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Social Capital and Glucose Control

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Abstract There is a growing diabetes epidemic in the United States and if we are to halt its progress we need to better understand the social determinants of this disease and its control. Social capital, which has been associated with general health and mortality, may be one important mediator of glucose control. In this study we determine if neighborhood social capital is associated with glucose control, independent of individual factors. We performed a cross-sectional study of Black veterans with diabetes living in Philadelphia. We merged individual-level data from surveys and charts with six area-level social capital descriptors. Holding all other variables constant, patients who lived in neighborhoods that scored near the 5th percentile of working together to improve the neighborhood were estimated to have glycosylated hemoglobin (HbA1c) values that were at least one point above a conservative clinical definition of "diabetes control" (HbA1c $\leq$ 8%). If these same patients were to live in neighborhoods in the 95th percentile, their expected HbA1c would be over ½ a point below the cut-off value 8%. No other measure of social capital was associated with HbA1c. In this study of black veterans with diabetes we observed that living in neighborhoods where people work together is associated with better glucose control.

Keywords Diabetes · Veterans · African Americans · Residence characteristics

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Introduction

The incidence and prevalence of diabetes is reaching epidemic proportions in the Unites States and disproportionately affects low income and minority populations [1–3]. These populations are not only burdened with the disease itself, they have worse diabetes control and higher rates of many disease specific complications [2, 4–8]. To date we have been unable to reverse these trends and calls have been made to better understand the social determinants of diabetes [9, 10].

In recent years there has been growing interest in the role of the social environment on health and much of this work has focused on social capital [11]. Social capital refers to the trust, norms, and networks that coordinate society [12]. It is the product of formal and informal community networks which engender public trust and engagement. For example measures of social capital such as civic participation, trust, and reciprocity (willingness to help one another) have been independently associated with mortality and general health [13–17]. Potential mechanisms by which social capital influences health are by increasing healthy behaviors, such as exercise, improving access to services, improving health care trust, and decreasing neighborhood violence and crime [11, 15, 18–20]. How social capital works in relationship to neighborhood deprivation, which has strongly been linked to health outcomes, is complex with some research indicating that social capital may be one route by which deprivation influences health and other research indicating social capital may help insulate poor, minority, or otherwise vulnerable populations from the consequences of their lower status [13, 15, 17, 21, 22].

Social capital may have similar effects in chronic disease but to date this evidence is lacking. Understanding if and how the social environment influences health outcomes for people with diabetes may provide opportunities for reducing disparities in diabetic outcomes for at-risk populations. It was therefore the aim of this study to determine if in a low-income population social capital is associated with glucose control in people with diabetes.

Methods

Study Design

We performed a clinic population based, cross-sectional study of veterans who use the Philadelphia VA Medical Center (PVAMC). Using PVAMC electronic records, we identified a source population with diabetes mellitus. This source population was composed of veterans who had been dispensed insulin or oral hypoglycemic medication at the PVAMC between 06/1/01 and 05/31/02. We monitored the source population and enrolled veterans as they had blood assessments for glycosylated hemoglobin (HbA1c). Enrollment occurred between 06/26/02 and 03/11/04. We included only veterans who developed diabetes after the age of 29, had diabetes for two or more years, and lived in Philadelphia. For veterans who agreed to participate we administered a telephone survey and reviewed their PVAMC electronic medical chart.

The fact that our sample was drawn from a clinical population rather then the general population of diabetics in the Philadelphia area, raised concerns about our ability to draw valid inferences concerning observed associations between patient level glucose control and ecological level measures. In order to examine this possibility, we compared the expected number of sampled respondents under simple random sampling in each of 69 Philadelphia neighborhoods to the neighborhood specific counts observed in our sample. These 69 neighborhoods are small spatially-coherent geographic units designated by the Philadelphia Neighborhood Information System (NIS) built from contiguous census tracts and represent the ecological level units of analysis employed in this study.

