Original Investigation

Association Between Social Integration and Suicide Among Women in the United States

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IMPORTANCE Suicide is one of the top 10 leading causes of mortality among middle-aged women. Most work in the field emphasizes the psychiatric, psychological, or biological determinants of suicide.

OBJECTIVE To estimate the association between social integration and suicide.

DESIGN, SETTING, AND PARTICIPANTS We used data from the Nurses' Health Study, an ongoing nationwide prospective cohort study of nurses in the United States. Beginning in 1992, a population-based sample of 72 607 nurses 46 to 71 years of age were surveyed about their social relationships. The vital status of study participants was ascertained through June 1, 2010.

EXPOSURES Social integration was measured with a 7-item index that included marital status, social network size, frequency of contact with social ties, and participation in religious or other social groups.

MAIN OUTCOMES AND MEASURES The primary outcome of interest was suicide, defined as deaths classified using the codes E950 to E959 from the *International Classification of Diseases, Eighth Revision*.

RESULTS During more than 1.2 million person-years of follow-up (1992-2010), there were 43 suicide events. The incidence of suicide decreased with increasing social integration. In a multivariable Cox proportional hazards regression model, the relative hazard of suicide was lowest among participants in the highest category of social integration (adjusted hazard ratio, 0.23 [95% CI, 0.09-0.58]) and second-highest category of social integration (adjusted hazard ratio, 0.26 [95% CI, 0.09-0.74]). Increasing or consistently high levels of social integration were associated with a lower risk of suicide. These findings were robust to sensitivity analyses that accounted for poor mental health and serious physical illness.

CONCLUSIONS AND RELEVANCE Women who were socially well integrated had a more than 3-fold lower risk for suicide over 18 years of follow-up.

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Suicide is one of the top 10 leading causes of mortality among middle-aged women in the United States.[1,2] Over the past decade, suicide rates among middle-aged women in the United States have increased by more than 30%, exceeding even the relative increases observed among middle-aged men, the demographic group with the highest age-adjusted rate of suicide in the United States.[3] These trends paralleled increases in suicide rates worldwide over the past decade,[4] with current projections anticipating a continued increase in its contribution to the global mortality and disease burden.[5]

With the exception of a growing literature based on data from the United Kingdom and Europe correlating changes in suicide rates with macroeconomic conditions during the recent economic crisis,[6-9] most work in the field emphasizes the psychiatric, psychological, or biological determinants of suicide.[10,11] There is a historical tradition of concern about the social determinants of suicide, beginning with Durkheim, who postulated that suicide varies inversely with social integration.[12] More recently, Joiner[13] and Van Orden et al[14] elaborated an interpersonal theory of suicide consistent with Durkheim's work in which the unmet "need to belong"[15]—one facet of the higher-order construct of social integration—is partly responsible for the development of passive suicidal ideation. Taken together, these conceptual models of suicide and

suicidal behavior suggest a need for more research on its social determinants.

Using individual-level data from the US Health Professionals Follow-up Study, we recently estimated the association between social integration and suicide among middle-aged men,[16] but there were 2 important limitations of that study. First, the data set lacked information about participants' mental health status. Depressive disorders may compromise social relationships,[17,18] and it has been well established that the presence of a mood disorder is a strong risk factor for suicidal behavior.[19,20] Not accounting for the potentially confounding influence of mental health status could therefore bias estimates of the relationship between social integration and suicide away from the null. Second, social relationships may exert different influences on the mental health of women compared with men. Social ties may be more draining than nurturing for women, given gendered patterning in role demands[21,22] or empathic concern for others.[23] Consistent with some of these lines of inquiry, for example, Kposowa[24] found that being married exerted a strongly protective influence against suicide among men but not among women.

