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Community-level social capital and recurrence of acute coronary syndrome

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Abstract

Social capital has been shown to be associated with reduced mortality due to cardiovascular disease. Our aim was to determine the association of time-varying community-level social capital (CSC) with recurrence of acute coronary syndrome using a retrospective cohort study design. A total of 34,752 men and women were identified, aged 30–85 years, who were hospitalized for acute coronary syndrome between January 1, 1998 and December 31, 2002 in Kaiser Permanente Northern California, USA, an integrated health care delivery system. The primary outcome was recurrent non-fatal or fatal acute coronary syndrome; median follow-up was 19 months. We estimated random-effects, three-level Cox proportional hazard models adjusting for sex, age, race/ethnicity, comorbidities, medication use, and revascularization procedures at level 1, median household income for the census block-group at level 2, and income inequality, racial/ethnic concentration, penetration of health maintenance organizations, and CSC at level 3. Our measure of CSC was the previously validated Petris Social Capital Index (PSCI). We found that a one-standard deviation increase in the PSCI, after adjusting for the above covariates, was significantly associated with decreased recurrence of acute coronary syndrome only for those living in areas where block-group level median household income was below the grand median compared to those living in areas where block-group level median household income was at the grand median or above. These results suggest that community-level social capital may be negatively associated with recurrence of acute coronary syndrome among lower-income individuals.

Keywords: USA; Cardiovascular disease; Social capital

Introduction

Where a person lives may affect their cardiovascular health (Diez Roux et al., 2001). A growing number of studies suggest that populations located in areas with higher levels of social capital have reduced mortality due to cardiovascular disease (Franzini & Spears,

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2003; Kawachi, Kennedy, Lochner, & Prothrow-Smith, 1997; Lochner, Kawachi, Brennan, & Buka, 2003; Sundquist, Johansson, Yang, & Sundquist, 2006). An important question is whether the associations between social capital and cardiovascular outcomes found in these studies may be attributable to unmeasured geographical variation in medical treatment that may be correlated with geographical variation in social capital. To determine whether this is the case, our analysis includes an extensive set of covariates based on individual-level clinical data representing variation in medical treatment. This enables us to more precisely determine the association of time-varying community-level social capital with recurrent cardiovascular disease. This is the first time, to our knowledge, that this association has been measured independently of medical treatment.

Definitions and measures of social capital vary (Harpham, Grant, & Thomas, 2002; Hawe & Shiell, 2000; Macinko & Starfield, 2001; Miller, Lam, Scheffler, Rosenberg, & Rupp, 2006; Paldam, 2000), but social capital can be broadly defined as the density of trust, networks, or cooperation within a given community. It is usually conceptualized to include at least two components: cognitive and structural. The cognitive component includes perceptions of trust, reciprocity and sharing, while the structural component includes the extent and intensity of associational links and activity in society such as the density of civic associations, measures of informal sociability and indicators of civic engagement (Harpham et al., 2002). The structural component facilitates linkages between people by lowering transactions costs and the cognitive component predisposes people towards making such linkages (Uphoff, 2000).

Both the cognitive and structural aspects of social capital can be bonding (social connections between individuals who are similar), bridging (social connections between individuals who are dissimilar), or linking (social connections across different levels of social status). Community-level social capital is distinguished from individual-level social capital, which is conceptualized and measured in terms of an individual's access to resources embedded within their social networks. Therefore, individual-level social capital is a concept that overlaps with the concepts of social support and social networks.

At least three different pathways have been suggested by which community-level social capital is theorized to affect health. These are illustrated in Fig. 1. We focus on these pathways with regard to structural social capital.

First, community-level social capital may increase the availability of information on behaviors that influence cardiovascular disease risk such as regular physician visits, compliance with medication, improved diet (Erlinger & Appel, 2005; Kromhout, 2005), moderate alcohol use (Bobak & Marmot, 2005), exercise (Morris, 2005) and quitting smoking. For example, Stephens, Rimal, and Flora (2004) and Viswanath, Randolph Steele, and Finnegan (2006) find that membership organizations (e.g., labor unions, church groups, business or trade groups, veterans' groups, hospital or medical service groups, service or fraternity groups, youth groups) serve as channels of health information.

