relative risk (95% confidence interval) of dementia
Less social engagement					
Cognitive leisure activities	Yates	2014	2	11,204	1.72 (1.35, 2.17)*
Cognitive leisure activities	Yates	2014	3	1,932	1.64 (1.11, 2.38)*
Cognitive leisure activities	Yates	2014	2	1,080	1.28 (1.11, 1.49)*
Social and community activity	Kuiper	2012	6	7,714	1.41 (1.13, 1.75)
Mentally stimulating leisure activities	Valenzuela	2004	4	7,061	2.00 (1.64, 2.38)*
Social activity	Penninkilampi	2017	6	11,187	1.61 (1.22, 2.08)
Less social contact					
	Kuiper	2012	8	15,762	1.57 (1.32, 1.85)
	Penninkilampi	2017	8	20,510	1.18 (1.08, 1.30)
Smaller social network					
	Kuiper	2012	5	7,750	0.99 (0.95, 1.03)
	Peninkilampi	2017	4	6,898	1.09 (0.91, 1.32)
Less social support					
	Penninkilampi	2017	4	15,798	1.02 (0.82, 1.27)
Unmarried marital status					
	Sommerlad	2016	6	812,047	1.42 (1.07, 1.90)
	Penninkilampi	2017	6	2,295,176	1.63 (1.37, 1.94)
Loneliness					
	Lara	2018	8	33,555	1.26 (1.14, 1.40)
	Kuiper	2012	3	3,252	1.58 (1.19, 2.09)
	Penninkilampi	2017	4	4,698	1.38 (0.98, 1.94)
Dissatisfaction with social networks					
	Kuiper	2012	4	5,789	1.25 (0.96, 1.62)
	Penninkilampi	2017	2	3,858	1.11 (0.69, 1.79)

0.50   1.00   1.50   2.00   2.50
Reduced risk   Increased risk

Fig. 1 | Key findings from systematic reviews of observation studies of social participation and dementia risk. Summary of the evidence from six systematic reviews[27,37–39,44,144] about the association in epidemiological studies of different aspects of social participation with dementia risk. Relative risks indicate the risk of dementia associated with having less social participation; those marked with an asterisk were inverted from the published paper for consistency.

membership of social organizations and community engagement with lower dementia risk[28–30,33,34].

Further insight can be gained from examination of trajectories of engagement in social activities leading up to dementia diagnosis using data from studies with repeated assessments of social participation. In two such studies of UK adults, not participating in social or leisure activities was associated with higher risk of dementia only with less than 10 years of follow-up[35,36]. And two studies found that declining social activity engagement was associated with higher dementia risk[28,35] suggesting that this decline occurs during the preclinical phase of dementia.

Altogether, less frequent engagement with social and leisure activities is linked with elevated subsequent dementia risk, but this association is at least partly due to reverse causation. Social activity engagement frequently co-occurs with cognitively stimulating activity, and social contact with others, so the specific contribution of activity engagement is unclear.

Social networks and social contact

Less frequent social contact with others is shown in two reviews to be associated with higher risk of dementia[37,38] (Fig. 1.). Being unmarried, taken as a marker for having less lifetime social contact with others, is associated with elevated risk of dementia in two systematic reviews[38,39] (Fig. 1). One study found that having children was associated with lower dementia risk[40], partly linked to marital status. Marital and parental status may also influence individuals' ability to manage their health, and access informal care, which may account for some of this association. By contrast, simply having a smaller social network has not been found to be associated with dementia risk[37,38], suggesting that interacting with people frequently, rather than interacting with more people, is important.

Duration of follow-up may again explain the inconsistency in results from these studies; seven of the eight studies in one of the reviews had less than 4 years of follow-up, and so it is impossible to judge the direction of causation[37]. However, a subsequent study with a longer duration of follow-up found that less frequent social contact in UK adults at age 60, particularly with friends rather than relatives, was associated with greater dementia risk and worse cognitive decline 15 years later[41]. Two studies of participants in the UK Biobank study with 9 years[42] and 12 years[43] of mean follow-up found that dementia risk was higher for those who were more socially isolated, with this finding consistent across different levels of genetic risk[42] and linked to lower gray matter volume[43].

Hence, there is strong evidence that frequent social contact with others, but not having a larger social network, reduces the risk of dementia.