In general, the "low base-rate problem"[25] (ie, there are 36 000 suicides in the United States, relative to a population exceeding 300 million with an average life expectancy of approximately 78 years) makes it difficult for researchers to study the social determinants of suicide prospectively. More in-depth analyses of social relationships and suicide among women have been limited by the lack of large, prospective studies that also contain detailed information about social relationships beyond the "married"/"not married" indicators that are typically available in national registries.[26,27] Consequently, most studies in this field have instead used proxy outcomes, such as suicide attempts,[28,29] or have been based on populations enriched for psychiatric morbidity (eg, persons under psychiatric care[30-33]). To address these important gaps in the literature, we used data from the US Nurses' Health Study to estimate the association between social integration and suicide among women over 18 years of follow-up.

Methods

Study Population

The Nurses' Health Study is an ongoing prospective cohort study of women in the United States who were 30 to 55 years of age when the study was initiated in 1976.[34,35] Of the 238 026 potentially eligible registered nurses who were contacted by mail at study initiation, 65 241 (27.4) were excluded for having questionnaires that were returned as unforwardable and 372 (0.2%) died, leaving 121 701 (70.6%) who responded to the baseline questionnaire. Every 2 years, follow-up questionnaires are mailed to participants to obtain updated information on medical history, diet, lifestyle habits, and other health behaviors, with a response rate of at least 90% in each follow-up cycle. All participants provided written informed consent. The Nurses' Health Study, and the analysis described herein, was approved by the Partners Human Research Com-

mittee. Further details on the design and analysis of the Nurses' Health Study can be obtained elsewhere.[34,35]

Mortality Ascertainment

The primary outcome of interest was suicide mortality, assessed continuously during the course of the study until June 1, 2010. Deaths were identified using reports from next of kin and by searching state mortality files and the US National Death Index, a method that has been shown to have 98% sensitivity and 100% specificity for ascertainment of deaths.[36,37] Physicians blinded to exposure status reviewed death certificates and hospital or pathology reports to classify individual causes of death. Deaths caused by self-inflicted injuries were classified according to the underlying causes listed on the death certificate. For the present study, we specifically examined deaths in the "Suicide and Self-Inflicted Injury" cluster (codes E950-E959) of the World Health Organization *International Classification of Diseases, Eighth Revision*.

Exposure Assessment

The primary exposure of interest was social integration, measured with a 7-item index that included questions about marital status, social network size, frequency of contact with social ties, and participation in religious or other social groups.[38,39] The responses to these 7 items yield a total score from 1 to 12 that is typically analyzed as a 4-level categorical variable (eTable 1 in the Supplement). At baseline, the index demonstrated good internal consistency (Cronbach α = .78). Additional psychometric analyses[40] and evidence of the construct validity of the social integration index[41,42] have been described elsewhere. Because the index was not added to the Nurses' Health Study survey instrument until 1992 (and then again in 1996), we considered 1992 as the baseline year in our analysis. At this time point, the participants in the Nurses' Health Study were 46 to 71 years of age.

Statistical Analysis

All statistical analyses were performed with the SAS software package (version 9.2; SAS Institute). Each participant was followed up from the return of the 1992 questionnaire until either death or the end of follow-up (June 1, 2010), whichever occurred earlier. We plotted the cumulative incidence of suicide across different categories of social integration, using a test statistic based on the nonparametric maximum likelihood estimator of the subdistribution hazard to compare cumulative incidence across categories.[43]

To estimate the association between social integration and suicide, we fit a multivariable Cox proportional hazards model to the data,[44] using the independent increment model to handle time-updated variables efficiently.[45] Under this data structure, a new data record was created for every questionnaire cycle at which a participant was at risk for suicide, with covariates set to their values at the time the questionnaire was returned. To adjust for potential confounding by age, calendar time, and any potential 2-way interactions between these time scales, we stratified the analysis jointly by age in months at the start of follow-up and calendar year of the questionnaire cycle. The time scale

for the analysis was then measured in months since the start of the current questionnaire cycle. We also adjusted our estimates for the following time-updated covariates: employment status,[46] family history of alcoholism, body mass index,[47,48] weekly physical activity,[49] alcohol intake,[50] caffeine intake,[51-53] smoking status,[54] and history of hypertension, diabetes mellitus, or hypercholesterolemia.[55,56] To test for linear trends across categories of exposure, we modeled the median values within each category of exposure.