Estimates of the neighborhood specific size of the diabetic population was based on an analysis of the 2004 Southeastern Pennsylvania Household Health Survey (SPHHS). The survey asked respondents about their diabetic status and was administered by telephone. Households were contacted using random digit dialing. In 2004 the SPHHS included 4,415 Philadelphia residents. A mixed logit model predicting diabetes was estimated on the data from the survey in order to obtain neighborhood specific empirical Bayes estimates of the proportion of residents with diabetes. These estimated proportions were then merged with race specific population counts for each neighborhood derived from the US Census in order to come up with an expected count of diabetics in each neighborhood.

The sum of square differences between the observed and expected counts (standardized by dividing by the expected) across all of the 69 neighborhoods for our sample of whites was $\chi^2_{69} = 337.74, \mathrm{P} < .001$, while for blacks it was $\chi^2_{269} = 41.80, \mathrm{P} = .997$. The magnitude of the difference in the chi-square statistics indicates that our sample of black diabetic patients drawn from the PVAMC is far more representative of the general population of black diabetics in Philadelphia then is our sample of whites. We therefore dropped white diabetic patients from our sample.

Participants

Among 946 consecutive veterans from our base population, 198 were unreachable and 93 were not eligible for inclusion. Of those contacted and eligible (656), 70% participated (458). Those who enrolled were similar in sex and recent HbA1c level from those who were not, except that those who enrolled had a mean age of 63.3 (SD ± 10.5) compared to 59.5 (SD ± 10.4) for those who were unreachable ($P < 0.001$). As stated above, we dropped whites from our sample and focused exclusively on diabetics who self-reported as black, 72.8% (301). Of these, 97.7% (294) provided complete data for all survey items and form the sample for these analyses.

Individual-Level Measures

The dependent measure of interest was HbA1c level. Individual-level variables reflected the following domains—demographics, clinical characteristics, and a group of potential individual level mediators of the impact of neighborhood level social capital on the dependent variable.

These variables were derived from either self-report or the medical chart. Demographic variables included self-reported age, marital status, education completed, and income. Income was categorized as ≤100% of the federal poverty line, above the federal poverty line, and missing (5.6%). Education was measured as a dichotomy: less then college education versus college education and higher. Sex was not included since over 98% of the population was male. Clinical variables included: physical health as measured by a question about general health (excellent/very good versus good/fair/poor); disease duration (0 = "<5 years", 1 = "5–9 years", 2 = "10–14 years", 3 = ">15 years"); and the body mass index (BMI).

Potential mediators of social capital include measures that tap health behaviors, access to medical care, and utilization of medical care. Health behavior measures include: self-care, assessed using the Diabetes Care Profile [23] self-care adherence scale and a variable indicating whether the patient missed medication doses in the last week. To measure access-to-care, we included questions on whether the veteran did not get or postponed needed medical care in the past year and whether the veteran also sought care outside of the VA health system [24, 25]. Measures of heath care utilization included use of disease specific education and number of visits to the participants VA primary care provider in the past year.

Neighborhood-Level Measures

There are multiple aspects of social capital, the measures here focus on communitarian aspects of social capital, as has been done in much of the health literature [26]. Measures of social capital were obtained from the 2004 SPHHS. Questions on social capital included the following. (1) PARTIC—"How many local groups or organizations do you currently participate in?" (2) COMM—"Overall how would you rate your community?" (1-excellent to 4-poor). (3) HELP—"Rate how likely people in your neighborhood are willing to help their neighbors with routine activities," (1-always to 5-never). (4) IMPROVE—"Have people in your neighborhood ever worked together to improve the neighborhood?" (5) BELONG—"Please tell me if you 1-strongly agree, 2-agree, 3-disagree, 4-strongly disagree with the following statement: I feel that I belong and am a part of my neighborhood." (6) TRUST—"Please tell me if you 1-strongly agree, 2-agree, 3-disagree, 4-strongly disagree with the following statement: most people in my neighborhood can be trusted."

In order to create neighborhood level measures of social capital, neighborhood scores were created for each measure based on the mean weighted response of the SPHHS participants living in one of 69 Philadelphia neighborhoods. In this analysis we include every neighborhood for which at least 20 people responded to the SPHHS (65/69 neighborhoods) so as to obtain a stable objective measure of the neighborhood's social capital.