Second, higher levels of community-level social capital, such as a higher density of voluntary organizations, may lower the effort required to politically organize which may result in more health resources being brought into a community (Kawachi, Berkman, & Gahler, 2000). This suggests that geographical variation in medical resources and medical treatment is likely to be correlated with the geographical variation in community-level social capital.

Third, higher levels of community-level social capital, such as a higher density of voluntary organizations, may make social support, which is associated with improved cardiovascular outcomes in many studies, more accessible (Berkman & Glass, 2000; Kuper, Marmot, & Hemingway, 2005; Stansfield & Rasul, 2005). For example, it has been found that annual changes in community-level structural social capital are negatively associated with non-specific psychological distress (Scheffler, Brown, & Rice, 2007).

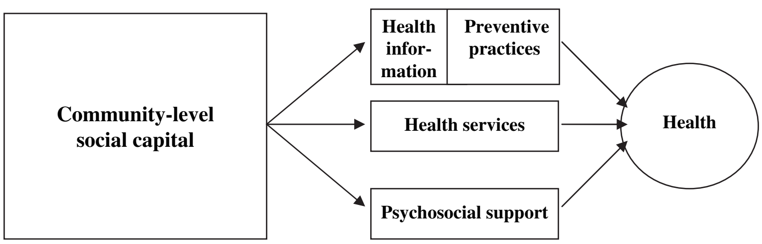

Fig. 1. Pathways between social capital and health.

Our hypothesis is that higher levels of community-level social capital, acting through pathways other than medical care, are associated with reduced recurrence of acute coronary syndrome. To this end we control for sex, age, race/ethnicity, median census block-group household income, comorbidities, medication, revascularization procedures, income inequality, racial concentration, and the penetration of health maintenance organizations. We tested this hypothesis by performing a large-scale, multi-year retrospective cohort study.

Methods

Participants

In Northern California, Kaiser Permanente (KP) provides full spectrum primary-to-tertiary care to approximately 3.1 million members, which represents a 30% share of the regional population. Kaiser Permanente is the nation's largest non-profit integrated health care delivery system. The demographic characteristics of KP membership are similar to the overall Northern California population, with the main difference being that KP members are somewhat less likely, relative to the general public, to live in census block groups where greater than one-fifth of the population lives in poverty and somewhat less likely to live in census block groups where greater than one-fourth of the adults have less than a high school education (Krieger, 1992).

We used three levels of data in our model. The first level contained individual-level information including sociodemographic information, medication use, medical procedures, and comorbid conditions. The second level contained block-group level information on median household income. The third level included county-level information including community-level social capital, an index of racial concentration, an index of income inequality, and the penetration level of health maintenance organizations.

We identified all members of KP of Northern California aged 30–85 years who were hospitalized for acute coronary syndrome in one of the 17 Northern California Kaiser Permanente hospitals or in out-of-plan hospitals (the latter captured using claims data) between January 1, 1998 and December 31, 2002. During the 5-year accrual period, we initially identified 43,269 such members. We omitted the following groups from the final analytical sample: 1763 members who did not survive initial hospitalization, 1072 members who did not have Kaiser membership information, 298 members who had less than three days of medical follow-up, 874 members who had missing or invalid residency information, 48 members who lived in an area where community-level social capital information was missing, 14 members who lived in counties with too few members to make statistically meaningful comparisons, and 4448 members who changed county of residency. The rationale for excluding movers was to avoid misclassification of exposure to community-level social capital arising from residing in two or more different counties during the follow-up period. The final sample was therefore 34,752 people (22,793 men and 11,959 women) nested within 6621 census block groups, which were nested within 35 counties. The 35 counties included Alameda, Amador, Butte, Calaveras, Contra Costa, El Dorado, Fresno, Glenn, Kings, Lake, Madera, Marin, Mendocino, Merced, Monterey, Napa, Nevada, Placer, Sacramento, San Benito, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Shasta, Solano, Sonoma, Stanislaus, Sutter, Tehama, Tulare, Tuolumne, Yolo and Yuba.