To assess the extent to which different trajectories of social integration[57] may affect subsequent risk of suicide, we fit multivariable Cox proportional hazards regression models with participants classified into 1 of 5 different groups based on their levels of social integration in 1992 and 1996: (1) no change in social integration, thus remaining in the lowest category (ie, category I) in both 1992 and 1996; (2) decrease in social integration from 1992 to 1996; (3) no change in social integration, thus remaining in an intermediate category (ie, category II or III) in both 1992 and 1996; (4) increase in social integration from 1992 to 1996; or (5) no change in social integration, thus remaining in the highest category (ie, category IV) in both 1992 and 1996. In this analysis of social integration trajectories, 1996 was specified as the baseline year, and the incidence of suicide was assessed during the 14-year period between the return of the 1996 questionnaire and June 1, 2010.

Sensitivity Analyses

To determine whether our findings were robust to the specific form of the social integration index that was used, we conducted sensitivity analyses specifying social integration as a continuous variable and disaggregated into its constituent components. We conducted several additional sensitivity analyses to assess the robustness of our estimates to additional sources of potential confounding. First, severe medical conditions have been shown to have a positive association with suicide risk,[58-60] and poor health has been shown to compromise social relationships.[57,61,62] We therefore refitted the multivariable regression models after excluding participants who, at baseline, had reported a history of cancer (specifically, any type of cancer with the exception of nonmelanoma skin cancer) or a serious cardiovascular condition (specifically, myocardial infarction, coronary artery bypass graft surgery, percutaneous transluminal coronary angioplasty, or stroke). Second, poor mental health may confound the observed relationship between social integration and suicide.[17,18,20] We therefore refitted the regression models after excluding participants who, at baseline, had poor mental health status, defined as a score of 52 or less on the 5-item Mental Health Inventory.[63,64] The Nurses' Health Study also included 2 variables for self-reported antidepressant medication use and self-reported physician-diagnosed depression, but these 2 variables were not added to the survey until 1996; therefore, in the sensitivity analyses for these variables, we adopted 1996 as the baseline year. In addition, instead of excluding these participants from analysis, we also conducted sensitivity analyses in which we adjusted for these conditions as baseline covariates.

Results

Of 121 701 women initially enrolled into the Nurses' Health Study, 104 064 (85.5%) remained under follow-up in 1992. Of these 104 064 women, 72 607 (69.8%) responded to the social integration questions in the 1992 survey and therefore constituted the primary sample for analysis. Compared with nonresponders, responders had a lower incidence of suicide during the subsequent 18 years of follow-up (4 vs 5 per 100 000 person-years; Mantel-Haenszel rate ratio, 0.76 [95% CI, 0.46-1.27]), but the difference was not statistically significant. Baseline summary statistics for the sample are provided in **Table 1**. The social integration index had a mean (SD) value of 6.62 (3.11). The majority of participants were classified into the highest (31 071 of 72 607 participants [42.8%]) category of social integration. Socially isolated (ie, less socially integrated) women were more likely to be employed full time, were less physically active, consumed more alcohol and caffeine, and were more likely to smoke compared with socially integrated women.

During 1 209 366 person-years of follow-up, there were 43 suicide events. The most frequently occurring means of suicide were poisoning by solid or liquid substances (21 suicide events [48.8%]), followed by firearms and explosives (8 suicide events [18.6%]) and strangulation and suffocation (6 suicide events [14.0%]). The cumulative incidence of suicide was highest among the most socially isolated women (**Figure**). The Gray[43] test rejected the null hypothesis that the cumulative incidence functions were equal across categories ($P < .001$). The same pattern was observed in estimates from the multivariable Cox proportional hazards regression models adjusted for covariates (**Table 2**). The hazard of suicide was lowest among participants in the highest (adjusted hazard ratio [AHR], 0.23 [95% CI, 0.09-0.59]) and second-highest (AHR, 0.26 [95% CI, 0.09-0.74]) categories of social integration. A decreasing trend was observed across the categories ($P = .001$).