Subjective aspects of social participation

Three reviews found that reporting loneliness is associated with greater dementia risk compared to people who were not lonely[37,38,44] (Fig. 1). Five subsequent studies of loneliness in the USA over 10 years[45–47], over 14 years in Sweden[48] and over 5 years in Japan[49] have found it to be associated with 34–91% elevated dementia risk. Some of these studies found the association to persist after adjusting for potential confounders including social isolation[46,49,50]. However, studies of UK adults found that loneliness was not independently associated with dementia risk and that the unadjusted association was probably mediated by depression symptoms[42,43]. Reporting less social support was also unrelated to dementia risk in a systematic review[38], although a recent study of Korean adults with 10 years of follow-up found low emotional, but not practical, support was associated with elevated risk of all-cause dementia and Alzheimer's disease in women, but not men[51]. The inconsistency in these findings may be due to measurement error because few of the included studies used validated scales measuring loneliness; cultural variation in conceptualization and expression of loneliness; duration and perceived intensity of loneliness exposure; and differences in studies' adjustment for potentially explanatory covariates especially social isolation, socioeconomic status and depression.

These findings suggest that loneliness but not perceived social support is associated with higher dementia risk, but it is unclear whether this association is only a consequence of having more social contact with others.

Social participation and cognitive decline

Our Review focused on dementia as the most clinically important syndrome, but some studies considered the link between social participation and conditions along the disease pathway such as mild cognitive impairment[52], providing further supportive evidence. Several studies have also examined the association of social participation with decline in cognitive function, which is relevant as cognitive decline is the core feature of dementia. While associations between potential risk factors and cognitive decline cannot directly indicate elevated dementia risk, the finding of an association is consistent with this possibility[53]. Two systematic reviews of social relationships and cognitive decline found that both the quantity and quality of social relationship participation were linked to subsequent increased risk of cognitive impairment[54,55]. However, the methodological quality of included studies precluded strong conclusions about beneficial aspects of social relationships for cognition, and the direction underpinning the association was unclear as 15 of the 19 studies had less than 5 years of follow-up, meaning that reverse causation was likely.

A further review found associations between social activity, networks and support and global cognitive function, although similar limitations apply to this Review[56]. Subsequent studies of German adults over 85 years found that small and declining social networks were associated with worse cognitive decline[57] and this finding was replicated in a study of Japanese adults who were followed for over 10 years[58]. Employment is frequently a source of social contact for many, and previous studies have found that retirement is associated with cognitive decline[59–61], which may indicate that withdrawal from work-related social networks has detrimental effects on cognitive function. However, leaving employment does not only cause loss of social contact, but may reflect loss of cognitively stimulating occupation, physical labor, social status and income, and the direction of the relationship is not clear as individuals with already declining cognitive function may be more likely to retire if given a choice. The report that countries in which people retire younger have a higher rate of declining cognition compared to countries with later retirement age suggests that there may be some causal relationship[62]. In line with this is the finding of more memory loss in retirees in a study adjusting for health as well as sociodemographic factors[63].

A systematic review of studies on loneliness and cognitive decline found that loneliness was associated with worse general cognitive function, intelligence quotient, processing speed and delayed and immediate recall[64]. However, confounding factors such as depression and social isolation may also have contributed to these findings. Furthermore, the directional relationship between cognitive impairment and loneliness was not clear as, for example, one study found that poor verbal ability predicted loneliness later in life[65].

More social network contact and less loneliness is associated with lower cognitive decline, which is consistent with a protective effect against dementia, although methodological limitations in this literature persist. Retirement is associated with cognitive decline, which may partly be due to less social participation.

Limitations of observational evidence

The epidemiological evidence is limited by the probability of reverse causation in studies with a short follow-up that have typically found strong associations of social participation with lower dementia risk. Studies with a longer follow-up have found mixed results and, where a protective effect was reported, the magnitude of associations has generally been small. Whether this is because of lower bias from reverse causation in these studies or greater effect dilution bias due to exposure

misclassification remains unclear. In long-term follow-up studies, a single baseline measurement may not accurately indicate social participation across the life course, and the longer the follow-up is, the more likely changes in social participation are to occur, contributing to exposure misclassification, resulting in artificial attenuation of effect estimates. These findings highlight the importance of studies with longer-term follow-up and repeated assessment of social participation, ideally comprising age ranges from early adulthood or even earlier. Such studies would allow further exploration of the life-course influence of social participation on dementia risk, including the ability to identify whether there are critical or sensitive risk periods, or whether an effect of social participation on dementia results from accumulation or chains of risk, guiding future interventions. Ultimately, it is likely that there is a bidirectional relationship between social participation and dementia, whereby low participation accelerates cognitive decline, and this decline impairs social participation.

Confounding is a major source of bias in observational evidence. Associations persisted in studies that adjusted for a wide range of potential confounders, but it is possible that residual confounding persists. Other study designs, such as Mendelian randomization, may help to tackle reverse causation and minimize other sources of confounding, and evidence from one study suggests only partial benefit of social engagement[43,66]. There is evidence of publication bias in the literature as reported in two reviews[38,54]. Sharing data to combine cohorts in larger, individual participant-data meta-analyses[67] may help to address publication bias, and increase power and generalizability of the findings. Many studies tend to recruit people with lower risk[68,69] who are less likely to develop dementia than the general population meaning that findings may not be generalizable.