Information on age and gender were obtained from the Patient's Demographics File. Race/ethnicity information was obtained from several complementary and overlapping sources including research surveys (i.e., self-reported ethnicity) and inpatient electronic records (i.e., assigned ethnicity). We preferentially use self-reported ethnicity when available (in 55% of the cohort); otherwise we used the race/ethnicity as assigned by a health professional in the inpatient record.

We did not have a measure of household income available at the individual level so we obtained an estimate of individual-level household income using median household income at the block-group level. We geocoded the address for each member of the cohort using MapMarker Plus 9.1. Using the patient address closest to January 1, 2000, we then extracted information on 1999 median household income at the block-group level from the 2000 U.S. Census (U.S. Census block groups contain between 600 and 3000 people, with an optimum size of 1500 people). Since our sample only included individuals who did not change counties during the study period, this patient address is accurate for the entire period with respect to community-level social capital.

Clinical data on all individual-level chronic conditions, interventions and therapies were derived from electronically available inpatient, outpatient, and pharmacy utilization data from the Northern California Kaiser Permanente Medical Care Program. All data were recorded by medical personnel; none of the clinical data are from patient self reports.

Prior history of coronary heart disease (including revascularization procedures), stroke, heart failure, and peripheral vascular disease was ascertained from hospital discharge and inpatient procedures data going back to 1980. Other comorbid conditions (hypertension, diabetes, and depression) were ascertained using the Automated Outpatient Services Clinical Records (OSCR), which includes emergency department visits. Using real-time computerized pharmacy data, we retrospectively identified all cardiovascular and anti-depressant medications dispensed during the study period. Depression was identified by having a diagnosis of depression from OSCR and/or a prescription for an anti-depressant drug.

The CVD medication classes included beta-blockers, nitrates and vasodilators, cholesterol lowering agents, ACE inhibitors, calcium channel blockers, and anti-arrythmics. Acute coronary syndrome recurrence and revascularization procedures during follow-up were ascertained using inpatient databases of all hospitalizations. The full diagnostic record is usually completed within 1–2 months following discharge. Deaths from 1998 through the end of 2002 were ascertained using the California Automated Mortality Linkage System (CAMLIS), which has a sensitivity of 0.97 compared with the National Death Index (Arellano, Peterson, Pettiti, & Smith, 1984).

Community-level social capital was measured using the Petris Social Capital Index (PSCI) for the years 1998–2002. The PSCI has been found to have appropriate content and criterion validity and has been used to study the association of community-level social capital with cigarette smoking and the association of community-level social capital with non-specific psychological distress (Brown, Scheffler, Seo, & Reed, 2006; Scheffler et al., 2007). The PSCI is measured as the number of individuals per 1000 population employed in voluntary organizations. It is designed to measure the structural portion of community-level social capital and is thus a supply side measure of the social resources that are available to individuals within a given area: resources that facilitate the development and maintenance of social capital. The PSCI is thus an actual measure of the level of organizational resources within a community and is not derived by aggregating individual survey responses.

An important issue that arises when measuring area-based social capital is whether to measure social capital only in the area in which a person lives, or also to include the area in which they work or are likely to travel within. The first approach assumes that an individual does not access social capital outside of the area in which they live. If a person accesses a significant amount of social capital outside of this immediate area, and the levels of social capital differ between areas, then measuring social capital only in the area in which they live can result in an incorrect estimate of the association of social capital with acute coronary syndrome.

The second approach assumes that a person accesses social capital across a larger area, such that the heterogeneity in social capital between the two areas is unimportant. In other words, the second approach assumes that people access social capital anywhere it is convenient to do so: around their home, around their place of employment or other places they regularly travel to, and anywhere along their regular journey between these locations. In this situation, the average level of social capital across these areas is the most accurate measure of available social capital. In this situation, someone living in a neighborhood with low social capital will often still be able to access needed social resources that are nearby, but outside of their neighborhood.

The fundamental issue in deciding which measurement approach to take is how convenient it is for a person to access the social capital that exists between their regular travel destinations. The level of convenience depends on the most common mode of transportation used in an area. If public transportation is the most common mode, then the convenience factor is low and making the assumption that individuals will access social capital anywhere between their home and workplace (or other places they frequent) may be inappropriate. However, if private vehicles are the most common mode, then the convenience factor is high and the assumption that individuals will access social capital anywhere between their home and workplace is warranted.

