Socioeconomic and Neighborhood Context Effects on Blood Sugar and Diabetes

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ABSTRACT

This study examines the role of residential neighborhood in racial/ethnic and socioeconomic disparities in individual blood sugar (HbA1c) and diabetes prevalence. Diabetes diagnosis data come from the Chicago Community Adult Health Study (CCAHS), a probability sample of 3105 participants aged 18 and over living in 343 Chicago neighborhoods. Blood sugar was collected from a sub-sample of 628 participants in 42 neighborhoods. We found that blacks have significantly higher levels of HbA1c, but neighborhood fixed-effects reduce the effects size and result in non-significance of the black-white blood glucose comparison when the regressions are weighted to represent the Chicago population. We develop a set of spatial social measures which explain much of the neighborhood effects revealed by the fixed effects by including the levels of social measures in the surrounding neighborhoods. Levels of HbA1c were lower in affluent neighborhoods and higher in Hispanic foreign-born neighborhoods, net of individual and neighborhoods controls. Blacks and persons of other non-Hispanic race, as well as people with income less than $10,000 per year are more likely to have diabetes, but the effect of neighborhoods is much less.

INTRODUCTION

Overall, 9.3% of Americans had diabetes in 1999-2002, including 2.8% undiagnosed (Cowie et al. 2006). On average, non-Hispanic blacks are twice as likely to have diabetes compared to non-Hispanic whites of similar age (13% vs. 7.8% overall; FactSheet). Diabetes is estimated to account for 3.3% of all-cause and 5.2% of cardiovascular disease mortality in U.S. adults (Saydah et al. 2002), as well as contributing to lower extremity amputation, retinopathy, and nephropathy (Harris 1995). Among diabetics, elevated glycosylated hemoglobin (HbA1c) levels increased the risk of all-cause and cardiovascular mortality (Shankar et al. 2007). Thus, black-white difference in diabetes prevalence and glycosylated hemoglobin levels contribute to overall health disparities.

Racial disparities in diabetes are not fully explained by racial genetic difference, individual socioeconomic status, or race-related differentials in access to medical care. Humphreys et al. (2007) show that diabetes prevalence was higher among white compared to black Civil War veterans, which suggests that genetics are not responsible for the current situation. Health researchers find that socioeconomic status predicts mortality even when health care is universal (i.e. Pincus et al. 1998). There are differences in adherence to diabetes treatment, but adjusting for them does not eliminate the black-white gap (Adams et al. 2008). Robbins et al. (2001) find that the poverty income ratio was a risk factor for diabetes for African-American women and White men and women but not African-American men, while education and occupation were also significant only for white women.

In this paper we investigate how differences in the neighborhoods where blacks and whites live may explain some of the observed racial/ethnic disparities in HbA1c and diabetes. Because different race/ethnic groups live in different areas of the city, they may be exposed to different stressors and social environments, which may generate divergent health outcomes across neighborhoods. Neighborhoods may also influence diagnosis and treatment of diabetes and high blood sugar, so that location could be related not only to the onset, but also the control, of diabetes. Mapping of all cases of diabetes in Winnipeg, Canada revealed substantial clustering and small-area variations associated with variations in socioeconomic, environmental and lifestyle characteristics of the population (Green et al. 2003). These spatial effects seem to operate across metropolitan neighborhoods rather than at the county level (Samuelsson and Löfman 2004 (Sweden)). Socioeconomic conditions in surrounding neighborhoods influence diabetes even when characteristics of the respondent's own neighborhood are controlled. Auchincloss et al. (2006) found that distance to a wealthy area was associated with insulin resistance independent of the weak effect of local poverty and person-level covariates, though physical activity, diet, and BMI reduced this association. Likewise, Cox et al. (2007) found that type 2 diabetes is more common in deprived areas in Scotland, but higher or lower in deprived areas that are surrounded by relatively more or less deprived areas, respectively.

Our study adds to the literature about racial/ethnic and socioeconomic disparities and spatial effects on health outcomes in several ways. We provide one of the only population-based analyses including individual- and neighborhood-level measures of HbA1c and diabetes, and the large sample covers a variety of different neighborhood types. Second, our use of fixed effects and hierarchical models contributes to understanding of the relative magnitudes of individual vs. neighborhood social characteristics, while the hierarchical models help to identify within- and between-area components of racial/ethnic disparities. Third, we produce a new way to characterize and model the socioeconomic characteristics of surrounding neighborhoods independent of the characteristics of the respondent's own neighborhood, and this method explains a substantial portion of the black-white disparities in both HbA1c and in diabetes.