In an effort to reduce the six measures of social capital in the SPHHS data, we conducted a principle component factor analysis using an oblique promax rotation. Since social capital in this paper represents a neighborhood level construct, the analysis was performed on the neighborhood level data sets ($N = 69$). After rotation, a clear, three factor solution emerged in which the social capital measures COMM, HELP, and BELONG, loaded strongly on a single factor, while the remaining social capital measures, PARTIC, TRUST and IMPROVE, loaded on three additional factors. We therefore created an additive social capital index based on the first factor by summing up the standardized values (z scores) on COMM, HELP, and BELONG for each of the 69 neighborhoods. The remaining three social capital measures were standardized (mean = 0, SD = 1) to aid in their interpretation.

We then merged the neighborhood scores of our social capital measures with the individual-level data. We assigned individuals to neighborhoods by geo-coding their addresses using ESRI GIS mapping software. Census tracts were used to assign participants to NIS neighborhoods. In order to control for possible confounding of poverty with social capital impacts on HbA1c, we attached a neighborhood level measure indicating the percentage of households living below the Federal poverty line based on the 2000 US Census.

Analysis

We began by estimating a series of linear mixed effects models. The linear mixed effects models were estimated using "full" maximum likelihood using the lme4 package in R 2.4.1 and included the full set of individual level controls and neighborhood level poverty. Four separate models were estimated due to the issues of correlation: each model containing one of the four social capital measures included in our study. The variance component for the neighborhood level random intercept proved difficult to estimate—usually returning an estimate close to the boundary and/or failing converge. This result was probably driven by two factors: (1) the fairly sparse sampling of subjects within neighborhoods, and (2) the low neighborhood level variance estimates that are typically found in studies of this kind [27]. We therefore dropped the mixed effects specification and estimated all models using OLS. Graphical diagnostic procedures indicated that the conditional distribution of HbA1c was slightly right skewed and heteroskedastic. However, transforming our outcome measure only had a very modest impact on our main findings, we therefore present the results of all analyses based on the untransformed measure.

Results

Descriptive statistics on each of the predictor variables for black diabetics from both samples (PVAMC and SPHHS) are shown in Table 1. The results from Table 1 indicate that although the subjects in our study were somewhat older (62 vs. 57 years) and more likely to live below the 100% federal poverty line (27 vs. 16%) then those sampled in the SPHHS study, the BMI and neighborhood context measures were largely similar across the two samples.

Table 2 presents the standardized regression coefficients and p-values for each of our social capital measures from the OLS estimated models in which each measure was entered separately. Only IMPROVE, was significantly associated with glucose control after adjusting the set of patient level control variables and neighborhood level poverty.

Table 2 Adjusted associations of social capital with HbA1c w/o mediators

Social capital measures	β^*	*P*-value
Participation in organizations (PARTICP)	0.006	0.911
Worked together (IMPROVE)	0.138	0.019
Neighbors trustworthiness (TRUST)	−0.058	0.439
Composite measure (INDEX)	−0.001	0.987

* Standardized regression coefficients

In Table 3 we turn to the question about the degree to which our *a priori* identified patient level mediators might explain the observed association between neighborhood level social capital and glucose control. This issue is only investigated in the case of IMPROVE, since none of the other social capital measures were associated with glucose control.

Table 1 Descriptive statistics and sample comparisons

	Study participants (*N* = 294)			SPHHS respondents (*N* = 290)		
		95% C.I.			95% C.I.	
HbA1c, mean	7.99	7.74	8.23	na	na	na
Individual-level controls						
Age, mean	62.44	61.23	63.64	56.79	55.07	58.51
Education Completed, %						
≥College	8.90	–	–	*na*	*na*	*na*
Federal Poverty Line, %						
≤100%	26.51	–	–	16.32	–	–
>100%	67.71	–	–	83.68	–	–
Missing	5.78	–	–	0.00	–	–
General health fair or poor, %	42.65			*na*	*na*	*na*
Body mass index, mean	31.97	31.24	32.70	31.80	31.01	32.59
Years with diabetes	1.73	1.60	1.86	*na*	*na*	*na*
Individual-level mediators						
SF12 mental health score, mean	50.01	48.75	51.27	*na*	*na*	*na*
Self-care adherence, mean	3.87	3.80	3.93	*na*	*na*	*na*
Missed any medication in last week, %	13.73	–	–	*na*	*na*	*na*
Did not get or postponed needed care, %	27.47	–	–	*na*	*na*	*na*
Seeks care outside of the VA,%	24.34	–	–	*na*	*na*	*na*
Visits in the past year to PCP, mean	3.99	3.74	4.24	*na*	*na*	*na*
Neighborhood-level measures, mean						
% Living in poverty	27.14	25.99	28.29	26.75	25.71	27.78
Social capital index (higher = better)	−1.21	−1.43	−0.99	−1.19	−1.42	−0.96
Trust neighbors (higher = better)—trust	−0.47	−0.55	−0.39	−0.43	−0.52	−0.35
Worked together (higher = better)—improve	−0.57	−0.63	−0.51	−0.47	−0.54	−0.40
Active participation in local organizations—PARTIC	0.03	−0.05	0.11	0.13	0.05	0.21

