Published in final edited form as:
*Stroke*. 2014 October ; 45(10): 2868–2873. doi:10.1161/STROKEAHA.114.005815.

# Social Network, Social Support, and Risk of Incident Stroke: The Atherosclerosis Risk in Communities Study

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## Abstract

**Background and Purpose—**Having a small social network and lack of social support have been associated with incident coronary heart disease, however epidemiologic evidence for incident stroke is limited. We assessed the longitudinal association of a small social network and lack of social support with risk of incident stroke, and evaluated whether the association was partly mediated by vital exhaustion and inflammation.

**Methods—**The Atherosclerosis Risk in Communities (ARIC) Study measured social network and social support in 13,686 men and women (mean, 57±5.7 years, 56% female, 24% black; 76% white) without a history of stroke. Social network was assessed by the 10-item Lubben Social Network Scale, and social support by a 16-item Interpersonal Support Evaluation List-Short Form (ISEL-SF).

**Results—**Over a median follow-up of 18.6-years, 905 incident strokes occurred. Relative to participants with a large social network, those with a small social network had a higher risk of stroke [HR (95% CI): 1.44 (1.02–2.04)] after adjustment for demographics, socioeconomic variables and marital status, behavioral risk factors and major stroke risk factors. Vital exhaustion, but not inflammation, partly mediated the association between a small social network and incident stroke. Social support was unrelated to incident stroke.

**Conclusions—**In this sample of US community-dwelling men and women, having a small social network was associated with excess risk of incident stroke. As with other cardiovascular conditions, having a small social network may be associated with a modestly increased risk of incident stroke.

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**Disclosures:** None

### Keywords

Social network; Social support; Stroke; Psychological distress; Inflammation; Epidemiology

## Introduction

Stroke is the fourth leading cause of death in the United States[1], and often results in serious long-term disability and reduced quality of life for both stroke patients and their families. Therefore, stroke prevention is a public health priority.

The social environment is believed to have a tremendous influence on physical and psychological health and well-being[2]. Social network refers to the structure of one's relationships, in terms of both quality and quantity[3]. Social support refers to the functions or provisions given by one's social relationships such as emotional concern, instrumental assistance, or information[3]. Although social support is downstream of social network[4], measuring both variables is meaningful because not all social networks or ties are supportive and there is variation in the type, frequency, intensity, and extent of support provided[4].

Prior epidemiological studies have demonstrated that having a small social network and lack of social support are associated with an increased incidence of coronary heart disease[5–8] and heart failure[6,9], but relatively few studies have examined whether these factors are associated with incident stroke[10–13]. The mechanisms underlying these associations have not been fully elucidated but likely include both behavioral factors (e.g. poor diet, smoking, alcohol use and low physical activity)[14] and physiological components (e.g. hypertension, diabetes, obesity, and inflammation)[15,16] which may be partly influenced by mental stress (e.g. depression, loneliness or vital exhaustion). Using data from the Atherosclerosis Risk in Communities (ARIC) study we tested the hypotheses that small social network and lack of social support are associated with greater risk of incident stroke, independent of behavioral factors, and other major risk factors for stroke. We also examined whether these associations were partially mediated by vital exhaustion and a marker of systematic inflammation (i.e. high sensitivity C-reactive protein (hsCRP).

## Methods

The ARIC study is a predominantly biracial prospective epidemiologic cohort which enrolled 15,792 adults aged 45–64 years at the baseline visit (1987–1989)[17]. Participants were recruited through population-based sampling from four US communities: Washington County, MD; suburban Minneapolis, MN; Forsyth County, NC; and Jackson, MS. A total of four cohort re-examinations have taken place (1990–1992, 1993–1995, 1996–1998 and 2011–2013). Institutional review boards at each of the participating institutions approved the study, and all participants gave informed consent.

