Social integration and healthy aging among U.S. women

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ABSTRACT

Background: Social integration has been related to risk of chronic diseases and mental health conditions.
Purpose: We investigated the association between social integration in midlife with subsequent health and well-being in aging.
Methods: We included women from the Nurses' Health Study in the United States, who had no major chronic diseases in 1996 when we assessed social integration, using the Berkman-Syme Social Network Index. We defined healthy aging after 16 years of follow-up, when women ranged from 66 to 91 years, on the basis of survival along with 4 health criteria, assessed in 2012: no history of major chronic disease diagnosis, no self-reported impairment in memory, and no major impairments in physical function or mental health.
Results: Of the 41,013 surviving participants in 2012 with information on social integration and health criteria, 6206 (15.1%) were healthy agers (i.e., met all four criteria) and the remaining 34,807 (84.9%) were usual agers. After multivariable adjustment, women who were socially integrated at midlife had modestly better odds (odds ratio = 1.38, 95% confidence interval: 1.23, 1.55) of healthy aging compared to women who were socially isolated.
Conclusions: In this study, we found that women who were more socially integrated were more likely to be healthy agers. The results provide evidence for a longitudinal association between social integration and healthy aging.

1. Introduction

As the proportion of the U.S. population 65 years and older continues to grow (Centers for Disease Control and Prevention, 2013), identifying factors that contribute to healthy aging are of increasing importance. Midlife factors likely contribute to many chronic health conditions that manifest during older age. Social integration is one such factor that may have a significant impact on both physical and mental health in later life (Berkman et al., 2000). Prior studies have suggested that increased social integration associated with better physiological function (Yang et al., 2016), reduced risk of chronic diseases (Crittenden et al., 2014; Yang et al., 2016), dementia (Kuiper et al., 2015), and mortality (Barger, 2013). Social integration includes marital status, contact with relatives and friends, religious service attendance, as well as community activities (Berkman and Syme, 1979). These individual components could each be related to healthy aging; for example, prior evidence has indicated that religious service attendance is associated with better physical and psychological health (Powell et al., 2003; Hackney and Sanders, 2001). Additionally, a recent study found

that frequent attendance at religious services was associated with lower risk of all-cause, cardiovascular, and cancer mortality (Li et al., 2016). Thus, we investigated the associations between social integration in midlife with subsequent healthy aging, a composite outcome including survival as well as self-reported measures of chronic disease, impairments in memory, physical function, and mental health, among women in the Nurses' Health Study.

2. Methods

2.1. Study population

The Nurses' Health Study began in 1976 when 121,700 U.S. married women aged 30 to 55 years completed a mailed questionnaire. Follow-up questionnaires were sent every 2 years and follow-up remains completed for > 90%. In 1992 and every four years thereafter, the Medical Outcomes Study Short-Form-36, a 36 item-questionnaire which evaluates eight health concepts (including mental health and physical functioning) was administered (Ware, 1993). In 2012, questions were

added that addressed subjective memory concerns. This study was approved by the Institutional Review Board of Brigham and Women's Hospital (Boston, MA).

2.2. Ascertainment of social integration

Social integration was measured by the Berkman-Syme Social Network Index (Berkman and Syme, 1979), a composite measure of four types of social connection: marital status (married versus not); sociability (number and frequency of contact with children, close relatives, and close friends); church group membership (yes versus no); and membership in other community organizations (yes versus no). Responses to the Social Network Index were categorized into four levels of social connection: socially isolated (individuals with low intimate contacts- not married, fewer than six friends or relatives, and no membership in either church or community groups), moderately isolated, moderately integrated, and socially integrated (Kawachi et al., 1996). We defined baseline in this analysis as social integration as assessed in the 1996 questionnaire (the Berkman-Syme Social Network Index = 1 for socially isolated, 2–5 for moderately isolated, 6–7 for moderately integrated, 8–12 for socially integrated). See the Online Supplement for further details of the calculation.