In a "car culture" such as California the convenience factor is quite high. In 2002, 92% of occupied housing units had one more vehicles available for use, 97% of those who were employed commuted to work (with an average commute time of 27 min), and 87% of those who commuted used private vehicles (U.S. Census Bureau, 2002a, 2002b). Thus, in California the average level of social capital as measured across a larger area that likely includes an individual's home, workplace, and other areas they frequent is more meaningful than a measure of social capital across a smaller area that only includes their home. Since the average commuter will often traverse an area larger than a city during their commute and since the next highest geographical level, counties, are areas with a high degree of economic and social integration, we measure community-level social capital at the county level. The PSCI measured at the county level is thus a measure of the average level of structural social capital across the intra-county areas that individuals are likely to frequent.

In addition, an important point made by Lochner, Kawachi, and Kennedy (1999) is that it is reasonable to measure social capital at different levels to reflect the different social forces that may occur at each level. For example, social capital measured at the level of the neighborhood may primarily reflect daily interactions between neighbors, social capital measured at the county level may mainly reflect the influence of socially focused organizational structures in these areas, and social capital at the state level may mainly reflect state-level social policy. Accordingly, the PSCI will primarily capture the influence of socially focused organizational structures.

Important potential area-level confounders of community-level social capital are health maintenance organization penetration, income inequality, and racial concentration. Health maintenance organizations are integrated delivery systems that have financial incentives to reduce the quantity of care provided. There is evidence that increases in health maintenance organizations penetration, measured at the level of the Metropolitan Statistical Area, reduce rates of cardiac procedures by small, but statistically significant, amounts among Medicare patients with acute myocardial infarction (Volpp & Buckley, 2004). There is also evidence that higher rates of health maintenance organizations penetration, measured at the county level, reduce the level of medically appropriate angiography (Heidenreich, McClellan, Frances, & Baker, 2002). We measure health maintenance organizations penetration as the number of individuals in a county enrolled in health maintenance organizations per 1000 population.

Income inequality is considered by many to be a potential determinant of health, while others suggest that any health effects attributable to income inequality may actually be due to individual-level household income (Mellor & Milyo, 2003; Subramanian & Kawachi, 2004). To control for these possibilities, we include both block-group level median household income (a proxy for individual-level household income) and county-level income inequality in our analysis. We use the county-level Gini coefficient as our measure of income inequality. This is a standard measure, ranging from 0 to 1, where higher values mean greater inequality (Dorfman, 1979).

There is also some evidence that areas in the United States where a higher percentage of the population is comprised of Blacks may also have higher mortality rates independent of income inequality (McLaughlin & Stokes, 2002). To control for this possibility and the possibility that other minority groups may also have higher mortality rates, we include a Herfindahl index of racial/ethnic concentration. The Herfindahl index is the constructed by determining the percentage of the population of each of seven racial/ethnic groups (White, Black, Hispanic, Asian, Pacific Islander, American Indian, and multi-racial), taking the square of each percentage, and then summing the squares (Davies, 1979). The Herfindahl index thus measures the level of racial/ethnic concentration within a given area and will range from 0 to 10,000. The more an area is dominated by a single racial/ethnic group, the higher the Herfindahl index will be. Where each group makes up an equal share in the population, this measure is equal to 10,000/N where N is the number of racial/ethnic groups. Where there is only a single group in the population, this measure is equal to 10,000.[1]

Data on county-level Gini coefficients for the year 1999 were collected from the Agency for Health Care Quality and Research (Billings & Weinick, 2003). Herfindahl indices of racial/ethnic concentration at the county level for 1998–2002 were constructed using data from the California Department of Finance. Data on health maintenance organizations penetration for 1998–2002 was collected from Cattaneo and Stroud, a consulting firm specializing in the health care industry, which produces an annual report of health maintenance organizations in California.

The study was approved by the Kaiser Foundation Research Institute's Institutional Review Board and the University of California at Berkeley's Committee for the Protection of Human Subjects. The requirement for informed consent by individual patients was waived.