### Study population

Social network size and perceived social support were measured at visit 2 (1990–1992), which was attended by 14,348 participants, and thus serves as baseline for the present analysis. We excluded from the analysis 275 participants with prevalent stroke at baseline, 42 participants whose race who were not white or black, and 47 black participants from the MD and MN study communities. We further excluded from relevant analyses participants with incomplete data on social network (N=298) and perceived social support (N=301), resulting in a final analytic samples of 13,686 and 13,683, respectively.

### Social network and perceived social support assessment

Social network was measured using the 10-item Lubben Social Network Scale[18] which assesses the size of the participant's active social network of family, friends, and neighbors. Each item ranged from 0–5. The total score is an equally weighted sum, with scores ranging from 0–50; the higher the score, the larger the social network. Consistent with prior work, four categories were created: score ≤20=small social network; 21–25=moderate small social network; 26–30=moderate large social network; ≥31=large social network[9,18]. Perceived social support was measured using a modified version of the Interpersonal Support Evaluation List-Short Form (ISEL-SF)[19]. This 16-item scale was constructed by prior ARIC investigators from the original 40-item scale[20], and assesses perceived social support with four subscales; (a) appraisal support, (b) tangible assets support, (c) belonging support, and (d) self-esteem support. Each item has choices as "definitely false" to "definitely true", and the score ranges from 0–3. The total score is an equally weighted sum, with scores ranging from 0–48; the higher the score, the greater perceived social support. There is no standard interpretation for this score. In the present analysis we interpreted the score as follows: ≤16=lack of social support; 17–23=low social support; 24–31=moderate social support; ≥32=high social support.

### Measurement of covariates and potential mediators

Information on covariates and potential mediators was assessed at ARIC visit 2, except educational attainment, which was assessed at ARIC visit 1. Questionnaires were used to attain information on age, sex, race-center, socioeconomic status (SES) (including educational attainment, income, and occupation), marital status, smoking status, alcohol use, and medications. Vital exhaustion was measured using the 21-item Maastricht Questionnaire to characterize excessive fatigue, irritability, and feelings of demoralization[21]. Higher scores indicate greater exhaustion.

Physiologic variables were measured by trained technicians. BMI was assessed as weight (kg) divided by height (m) squared. Hypertension was defined as diastolic blood pressure ≥90 mmHg, systolic blood pressure ≥140 mmHg, or self-reported antihypertensive medication use during the previous 2 weeks. Diabetes mellitus as fasting serum glucose level ≥126 mg/dL, nonfasting glucose ≥200 mg/dL, or self-reported history of physician-diagnosed diabetes or medication use for diabetes over the last 2 weeks. Cholesterol was measured enzymatically. Low-density lipoprotein (LDL) was calculated. hsCRP was measured in serum using a latex-particle enhanced immunoturbidimetric assay kit (Roche Diagnostics).

## Stroke Ascertainment

Possible stroke events were identified through annual follow-up phone calls to participants or proxies, which asked about recent hospitalizations and deaths, surveillance of discharges from local hospitals, and death certificates. Medical records were obtained if the list of discharge diagnoses included an International Classification of Diseases, 9th Revision, code of 430–438, if a cerebrovascular condition or procedure was mentioned in the discharge summary, or if a cerebrovascular finding was noted on a CT or magnetic resonance imaging (MRI) report. Abstractors recorded stroke signs and symptoms and photocopied neuroimaging (CT or MRI) and other diagnostic reports.

Each potential stroke case was classified by computer algorithm and by physician reviewers according to criteria adapted from the National Survey of Stroke[22]. Disagreements were adjudicated. Qualifying strokes were classified as definite or probable ischemic stroke (neuroimaging showed acute infarction or no hemorrhage) or hemorrhagic stroke (intraparenchymal or subarachnoid) on the basis of neuroimaging studies or autopsy, when available.

