



Social integration and risk of mortality among African-Americans: the Jackson heart study

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Abstract

Objective Evidence suggests that greater social integration is related to lower mortality rates. However, studies among African-Americans are limited. We examined whether higher social integration was associated with lower mortality in 5306 African-Americans from the Jackson Heart Study, who completed the Berkman-Syme Social Network Index in 2000–2004 and were followed until 2018.

Methods We estimated hazard ratios (HR) of mortality by categories of the Social Network Index (i.e., high social isolation, moderate social isolation [reference group], moderate social integration, high social integration) using Cox proportional hazard models. Covariates included baseline sociodemographics, depressive symptoms, health conditions, and health behaviors.

Results Compared with moderate isolation, moderate integration was associated with an 11% lower mortality rate (HR = 0.89, 95% confidence interval [CI] 0.77, 1.03), and high integration was associated with a 25% lower mortality rate (HR = 0.75, 95% CI 0.64, 0.87), controlling for sociodemographics and depressive symptoms; compared with moderate isolation, high isolation was related to a 34% higher mortality rate (HR = 1.34, 95% CI 1.00, 1.79). Further adjustment of potential mediators (health conditions and health behaviors) only slightly attenuated HRs (e.g., $HR_{\text{moderate integration}} = 0.90$, 95% CI 0.78, 1.05; $HR_{\text{high integration}} = 0.77$, 95% CI 0.66, 0.89).

Conclusion Social integration may be a psychosocial health asset with future work needed to identify biobehavioral processes underlying observed associations with mortality among African-Americans.

Keywords Social integration · Social networks · Social isolation · Social exclusion · Longevity · Mortality · African-American

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Introduction

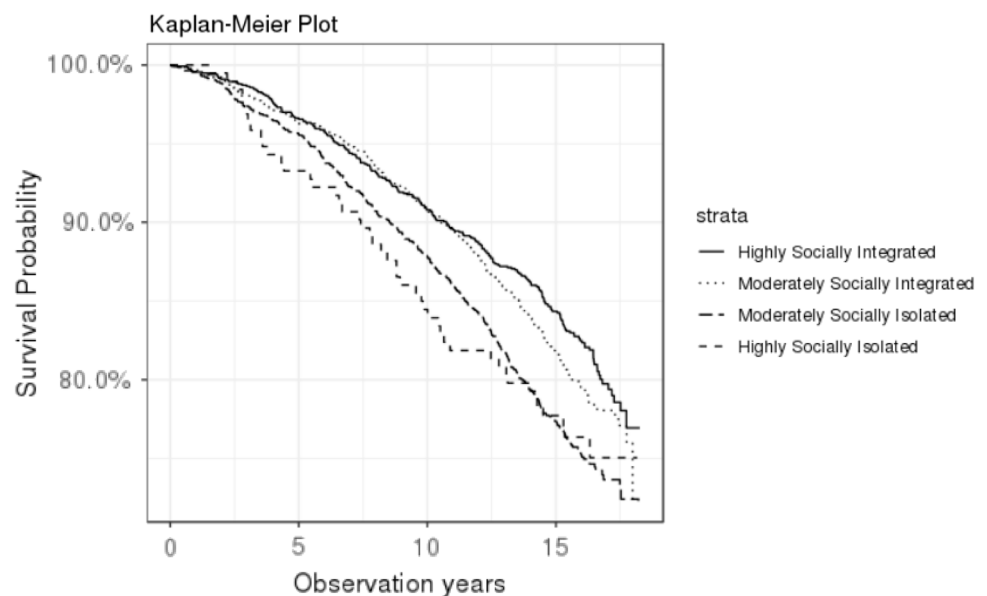
Emerging empirical studies from wild mammals consistently show a positive relationship between social connection and survival [1–3], suggesting the link between social connection and health is an evolutionarily conserved mechanism. Consistent with this observation, a large body of epidemiological research in humans suggests that both quantity and quality of social connections are related to mortality risk. Notably, there are various types of social connections. In a meta-analysis of 148 studies that examined mortality rates associated with various indicators of social connectedness in humans (e.g., quality or number of social relationships, perceived loneliness), mortality was most strongly associated with measures of social integration [4].

Social integration refers to structural (vs. functional or perceived) aspects of social connection, and has been conceptualized based on an individual's social network's characteristics, size, and contact frequency, such as marital status, contacts with close friends and relatives, and participation in religious and group activities [5]. These various ways of being socially integrated, in turn, influence health through many multifaceted downstream factors, many of which have systemic effects on health, such as social support, access to knowledge, material, or other resources, and biobehavioral factors, to name a few (for the conceptual model for social integration and health, see Fig. 1 in Berkman et al. [5]). While pathways via one or two of these factors could be blocked in certain populations, for example, due to aspects of their socio-cultural milieu (e.g., limited access to resources due to

having lower socioeconomic position; discrimination and racism in African Americans [6, 7]), it is unlikely that most or all of these pathways could be uniformly compromised in such a way as to block all potential health benefits. Thus, the theoretical model suggests that social integration's impact on health is likely to be evident in most populations.