Most meta-analyses dichotomize the social exposure variables although social participation is not a binary concept, so nuanced examination to clarify dose–response associations and different dimensions of social participation, as used in some studies[41], would be beneficial. The heterogeneity in social participation measurement related to the different construct definitions and the lack of validated established instruments is another contributing factor to the heterogeneity in findings. There is also limited evidence for whether social participation has a differential effect on different subtypes of dementia, as relatively few studies have examined dementia subtypes. One study found that the association of leisure activity participation was similar for Alzheimer's dementia and vascular dementia[70], and results were inconsistent for whether marital status association with dementia differed for Alzheimer's and vascular etiology[39].

Social participation is culturally patterned, making it important to understand how the contribution of social participation varies in different settings. Most studies have been conducted in North America, Europe and China, and there is little consistency in the findings (Fig. 2). This may be due to differences in study design and measurement of social participation in these studies. It may also reflect that social participation effects differ across settings as the nature of the participation and associated health behaviors vary. The prevalence of social behaviors is also likely to be conditioned by contextual factors, for example, social isolation is reported less commonly in Latin American countries, India and China than the global average[15]. Within countries, there is also ethnic and socioeconomic variation in social participation, for example, in Aotearoa/New Zealand, the contribution of social isolation to dementia risk was greater in European and Māori populations groups than Asian and Pasifika populations[71], and in Brazil it was greater in poor regions than wealthy ones, although there was no ethnic variation[16]. Interventions therefore need to be designed with consideration to culture and social environments and target different components of social participation to be acceptable and effective in different cultures.

In summary, major methodological limitations of previous observational literature on social participation and dementia risk include reverse causation bias, confounding, publication bias, poor
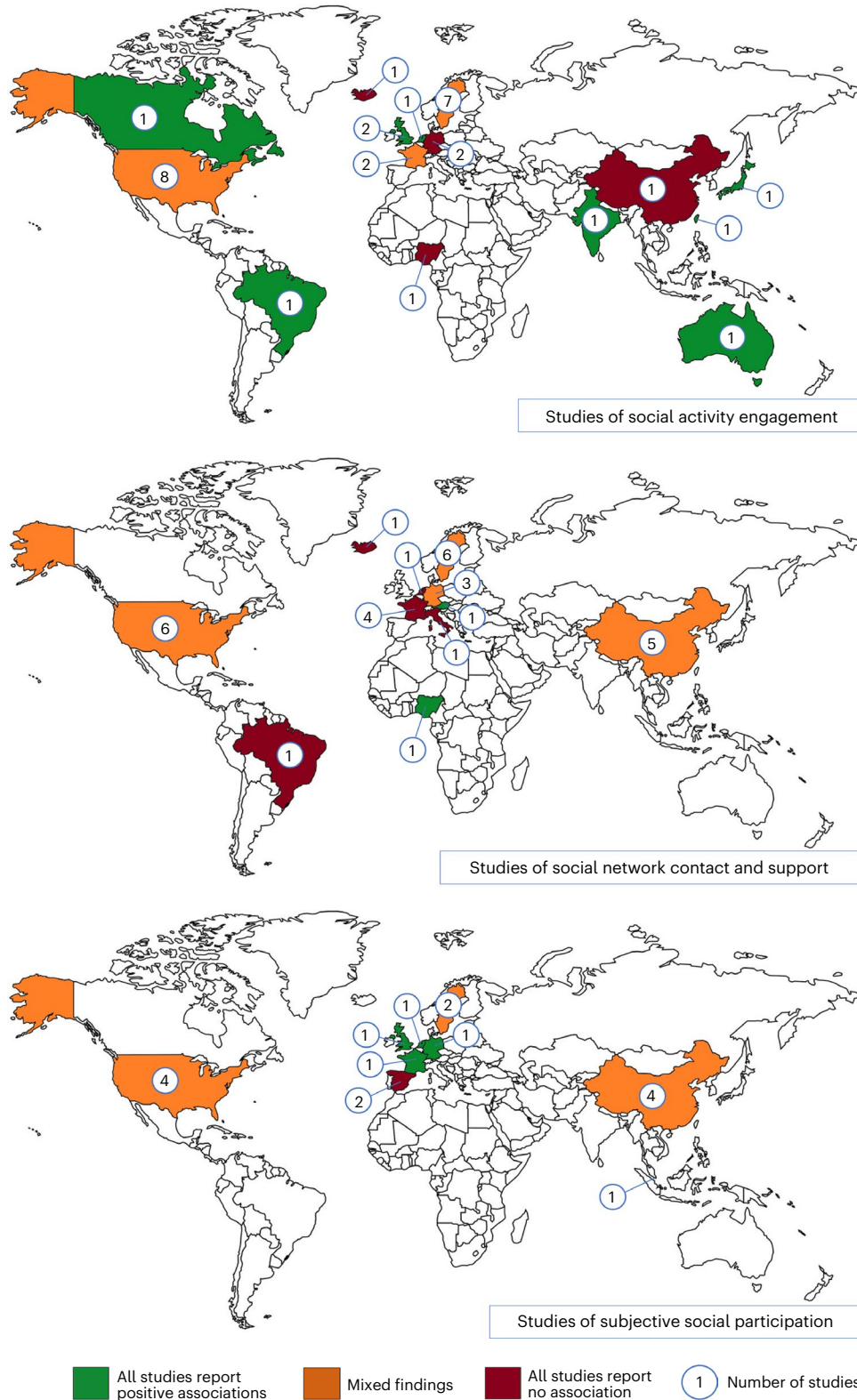
Fig. 2 | Observational studies on social participation and dementia risk.
Summary of the findings of studies included in six systematic reviews of observational studies related to social participation and dementia[27,37–39,44,144], according to the country studied. Studies were divided into those examining social activity engagement, social network contact and support and subjective aspects of social participation. The number of studies of each kind conducted in each country and the consistency of findings are shown. Green indicates countries where all included studies found that more social participation was associated with lower dementia risk (positive association). Red indicates countries where all studies found no association. Orange indicates mixed findings.