### Statistical analysis

Descriptive statistics of covariates and potential mediators, according to categories of social network score and perceived social support score were generated using analysis of variance and $\chi^2$ tests, as appropriate. Pearson correlation coefficients were calculated. Cox proportional hazards regression model were used to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) for incident total stroke, by categories of social network and social support, after sequential adjustment for potential confounding variables. In secondary analyses we also looked separately at ischemic and hemorrhagic stroke. Follow-up time was calculated from the date of the visit 2 exam until the date of the incident stroke, loss-to-follow-up, death, or December 31, 2010, whichever came first.

We fit four sequential models: Model 1 adjusted for age, sex and race-center, Model 2 additionally adjusted for socioeconomic and marital status, Model 3 further adjusted for behavioral risk factors (smoking status, alcohol use and physical activity), and Model 4 additionally adjusted for major stroke risk factors (hypertension, diabetes, HDL-cholesterol, LDL-cholesterol, lipid-lowering medication use and BMI). We further adjusted for variables in Model 4 for vital exhaustion, and separately for hsCRP, to assess whether they mediated the associations. Mediation was suggested if regression coefficients changed by ≥10%. In secondary analyses, we looked separately at ischemic and hemorrhagic stroke. We also examined whether either race or sex modified the relationships between social network or perceived social support and incident stroke, by including cross-product terms in the models. The proportional hazards assumption was tested by logrank tests with Kaplan–Meier curves. All analyses were performed using SAS 9.3 (SAS Institute Inc.).

## Results

The 13,686 participants in our final analytic sample were on average 57 years old, 56% female, and 24% African American. Over a median follow-up of 18.6 years (max=20.9

years), a total of 905 incident strokes occurred (114 hemorrhagic strokes and 804 ischemic strokes), yielding a crude total stroke incidence of 4.0 per 1000 person-years.

The social network score was correlated with perceived social support (r=0.49, p<0.0001) and vital exhaustion (r=−0.21, p<0.0001), but not with hsCRP (r=−0.01, p=0.46). The perceived social support score was correlated with vital exhaustion (r=−0. 41, p<0.0001) and hsCRP (r=−0.04, p<0.0001).

### Small Social Network

Table 1 shows the age-adjusted characteristics of participants according to social network size categories at baseline. A total of 380 (2.8%) were classified as having a small social network. Relative to people with large social networks, those with a small social network were more likely to be black, male, not married, unemployed, have a high score on the vital exhaustion measure, be diabetic, smokers, have low income, low educational attainment, and higher hsCRP (Table 1). Among participants with a small social network, 9.2% were classified as lacking social support based on the ISEL-SF responses.

The relation between social network and risk of incident stroke was nonlinear; only those in the small social network group were at greater risk (Table 2). The age, sex and race-adjusted HR for those classified as having a small social network was 1.60 (95% CI: 1.17–2.20), relative to those with a large social network. Results were only slightly attenuated with further adjustment for SES and marital status [Model 2: 1.43 (1.03–2.00)], behavioral risk factors [Model 3: 1.36 (0.97–1.90)], and major stroke risk factors [Model 4: 1.44 (1.02–2.04)]. There was no evidence that either race or sex modified relations between small social network and incident stroke.

Vital exhaustion and hsCRP, possible mediators, were both associated with incident stroke in age, sex and race-adjusted models [HR (95% CI) for 1-point higher vital exhaustion score = 1.02 (1.01–1.03); HR for 1 mg/dL higher hsCRP = 1.02 (1.01–1.03)]. The beta for small social network in Model 4 was 0.366. With additional adjustment for vital exhaustion the beta was 0.336 (an 8.1% change), while with adjustment for hsCRP it was 0.361 (a 1.4% change). These results suggest that vital exhaustion, but not hsCRP, may partially mediate the association between small social network and incident stroke.

In secondary analyses we looked separately at small social network and risk of ischemic stroke, and hemorrhagic stroke. The associations for ischemic stroke were similar to those for total stroke [e.g. Model 4 HR: 1.41 (0.98–2.03)], as expected since 89% of total strokes were classified as ischemic (Supplemental Table I). There were too few hemorrhagic strokes to examine separately.