For the analysis of changes in social integration from 1992 to 1996, 65 507 participants were included (**Table 3**). Over these 4 years, the mean (SD) change in the social integration index was −0.21 (2.50); 14 231 participants (21.7%) experienced a decrease in social integration, 11 068 participants (16.9%) experienced an increase in social integration, and 40 208 participants (61.4%) experienced no change in social integration. Participants who were categorized as having the highest level of social integration in both 1992 and 1996 had a reduced hazard of suicide over the subsequent 14 years of follow-up (AHR, 0.15 [95% CI, 0.03-0.65]), while other trajectories of social integration were less protective; a decreasing trend across trajectory categories was observed ($P = .03$).

The sensitivity analyses did not substantively alter our findings. When the social integration index was specified as a continuous variable, each 1-point difference in the index was associated with an 18% lower relative hazard of suicide (AHR, 0.82 [95% CI, 0.74-0.92]). When we disaggregate the social integration index into its constituent components, no single dimension of social integration appeared to drive our findings (eTable 2 in the Supplement). The estimates remained quali-

Table 1. Adjusted Baseline Sample Characteristics of Women in the Nurses' Health Study,
by Social Integration Category Measured in 1992[a]

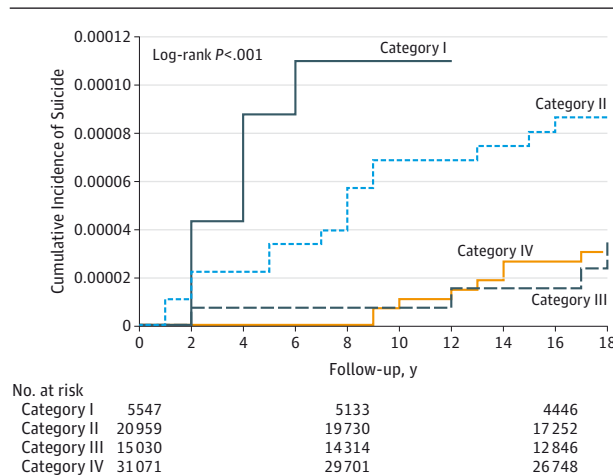| Characteristic	Social Integration Category[b]			
	I (Lowest) (n = 5547)	II (n = 20 959)	III (n = 15 030)	IV (Highest) (n = 31 071)
Age, mean (SD), y	57.9 (7.1)	58.5 (7.3)	57.8 (7.1)	58.6 (7.1)
White, %	97.6	97.6	98.0	97.9
Employment status, %				
Not employed outside the home/retired	23.2	26.4	29.4	31.8
Employed part time	14.2	17.5	20.8	22.2
Employed full time	50.0	44.7	40.1	36.5
Missing data	12.6	11.3	9.8	9.5
Family history of alcoholism, %	23.6	23.1	21.2	19.9
BMI, mean (SD)	26.2 (5.5)	26.1 (5.2)	25.9 (4.9)	26.1 (4.9)
Physical activity, mean (SD), METs/wk	16.2 (21.8)	17.8 (21.6)	19.7 (24.1)	20.4 (23.8)
Intake, mean (SD), g/d				
Alcohol	6.5 (12.3)	5.5 (10.2)	5.5 (9.4)	4.5 (8.4)
Caffeine	297 (234)	275 (227)	265 (218)	240 (212)
Smoking status, %				
Never	31.9	39.1	40.9	50.6
Former	42.6	43.2	44.7	39.8
Current				
1-14 cigarettes/d	8.1	6.9	6.3	4.6
15-24 cigarettes/d	10.6	7.4	5.8	3.6
≥25 cigarettes/d	6.8	3.4	2.3	1.4
History, %				
Hypertension	37.1	35.0	34.6	33.2
Diabetes mellitus	7.1	6.0	5.2	5.1
Hypercholesterolemia	45.1	45.9	45.7	46.0

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); METs, metabolic equivalent tasks.