generalizability and measurement error. There are few studies in lower-income and middle-income countries, thus we do not know whether these findings generalize to these settings.

Potential underlying mechanisms

Social participation could plausibly result in reduced dementia risk, irrespective of genetic risk[42,72], through one or more mechanisms. These
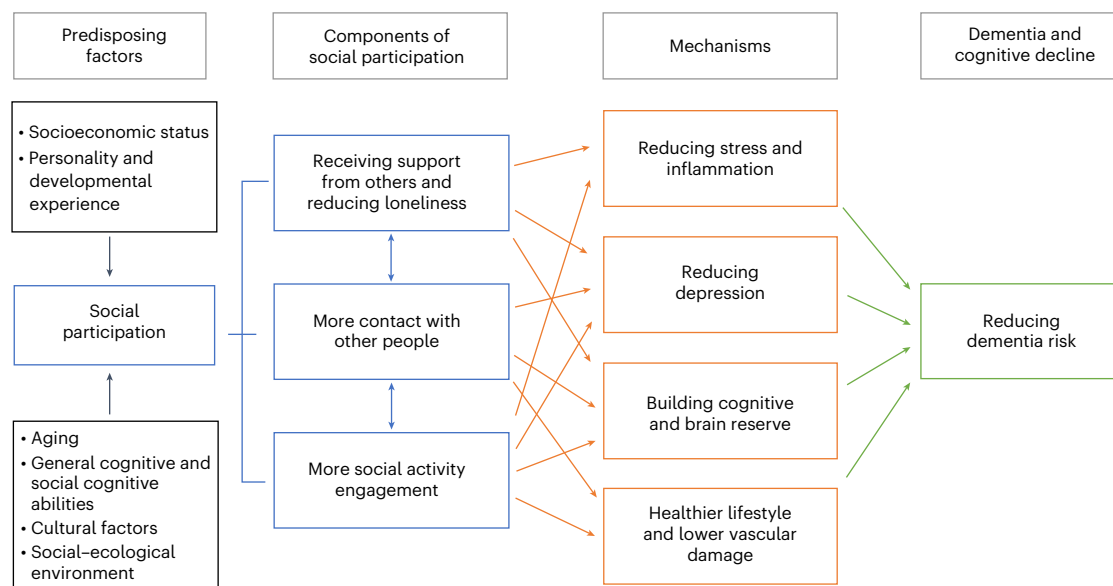
Fig. 3 | Potential mechanisms for influence of social participation on dementia risk. Summary of the mechanisms by which social participation may reduce dementia risk. Neuropsychological factors such as personality, cognition and developmental experiences, and social factors like socioeconomic status and the social and ecological environment predispose individuals to having more or less need for and access to social participation in a range of different domains. Social participation may act through several mechanisms, including brain maintenance by reducing stress, inflammation and cerebrovascular damage, building cognitive reserve and reducing depression to reduce dementia risk.

include building cognitive reserve[73], and better brain maintenance[74] by reducing neurodegeneration by lower vascular damage, reduced stress[75], promotion of healthy lifestyles and behaviors and enhanced mental stimulation[76] (Fig. 3).