However, empirical studies in African Americans have shown mixed results. In this nascent body of research, some work suggests the relationship may differ in African-Americans compared to Whites [8–10]. For example, in one study using data from the US National Health Interview Survey, which included African-Americans and Whites, authors classify participants as “highly isolated”, “moderately isolated”, “moderately integrated”, and “highly integrated”. Higher integration was associated with lower mortality in a dose–response manner among Whites; among African-Americans, the protective association with mortality was observed only at the highest social integration level [9]. Notably, this study had a substantially smaller sample size for African-Americans ($n=4201$) than Whites ($n=20,217$), limiting the ability to detect relations across the full distribution of social integration in African-Americans. Another study followed 20,668 African-Americans in the Cancer Prevention Study II for 40 years and found higher social integration was associated with a lower mortality rate in African-Americans [11]. However, despite the large sample size of Cancer Prevention Study II, participants in this study were generally well-educated (e.g., 38% are college graduates) and older (69% greater than 60 years), thus further research is needed in broader and more diverse segments of the population. Since age and socioeconomic status may modify the relationship between social integration and health [12],

Fig. 1 Kaplan–Meier survival curves for participants in the Jackson Heart Study 2001–2018, stratified by level of social integration



investigating these associations in more socioeconomically diverse African-Americans with a wide age range will add crucial empirical evidence to the currently limited body of research in this population.

We examined the relationship between social integration and mortality using data from the Jackson Heart Study (JHS), a community-based longitudinal cohort comprised of socioeconomically diverse African-American men and women. We speculate that the social integration is a resource that protects health, likely transcending specific sociocultural milieus. Thus, we hypothesized that higher social integration would be associated with lower mortality rates over the follow-up period in this sample of African American adults. Given prior systematic reviews linking depression, health conditions (e.g., hypertension, diabetes) and behaviors (e.g., physical activity, smoking) with both lower social integration and greater risk of mortality [13, 14], these factors were examined as potential confounders. Prior research found differences in the social integration-mortality relationship by sex [11], and JHS is comprised of a socioeconomically diverse population with a wide age range. Thus, we examined sex, age, education, and income as potential effect modifiers.

Methods

Study population

At baseline, 5,306 African-American adults ages 20–95 were recruited into JHS, from Hinds, Madison, and Rankin counties in the Jackson, Mississippi, metropolitan area. Participants came from four recruitment pools as follows: community random sample (17%), volunteer sample (22%), the Atherosclerosis Risk in Communities Study sample (30%), and family sample which included individuals who were members of families that already had at least two members enrolled in the study (31%). Recruitment was limited to noninstitutionalized African Americans aged 35 to 84 years, except in the family sample, in which those aged 21 to 34 years were also eligible [15]. Additional details of the design and recruitment are published elsewhere [16–18]. After completing baseline clinical visits (exam1: 2000 to 2004), participants returned for 2 additional examinations (exam2: 2005–2008, and exam3: 2009–2013), and follow-up questionnaires were administered annually by telephone. All participants ($n=5306$) were followed up through 2018 for mortality status.

In general, missing data was low, on both primary variables of interest and covariates ($<3\%$). For example, for most components of the social integration measure including marital status, contact with close friends and relatives, and participation in group activities, there were few missing

data at $<1\%$; missing data was higher for church attendance ($n=1033$; 19% missing). JHS participants who did not versus did provide social integration data did not differ significantly in age (56 vs. 54 years) and body mass index (BMI; 31.7 vs. 31.8 kg/m²), but they did have lower income (e.g., 22% vs. 27% are affluent), lower education (e.g., 51% vs 64% attended vocational/trade, or college), and were slightly more likely to engage in unhealthy behaviors (e.g., 16% vs. 12% are current smokers) (Supplemental Table S1). Most covariates had little missing data ($<3\%$), with somewhat higher missing data for income (15%), cholesterol (13%), diet (10%), and depression status (36%). As all missing data occurred at random, we imputed these missing data in all 4 domains of social integration as well as covariates to retain sample size for our analyses. Thus, all participants were retained for the analytic sample. The Institutional Review Boards approved the study at the [blinded for review]. All participants provided written informed consent. The Institutional Review Board at [blinded for review] approved the current analysis.

Measures

Social integration

At the baseline period, social integration was assessed based on the Berkman-Syme Social Network Index [5], using information from the following four domains: (1) marital status, (2) contact with close friends and relatives, (3) participation in group activities, and (4) participation in religious activities. Following prior work [19], we assigned a score of 0 to those who were least integrated and a score of 3 to those who were most integrated within each domain, as described in more detail below.

Marital status assesses whether participants are married or in a relationship, divorced, never been married, separated, widowed, or not in a relationship. We created a binary variable assigning a score of 3 to those who were married or in a relationship and 0 to all others. Contact with friends and relatives assesses the number of (a) close friends and (b) close relatives participants can talk to; response options for each include the following: ‘none’, ‘1 to 2’, ‘3 to 5’, ‘6 to 9’, and ‘10 or more.’ For an overall measure, we assigned the median value to each response (‘none’ = 0, ‘1 to 2’ = 1.5, ‘3 to 5’ = 4, ‘6 to 9’ = 7.5, ‘10 or more’ = 10), then summed across friends and relatives to obtain a score ranging from 0–20; we then categorized the score as follows: 0 = none; 1 = 1–2; 2 = 3–5; 3 = 6 or more. Participation in group activities was assessed by summing the number of groups to which participants reported belonging, and then categorizing this continuous score: 0 = 0; 1 = 1 group; 2 = 2–3 groups; 3 = 4 or more groups. Participation in religious activities was assessed according to self-reported frequency of church

attendance. Following prior work [19], we categorized this as: 0 = not at all; 1 = a few times a year or < once a year; 2 = a few times a month; 3 = nearly every day or at least once a week. We then created a continuous social integration score for all participants by summing scores across domains, for a total score ranging from 0 to 12. To examine threshold effects, this continuous social integration score was also categorized as: highly isolated (0–4), moderately isolated (5–7), moderately integrated (8–9), highly integrated (10 or higher).

Mortality

Mortality was assessed using information from the Mississippi Department of Health and the National Death Index. Specifically, JHS obtained mortality status at annual follow-up and from physician and coroner reports, and this information was adjudicated by trained clinical staff. Death certificates were requested from the Mississippi State Department of Health for JHS participants when needed [20]. For example, as part of data collection for mortality, the JHS uses age-specific death lists of African Americans in the tri-county area and requests death certificates from the State Department of Health. For the present analysis, data on mortality were available through May 31, 2018.