### Perceived Social Support

A total of 75 participants (0.5%) were classified as lacking perceived social support. Associations between perceived social support categories and participant characteristics (Supplemental Table II) were, overall, similar to those observed with stratification by social network size. Among the lack of social support group, 46.6% were also classified as having a small social network.

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Only 7 cases of incident stroke occurred in the lack of social support group. Relative to those with high social support, participants in the lack of social support group were at qualitatively higher, though not significantly higher, risk of incident stroke [Model 1 HR: 1.66, (95% CI 0.79–3.50)] (Supplemental Table III). The estimate was attenuated with adjustment for additional confounding factors (Model 2–4). Associations between degree of social support and risk of ischemic stroke were similar to those for total stroke (data not shown). In secondary analyses, we defined lack of social support more broadly, comparing those in the lowest quintile of social support (score of ≤31), to those in the highest quintile (scores ≥43). The HR (95% CI) observed for Model 1 was 1.14 (0.93–1.39).

## Discussion

In this population-based longitudinal study of 13,686 participants, those who reported having a small social network were at approximately 40% greater risk of incident stroke, relative to their counterparts who reported a large social network. This association was independent of participant demographics, behavioral factors, BMI, and traditional stroke risk factors. While this suggests a causal association our results need to be interpreted cautiously given the observational nature of the data. Though not statistically significant, participants in our sample reporting lack of social support tended to be at qualitatively higher risk of stroke.

Our results are consistent with a previous study of 32,624 US male health professionals, which reported that men with a small social network (5.8% of their sample) experienced a 2-fold higher risk of incident stroke during 4-years of follow-up[10]. Having a small social network also has been associated with risk of incident stroke in a population of women with suspected MI[12]. Another study of 2,603 HMO members randomly sampled in 1970–71 and followed for 15 years reported no association between small social network and incident stroke[11]. However, this study defined a small social network by having a score in the lowest tertile of scores on a social network scale. It is possible that only individuals with a very small social network are at greater risk of incident stroke, in which case the cut-point selected may not have effectively identified people who had a truly limited social network. Notably, it is difficult to make direct comparisons across these studies as different questionnaires were used to measure social network size, and different cut-points employed.

The mechanisms underlying the association between small social network and incident cardiovascular disease have not been fully elucidated but likely include both behavioral and physiological components. Individuals who have a small social network may be less likely to take part in health-promoting behaviors (e.g. consuming a healthy diet, exercising, not smoking)[14], and may be less likely to follow medical recommendations (e.g. taking medications)[23]. Additionally psychological stress is correlated with small social network[24], and may also impact the cardiovascular system via various mental and physical changes[15]. Activation of the hypothalamic–pituitary adrenal (HPA) axis is an adaptive response to stress, although prolonged stress or HPA activation is deleterious because sustained elevations in glucocorticoids may compromise the neuroimmune system or neuronal survival following an ischemic attack[15]. Prior epidemiologic studies have reported that people who have a small social network score are more likely to have elevated circulating levels of hsCRP and interleukin-6[16].

In our analysis, vital exhaustion partly mediated the relation between small social network and risk of incident stroke. Although vital exhaustion overlaps more strongly with somatic depressive symptoms (e.g., fatigue, sleep disturbance, or appetite change) than cognitive-affective depressive symptom (e.g., guilt, feelings of worthlessness, suicidal thoughts), they are highly correlated[25]. Depression, which is linked to elevated inflammatory marker levels[26], has been associated with stroke morbidity, mortality[27] and incidence[28] in meta-analyses and systematic reviews.

In the ARIC cohort, lack of perceived social support was not significantly associated with risk of incident stroke. Importantly, this analysis was underpowered as a very low proportion of our study sample was in the lowest social support category [i.e. 0.5 %, who went on to experience 7 incident strokes]. The optimum cut-off point for the social support scale employed in ARIC is unknown.