Statistical analysis

Our analysis included random-effects multi-level models and attributable fraction calculations. We estimated random-effects multi-level (three levels: person, census block-group, county) Cox proportional hazards models with fixed-level exposure to individual factors (age, gender, race/ethnicity), a block-group level factor (median household income), and a county-level factor (Gini coefficient) (Mason, 2004; Snijders & Bosker, 1999; Sundquist, Winkleby, Ahlén, & Johansson, 2004). The model also incorporated time-dependent exposure to selected individual factors (comorbidities, medication use, revascularization), and county-level

[1] For example, if only Whites live in a given county, the Herfindahl index is $(100)^2 = 10{,}000$. If the distribution between White, Black, Asian, and Hispanic is 25% each, the Herfindahl index is $(25)^2 + (25)^2 + (25)^2 + (25)^2 = 2500$. If the distribution between White, Black, Asian, Hispanic, and Pacific Islander is 35, 10, 20, 30, and 5%, respectively, the Herfindahl index is $(35)^2 + (10)^2 + (20)^2 + (30)^2 + (5)^2 = 2650$.

factors (Petris Social Capital Index, Herfindahl racial/ethnic concentration index, and health maintenance organizations penetration) (Goldstein, Healy, & Rasbash, 1994). Statistical analysis was conducted using MLwiN 2.0, and consistent results were obtained using SAS 9.13 and Stata 8.2 (Littell, Milliken, Stroup, & Wolfinder, 1996; Rabe-Hesketh, Skrondal, & Pickles, 2004; Rasbash, Steele, Browne, Prosser, & Goldstein, 2004).

A series of four models were used to model the association between the PSCI and the hazard of acute coronary syndrome recurrence, with increasing level of multi-variate adjustment. Note that the parameters for time-varying covariates will reflect the effects of both within-person (or county) variation as well between-person (or county) variation.

Models 1 and 2 focus on potential confounders of the association between community-level social capital and recurrent acute coronary syndrome at the individual level and the area level. Model 1 includes the PSCI along with the following demographic characteristics: age, the square of age, gender, and race/ethnicity. Model 2 includes all the variables included in model 1 and also adds the following potential area-level confounders: median household income for the block-group, the county-level Gini coefficient, the county-level Herfindahl racial/ethnic concentration index, and county-level health maintenance organizations penetration.

Model 3 focuses on potential mediators of the association between community-level social capital and recurrent acute coronary syndrome. It includes all of the variables in model 2 and also adds each patient's medical history/treatment (comorbidities, medication, and revascularization procedures).

Finally, model 4 focuses on effect modification. The specification is identical to model 3 with the following modification. In keeping with findings with regard to community-level social capital and self-rated health that suggest that community-level social capital may have more pronounced effects among those with lower incomes (Mellor & Milyo, 2005) we stratified the sample into those living in areas with below median household income and those living in areas at or above median household income, both at the block-group level.

We also estimated the attributable fraction (or attributable risk) (Lilienfeld & Stolley, 1994) by considering three different exposures to "low" social capital: the lowest quartile (vs. higher level), the lowest tertile (vs. higher level) and the lowest half (vs. the upper half). These estimates were based on the unadjusted relative risk from the multi-level Cox regression when only the PSCI was entered into the regression.

Results

As seen in Table 1, the cohort was made up of mostly Whites (73%), with similar-sized groups of Blacks (7%), Asians (8%), and Hispanics (9%). Prevalent medical conditions included coronary heart disease (29%), hypertension (58%), diabetes (29%), depression (34%), stroke (12%), heart failure (6%), and peripheral vascular disease (3%). Medication use included beta-blockers (82%), nitrates and vasodilators (77%), cholesterol lowering agents (76%), ACE inhibitors (57%), calcium channel blockers (32%), anti-depressants (28%), and anti-arrhythmics (10%). Revascularization procedures were performed in about half of the cohort (54%).

During the follow-up period, less than a quarter of the cohort experienced a recurrence of acute coronary syndrome ($n = 7916$, 22.8%), with non-fatal recurrences being the most common among those with recurrence ($n = 6590$, 83%) (Table 2). The median time to recurrence was 139 days.