Covariates

All covariates were obtained at baseline. Demographic measures were self-reported. Based on income, family size, and inflation, JHS investigators classified annual household income into 4 categories: low (less than poverty level), lower-middle (1–1.6 times the poverty level), upper-middle (1.6–3.5 times the poverty level), and affluent (at least 3.5 times the poverty level). We classified education into three categories: vocational/trade school/college or higher, high school graduate/GED, and less than high school. Depressive symptoms were assessed using the 20-item Center for Epidemiologic Studies Depression Scale (CES-D), and a score ≥ 16 was defined as probable depression [21, 22].

The measurements and categorizations of health conditions and health behavior-related factors are detailed in Supplemental Text 1. Briefly, health conditions included prevalent or history of high cholesterol, type 2 diabetes mellitus, hypertension, cardiovascular disease, and cancer. Health behavior-related factors included smoking, physical activity, diet, alcohol consumption, and BMI.

Statistical analysis

We visually observed the unadjusted relationship between social integration and mortality rate using Kaplan–Meier curves. Then, we used Cox proportional hazards regression

to examine the relationship between social integration and mortality, accounting for relevant covariates, with 5 increasingly covariate adjusted models. Respondents were censored (i.e., follow-up ended) after (1) death, (2) loss to follow-up (i.e., could not be found for further evaluation), or (3) the end of follow-up (May 31, 2018). The first model included age. The second model further added sex, income, and education. The third model additionally controlled for depressive symptoms as a potential confounder (and/or intermediate variable), constituting the core model that accounts for key covariates related to mortality and social integration. The fourth and fifth models included health conditions and behaviors that could be confounders or intermediate variables. The fourth model added prevalent/history of high cholesterol, diabetes, hypertension, cardiovascular disease, and cancer. The fifth model further added health behaviors (i.e., smoking, physical activity, alcohol consumption, diet quality) and BMI, constituting the fully adjusted model. We examined whether the proportional hazards assumption of Cox models was violated by Schoenfeld residuals [23], and the proportionality assumption was upheld in the full model ($P=0.27$). In all models, we included the categorical measure of social integration, with the category ‘moderately isolated’ serving as the reference group to facilitate examining potential effects of either extreme (i.e., highly isolated or highly integrated). To evaluate potential linear trends, P values for trend were determined using the continuous social integration score (range 0–12).

With secondary analyses, we tested potential effect modification by sex (male/female), age (binary; age ≥ 55 vs. < 55), education (binary; years of education ≤ 13 vs. > 13), and income (binary; low and low middle vs. middle and affluent), including interaction terms separately in the core model. We also examined each component of the social integration score separately in relation to mortality risk using the same set of models described above. We further conducted several sensitivity analyses. First, we calculated E -values [24, 25] to quantify the extent to which an unmeasured confounder would need to be associated with both social integration and mortality to explain away the observed association. Second, to reduce concerns about reverse causation (i.e., underlying illness could lead to changes in social integration) we conducted 2 analyses whereby we: (1) excluded 190 participants who died within 4 years of study baseline (resulting in $n=5116$); or (2) excluded 837 individuals with cardiovascular disease and cancer at baseline (resulting in $n=4470$). Third, instead of imputing social integration data, we conducted analyses after excluding 1082 participants missing any components in the social integration measure (resulting in $n=4224$). Finally, to facilitate more direct comparison with the existing body of research on social integration, we conducted analyses combining ‘highly isolated’ and ‘moderately isolated’. All analyses were conducted in

R Statistical Software (version 1.1456) (16). We conducted multiple imputations ($n = 10$) by chained equations using the MICE package in R and combined results from each imputed dataset using the MITOOL package in R [26].

Results

The mean social integration score was 8.19. Table 1 shows the distributions of covariates at baseline by levels of social integration. Participants had a mean age of 55 years (range 20–95 years), and 64% were women. At baseline, 58% of participants were married or living together, 53% reported having 6 or more close friends/relatives, 79% reported attending religious activities once a week or more, and 11% reported belonging to 4 or more social/church groups. The continuous social integration score was negatively skewed, indicating most of the JHS participants reported relatively high social integration (Supplemental Figure S1). Compared to those who were moderately isolated, those categorized as highly integrated reported higher income and education, were less likely to be depressed and were less likely to be a current smoker.

Social integration and mortality

Over approximately 18 years of follow-up, 23% of participants died ($n = 1238$). Overall, we observed strong dose–response associations between higher social integration levels and lower mortality rates in unadjusted Kaplan–Meier curves (Fig. 1). These trends remained largely unchanged in findings from multivariable proportional hazards analyses (Table 2). Compared to moderately isolated individuals, those who were more integrated had lower hazard ratios (HRs) while those who were more isolated had higher HRs of mortality over the follow-up. For example, in the core model (Model 3), the highly integrated group was related to a 25% reduced hazard for death during follow-up. Adding health conditions and factors related to health behaviors to the core model did not yield a substantial attenuation with the association indicating 23% reduced hazard. Reduced mortality rates were also observed for the moderately integrated group, though the association did not reach statistical significance (e.g., core model: HR = 0.90, 95% CI 0.78–1.05). Conversely, compared to individuals who were moderately isolated, those who were highly isolated had an HR of 1.35 (95% CI 0.98–1.86) for death during the follow-up in the core model. However, after adding health conditions and health-behavior-related factors to the core model, the primary association was substantially attenuated (HR = 1.19, 95% CI 0.88–1.62); of note, relatively few participants were highly isolated ($n = 242$). The relationship

between social integration and mortality was not modified by sex, age, education, or income (Supplemental Table S2).