Cognitive reserve
Social contact with others may build cognitive reserve, implying that increased cognitive adaptability improves the ability of individuals to tolerate neuropathology without corresponding decline in cognition and function[73]. Socialization is cognitively demanding, requiring deployment of numerous social cognitive domains[77], as well as planning, memory and language and, according to the social brain hypothesis, social complexity may be the major driving force for evolutionary brain development[78]. Social participation may therefore exercise cognitive domains, reducing vulnerability to late-life decline[79]. An autopsy study found that more social contact before death modified the relationship between neuropathology and cognition, such that more amyloid load and neurofibrillary tangle density was less strongly associated with cognitive decline in people who had more frequent social contacts[80], supporting the hypothesis that cognitive reserve was greater in those with more frequent social contact. Another study found that the detrimental effect of diabetes on dementia risk was attenuated by social participation[81].

Brain maintenance
Social participation may affect dementia risk through brain maintenance, which refers to reduced accumulation of brain pathology and preservation of a healthy brain conferring better late-life cognitive function[74]. Better social health, defined as less loneliness, more social support and being married, was associated in one study with greater brain volume[82]. Another study showed that socially isolated individuals had lower frontal and temporal gray matter volumes and that differences in gray matter volume partly mediated the association between social isolation at baseline and cognitive function at follow-up[43]. This may partly reflect reverse causation whereby people with larger brains are able to maintain more complex social lives. However,

mental stimulation within the occupational context has been linked to greater hippocampal volume[83] and lower levels of proteins that inhibit axonogenesis and synaptogenesis[84], although it is unclear to what extent the level of mental stimulation during social participation is important. Brain maintenance from social participation may therefore be achieved through several mechanisms.

Lifestyle behaviors and vascular risk
Social participation may improve brain maintenance through healthy lifestyle behaviors. Social isolation is associated with increased mortality through health behaviors such as smoking[85], high alcohol consumption[86] and cardiovascular diseases[87]. All-cause dementia and dementia subtypes are related to cardiovascular and cerebrovascular health[88,89] and heavy alcohol consumption is an established dementia risk factor[14], so the mechanisms by which lower social contact is associated with cardiovascular risk factors and illness may also extend to dementia risk. Contact with others may, in many cases, model and encourage better health behaviors leading to lower risk of vascular disease and subsequent better cognitive health and lower dementia risk. This is supported by a study of Ecuadorean adults in whom poor social relationships and lower support networks were associated with worse progression of cerebrovascular disease[90]. However, smoking and alcohol consumption may accompany social participation to mitigate socioeconomic stress, so some social contact may not confer cerebrovascular health benefits.

Stress, accelerated aging and inflammation
The effect of social participation on brain maintenance could act through the stress response[91]. A detrimental effect of stress through, for example, restraint, social isolation or other chronic stressors, on hippocampal networks has been demonstrated in animal models[92], and persistent midlife stress has been associated with elevated dementia risk in human epidemiological studies[93]. Social isolation and poor social support are associated with biological stress markers including dysregulation of the hypothalamic–pituitary–adrenal axis and cortisol responses[94], increased sympathetic nervous system activation[95], accelerated cellular aging[96–98] and raised inflammatory markers[99], suggesting

that social isolation may affect dementia risk through the pathological effect of stress. The important role of systemic inflammation in the etiology of dementia is increasingly being recognized[100–103].

Immunity

Some large-scale studies have linked severe infections to increased dementia risk[104,105], suggesting that human-to-human contact could increase dementia risk through the adverse effect of infection. The reduced human contact of socially isolated individuals might therefore potentially decrease their exposure to transmitted pathogens. However, some studies have observed increased risk of severe infections among socially isolated individuals[106], reflecting overall adverse impacts of social isolation on general health, and this may also reflect the immune suppression linked to stress induced by social isolation[107]. In an analysis making a distinction between subjective loneliness and objective social isolation, the occurrence of hospital-treated infections was higher among lonely people than others, while no robust association was observed between social isolation and the incidence of hospital-treated infections[108]. This preliminary evidence requires further study, and research on long-term impacts of COVID-19-related isolation may be informative.

Depression

Social participation, depression and cognitive function are interrelated in a complex fashion. Late-life depression is consistently associated with dementia risk[109], although this may be partially due to low mood arising in preclinical dementia[110]. However, social participation may arise from and result in low mood, so it is plausible that social participation affects cognition and dementia through affecting mood.

Interventions for social participation

Clarifying the potential of social participation as a target for intervention is crucial but the design of research to test whether increasing social participation affects dementia risk is challenging. It would be unethical to deprive some people of aspects of social participation and impractical to enforce greater social participation in others. While desire for social participation is an inherent aspect of human nature that may have neurobiological underpinnings[111], and social contact with other people is a core part of individual identity and important for wider society[112], it is not clear how to improve social participation. Furthermore, some individuals may not wish to change their social participatory habits as, although social contact with others is usually associated with positive affective experiences, personality characteristics such as introversion[113], autistic traits[114] or internalized stigma related to mental illness[115] may encourage some to seek and prefer solitude.