[a] Values are standardized to the age distribution of the study population.

[b] Construction of the social integration index is described in Berkman and Syme.[39]

Figure. Cumulative Incidence of Suicide Among Women in the Nurses' Health Study

No. at risk			
Category I	5547	5133	4446
Category II	20959	19730	17252
Category III	15030	14314	12846
Category IV	31071	29701	26748

The follow-up period was from 1992 to 2010, with estimates of the incidence of suicide stratified by social integration category measured in 1992.

tatively similar when we excluded participants who, at baseline, had poor mental health status or had a history of cancer or a serious cardiovascular condition, or when we adjusted for these factors as covariates (eTables 3 and 4 in the Supplement), or when we excluded participants who, at baseline, re-

ported antidepressant medication use and/or a history of physician-diagnosed depression (or when we adjusted for these factors as covariates) (eTable 5 in the Supplement).

Discussion

In this longitudinal study of 72 607 women in the United States, we found that social integration at baseline was associated with a lower risk of suicide over 18 years of follow-up. The association was statistically significant, even stronger in magnitude than that observed in our recently published study of social integration and suicide among men,[16] and robust to several sensitivity analyses. Furthermore, excluding participants with poor mental health status, as measured at baseline by several different indicators, did not overturn the observed associations.

There are a number of important strengths and weaknesses to our study. First, this analysis was based on long-term follow-up data derived from a well-characterized, nationwide, population-based cohort. However, the participants in the Nurses' Health Study are also racially, generationally, and socioeconomically homogeneous. Second, US national suicide rates exceed the incidence rate observed in our sample,[1] suggesting a lower overall level of psychiatric morbidity. These 2 points suggest important limitations in the generalizability of our findings, given the higher socioeconomic status and

Table 2. Relative Hazard Ratios for Suicide Among Women in the Nurses' Health Study, 1992-2010, by Social Integration Category Measured in 1992

Social Integration	Hazard Ratio (95% CI)	
	Adjusted for Age	Adjusted for Age and Other Variables[a]
Category[b]		
I (lowest)	1 [Reference]	1 [Reference]
II	0.43 (0.20-0.94)	0.51 (0.23-1.16)
III	0.21 (0.08-0.59)	0.26 (0.09-0.74)
IV (highest)	0.17 (0.07-0.42)	0.23 (0.09-0.59)
P value for trend	<.001	.002

[a] Estimates were adjusted for age; employment status (not employed outside the home or retired, employed part time outside the home, or employed full time outside the home); family history of alcoholism (yes/no); body mass index (calculated as weight in kilograms divided by height in meters squared; <20.0, 20.0-24.9, 25.0-29.9, 30.0-34.9, and ≥35.0); physical activity in metabolic equivalent tasks per week (quintiles); caffeine intake; alcohol intake; smoking status (never, former, and current in categories of 1-14, 15-24, and ≥25 cigarettes per day); and baseline history of diabetes mellitus, hypertension, or hypercholesterolemia (yes/no).

[b] Construction of the social integration index is described in Berkman and Syme.[39]

Table 3. Relative Hazard Ratios for Suicide Among Women in the Nurses' Health Study, 1996-2010, by Social Integration Trajectory From 1992 to 1996

Social Integration	Hazard Ratio (95% CI)	
	Adjusted for Age	Adjusted for Age and Other Variables[a]
Trajectory from 1992 to 1996[b]		
No change (remained in category I)	1 [Reference]	1 [Reference]
Decrease in level of social integration	0.35 (0.10-1.20)	0.37 (0.10-1.34)
No change (remained in category II or III)	0.22 (0.06-0.81)	0.24 (0.06-0.97)
Increase in level of social integration	0.25 (0.06-1.01)	0.29 (0.07-1.25)
No change (remained in category IV)	0.13 (0.03-0.53)	0.15 (0.04-0.65)
P value for trend	.01	.02

[a] Estimates were adjusted for all sociodemographic, health behavior, and medical history variables listed in Table 2.