Subcomponents of social integration and mortality

In Cox proportional hazard models assessing the subcomponents of social integration separately, greater social integration in all 4 domains was associated with lower mortality in the models controlling only for age (Table 3). Except church attendance, all associations remained significant after further controlling for sociodemographic factors and depressive symptoms. Specifically, in the core models, being married/partnered (vs. not married/not in partnership) was associated with an HR of 0.80 (95% CI 0.71–0.91); having contacts with 6 or more close friends/relatives (vs. 0–2 contacts per month) was associated with an HR of 0.69 (95% CI 0.57–0.85); the highest vs. lowest level of group attendance was associated with an HR of 0.78 (95% CI 0.63–0.96) for mortality over follow-up.

Sensitivity analyses

Sensitivity analyses suggest associations between social integration and mortality are unlikely to be explained by unmeasured confounding. The *E*-value in the core model comparing moderately vs. highly integrated groups was 1.74 [24], suggesting an unmeasured confounder would need to have a minimum HR of 1.74 with both higher social integration and lower mortality (above and beyond the measured covariates) to fully explain away the observed association [25]. After excluding those who died within 4 years from baseline, estimates remained largely unchanged from the primary analyses (Supplemental Table S3). Findings were largely consistent in analyses excluding individuals with cardiovascular disease and cancer at baseline (Supplemental Table S4), in analyses in which we did not impute missing observations for church attendance (Supplemental Table S5), and in analyses in which we combined “highly isolated” and “moderately isolated” groups and used them as the reference group (Supplemental Table S6).

Discussion

In a prospective, community-based cohort of socioeconomically diverse African-American men and women with a broad age range, we found higher social integration was robustly related to reduced risk of premature mortality in a dose–response manner over ~18 years of follow-up. Compared with those who were moderately isolated, being moderately integrated was associated with 11% lower mortality

Table 1 Baseline Characteristics of Participants by Categories of Social Integration Score^a, Jackson Heart Study, 2000–2004 (*N* = 5306)

| | Highly isolated (0–4) (<i>N</i> = 193) | Moderately isolated (5–7) (<i>N</i> = 1410) | Moderately integrated (8–9) (<i>N</i> = 1286) | Highly integrated (10–12) (<i>N</i> = 1332) |
|-----------------------------------|--|---|---|---|
| Demographic factors | | | | |
| Age, years, M (SD) | 48.3 (13.2) | 54.7 (13.5) | 54.3 (12.1) | 55.6 (11.6) |
| Female, % | 112 (58.0%) | 1041 (73.8%) | 801 (62.3%) | 773 (57.9%) |
| Income, ^b % | | | | |
| Poor | 64 (33.2%) | 268 (19.0%) | 115 (8.9%) | 68 (5.1%) |
| Lower-middle | 41 (21.2%) | 383 (27.2%) | 253 (19.7%) | 186 (13.9%) |
| Upper-middle | 29 (15.0%) | 349 (24.8%) | 347 (27.0%) | 378 (28.3%) |
| Affluent | 26 (13.5%) | 230 (16.3%) | 391 (30.4%) | 473 (35.4%) |
| Educational level, % | | | | |
| Less than high school | 40 (20.7%) | 287 (20.4%) | 205 (15.9%) | 156 (11.7%) |
| High school graduate/GED | 47 (24.4%) | 330 (23.4%) | 248 (19.3%) | 205 (15.4%) |
| Vocational/trade, or college | 105 (54.4%) | 790 (56.0%) | 832 (64.7%) | 973 (72.9%) |
| Mental health | | | | |
| Depressive symptoms, % | 55 (28.5%) | 257 (18.2%) | 184 (14.3%) | 150 (11.2%) |
| Baseline health conditions | | | | |
| High cholesterol, ^c % | | | | |
| Poor | 25 (13.0%) | 179 (12.7%) | 194 (15.1%) | 160 (12.0%) |
| Intermediate | 57 (29.5%) | 517 (36.7%) | 437 (34.0%) | 500 (37.5%) |
| Ideal | 89 (46.1%) | 546 (38.7%) | 515 (40.0%) | 530 (39.7%) |
| Type 2 mellitus, % | 48 (24.9%) | 342 (24.3%) | 270 (21.0%) | 309 (23.1%) |
| Hypertension, % | 85 (44.0%) | 825 (58.5%) | 733 (57.0%) | 731 (54.8%) |
| CVD history, % | 21 (10.9%) | 158 (11.2%) | 128 (10.0%) | 118 (8.8%) |
| Cancer history, % | 10 (5.2%) | 52 (3.7%) | 59 (4.6%) | 67 (5.0%) |
| Health behaviors | | | | |
| Smoking status, % | | | | |
| Current smoker | 60 (31.1%) | 213 (15.1%) | 166 (12.9%) | 84 (6.3%) |
| Former smoker | 31 (16.1%) | 256 (18.2%) | 246 (19.1%) | 262 (19.6%) |
| Never smoked | 101 (52.3%) | 932 (66.1%) | 869 (67.6%) | 980 (73.4%) |
| Physical activity, ^d % | | | | |
| Poor | 109 (56.5%) | 751 (53.3%) | 612 (47.6%) | 560 (41.9%) |
| Intermediate | 49 (25.4%) | 449 (31.8%) | 394 (30.6%) | 450 (33.7%) |
| Ideal | 35 (18.1%) | 210 (14.9%) | 280 (21.8%) | 325 (24.3%) |
| Diet, ^e % | | | | |
| Poor | 110 (57.0%) | 700 (49.6%) | 670 (52.1%) | 652 (48.8%) |
| Intermediate | 50 (25.9%) | 539 (38.2%) | 485 (37.7%) | 565 (42.3%) |
| Ideal | 0 (0%) | 20 (1.4%) | 9 (0.7%) | 16 (1.2%) |
| Alcohol, ^f % | | | | |
| Excessive drinker | 21 (10.9%) | 67 (4.8%) | 34 (2.6%) | 19 (1.4%) |
| Moderate drinker | 107 (55.4%) | 520 (36.9%) | 504 (39.2%) | 482 (36.1%) |
| No drinker | 55 (28.5%) | 789 (56.0%) | 711 (55.3%) | 798 (59.8%) |
| Body mass index, M (SD) | 31.3 (8.28) | 32.2 (7.77) | 31.7 (7.15) | 31.3 (6.57) |