Local cultures and traditions are important in the roles of individuals within wider society, and an intervention to encourage social participation would need to be acceptable to participants, feasible to administer and sustainable to potentially have an effect. Furthermore, considering the gradual onset of dementia pathology and symptoms, and the likely lifelong contribution of symptoms, interventions may best be delivered at a relatively young age, and many decades of follow-up would be required to assess dementia risk, which is impractical. Interventions have therefore often focused on cognitive change, rather than dementia incidence, as a primary outcome. Randomized controlled trials (RCTs) of social interventions or multicomponent interventions that include a social focus are summarized in Table 2.

Social interventions for cognitive function

Evidence from studies testing social interventions for people at risk of developing dementia is variable. Interventions for improving cognition through social activities, networks and relationships were summarized in a 2017 systematic review[56], which found three RCTs, the results of which were not suitable for meta-analysis due to study design heterogeneity. The trials of between 120 and 235 participants tested social activity interventions, which all included facilitator-led group activities. One Finnish study led to a significant but small improvement in cognitive performance on the Alzheimer's Disease Assessment Scale–Cognitive Subscale (ADAS-cog)[116] at 3 months (1 point difference, −2.6 (3.4, −1.8) versus −1.6 (−2.2, −1.0)) and better subjective cognitive function[117]. The other studies were from China[118] and the USA[119] and showed better but non-significant overall cognitive performance compared to control groups, although one reported improved immediate recall and verbal fluency[118] and a 0.6% increase in total brain volume compared to the control group[118]. These studies were too small and the follow-up time too short to identify any effect on the risk of incident mild cognitive impairment or dementia.

Interventions aimed at improving loneliness in older adults have usually focused on encouraging study participants to engage in purposeful activity and maintain contact with their social networks[120]. Although there is some evidence of efficacy of these programs in reducing loneliness compared to control groups, no studies have assessed effects on cognition[121].

Interventions to increase social participation through facilitator-led group activities have not consistently been shown in RCTs to improve general cognitive function; studies were too small and short to identify any effect on the development of dementia.

Interventions combining social participation with other strategies

Interventions using a combination of strategies to improve cognition have gained increasing interest as they target several risk factors and can be tailored according to individual risk profiles. A Cochrane review of multi-domain interventions[122] was inconclusive about whether these overall affected dementia risk, but the review determined that only two of these interventions targeted social participation—the Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER) RCT[123] and an RCT of Korean community-dwelling adults[124].

The FINGER study was a 2-year intervention for people with elevated vascular risk for dementia where the intervention consisted of advice on diet, physical activity, cognitive training and improved management of vascular risk. There was no explicit social element to the study, but it was achieved implicitly through group meetings[123]. The intervention resulted in less cognitive decline than the control group with a small effect size (Cohen's d = 0.13), and this difference persisted irrespective of baseline risk factors[125], but results using dementia as an outcome have not yet been published. An RCT of a multi-domain intervention delivered over 18 months in Korea included promotion of cognitive and social activities alongside physical activity, alcohol and smoking interventions and weight loss, lean body mass and healthy diet with four different modes of delivery including, at its most intensive, bimonthly health worker-initiated visits, counseling, and rewards for adherence to the program[124]. Only the most intensive approach to delivering the intervention led to better cognitive function compared to the control group at 18 months follow-up on the mini-mental state examination (MMSE; mean performance, 0.99 points better than control (standard error, 0.49)). Both interventions were time-consuming, intensive and costly with small effect sizes for cognition.

A subsequent RCT, SUPERBRAIN, tested a multi-domain intervention including social activities through group meetings and additional scheduled monthly social activities[126]. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) score improved significantly at 24 weeks of follow-up of participants in the intervention group who received the intervention in a clinical setting (5.46 ± 7.50, P = 0.004) or at home (5.50 ± 8.14, P = 0.004) compared to the control group (−0.74 ± 11.51)[127]. This improvement was associated with changes in learning and cognitive neural networks[128].

In all these studies, the specific social contribution to any positive effect is unclear due to the multi-domain nature of the intervention. One study described which health behaviors changed and found that

Table 2 | Key findings from intervention studies aimed at increasing social participation to improve cognition