2.3. Ascertainment of healthy aging

We separated "healthy" from "usual" aging on the basis of survival as well as 4 health domains measured in 2012. We considered persons free of 11 chronic diseases, with no reported memory impairment, no physical disabilities, and intact mental health as healthy agers; remaining women were usual agers.

Incidence of 11 chronic diseases was reported on the biennial questionnaires (Colditz et al., 1995; Barr et al., 2002; Alonso et al., 2008; Sun et al., 2007). This list combined primary causes of death in the United States (cancer other than non-melanoma skin cancer, myocardial infarction, coronary artery bypass surgery, percutaneous transluminal coronary angioplasty, congestive heart failure, and stroke) and diseases commonly found in the literature on healthy aging (type 2 diabetes, kidney failure, chronic obstructive pulmonary disease, Parkinson disease, multiple sclerosis, and amyotrophic lateral sclerosis). To avoid redundancy, we did not include diseases that were reflected by other components of our healthy aging outcome (for example, dementia was not one of the chronic diseases considered because subjective memory concerns were a separate domain).

Subjective memory complaints were assessed through a set of 7 yes/no questions from the 2012 biennial questionnaire. These questions were based on a prior study that used these same questions to detect individuals with possible cognitive impairment (Go et al., 1997). No impairment in memory was defined as at most one memory complaint.

We identified impairment of physical function as any of the following: limited at least "a little" on moderate activities as assessed by the Medical Outcomes Study Short-Form-36 (such as moving a table, bowling, or pushing a vacuum cleaner, climbing one flight of stairs, walking > 1 mile or walking several blocks; bathing or dressing) or limited "a lot" on more difficult items (such as running, lifting heavy objects, lifting or carrying groceries, climbing several flights of stairs, bending, kneeling, or stooping).

Lastly, on the basis of answers to the Geriatric Depression Scale-15(Lyness et al., 1997) (range: 0–15, lower scores indicating better mental health), we defined good mental health as a score less than or equal to 1 (the median value in the cohort).

2.4. Ascertainment of covariates

Sociodemographic, lifestyle and health-related covariates (age; smoking; body mass index; physical activity; alcohol consumption; diet quality; husband's education; hypertension, hypercholesterolemia,

physical exam in the past two years; post-menopausal hormone use) were obtained from the 1996 biennial questionnaire. Median annual household income and home value were estimated from the census tract of participant's residence, geocoded to the 1994 U.S. Census.

2.5. Population for analysis

Among 100,952 women who returned their 1996 questionnaire, 14,224 were excluded because of missing information on social integration. An additional 21,876 women were excluded because they had reported a history of any of the 11 chronic diseases as of 1996. We excluded 23,839 women missing the healthy aging outcome due to an incomplete Medical Outcomes Study Short-Form-36, skipping any items on the Geriatric Depression Scale-15, skipping > 5 items on the physical function scale, or the missing responses to the questions on subjective memory complaints on the 2012 questionnaire. Thus, we had 41,013 participants available for analyses.

2.6. Statistical analysis

To evaluate the association between social integration in midlife and healthy aging, we used age-adjusted and multivariable-adjusted logistic regression models. Sociodemographic, lifestyle, and health-related covariates were obtained from the 1996 questionnaire. We also secondarily conducted analyses in which we examined the individual components of the social integration score (marital status, religious service attendance, membership in other community organizations, and sociability level). When considering the individual components, all components were included in models simultaneously and multivariable models were adjusted for the same confounders as in the main analysis. In sensitivity analyses, we considered social integration in 2000, 2004, and 2008 in relation to healthy aging in 2012; these were not primary analyses since we were concerned that as the women aged, their level of social integration may become increasingly linked with their underlying health, possibly leading to reverse causation bias. We used sensitivity analysis for unmeasured confounding to assess the robustness of our results to uncontrolled and residual confounding (Ding and VanderWeele, 2016).

3. Results

Compared to women who were socially isolated at midlife, women who were socially integrated (Table 1) tended to drink less, were more physical active, were less likely to be current smokers, were more likely to be not employed outside the home or retired, were more likely to have a physical exam in the past two years, and their husbands tended to have a higher education level. The groups were similar in terms of body mass index, diet quality, median family income, and prevalence of hypertension and high cholesterol.