Percentage may not add up to 100% due to missing values

This table was created using data prior to imputing social integration variable

^aSocial integration was derived from Berkman–Syme Social Network Index, a continuous score ranging from 0 to 12

^bIncome status derived from family income and family size and adjusted for inflation

^cPoor: total cholesterol \geq 240 mg/dL; Intermediate: 200–239 mg/dL, or if treated ($<$ 200 mg/dL); Ideal: $<$ 200 mg/dL

^dPoor: 0 min of moderate or vigorous physical activity; Intermediate: 1–149 min/wk of moderate physical

Table 1 (continued)

activity, 1–74 min/wk of vigorous physical activity, or 1–49 min/wk of combined moderate and vigorous physical activity; and Ideal: ≥ 150 min/wk of moderate physical activity; or ≥ 75 min/wk of vigorous physical activity; or ≥ 150 min/wk of combined moderate and vigorous physical activity

^eDiet quality was assessed by evaluating ideal consumption levels for 5 dietary components (fruits and vegetables: ≥ 4.5 cups/day; fish: > 3.5 oz, twice per week; sodium: < 1500 mg/day; sugary beverages: < 450 kcal/wk and whole grains: ≥ 3 servings/day). The food frequency questionnaire was then categorized into three groups based on the number of components that meet the guideline. Poor: 0–1 components; Intermediate: 2–3 components; Ideal: 4–5 components

^fPoor: > 7 drinks/wk for women and > 14 for men; Intermediate: zero drinks/wk; and Ideal: 1–7 drinks/wk for women and 1–14 for men

rates, and being highly integrated with 25% lower mortality rates over the follow-up, after controlling for core confounders. Compared with those who were moderately isolated, being highly isolated was related to a 34% higher mortality rate, controlling for core confounders. Further adjustment for health conditions and health behaviors, which may be confounders or intermediate variables on the pathway from social integration to mortality, only slightly attenuated most associations. In analyses assessing social integration domains separately, higher social integration in each domain except church attendance was associated with lower risk of mortality even after adjustment for core confounders. Taken together, these findings suggest that social integration may be a psychosocial asset that deserves further consideration as a possible intervention target to reduce mortality among African-Americans.

Our findings generally converge with the body of evidence in predominantly White populations suggesting that higher social integration is related to reduced mortality risk. Although some studies hinted that the social integration-mortality link differed between Whites and African-Americans [8–10], in all of these studies the sample size was substantially smaller for African-American than for Whites. Our findings align with several other studies that reported similar associations of social integration and mortality across Whites and African-Americans that included larger numbers of African-Americans [11, 27]. For example, in the Cancer Prevention Study II (CPS-II), in which 20,668 well-educated and relatively older (50–79 years) African-Americans were followed for up to 40 years, the most isolated Black men had a 60% higher mortality rate than the least isolated Black men, while Black women had an 84% higher rate [11]. Of note, compared to the present study, risk estimates regarding the association of the social isolation with mortality were larger in the meta-analysis with individuals of predominantly European descent and in the study of African Americans in CPS-II (i.e., hazard ratios for high social isolation: 2.00 in CPS-II [11] and 1.92 in the meta-analysis [4] > vs. 1.31 in the present study). While the differences in effect sizes between these studies and the present one partially due to heterogeneity in which social integration measures were used and different scaling of these measures, the subcomponents examined in each study are conceptually similar and

the general patterns of results, including a dose-response relationship, is consistent across studies. Moreover, although African-Americans in JHS represent a broader spectrum of education levels and ages compared to CPS-II participants, the social integration-mortality associations did not differ by education or age, suggesting these associations are not only evident among those who are more socioeconomically advantaged. In subcomponent analyses, we found associations with reduced mortality risk for 3 of the 4 domains of social integration, suggesting there may not be only one component driving these associations. These results align with previous studies among African-Americans, demonstrating favorable associations for contact with friends, marital status, and the number of groups with other health-related outcomes (e.g., health behavior, health care practices, coping/mental health) [28–32]. Given prior studies showed that higher church attendance is associated with lower mortality rates [33, 34], the null association in the present study is unexpected and may be due to a lack of variation in church attendance (i.e., 79.1% reported attending religious activities once a week or more).

Drawing on a conceptual framework developed after systematically reviewing relevant studies, Hodgson et al. recently proposed 4 major pathways that could underlie the association of social integration and mortality [14]. These include physiological (e.g., hypothalamic-pituitary-adrenal axis and inflammation), psychological (e.g., anxiety and cognitive decline), sociological (e.g., access to health care, health literacy), and behavioral pathways (e.g., physical activity and smoking). For example, empirical studies show that increases in social integration levels were associated with reduced inflammation and more frequent healthy dietary choices. While social integration was associated with several factors in the current study (e.g., diet and physical activity), the social integration-mortality associations were only slightly attenuated when including them in the models. Future research should further evaluate the role of these and other mechanisms we could not assess in the current study (e.g., inflammation).