Author	Year	Setting and participants	Intervention	Control	Main findings for cognition
Social participation interventions					
Pitkala et al.[117]	2011	People aged over 75 years from day care centers in Finland, with subjective feelings of loneliness, willing to participate in one of three interventions.	Social activity through facilitated group meetings with active discussions, sharing of experiences and peer support + therapeutic writing, or group exercise, or art class	Normal community care	At the 3-month follow-up, ADAS-Cog scores improved significantly more for participants receiving the intervention (improved by 2.6 points (1.8, 3.4)) than in the control group (improved by 1.6 (1.0, 2.2); P=0.023).
		n=235, mean age=80	6h per week for 3 months		
Mortimer et al.[118]	2012	People aged 60–79 years from census list in Shanghai, China, who were cognitively healthy (MMSE>26) and physically able to take part in interventions.	Social activity through group meetings facilitated by a group leader and assistant at a community center. Direction provided for conversational topics.	No intervention	At the 40-week follow-up, improved verbal fluency (P<0.05), and better trail-making and verbal learning performance (P<0.10), but no other cognitive improvement domains. No significant difference in Mattis Dementia Rating Scale compared to control.
		n=120, mean age=68	3h per week for 40 weeks	Two other intervention groups for comparison (tai chi and walking)	
Park et al.[119]	2014	People aged 60–90 years in Dallas, USA, with education to grade 10 and MMSE>25.	Activity mimicking a social club with facilitator-instructed activities including cooking, games, movies and reminiscence, based on participants existing knowledge with no active knowledge or skill acquisition.	1. Placebo	Social group showed greater, but non-significant pretest–posttest improvement in processing speed compared to placebo (P<0.10).
		n=259, mean age=72	15h per week for 14 weeks	2. No intervention	No difference in mental control, episodic memory or visuospatial processing.
		Non-RCT: participants excluded one intervention that they were unwilling to do.		Three other intervention groups (quilt-making, photography and both)	
Multicomponent interventions					
Ngandu et al.[123]	2015	People aged 60–77 years in Finland, with vascular risk (CAIDE score>6) but average cognitive performance.	Diet: group and individual sessions with nutritionists and exercise; cognitive training: group sessions and computerized training, social activities through group meetings, clinician-led vascular risk management.	Regular health advice	At 2 years, the intervention group showed mean improvement versus control group in composite measure of cognition (Cohen's d=0.13) on executive function and processing speed, but not memory.
		n=1,260, mean age=69	Around 300h of meetings over 2 years		
Lee et al.[124]	2014	Regular attendees at centers for older people in Korea, aged >60	Physical activity, cognitive and social activities, alcohol, smoking, diet advice administered via one of four different methods of delivery including regular health worker care management, and rewards	Lifestyle advice	At 18 months, the most intensive delivery method led to better cognitive function compared to control on MMSE (mean 0.99 points better than control (standard error 0.49)). Other delivery methods were ineffective.
		n=1,115, mean age 77			
Moon et al.[127]	2021	People aged 60–79 in Korea with at least one modifiable dementia risk factor, normal cognition and an informant.	Monitoring and management of vascular risk factors, cognitive training, physical exercise, dietary guidance, motivational enhancement and social activity via group meetings and monthly external activities.	Usual care control group	At 24 weeks, RBANS score improved significantly in intervention groups in a clinical setting (5.46±7.50, P=0.004) or at home (5.50±8.14, P=0.004) compared to control group (−0.74±11.51).
		n=152, mean age=71	2h per week for 24 weeks		

CAIDE, Cardiovascular Risk Factors, Aging, and Incidence of Dementia risk score.

social participation did not significantly increase after the intervention, and analysis instead attributed the cognitive benefit to increased cognitive activity[124]. Other studies to test combination strategies for dementia prevention with interventions, including AgeWell.de[129], MIND China[130] and US Pointer[131], are still ongoing.

Interventions targeting several domains including social participation have shown cognitive benefit, although they are time-consuming and costly, and no effect on dementia risk has yet been demonstrated. The specific contribution of social participation to improving cognition is not yet established.

Quasi-experimental research

Considering the challenges of RCTs in this area, quasi-experimental research may be informative. COVID-19-related social isolation measures, introduced to contain the disease, resulted in a reduction in social participation, which affected some, such as those living alone, more than others. The evidence on how this affected dementia risk may become evident in future years. However, some studies have found that social restrictions may have affected cognitive function.

A review of the effect of COVID-19-related isolation on the cognition of people with dementia found that 60% of 15 studies reported a detrimental effect on cognition[23]. Similar findings have been reported in a study of adults without dementia in which adherence to stricter isolation was associated with worse short-term performance on cognitive tasks[132], but this deterioration of performance may be related to anxiety or affective symptoms. A study found that the link between COVID-19-related social restrictions and poor cognitive performance was more pronounced in younger than older individuals, which would not be expected if poor cognitive performance were related to acceleration, or greater susceptibility to the effects, of neurodegeneration[133]. Findings should be interpreted with caution as reverse causation may partly account for findings; for example, one cross-sectional study of Chinese adults found that worse cognition was associated with lower adherence to COVID-19 prevention regulations[134] and COVID-19 itself may increase risk of dementia[135]. Thus, while isolation measures may be required during periods of high COVID-19 rates or other future infectious disease epidemics, the principle of 'isolating the virus rather than isolating people' should be used to decide on measures.