SPHHS survey Southeastern Pennsylvania Household Health Survey

Both samples are restricted to blacks with diabetes (self-report in SPHHS survey)

na: Variable *na* = not available in SPHHS survey

Table 3 Regression of HbA1c on individual level controls, neighborhood measures, and individual level mediators

Parameter	Model 1 β (SE)	Model 2 β (SE)
Constant	7.422 (0.594)	7.428 (0.605)
Individual level controls		
<College education	0.981 (0.473)*	0.842 (0.468)
Below poverty	0.137 (0.274)	0.134 (0.275)
Missing income	−0.095 (0.474)	−0.107 (0.471
Age	−0.061 (0.012)***	−0.055 (0.013)***
Body Mass Index	−0.025 (0.020)	−0.044 (0.020)*
Years with diabetes	0.212 (0.110)	0.189 (0.109)
General health good	−0.558 (0.248)*	−0.436 (0.255)
Neighborhood level measures		
% Poverty	0.007 (0.013)	0.011 (0.013)
Worked together (IMPROVE)	0.542 (0.230)*	0.517 (0.228)*
Individual level mediators		
SF 12 mental health score		0.012 (0.011)
Self-care adherence		−0.472 (0.222)*
Missed medications		0.913 (0.325)**
Missed/postponed needed care		−0.251 (0.268)
Seeks care outside VA		−0.122 (0.336)
# Visits to PCP		−0.043 (0.054)
Model summary		
R^2	0.137	0.186

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

In the first model, only the patient level demographic and clinical variables, neighborhood level poverty, and IMPROVE are included in the model. All the patient level demographic and clinical variables have p-values below our conservative cut-off criteria for remaining in the model ($P < .20$), but only college education, age, and having generally good health have statistically significant associations with the outcome ($P < .05$). In the second model, the potential mediators are included, but only two of them are statistically significant: the self-care adherence index and having missed medications in the last week. Contrary to our expectations, these two predictors do not appear to "explain" the association between IMPROVE and glucose control observed in Model 1. Although a slight reduction in the coefficient for IMPROVE was observed (proportion treatment effect (PTE) = 4.6%), bootstrapped confidence intervals based on the biased corrected percentiles for the observed PTE where too large to reject the null of 0%.

In Fig. 1, we examine the clinical significance of the association between IMPROVE and glucose control observed in Model 1. Holding all of the other variables in Model 1 at their respective sample means, black patients that lived in neighborhoods that scored near the 5th percentile of the IMPROVE measure are estimated to have HbA1c values that are at least one point above a conservative clinical definition of "diabetes control" (HbA1c ≤ 8%). On the other hand, if these same black patients were to live in neighborhoods in the 95th percentile of the IMPROVE measure, their expected level of HbA1c would be over ½ a point below the cut-off value 8%.

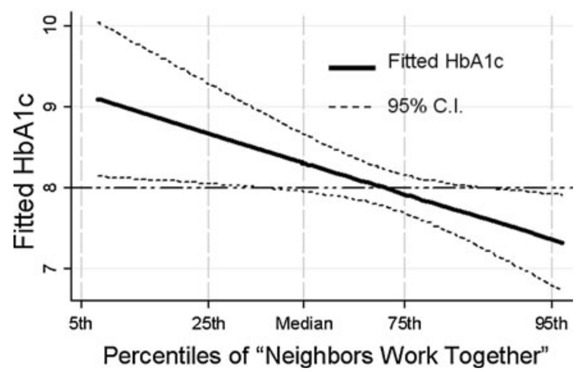

Fig. 1 Adjusted HbAlc by IMPROVE with 95% C.I

Discussion

For black veterans living in Philadelphia, living in a neighborhood where people work together is associated with diabetes control in a clinically meaningful way. However, this association was not observed for other measures of social capital.