The associations between social integration and mortality were not modified by sex, age, education, or income. Combining this observation with the larger body of research on social integration and health in Whites and

Table 2 Hazard ratios for associations of social integration with all-cause mortality, Jackson Heart Study, 2000–2018 ($N = 5306$)

| Exposure | Person-years | Cases | Model 1 ^a | | Model 2 ^b | | Model 3 ^c | | Model 4 ^d | | Model 5 ^e | |
|-----------------------------------|--------------|-------|----------------------|------------|----------------------|------------|----------------------|-----------|----------------------|------------|----------------------|------------|
| | | | HR | 95%CI | HR | 95%CI | HR | 95%CI | HR | 95%CI | HR | 95%CI |
| Berkman–Syme social network index | | | | | | | | | | | | |
| Highly integrated | 20,031 | 246 | 0.70 | 0.61, 0.81 | 0.75 | 0.65, 0.88 | 0.75 | 0.65,0.88 | 0.74 | 0.64, 0.87 | 0.77 | 0.66, 0.90 |
| Moderately integrated | 19,195 | 268 | 0.88 | 0.76, 1.01 | 0.90 | 0.78, 1.05 | 0.90 | 0.78,1.04 | 0.90 | 0.78,1.04 | 0.91 | 0.79, 1.06 |
| Moderately isolated | 20,468 | 351 | 1.00 | Ref | 1.00 | Ref | 1.00 | Ref | 1.00 | Ref | 1.00 | Ref |
| Highly isolated | 2,752 | 46 | 1.73 | 1.28, 2.35 | 1.35 | 0.98, 1.86 | 1.33 | 0.97,1.82 | 1.29 | 0.95, 1.74 | 1.19 | 0.88, 1.62 |
| P for trend | | | < 0.001 | | < 0.001 | | < 0.001 | | < 0.001 | | < 0.001 | < 0.001 |

CI confidence interval, Ref. reference, HR hazard ratio, CES-D center for epidemiologic studies depression scale

Model 1^a Age adjusted

Model 2^b Model 1 + sociodemographic conditions (sex, income, and educational status)

Model 3^c Model 2 + depression symptom measured by CES-D

Model 4^d Model 3 + health conditions (cholesterol, diabetes, hypertension, cardiovascular disease, and cancer)

Model 5^e Model 4 + health behaviors (smoking, physical activity, diet, alcohol consumption, and body mass index)

African-Americans, such findings may suggest that once individuals become socially integrated, relations with health may be positive across racial/ethnic and sociodemographic groups regardless of how one achieves social integration. Aligning with this observation, emerging results from wild mammals consistently show a positive relationship between social integration and survival with remarkably similar effect sizes as reported in humans (i.e., odds ratios ranging from 1.23 to 1.72) [1–3], suggesting the link between social integration and health is an evolutionarily conserved mechanism. However, since structural factors can pattern social network structures and functions [35, 36], different racial/ethnic groups may have different paths to or experiences of social networks. Thus, network characteristics might differ for African-Americans relative to individuals from other sociocultural backgrounds like Hispanic Americans and non-Hispanic White Americans, as well as non-Westerners. For example, compared to White Americans, some work suggests African Americans may have more kin than friends in their networks [37–39] and rely more on kin-centered networks for support [40–43]. In non-kin social networks, religious involvement and ties to one's church community are particularly salient in African American culture [35, 44]. Such sociocultural contexts could be more explicitly considered when designing studies to assess how social integration in different groups may influence health. Extrapolating from this, the degree of “kin-centeredness” is potentially a useful factor to consider when evaluating effects of social integration, given humans are genetically predisposed to be more altruistic to those who share a higher proportion of genomic information with themselves (i.e., genetic relatives) [45, 46] while culture might also play a central role on individuals' tendency to engage in prosocial behaviors with non-kin or strangers [47].

Our study has several limitations. First, confounding is always a limitation in observational studies. However, we did control for a wide range of potential confounders, including depressive symptoms, and the calculated *E*-values suggested that observed associations were relatively robust to unmeasured confounding. Reverse causation is possible, however, in sensitivity analyses where we excluded those who died early in the follow-up or with chronic diseases at baseline, findings remained highly consistent. The JHS was conducted in a single metropolitan area in the southern United States, where African Americans are more concentrated compared to other cities. As a result, levels of social integration may differ from those found in other regions. In addition, according to the US census, there are more female than male African Americans in the general population; JHS also includes more women than men [48]. Further, the higher proportion of female participants in the JHS is due in part to the strategy of supplementing the random sample with community volunteers who met specific criteria based

Table 3 Hazard ratios for associations of social integration subcomponents with all-cause mortality, Jackson Heart Study, 2000–2018 ($N=5306$)

| Exposure ^a | Person-years | Cases | Model 1 ^b | | | Model 2 ^c | | |
|--|--------------|-------|----------------------|------------|-------------|----------------------|------------|-------------|
| | | | HR | 95%CI | P for Trend | HR | 95%CI | P for Trend |
| Component of the social network index ^a | | | | | | | | |
| Marital status | | | | | | | | |
| Married/in partnership | 45,629 | 618 | 0.81 | 0.73, 0.91 | NA | 0.80 | 0.71, 0.91 | NA |
| Not married/not in partnership | 31,801 | 634 | 1.00 | Ref | | 1.00 | Ref | |
| Contact with close friends/relatives | | | | | | | | |
| 6 or more contacts/month | 40,583 | 699 | 0.60 | 0.49, 0.73 | 0.015 | 0.69 | 0.57, 0.85 | 0.038 |
| 3–5 contacts/month | 30,805 | 439 | 0.61 | 0.50, 0.75 | | 0.71 | 0.57, 0.88 | |
| 0–2 contacts/month | 5854 | 110 | 1.00 | Ref | | 1.00 | Ref | |
| Group attendance | | | | | | | | |
| 4 or more group attendance | 48,652 | 107 | 0.63 | 0.51, 0.77 | <0.001 | 0.78 | 0.63, 0.96 | 0.010 |
| 2–3 group attendance | 19,154 | 273 | 0.77 | 0.67, 0.88 | | 0.88 | 0.76, 1.01 | |
| 0–1 group attendance | 9270 | 869 | 1.00 | Ref | | 1.00 | Ref | |
| Church attendance | | | | | | | | |
| More than once a week | 50,278 | 766 | 0.75 | 0.57, 1.00 | 0.021 | 0.97 | 0.73, 1.29 | 0.748 |
| A few times a month | 8571 | 104 | 0.86 | 0.62, 1.19 | | 1.00 | 0.72, 1.39 | |
| Less than few times a year | 4375 | 51 | 1.00 | Ref | | 1.00 | Ref | |