Uncertainties of interventional evidence

There are several uncertainties from the interventional research. Although there is preliminary evidence that group social interventions can improve cognition, there is no evidence about prevention of dementia, and interventions that have demonstrated effect on cognition may not carry through to delay or prevent dementia. However, accelerated cognitive decline begins years before dementia diagnosis and this decline predicts dementia risk[136]. Therefore, the US Food and Drug Administration have encouraged the use of cognitive and functional endpoints, rather than dementia, for drug trials[137], so improvement in cognition can be considered necessary but not sufficient evidence for identifying dementia prevention strategies. Extended follow-up of previous studies by attaining dementia status from clinical records will support existing evidence.

Additional follow-up may also clarify whether interventions lead to long-lasting changes in social behavior, which would guide timing of an intervention. Considering that dementia results from accumulated lifetime risk, it may be that changing behavior earlier would confer more benefit. The move toward multi-domain interventions, rather than interventions targeting a single risk factor, is reasonable as it allows tailored interventions to change risk profiles. However, it obscures the understanding whether a single component of the intervention is an active ingredient. This may be helped by process evaluation of trials, examination of mechanisms through assessment of biomarkers and analyses that determine adherence to different intervention components and estimate their effects[124].

Policy implications

Public health policy could promote social participation through several approaches, focusing particularly on the areas with the strongest evidence for dementia prevention, related to social contact and activity engagement (Fig. 4). Policy should aim to restore pre-pandemic social participation, including promotion of face-to-face contact and support alongside remote approaches where necessary during periods of high contagion. There should be guidance and support for retirees, because retirement is a potential sensitive period, such as by providing volunteering opportunities and further education to

Fig. 4 | Policy approaches to increasing social participation in older people for reduced dementia risk. Summary of the potential policy approaches to increasing social participation.

promote social participation. Provision of adequate socially connected housing for older people is a focus of several governmental and third-sector organizations[138], and has potential to reduce social isolation and loneliness as well as provide support networks for older people. Physical environmental adaptations by optimizing urban planning, accessibility and infrastructure, as recommended in the WHO's *Global Age Friendly Cities: A Guide*[139], could help to promote social inclusion. Finally, provision of leisure time with social connection through social centers would promote social and cognitive activity and participation.

Conclusion

This Review highlights the current evidence for the effect of social participation on dementia risk. There is a pressing need to clarify risk factors for dementia to guide prevention approaches to mitigate the projected future rise in the number of people with dementia. The evidence for a direct causal link between social participation and dementia is not definitive due to limitations in observational research but is consistent and biologically plausible, with evidence for several potential mechanistic pathways underlying an association. There are few RCTs of social interventions and they are consistent with showing a positive effect on cognition, but none include dementia as an outcome.

Evidence has accumulated since the WHO[19] published guidelines on risk reduction for cognitive decline and dementia[19], which rated evidence on a range of risk factors based on confidence about whether the desirable effects of the intervention outweigh any undesirable effects. The guidelines reported that there was insufficient evidence to recommend social activity for reducing cognitive decline or dementia due to limited and inconclusive evidence and risk of bias arising from reverse causality. There is now considerably more evidence for the link between social participation and dementia, particularly for social contact with others, although the evidence for activity engagement is weaker, suggesting that these guidelines should be reassessed and that future guidelines should highlight social participation as a modifiable risk factor for dementia. There is good evidence that social

participation overall is beneficial for general health and well-being[140] and the WHO[141] position paper on optimizing brain health concludes that social connection is an important determinant for brain health across the life course[141].

Implications for treatment

The US National Academies of Sciences recommend applying quality of evidence standards, which take into account the priority of the problem, how substantial the benefits and harms are, the certainty of the evidence, the value of the outcomes to stakeholders, how an intervention's clinical and cost effectiveness compares with others, resource requirements, the impact on health equity, the intervention's acceptability and the feasibility of implementation[142]. These standards could be applied to evaluate social participation interventions. While trials today suggest potential individual-level strategies, there is currently insufficient RCT effectiveness or cost-effectiveness evidence for definitive recommendations, so further research is required on effective and scalable interventions.

Social isolation is closely linked with socioeconomic deprivation[143], so targeting individuals to improve social participation may be inequitable and ineffective, but health status can be shaped by policies with a societal rather than individual focus. The lower numbers of people with dementia due to higher education standards or reduced smoking are a consequence of societal changes, by, for example, increasing the number of mandatory years in education, and improving public understanding of the harm of, and limiting the opportunities for, cigarette smoking. The key area for applying the understanding that social participation is beneficial for brain health is therefore likely to be in social policies, community awareness, and advice around individuals' choices related to social participation over the life cycle. These policy approaches should particularly aim to support those from socioeconomic and cultural groups at highest risk of dementia who may find it hardest to access social participation, by reducing financial and logistical barriers to social activities and participation to have a substantial benefit for health and society.

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Competing interests

The authors declare no competing interests.

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