Why was only one measure of social capital associated with glucose control? Social capital is thought to engender public trust and engagement [12]. Four of the five measures not associated with glucose control assessed personal perceptions of the neighborhood and the fifth assessed personal engagement. IMPROVE was the only measure of actual past actions within the neighborhood, which may be a more accurate way to determine that informal social ties actually exist in the surrounding environment. Another possible explanation may be specific to the measure itself. Living in a neighborhood where people have worked together to improve the neighborhood may be a sign of a neighborhoods collective efficacy or ability to engender neighborhood action and this itself may be particularly important for diabetic health [28]. For example, in a predominantly low-income black Philadelphia neighborhood a local neighborhood association successfully blocked the establishment of a McDonalds restaurant in their neighborhood [29]. Living in neighborhoods where people work together to improve access to healthy food, safe places to exercise, and quality healthcare may be particularly important for people with diabetes, or may reflect underlying cultural characteristics that also support the health of people with diabetes.

Like our results, the growing body of literature evaluating social capital and health is also inconsistent. Drukker and colleagues found a scale measuring neighborhood social cohesion and trust was associated with self-rated health in Hispanic adolescents living in Chicago but not non-Hispanics [30]. While, Lochner and colleagues found in their evaluations of Chicago, neighborhood reciprocity, trust, and civic participation to be strongly predictive of all cause, cardiovascular, and other causes of mortality for adult whites, but less consistent effects were observed for blacks [14]. Clearly, although measures of social capital have frequently been associated with health outcomes, we are still sorting out how to measure it and what it means for different populations and different health outcomes [31–34]. Our study looks at a health outcome that has previously not been evaluated in regards to social capital. It may be that among people with diabetes, social capital is most important in settings of individual or neighborhood deprivation—functioning in part as a safety net. Indeed, it is quite plausible that beneficial effects of social capital for people with diabetes may be most important in the setting of adversity where access to healthy food and places to exercise are limited [28–41].

This study is subject to several limitations. First, it is cross sectional and the association we found between neighborhoods working together to improve the neighborhood and glucose control suggest but do not demonstrate a causal relationship. Second, our study cohort was derived from a clinical population in one city. Broader geographic samples may have uncovered more or different effects. Third, we studied a black veteran population, which may not be representative of other populations with diabetes. Fourth, the observed associations between diabetic control and neighborhood social capital might simply reflect confounding by neighborhood SES; however, this possibility seems unlikely. Living in a neighborhood where people have worked together to improve the neighborhood was not correlated highly with the percent of the population living below poverty (our measure of neighborhood SES), and when both were entered into our models, the social capital measure remained an independent predictor of glucose control.

This study also has strengths. Previous studies of population health have relied largely on administrative clinical data. Our individual-level data were drawn from chart reviews and individual interviews we performed and were detailed enough to include measures of disease duration, chart documented clinical co-morbidity, and self-care practices. Finally, we utilized multiple measures of social capital in order to help characterize what is clearly a broad based concept.

Advances in diabetes care will come not only from our efforts to understand the physiologic and molecular mechanisms of the disease, but also from our understanding of how social forces shape its management and outcomes. To date our clinical based efforts have not improved population health and have missed those in greatest need. The results of this study suggest that where a patient lives, particularly the degree to which neighbors come together to work within the neighborhood, may determine how effectively that patient's diabetes is managed. The specific mechanism by which social capital achieves its health effects—if the association is indeed causal—may remain unknown for a long time. But whatever mechanisms or pathways are discovered, they are likely to have broad implications across a variety of health and social conditions. Although debate exists about whether we can and should try to influence neighborhood social capital, [34, 42, 43] modifications to neighborhood social capital may emerge as an effective adjunct to address the growing epidemic of diabetes that disproportionately affects low income and minority populations.

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