Of the 41,013 participants, 6206 (15.1%) were considered healthy agers and the remaining 34,807 (84.9%) were considered usual agers. In age-adjusted analyses of social integration at midlife and subsequent odds of healthy aging, women who were socially integrated had 48% higher odds (odds ratio (OR) = 1.48, 95% confidence interval (CI): 1.33, 1.65) of healthy aging compared to women who were socially isolated at midlife. After adjusting for potential confounders, results were attenuated but remained significant (multivariable-adjusted OR comparing socially integrated vs. socially isolated = 1.34, 95% CI: 1.18, 1.51, Table 2). In sensitivity analysis for unmeasured confounding, an unmeasured confounder that was associated with both social integration and healthy aging by a risk ratio of 2.01-fold each could explain away the estimate, but weaker confounding could not; to shift the confidence interval to include the null, an unmeasured confounder that was associated with social integration and healthy aging by a risk ratio of 1.64 each could do so, but weaker confounding could not.

Table 1

Age-adjusted baseline characteristics in 1996 of women in the Nurses' Health study in the United States by categories of social integration[a].

	Social integration in 1996			
	Socially isolated (*n* = 3590), %[b]	Moderately isolated (*n* = 12,185),%[b]	Moderately integrated (*n* = 6477), %[b]	Socially integrated (*n* = 18,761), %[b]
Caucasian	97	97	98	98
Education				
Registered nurse	66	66	66	68
Bachelor's	22	22	22	22
Master's/doctoral	12	12	12	10
Not employed outside the home or retired	39	47	51	54
Husband's education level				
College or above	54	56	60	59
Smoking status				
Never	37	43	44	54
Former	44	45	46	40
Current	19	12	10	6
Current post-menopausal hormone use	16	15	15	15
Physical exam in the past 2 years	85	88	89	91
Hypertension	33	34	33	32
High cholesterol	50	50	50	50
Age, years[c,d]	59.2 (6.2)	60.2 (6.6)	60.0 (6.2)	60.3 (6.5)
Body mass index[c,e]	26.4 (5.3)	26.3 (5.0)	26.2 (4.9)	26.3 (4.8)
Physical activity, METs/wk[c]	16.9 (20.5)	18.8 (22.6)	19.5 (22.2)	19.9 (22.5)
Alcohol intake, g/day[c]	6.1 (10.3)	5.3 (9.0)	5.7 (8.9)	4.5 (8.0)
AHEI score[c]	53.2 (11.0)	53.2 (10.6)	53.8 (10.6)	53.5 (10.2)
Family income, dollars/year[c]	66,972 (26,020)	66,948 (26,122)	68,421 (27,249)	64,877 (24,842)
1994 tract median house value[c]	193,500 (147,327)	183,538 (135,895)	190,315 (146,090)	169,207 (124,698)

Abbreviations: MET, metabolic equivalent of task; AHEI, Alternative Healthy Eating Index.

[a] Social Integration was measured using the Berkman-Syme Social Network Index.

[b] Values of polytomous variables may not sum to 100% because of rounding.

[c] Values are expressed as mean (standard deviation).

[d] Value is not adjusted for age.

[e] Weight (kg)/height (m)^2.

Table 2

ORs (95% CIs) of healthy aging, according to categories of social integration in 1996 (*n* = 41,013).

	Social integration in 1996			
	Socially isolated	Moderately isolated	Moderately integrated	Socially integrated
Healthy agers	466	1655	1065	3020
Age-adjusted OR (95% CI)	Reference	1.17 (1.04, 1.31)	1.48 (1.31, 1.67)	1.48 (1.33, 1.65)
Multivariable-adjusted OR (95% CI)[a]	Reference	1.09 (0.97, 1.23)	1.33 (1.16, 1.51)	1.34 (1.18, 1.51)

[a] Adjusted for age (continuous), smoking (never, past, current), body mass index (continuous), physical activity (continuous), alcohol consumption, diet quality, Nurses' education (RN, BA, or MA/DR), husband's education (< high school, some high school, high school grade, college, graduate school), median family income, hypertension (yes/no), high cholesterol (yes/no), physical exam in the past 2 years (yes/no), post-menopausal hormone use (never, past, current), religious service attendance in 1992.