The means and standard deviations of our area-level variables are as follows, using the year 2000 (1999 for the income variable) for illustrative purposes: median block-group level household income (mean ± SD [median]; \$58,734 ± \$27,683 [\$54,000]), Gini coefficient (0.37 ± 0.02 [0.37]), Herfindahl racial/ethnic concentration index (5100 ± 1600 [4500]), health maintenance organizations penetration (3.7 ± 2.2 [2.9]), and the PSCI (6.1 ± 2.9 [5.6]). An important point to note is that the PSCI is not static. The standard deviation for within-county changes over the 1998–2000 period ranges from a low in Solano County (mean ± SD: 4.073 ± 0.079) to a high in Butte County (7.491 ± 1.545).

Table 3 shows the results of models 1–3 presented in terms of hazard ratios.[2] In all models, the following

[2] The hazard rate with respect to analysis in this paper is the conditional instantaneous rate of recurrent acute coronary syndrome calculated as a function of time. The hazard ratio is therefore the ratio of the hazard rate of having recurrent acute coronary syndrome in the next period relative to the hazard rate of not having recurrent acute coronary syndrome in the next period. For example, with respect to community-level social capital, a hazard ratio of 1.0 means that a one-standard deviation move in social capital does not change the hazard of having recurrent acute coronary syndrome in the next period. A hazard ratio of 2.0 would mean that a one-standard deviation increase in social capital is associated with twice as many patients who live in that area having recurrent acute coronary syndrome compared to those who live in an area with the average level of community-level social capital. A hazard ratio of 0.5 means that a one-standard deviation increase in social capital is associated with half as many patients who live in that area having recurrent acute coronary syndrome compared to those who live in an area with the average level of community-level social capital.

Table 1
Baseline individual-level characteristics of the cohort of acute coronary syndrome survivors. Kaiser Permanente Northern California Medical Care Program, 1998–2002

	Retrospective cohort ($n = 34{,}752$)
	Number (%)
Demographic characteristics	
Ages 30–44 years	1345 (4)
Ages 45–54 years	5530 (16)
Ages 55–64 years	8805 (25)
Ages 65–74 years	10,595 (31)
Ages ≥ 75 years	8477 (24)
Female	11,959 (34)
White	25,346 (73)
Black	2475 (7)
Asian	2705 (8)
Hispanic	3268 (9)
Other/unknown race/ethnicity	958 (3)
Prevalent medical conditions[a]	
Coronary heart disease	10,198 (29)
Hypertension	20,319 (58)
Diabetes	10,159 (29)
Depression	11,778 (34)
Stroke	4137 (12)
Heart failure	2048 (6)
Peripheral vascular disease	1039 (3)
Comorbidities	
Hypertension	4846 (14)
Diabetes	1850 (5)
Depression	3425 (10)
Stroke	1727 (5)
Heart failure	1526 (4)
Peripheral vascular disease	461 (1)
Medication use[b]	
Beta-blockers	28,621 (82)
Nitrates & vasodilators	26,826 (77)
Cholesterol lowering agents	26,577 (76)
ACE inhibitors	19,860 (57)
Calcium channel blockers	11,158 (32)
Anti-depressants	9804 (28)
Anti-arrhythmics	3447 (10)
Procedures	
Revascularization	18,591 (54)
Outcomes	
Acute coronary syndrome recurrence, non-fatal	6590 (19)
Acute coronary syndrome recurrence, fatal	1326 (4%)

[a] Going back to 1980.
[b] At discharge of index acute coronary syndrome event or anytime thereafter during follow-up.

variables were converted to z-scores: median block-group level household income, the Gini coefficient, the Herfindahl racial/ethnic concentration index, health maintenance organizations penetration, the

Table 2
1998–2002 Cohort, acute coronary syndrome outcome: recurrence (1) or censorship (0) with median follow-up time

	Number of patients	Percent	Median follow-up time, in days
Acute coronary syndrome cohort	34,752	100	593
Recurrence	7916	22.8	139
Non-fatal	6590	(19)	130
Fatal	1326	(3.8)	194
Censorship	26,836	77.2	749
Left Kaiser Health Plan	1855	(5.3)	497
Death	2005	(5.8)	346
End of study	22,976	(66.1)	813

PSCI, and age.[3] For comparison purposes, a model that only included the PSCI gave the following results (hazard ratio [HR] = 0.90; 95% confidence interval [CI], 0.84–0.97).