[b] Construction of the social integration index is described in Berkman and Syme.[39]

lower psychiatric morbidity of the study participants relative to the general population. Third, in contrast to our previously published study on social integration and suicide among men,[16] these data contained multiple indicators of mental health status. Adjustment for the potentially confounding effects of poor mental health did not appreciably change our estimates. Although the 5-item Mental Health Inventory is only a screening measure, it has been shown to have excellent sensitivity and specificity for detecting major depressive disorder.[63,64] Similarly, recall for "self-reported, physician-diagnosed" chronic conditions has been shown to be accurate when compared with medical record review.[55,65,66] Fourth, relatively few suicide events were observed, with only 43 suicides occurring in the study sample over the 18-year follow-up period, thereby limiting our ability to detect statistically significant associations in the analysis of social integration trajectories. We also attempted to disaggregate the social integration index into its individual components but were similarly limited by small cell sizes. Nonetheless, the number of events observed in our study was larger than any other previously published study of suicide among women with comparable data on social determinants.[26] Fifth, although our exposure variable has been previously validated and is frequently used in the literature, the social integration index fails to capture a number of different aspects of social integration, such as relationship quality, degree of reciprocity, geographic proximity, or network density.[67-73] Sixth, unobserved confounding could potentially explain the estimated associations. Even with adjustment for age, adverse health behaviors and chronic conditions were less prevalent among women who were socially well integrated. Thus, it is possible that social integration may, to a certain extent, be a proxy for good health—which is a known protective factor against suicide.[58-60]

Classically, researchers have argued that men may be more advantaged by social relationships compared with women.[74-77]

Although our primary finding may be interpreted as standing in contrast to this earlier body of literature, it is also possible that the social integration index used in our analysis systematically captured supportive relationships while ignoring negative aspects of these relationships[76-78] and that a scale that captures both positive and negative aspects of social relationships may have yielded more nuanced results. It is also possible that social integration may have differential associations with suicide vs suicide ideation or attempts, and that its association with suicidal behavior overall (eg, a composite outcome that includes suicide ideation, suicide attempts, or suicide) among women may be muted.

Our study has important implications for suicide prevention. Guidelines for clinical practice have generally focused on suicide risk screening, assessment, and treatment.[79-82] Our study confirms some of the prior studies that have informed these guidelines in emphasizing the importance of social isolation as a potential risk factor for suicide. In clinical practice, asking patients about the extent of their participation in a range of social relationships may yield information useful for risk assessment or in developing tailored interventions aimed at strengthening social relationships to be more functional and satisfying. In addition to individually targeted approaches, however, our findings suggest that a public health approach to suicide prevention may also be of benefit. As Knox et al[83] and Knox[84] have convincingly argued, based in part on the classic argument by Rose[85] for shifting the entire population distribution of disease, community-based interventions may be able to reduce the overall burden of suicide more effectively than intensive efforts focused on "high-risk" individuals. For example, health and social policy may be used to promote certain types of social ties, increase civic engagement, develop public spaces for group activities, or reduce the strain of relationships.[86] Clearly, the "high-risk" and "population-strategy" approaches each have their advantages and disadvantages, and the optimal prevention strategy likely requires a judicious mix of both.[87]

Conclusions

Although it has been frequently assumed that social integration has an inverse association with poor mental health outcomes, including suicide, most evidence in support of this hypothesis has been based on aggregate data.

Our study strongly suggests that social integration has a protective association against suicide risk for women, even after adjustment for multiple indicators of poor mental health. Interventions aimed at strengthening existing social network structures, or creating new ones, may be valuable programmatic tools in the primary prevention of suicide.

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