We also ascertained relations of specific components of the social integration score with healthy aging (Table 3). In multivariable models including all the components simultaneously, we found that sociability level was significantly related to healthy aging (OR comparing high vs. low sociability level: 1.41, 95% CI: 1.26, 1.58, OR comparing medium vs. low sociability level: 1.28, 95% CI: 1.16, 1.42). Religious service attendance was not associated with healthy aging in the age-adjusted or multivariable-adjusted model (multivariable-adjusted OR = 0.99, 95% CI: 0.91, 1.08), and membership in other community organizations was not associated with odds of healthy aging, (multivariable-adjusted OR = 1.04, 95% CI: 0.97, 1.11). We did not find substantial evidence for a relation between marital status (yes/no) and healthy aging (multivariable-adjusted OR = 1.08, 95% CI: 0.98, 1.18).

As a sensitivity analysis we also assessed associations between social integration in 2000, 2004 and 2008, in relation to healthy aging in 2012 (Supplementary Table 1–3). The multivariable adjusted OR (95% CI) for healthy aging comparing those who were socially integrated to those who were socially isolated in 2000 was 1.43 (1.24, 1.65); in 2004: 1.65 (1.41, 1.95); and 2008: 1.48 (1.27, 1.72).

4. Discussion

In this study, we observed a significant positive association between social integration and healthy aging. The results were moderately robust after multivariable adjustment, as well as in sensitivity analysis. We provided some evidence for modest associations between social integration with healthy aging, adding to the already documented relations reported for other more specific dimensions of health (Berkman et al., 2000; Crittenden et al., 2014; Yang et al., 2016; Kuiper et al., 2015; Barger, 2013).

We are currently living in a world that is rapidly aging. According to the United Nations 2015 report, 13% of the global population was over 60 years in the year of 2015, and by the year of 2040 it will increase to approximately 2.1 billion people. The elderly are at an increased risk of social isolation because of physical functional deficits that prevent social participation, lack of access to adequate transportation, and the loss of formal social roles and meaningful interpersonal connections (Barger, 2013; Berkman and Syme, 1979; Powell et al., 2003). With aging, people might also have a sense of limited time and therefore choose to maintain or strengthen their relations with family and intimate friends, while withdrawing from interactions with peripheral acquaintances (Yang et al., 2016).

The association and underlying mechanisms through which social integration affect healthy aging have been analyzed based a cascading causal model started with the macro-social level down to

Table 3
Odds ratios of healthy aging, according to components of social integration score in 1996 (*n* = 41,013).

Marital status in 1996				
	Not married		Married	
Healthy agers	914		5292	
	OR	95% CI	OR	95% CI
Age-adjusted	1.00	Referent	1.12	1.04, 1.21
Multivariable-adjusted[a]	1.00	Referent	1.08	0.98, 1.18

Church group membership in 1996				
	No		Yes	
Healthy agers	2620		3586	
	OR	95% CI	OR	95% CI
Age-adjusted	1.00	Referent	0.99	0.93, 1.05
Multivariable-adjusted[a]	1.00	Referent	0.99	0.91, 1.08

Membership in other community organizations in 1996				
	No		Yes	
Healthy agers	2482		3724	
	OR	95% CI	OR	95% CI
Age-adjusted	1.00	Referent	1.16	1.09, 1.21
Multivariable-adjusted[a]	1.00	Referent	1.04	0.97, 1.11

Sociability in 1996 (# and frequency of contact with close friends and relatives)

	Low		Medium		High	
Healthy agers	563		4038		1605	
	OR	95% CI	OR	95% CI	OR	95% CI
Age-adjusted	1.00	Referent	1.32	1.20, 1.46	1.43	1.29, 1.59
Multivariable-adjusted[a]	1.00	Referent	1.28	1.16, 1.42	1.41	1.26, 1.58

Abbreviations: CI, confidence interval; OR, odds ratio.