Model 1 showed that when including gender, race/ethnicity, and age (both age and the square of age have been incorporated into the hazard ratio for age), community-level social capital is associated with an 11% reduction in the recurrence of acute coronary syndrome (HR = 0.89; CI, 0.83–0.95) per one-standard deviation increment in the PSCI. A one-standard deviation increment in the PSCI amounts to 29 employees in voluntary organizations per 10,000 population.

The addition of potentially confounding variables at the area level (median household income at the block-group level, the Gini Coefficient, the Herfindahl racial concentration index, and health maintenance organizations penetration) did not alter this association as shown in model 2 (HR = 0.89; CI, 0.83–0.94). Further adjustment, as shown in model 3, which consisted of adding potential effect mediators (personal medical history, treatment, and medication use) also did not significantly alter this relationship (HR = 0.92; CI, 0.88–0.97).

Finally, in model 4, stratifying the sample on the block-group level by the grand median of block-group median household income showed that those living in areas with median household income below $54,000 (HR = 0.91; CI, 0.86–0.96) appeared to benefit from exposure to community-level social capital. However, we found no statistically significant association for those living in areas where median household income was $54,000 or greater (HR = 0.97; CI, 0.92–1.03).

[3] Age was transformed to the following: (age − grand median)/10 in order to give a z-score per 10 years.

Table 3
Hierarchical proportional hazard regression survival analysis of acute coronary syndrome recurrence

Variables	Model 1	Model 2	Model 3
	Hazard ratio (95% CI)	Hazard ratio (95% CI)	Hazard ratio (95% CI)
Community-level social capital			
Petris Social Capital Index (per one-standard deviation)[a]	0.89 (0.83–0.95)	0.89 (0.83–0.94)	0.92 (0.88–0.97)
Individual demographics			
Female[b]	0.96 (0.91–1.01)	0.95 (0.91–1.00)	0.85 (0.82–0.90)
Race/ethnicity[b]			
Black	1.2 (1.1–1.31)	1.15 (1.06–1.26)	0.96 (0.88–1.04)
Asian	0.97 (0.89–1.07)	0.97 (0.89–1.06)	0.96 (0.88–1.05)
Hispanic	1.07 (0.99–1.15)	1.05 (0.97–1.13)	0.97 (0.9–1.05)
Other race	0.5 (0.4–0.61)	0.49 (0.4–0.61)	0.56 (0.46–0.69)
Age (per 10 years)	1.3 (1.27–1.33)	1.29 (1.27–1.32)	1.14 (1.11–1.16)
Area-level characteristics			
Median income (per one-standard deviation)[c]		0.94 (0.91–0.97)	0.97 (0.95–1.00)
Gini coefficient (per one-standard deviation)[a]		1.08 (1.01–1.16)	1.06 (1–1.13)
Herfindahl index (per one-standard deviation)[a]		0.93 (0.86–100)	0.96 (0.9–1.02)
Health maintenance organizations penetration, % (per one-standard deviation)[a]		1.02 (0.94–1.11)	0.99 (0.92–1.06)
Personal medical history[b]			
Coronary heart disease			1.27 (1.21–1.33)
Hypertension			1.08 (1.02–1.13)
Diabetes			1.29 (1.26–1.33)
Depression			1.15 (1.1–1.21)
Stroke			1.17 (1.11–1.24)
Heart failure			1.56 (1.46–1.66)
Peripheral vascular disease			1.33 (1.21–1.46)
Treatment and medication use[b]			
Beta-blockers			0.83 (0.79–0.87)
Nitrates & vasodilators			1.5 (1.42–1.57)
Cholesterol lowering agents			0.79 (0.75–0.83)
ACE inhibitors			0.9 (0.86–0.95)
Calcium channel blockers			1 (0.95–1.06)
Anti-arrhythmics			0.71 (0.64–0.79)
Revascularization procedures			0.69 (0.66–0.72)

Table entries are hazard ratios and 95% confidence intervals.
[a] Measured at the county level (level 3).
[b] Measured at the individual level (level 1).
[c] Measured at the block-group level (level 2).