Our study findings should be interpreted in light of several limitations. Although social network was assessed using a validated questionnaire, the abbreviated 16-item social support scale was constructed by the original ARIC investigators from the original 40-item full scale[20] and was not validated. Measurement error (and subsequent misclassification) in both social network and social support certainly occurred as the data were self-reported, and these questionnaires were administered at a single point in time (in some instances many years prior to the incident stroke event). Although we do not know how each individual's social network changed across time, as adults age the size of their social network typically becomes progressively smaller[29]. Second, because the prevalence of small social network was only 2.8%, and of lack of social support was only 0.5%, we had limited power to detect associations with stroke events. Third, although we adjusted for potential confounders, residual confounding or unmeasured confounders (such as depression, or health services utilization) may have influenced the relation between small social network and incident stroke through other pathways. Despite these limitations, our study has several strengths. The ARIC study has a wealth of information on potential confounding factors, which allowed us to examine whether the relation between small social network and incident stroke was independent of many known risk factors. Also, stroke events in the ARIC study were adjudicated, using a standardized protocol.

In summary, having a small social network was independently associated with increased risk of incident stroke in a community-dwelling sample of black and white men and women. Vital exhaustion partly mediated this association, while hsCRP did not. This study adds to the literature documenting the impact of social factors and relationships on health outcomes. If the observed association were found to be causal, it would argue for encouraging health professionals to screen for network size and discuss the importance of social connections for health and well-being with their patients, and for making sure that information is provided about community resources that offer opportunities for enhancing one's social network.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

The authors thank the staff and participants of the ARIC study for their important contributions.

**Sources of Funding**

The Atherosclerosis Risk in Communities Study is carried out as a collaborative study supported by National Heart, Lung, and Blood Institute contracts (HHSN268201100005C, HHSN268201100006C, HHSN268201100007C, HHSN268201100008C, HHSN26820110 0009C, HHSN268201100010C, HHSN268201100011C, and HHSN268201100012C).

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**Table 1**

Age-adjusted demographic, behavioral and physiologic characteristics stratified by social network size: The ARIC study 1987–1989.

| | Small Social Network | Moderately Small Social Network | Moderately Large Social Network | Large Social Network |
|---|---|---|---|---|
| **Social Network score** | **≤20** | **21–25** | **26–30** | **≥31** |
| **N** | **380** | **778** | **1908** | **10620** |
| Demographics | | | | |
| Age, years* | 57.1 (5.7) | 57.1 (5.8) | 57.2 (5.9) | 56.9 (5.7) |
| Male, % | 58.1 | 52.4 | 49.3 | 42.5 |
| White, % | 67.8 | 70.5 | 73.0 | 77.2 |
| Married, % | 42.0 | 53.9 | 65.3 | 84.9 |
| Socioeconomic Status | | | | |
| Income, % | | | | |
| <$25,000 | 60.0 | 50.3 | 40.4 | 32.4 |
| $25,000–$49,999 | 29.1 | 32.0 | 37.9 | 39.5 |
| ≥$50,000 | 10.9 | 17.8 | 21.7 | 28.1 |
| Education, % | | | | |
| Less than high school | 33.8 | 25.9 | 23.1 | 20.2 |
| High school graduate | 37.7 | 38.5 | 41.7 | 42.0 |
| Beyond high school | 28.5 | 35.6 | 35.2 | 37.8 |
| Occupation, % | | | | |
| Employed | 65.0 | 69.8 | 73.4 | 70.1 |
| Managerial & Professional | 16.5 | 20.1 | 24.3 | 23.7 |
| Social Network (0–50)* | 16.9 (3.5) | 23.3 (1.4) | 28.3 (1.4) | 37.7 (4.2) |
| Family Networks | 5.8 (3.3) | 7.8 (2.9) | 9.3 (2.3) | 12.2 (1.9) |
| Friends Networks | 2.8 (3.1) | 4.9 (3.4) | 6.6 (2.8) | 9.6 (2.4) |
| Confidant Relationship | 3.6 (1.8) | 5.0 (1.8) | 5.7 (1.8) | 7.2 (1.6) |
| Helping Arrangements | 2.2 (1.8) | 2.7 (1.7) | 3.1 (1.6) | 4.2 (1.3) |
| Living Arrangements | 2.6 (2.4) | 3.0 (2.3) | 3.6 (2.1) | 4.6 (1.2) |
| Social Support (0–48)* | 26.6 (7.5) | 31.3 (6.9) | 33.8 (6.6) | 38.3 (5.7) |
| Behavioral risk factors | | | | |
| Physical activity* | 2.3 (0.8) | 2.3 (0.8) | 2.4 (0.8) | 2.5 (0.8) |