CI Confidence Interval, Ref. Reference, HR Hazard Ratio, CES-D Center for Epidemiologic Studies Depression Scale

^aWhile each component of social network index are presented in the same table, they represent distinct analyses

^bAdjusted for age

^cAdjusted for age, sex, educational status, income, and depression symptom measured by CES-D

on age, sex, and socioeconomic status [49]. This approach was necessary to overcome the challenges of cost and low response rates associated with random sampling. Finally, we were unable to investigate all facets of social integration given the available data. For example, some individuals with less social integration may prefer and find comfort in solitude. Future studies may investigate such effect heterogeneity by individual characteristics in greater detail. However, our study also has several important strengths. We examined the social integration-mortality relationships in a large and socioeconomically heterogeneous sample of African-American men and women. Moreover, we had a substantial follow-up period and accounted for numerous potential confounders and intermediate factors, including some that were clinically assessed.

In summary, higher levels of social integration were associated with reduced mortality risk among African-American adults in a dose–response manner over ~ 18 years of follow-up. Our findings extend prior research by testing if associations hold in a diverse sample of African-Americans regarding socioeconomic status and age. Relatedly, in the present study, the association between social integration and mortality did not differ by sex, age, education, or income, suggesting social integration may be an essential psychosocial asset that promotes health regardless of either race/ethnicity and sociodemographic factors. Thus, social integration may be an intervention target to evaluate further. However, since

the specific ways through which individuals acquire and maintain high social integration may differ based on socio-cultural background, it is important to recognize approaches to fostering social integration may need to differ as well depending on which groups are targeted for intervention. Recognizing key strengths and assets within diverse groups may provide additional critical levers for improving population health.

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Data availability The data used in this study were obtained from the Jackson Heart Study (JHS), which is supported and conducted in collaboration with Jackson State University (HHSN268201800013I), Tougaloo College (HHSN268201800014I), the Mississippi State Department of Health (HHSN268201800015I) and the University of Mississippi

Medical Center (HHSN268201800010I, HHSN268201800011I and HHSN268201800012I) contracts from the National Heart, Lung, and Blood Institute and the National Institute for Minority Health and Health Disparities. The JHS data are available to qualified researchers upon request from the JHS Coordinating Center (<https://www.jacksonheartstudy.org>). Restrictions may apply to the availability of these data, which were used under license for the current study, and so are not publicly available. However, access to the data can be requested through the JHS Coordinating Center, subject to the JHS Data Use and Publication Policy. Any publications resulting from the use of JHS data should include an acknowledgment of the source of the data and funding support.

Declarations

Conflict of interest The views expressed in this manuscript are those of the authors and do not necessarily represent the views of the National Heart, Lung, and Blood Institute; the National Institutes of Health; or the US Department of Health and Human Services.