[a] Adjusted for age (continuous), smoking (never, past, current), body mass index (continuous), physical activity (continuous), alcohol consumption, diet quality, Nurses' education (RN, BA, or MA/DR), husband's education (< high school, some high school, high school grade, college, graduate school), median family income, hypertension (yes/no), high cholesterol (yes/no), physical exam in the past 2 years (yes/no), postmenopausal hormone use (never, past, current), religious service attendance in 1992

psychobiological pathways that are simultaneously and dynamically connected each other (Crittenden et al., 2014). Berkman proposed that the social network operate at the behavioral level through four main pathways: 1) provision of social support; 2) social influence; 3) on social engagement and attachment; 4) access to resources and material goods (Berkman et al., 2000). Neither networks nor social support are evenly dispersed throughout people's social environments. Social resources clustered together in social institutions tend to make up of different nonintersecting networks and therefore offer substantially different kinds of support (Kawachi et al., 1996). Our measure of social integration is mostly focused on the structural characteristics of the personal network. Future work needs to expand on the functional characteristics of the social network.

Healthy aging is by definition conditional on survival. This can create methodological challenges concerning selection. For example, religious service attendance at baseline in 1996 was not associated with healthy aging. Prior literature has suggested a positive association between religious service attendance and healthy aging among older persons (Idler and Kasl, 1997). One possible explanation for the discrepancy between our results and prior literature may be selection. It has been shown in other work that religious service attendance is strongly predictive of lower subsequent mortality (Li et al., 2016). Since

healthy aging focuses on health among survivors, if religious service attendance is associated with prolonged survival, it may keep alive individuals who are relatively unhealthy and, might have, in the absence of such attendance, died during follow-up. If this is so, the comparison among those who survived of those attending versus not attending services may be biased because those who are less healthy at baseline in the latter group die during follow-up and are not in the comparison (Chiba and VanderWeele, 2011); such selection tends to yield associations between the service attendance exposure and the primary outcome, healthy aging, which are closer to the null and could result in conservative estimates (Chiba and VanderWeele, 2011). That odds ratios were larger in magnitude when examining association between healthy aging in 2012 and social integration measures in 2008 (OR = 1.48, 95% CI: 1.27, 1.72, Supplementary Table 3) provides some evidence that this may be so. On the other hand, a shorter follow-up may create more potential for reverse causation insofar as it may be only those who are healthy who can attend religious services or be more socially integrated (VanderWeele et al., 2016). A longer follow-up may partially mitigate this concern. There is also some evidence to suggest that disability among older persons does not have a substantial, or only temporary, effect on subsequent attendance (Idler and Kasl, 1997). These selection factors could be relevant for other forms of social support also, since other studies have indicated that social support is also likewise associated with less mortality (Barger, 2013).

The strengths of our study includes large sample size, long duration of follow up, high follow-up rate, prospectively repeated measurement of social integration items, a comprehensive definition for healthy aging, and extensive covariate adjustment. We were able to adjust for covariates in 1992 as well as excluding participants with existing chronic diseases at baseline to minimize issues of reverse causation. Our study is also restricted to Caucasian women with relatively high socioeconomic status. Future studies in men, minorities, immigrants, as well as vulnerable populations would be needed. Both social integration and healthy aging are conceptually dynamic process. Further studies are needed to examine this relation in their time-varying contexts.

Social support has previously been shown to be associated with a number of physical and mental health outcomes (Berkman et al., 2000; Crittenden et al., 2014; Yang et al., 2016; Kuiper et al., 2015; Barger, 2013). Our study suggests an association with health aging as well. Systems to enhance social integration for the elderly might well be important steps in improving health and quality of life as the population ages.

Conflict of interest

The authors declare there is no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2018.01.013.