| | **Small Social Network** | **Moderately Small Social Network** | **Moderately Large Social Network** | **Large Social Network** |
|---|---|---|---|---|
| **Social Network score** | **≤20** | **21–25** | **26–30** | **≥31** |
| **N** | **380** | **778** | **1908** | **10620** |
| Current drinkers, % | 55.4 | 59.0 | 57.1 | 56.7 |
| Current smokers, % | 35.9 | 29.0 | 27.5 | 20.3 |
| Major stroke risk factors | | | | |
| BMI, kg/m2* | 27.7 (5.6) | 27.6 (5.3) | 27.8 (5.4) | 28.0 (5.4) |
| Hypertension, % | 41.1 | 40.4 | 41.6 | 40.2 |
| Diabetes, % | 19.1 | 16.7 | 13.9 | 14.5 |
| Lipid-lowering medication use, % | 3.9 | 6.4 | 6.6 | 6.3 |
| Low-density lipoprotein, mg/dl* | 134.2 (35.0) | 131.5 (38.2) | 132.7 (35.7) | 133.6 (36.9) |
| High-density lipoprotein, mg/dl* | 49.7 (20.1) | 49.2 (16.5) | 49.1 (17.0) | 49.7 (16.6) |
| Potential Mediators | | | | |
| Vital Exhaustion* (0–42) | 16.7 (11.3) | 13.8 (10.5) | 11.7 (9.3) | 9.6 (8.1) |
| Highly Vital Exhausted (≥14), % | 55.5 | 43.8 | 36.7 | 27.4 |
| hsCRP*, mg/dL | 5.0 (8.6) | 4.6 (8.7) | 4.3 (6.4) | 4.3 (6.7) |

*Represented as mean (SD)

**Table 2**

Social network size and risk of incident stroke: The ARIC study 1987–2010.

| | Social Network Score | | | |
|---|---|---|---|---|
| | **Small Social Network** | **Moderately Small Social Network** | **Moderately Large Social Network** | **Large Social Network** |
| | **≤20** | **21–25** | **26–30** | **≥31** |
| Number of participants | 380 | 778 | 1908 | 10620 |
| Person years | 5867 | 12541 | 31002 | 178775 |
| Total incident strokes | 41 | 51 | 119 | 694 |
| Model 1 | 1.60 (1.17–2.20) | 0.98 (0.73–1.30) | 0.93 (0.77–1.13) | 1.00 |
| Model 2 | 1.43 (1.03–2.00) | 0.92 (0.69–1.23) | 0.90 (0.73–1.10) | 1.00 |
| Model 3 | 1.36 (0.97–1.90) | 0.89 (0.66–1.20) | 0.87 (0.71–1.06) | 1.00 |
| Model 4 | 1.44 (1.02–2.04) | 0.93 (0.69–1.26) | 0.90 (0.73–1.11) | 1.00 |

Model 1: Adjust for age, sex and race

Model 2: Adjusted for Model 1 + socioeconomic status (education attainment, income, occupation) +marital status

Model 3: Adjusted for Model 2 + behavioral risk factors (smoking status, alcohol drinking, physical activity)

Model 4: Adjusted for Model 3 + major stroke risk factors (hypertension, diabetes, LDL, HDL, lipid-lowering medication use, and BMI)