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References

- Silk JB et al (2010) Strong and consistent social bonds enhance the longevity of female baboons. *Curr Biol* 20(15):1359–1361
- Archie EA et al (2014) Social affiliation matters: both same-sex and opposite-sex relationships predict survival in wild female baboons. *Proc R Soc B Biol Sci* 281(1793):20141261
- Snyder-Mackler N et al (2020) Social determinants of health and survival in humans and other animals. *Science*. <https://doi.org/10.1126/science.aax9553>
- Holt-Lunstad J, Smith TB, Layton JB (2010) Social relationships and mortality risk: a meta-analytic review. *PLoS Med* 7(7):e1000316
- Berkman LF, Syme SL (1979) Social networks, host resistance, and mortality: a nine-year follow-up study of Alameda County residents. *Am J Epidemiol* 109(2):186–204
- James D (2017) Internalized racism and past-year major depressive disorder among African-Americans: the role of ethnic identity and self-esteem. *J Racial Ethn Health Disparities* 4(4):659–670
- LaVeist TA, Sellers R, Neighbors HW (2001) Perceived racism and self and system blame attribution: consequences for longevity. *Ethn Dis* 11(4):711–721
- Schoenbach VJ et al (1986) Social ties and mortality in Evans County, Georgia. *Am J Epidemiol* 123(4):577–591
- Barger SD, Uchino BN (2017) Racial and ethnic variation in the association of social integration with mortality: Ten-year prospective population-based US Study. *Sci Rep* 7:43874
- Assari S (2017) Whites but not blacks gain life expectancy from social contacts. *Behav Sci* 7(4):68
- Alcaraz KI et al (2019) Social isolation and mortality in US black and white men and women. *Am J Epidemiol* 188(1):102–109
- Demakakos P et al (2016) Wealth and mortality at older ages: a prospective cohort study. *J Epidemiol Community Health* 70(4):346–353
- Holt-Lunstad J et al (2015) Loneliness and social isolation as risk factors for mortality: a meta-analytic review. *Perspect Psychol Sci* 10(2):227–237
- Hodgson S et al (2020) Loneliness, social isolation, cardiovascular disease and mortality: a synthesis of the literature and conceptual framework. *J R Soc Med* 113(5):185–192
- Wilson JG et al (2005) Study design for genetic analysis in the Jackson Heart Study. *Ethn Dis* 15:30–37
- Fuqua SR et al (2005) Recruiting African-American research participation in the Jackson Heart Study: methods, response rates, and sample description. *Ethn Dis* 15(4 Suppl 6):S6-18
- Payne TJ et al (2005) Sociocultural methods in the Jackson Heart Study: conceptual and descriptive overview. *Ethn Dis* 15(4 Suppl 6):S6-38
- Taylor HA et al (2005) Toward resolution of cardiovascular health disparities in African Americans. *Ethn Dis* 15:4–17
- Trudel-Fitzgerald C et al (2019) The prospective association of social integration with life span and exceptional longevity in women. *J Gerontol Ser B*. <https://doi.org/10.1093/geronb/gbz116>
- Diaz KM et al (2016) Sedentary behavior and subclinical atherosclerosis in African Americans: cross-sectional analysis of the Jackson heart study. *Int J Behav Nutr Phys Act* 13(1):31
- O'Brien EC et al (2015) Depressive symptoms and risk of cardiovascular events in blacks: findings from the Jackson Heart Study. *Circ Cardiovasc Qual Outcomes* 8(6):552–559
- Vilagut G et al (2016) Screening for depression in the general population with the Center for Epidemiologic Studies Depression (CES-D): a systematic review with meta-analysis. *PLoS One* 11(5):e0155431
- Grambsch PM, Therneau TM (1994) Proportional hazards tests and diagnostics based on weighted residuals. *Biometrika* 81(3):515–526
- Mathur MB et al (2018) Website and R package for computing E-values. *Epidemiology* 29(5):e45
- VanderWeele TJ, Ding P (2017) Sensitivity analysis in observational research: introducing the E-value. *Ann Intern Med* 167(4):268–274
- Zhang Z (2016) Multiple imputation with multivariate imputation by chained equation (MICE) package. *Ann Transl Med*. <https://doi.org/10.3978/j.issn.2305-5839.2015.12.63>
- Pantell M et al (2013) Social isolation: a predictor of mortality comparable to traditional clinical risk factors. *Am J Public Health* 103(11):2056–2062
- Reese AM et al (2012) The effect of religious service attendance on race differences in depression: findings from the EHDIC-SWB study. *J Urban Health* 89(3):510–518
- Felix Aaron K, Levine D, Burstin HR (2003) African American church participation and health care practices. *J Gen Intern Med* 18(11):908–913
- Van Olphen J et al (2003) Religious involvement, social support, and health among African-American women on the east side of Detroit. *J Gen Intern Med* 18(7):549–557
- Holt CL et al (2014) Religion and health in African Americans: the role of religious coping. *Am J Health Behav* 38(2):190–199
- Fothergill KE et al (2011) Effects of social integration on health: a prospective study of community engagement among African American women. *Soc Sci Med* 72(2):291–298
- VanderWeele TJ et al (2017) Attendance at religious services, prayer, religious coping, and religious/spiritual identity as

- predictors of all-cause mortality in the Black Women's Health Study. *Am J Epidemiol* 185(7):515–522
34. Li S et al (2016) Association of religious service attendance with mortality among women. *JAMA Intern Med* 176(6):777–785
 35. Kim HK, McKenry PC (1998) Social networks and support: a comparison of African Americans, Asian Americans, Caucasians, and Hispanics. *J Comp Fam Stud* 29(2):313–334
 36. Chatters LM et al (2002) Patterns of informal support from family and church members among African Americans. *J Black Stud* 33(1):66–85
 37. Ajrouch KJ, Antonucci TC, Janevic MR (2001) Social networks among blacks and whites: the interaction between race and age. *J Gerontol B Psychol Sci Soc Sci* 56(2):S112–S118
 38. Keith PM, Kim S, Schafer RB (2000) Informal ties of the unmarried in middle and later life: Who has them and who does not? *Sociol Spectr* 20(2):221–238
 39. Pugliesi K, Shook SL (1998) Gender, ethnicity, and network characteristics: variation in social support resources I. *Sex Roles* 38(3):215–238
 40. Peek MK, Coward RT, Peek CW (2000) Race, aging, and care: Can differences in family and household structure account for race variations in informal care? *Res Aging* 22(2):117–142
 41. Perry CM, Johnson CL (1994) Families and support networks among African American oldest-old. *Int J Aging Hum Dev* 38(1):41–50
 42. Taylor RJ et al (2014) Informal social support networks of African American, Latino, Asian American, and native American older adults. In: *Handbook of minority aging*. Springer Publishing Company, New York, p 417–434
 43. Gerstel N (2011) Rethinking families and community: the color, class, and centrality of extended kin ties 1. In: *Sociological forum*. Wiley Online Library
 44. Lee E-KO, Sharpe T (2007) Understanding religious/spiritual coping and support resources among African American older adults: a mixed-method approach. *J Relig Spiritual Aging* 19(3):55–75
 45. Dawkins R, Davis N (2017) *The selfish gene*. Macat Library
 46. Hamilton WD (1964) The genetical evolution of social behaviour. II. *J Theor Biol* 7(1):17–52
 47. Schulz JF et al (2019) The Church, intensive kinship, and global psychological variation. *Science* 366(6466):eaau5141
 48. Demographics B (2018) Black women: statistics. <https://blackdemographics.com/population/black-women-statistics/>. Accessed 8 Mar 2023
 49. Fuqua SR et al (2005) Recruiting African-American research participation in the Jackson Heart Study. *Ethn Dis* 15:18–29