References

Alonso, A., Hernán, M.A., Asherio, A., 2008. Allergy, family history of autoimmune disease, and the risk of multiple sclerosis. Acta Neurol. Scand. 117 (1), 15–20.
Barger, S.D., 2013. Social intergration, social support and morality in the US National Health Interview Survey. Psychosom. Med. 75 (5), 510–517.
Barr, R.G., Herbstman, J., Speizer, F.E., et al., 2002. Validation of self-reported chronic obstructive pulmonary disease in a cohort study of nurses. Am. J. Epidemiol. 155 (10), 965–971.
Berkman, L.F., Glass, T., Brissette, I., et al., 2000. From social intergration to health: Durkheim in the new millennium. Soc. Sci. Med. 51 (6), 843–857.
Berkman, L.F., Syme, S.L., 1979. Social networks, host resistance, and morality: a nine-year follow-up study of Alameda County residents. Am. J. Epidemiol. 109 (2), 186–204.
Centers for Disease Control and Prevention, 2013. The State of Aging and Health in America 2013. Centers for Disease Control and Prevention, US Department of Health and Human Services, Atlanta (GA).

Chiba, Y., VanderWeele, T.J., 2011. A simple method for principal strata effects when the outcome has been truncated due to death. Am. J. Epidemiol. 173 (7), 745–751.

Colditz, G.A., Willett, W.C., Rotnitzky, A., et al., 1995. Weight gain as a risk factor for clinical diabetes mellitus in women. Ann. Intern. Med. 122 (7), 481–486.

Crittenden, C.N., Pressman, S.D., Cohen, S., et al., 2014. Social intergration and pulmonary function in the elderly. Health Psychol. 33 (6), 535–543.

Ding, P., VanderWeele, T.J., 2016. Sensitivity analysis without assumptions. Epidemiology 27 (3), 368–377.

Go, R.C., Duke, L.W., Harrell, et al., 1997. Development and validation of a structured telephone interview for dementia assessment (STIDA): the NIMH genetics initiative. J. Geriatr. Psychiatry Neurol. 10 (4), 161–167.

Hackney, C.H., Sanders, G.S., 2001. Religiosity and mental health: a meta-analysis of recent studies. J. Sci. Study Relig. 42 (1), 43–56.

Idler, E.L., Kasl, S.V., 1997. Religion among disabled and nondisabled persons II: attendance at religious services as a predictor of the course of disability. J. Gerontol. B Psychol. Sci. Soc. Sci. 52((6), S306–316.

Kawachi, I., Colditz, G.A., Ascherio, A., et al., 1996. A prospective study of social networks in relation to mortality and cardiovascular disease in men in the USA. J. Epidemiol. Community Health 50 (3), 251–254.

Kuiper, J.S., Zuidersma, M., Oude Voshaar, R.C., et al., 2015. Social relationships and risk of dementia: a systematic review and meta-analysis of longitudinal cohort studies. Ageing Res. Rev. 22, 39–57.

Li, S., Stampfer, M.J., Williams, D.R., et al., 2016. Association of religious service attendance with morality among women. JAMA Intern. Med. 176 (6), 777–785.

Lyness, J.M., Noel, T.K., Cox, C., et al., 1997. Screening for depression in elderly primary care patients. A comparison of the Center for Epidemiologic Studies-Depression Scale and the Geriatric Depression Scale. Arch. Intern. Med. 157 (4), 449–454.

Powell, L.H., Shahabi, L., Thoresen, C.E., 2003. Religion and spirituality. Linkages to physical health. Am. Psychol. 58 (1), 36–52.

Sun, Q., Ma, J., Campos, H., et al., 2007. A prospective study of trans fatty acids in erythrocytes and risk of coronary heart disease. Circulation 115 (14), 1858–1865.

VanderWeele, T.J., Jackson, J.W., Li, S., 2016. Causal inference and longitudinal data: a case study of religion and mental health. Soc. Psychiatry Psychiatr. Epidemiol. 51 (11), 1457–1466.

Ware, J.E., 1993. SF-36 Health Survey: Manual and Interpretation Guide. The Health Institute, New England Medial Center, Boston.

Yang, Y.C., Boen, C., Gerken, K., et al., 2016. Social relationships and physiological determinants of longevity across the human life span. Proc. Natl. Acad. Sci. U. S. A. 113 (3), 578–583.