To understand the meaning of this result more clearly, we estimated the attributable fraction considering three different exposures to social capital: the lowest quartile (vs. higher level), the lowest tertile (vs. higher level) and the lowest half (vs. the upper half). The unadjusted relative risks from multi-level Cox regression are 1.23 for the lowest quartile, 1.15 for the lowest tertile and 1.11 for the lowest half. The corresponding attributable fractions are 5.5, 4.7 and 5.4%. The interpretation of these numbers is that about 5% of acute coronary syndrome recurrence, respectively, will be avoided if the population were no longer exposed to those three levels of low social capital.

Discussion

In this large cohort study, we observed that each increment of one-standard deviation in community-level social capital (which amounts to 29 employees in voluntary organizations per 10,000 people), as measured by the Petris Social Capital Index, is associated with a 9% reduction in the relative risk of acute coronary syndrome recurring for individuals living in block-group areas with less than median household income after controlling for sex, age, race/ethnicity, comorbidities, medication use, revascularization procedures, income inequality, racial concentration, and health maintenance organizations penetration. Although the association was not large, this finding has potentially large public health implications since acute coronary syndrome is the leading cause of morbidity and mortality among both men and women in the United States, currently affecting more than 13.9 million people (National Heart, Lung, and Blood Institute, 2004). Based on our attributable fraction calculations, approximately 5% of acute coronary syndrome recurrence will be avoided if the population were no longer exposed to low levels of community-level social capital (the lowest quartile, tertile, or half).

Our findings are consistent with earlier findings on the association of social capital and cardiovascular mortality but extend those findings by, for the first time, controlling for medical history and medical treatment using clinical data from an integrated health care system (Kaiser Permanente of Northern California). The pathway of increasing access to medical resources was controlled for in this study. Thus, the likely pathways by which community-level social capital may influence acute coronary syndrome outcomes include increasing access to psychosocial resources and increasing the diffusion of health information that promote health-enhancing behaviors.

Using data from the National Health Interview Survey, we have conducted an examination of whether the Petris Social Capital Index is associated with the intermediate outcomes by which community-level social capital is theorized to affect cardiovascular disease, including information diffusion, exercise, diet, smoking, and psychological distress (Brown et al., 2006). We found a positive association between the Petris Social Capital Index and exercising, eating higher amounts of fruits and vegetables, and the amount of knowledge an individual possesses on the symptoms of a heart attack or stroke. We found a negative association between the PSCI and the demand for cigarettes (Brown et al., 2006), and also found a negative association between the PSCI and non-specific psychological distress (Scheffler et al., 2007).

This latter finding may explain why we only find an association between community-level social capital and acute coronary syndrome among individuals living in block-group areas with less than median household income. A number of studies have documented the association of psychological distress and cardiac outcomes and find that psychological distress is negatively related to positive cardiac outcomes (Rasul, Stansfeld, Hart, Gillis, & Smith, 2004; Robinson, McBeth, & MacFarland, 2004; Stansfeld, Fuhrer, Shipley, & Marmot, 2002). However, Scheffler et al. (2007) found that the PSCI is only negatively associated with non-specific psychological distress among those whose family income is less than the median. Thus, our finding of a reduction in recurrent acute coronary syndrome only occurring among individuals living in block-group areas with less than median household income is consistent with the PSCI affecting recurrent acute coronary syndrome through the pathway of reduced psychological distress, which has been documented to occur primarily among those with less than median family income.

A limitation of this study is the fact that our population, while being largely representative of the population in Northern California, is not fully representative at the extreme lower tail of the income distribution. Another limitation is that we did not have information about participants' educational level and household income. We alleviated the issue of missing individual-level household income by using median household income at the block-group level. This will lower the variation (heterogeneity) of household income in our sample and may understate the association between household income and recurrent acute coronary syndrome.

An additional limitation is that our measure of community-level social capital only explicitly measures the structural component of social capital. The addition of cognitive measures would likely add to the explanatory power of the model.

A final limitation is that we only measured social capital at the county level. We did not measure social capital at the neighborhood level, nor did we measure social capital at levels higher than the county. For individuals who do not routinely travel by car, the neighborhood level of social capital may be more likely to influence their health than the county level.

In summary, this longitudinal cohort study suggests that the recurrence of acute coronary syndrome is negatively associated with community-level social capital, particularly for individuals living in block-group areas with less than median household income.

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