METHODS

Data

Data come from the Chicago Community Adult Health Study (CCAHS), a prospective multi-level study of the impact of individual and social environmental factors on health, their role in understanding socioeconomic and racial-ethnic disparities in health, and the biological and behavioral pathways that are involved. This project has completed a major survey of a probability sample of 3105 adults age 18 and older in the city of Chicago, with a response rate of 71.8% and including physical measurements of height, weight, waist, hip length, and blood pressure. In addition, saliva and a blood sample have been collected for 681 people (about 60% of respondents - a subsample of 80 of the 342 neighborhood clusters (NCs) covering the entire city of Chicago, developed and characterized by the Project on Human Development in Chicago Neighborhoods (PHDCN) (http://phdcn.harvard.edu/), from which the CCAHS sample is drawn. In addition to utilizing existing and collecting new archival data on these areas, the CCAHS carried out Systematic Social Observations of all 1672 blocks containing sampled households for the study. Further, the locations of all businesses in the area are available from InfoUSA (Ailshire and Bader forthcoming).

HbA1c measures the amount of glycosylated hemoglobin in the respondent's red blood cells formed when blood sugar (glucose) attaches to hemoglobin. An HbA1c value of 6% or less is normal, while a value over 7% indicates poor diabetes control (Medline). In our data, 16% of respondents had HbA1c levels over 6%, while 9% reported having been diagnosed with diabetes. Other summary statistics are reported in Table 1, with separate tabulations for the full sample and for the sample from whom HbA1c levels were collected. Because the data were collected over a time span of almost two years, we include a control for the season and year of the blood draw.

We use the set of neighborhood-level variables developed by Morenoff et al. (2008) using factor analysis and 2000 Census NC-level measures. The first factor, which we interpret as socioeconomic deprivation, is characterized by low family incomes, high levels of poverty, public assistance, unemployment, female-headed families, never-married adults, and few owneroccupied homes. The second factor represents a mix of characteristics associated with neighborhood affluence (concentrations of people with high education and in professional/managerial occupations) and gentrification (a residentially mobile population consisting of young adults and few children under the age of 18). The third factor represents racial/ethnic/immigrant composition, (higher values indicate more Hispanic and foreign born and fewer non-Hispanic blacks), and the final factor captures older age composition (especially people over 70 but also those between ages 50-69, and few young adults or people who have never married).

Analytic Plan

This analysis focuses on the extent to which consideration of variation in neighborhood context changes estimates of racial/ethnic and socioeconomic disparities in blood sugar and diabetes outcomes. We first apply conventional regression models (ordinary least squares for continuous HbA1c levels and logistic regression for diabetes diagnosis) to estimate racial/ethnic and socioeconomic disparities in blood pressure/hypertension outcomes. As a baseline, we estimate one model with a limited set of individual covariates, including sex, age, race/ethnicity, immigrant generation, a dummy variable indicating whether the respondent is currently married, education, and income. A second model includes additional individual measures which the literature suggests may be related to socioeconomic disparities in diabetes (waist size, physical activity, smoking, drinking, and sleep). These models were estimated with Stata software, version 10. Summary statistics on the individual-level covariates used in our models are presented in Table 1.

In the second stage of our analysis we examine how adjusting for neighborhood context changes estimates of individual-level disparities in HbA1c/diabetes by restricting comparisons of social groups to people who share the same residential neighborhoods. To model HbA1c, we added a fixed effect for each neighborhood (with one omitted as a reference category) to the OLS models. To model whether the respondent reported having been diagnosed with diabetes, we added a hierarchical structure to the logistic regression models, centering each individual-level covariate around its neighborhood mean to estimate its within-neighborhood partial association with the log-odds of the dependent variable, as shown in Raudenbush and Bryk (2002:137). The hierarchical model is necessary because nonlinear fixed-effect models become unstable with many strata (Breslow and Day, 1980: 249). We estimated this model using the HLM software package, version 6. Both methods adjust for group differences in neighborhood context by restricting comparisons to people who share the same neighborhoods.

Third, we introduce neighborhood-level variables into our hierarchical models. This allows us to compare individuals who live in similar types of neighborhoods (according to the structure of the neighborhood models) and also provides more power to investigate within-neighborhood disparities. Unlike the neighborhood fixed effects models, these hierarchical models impose a structure on the neighborhood-level model, which assumes that the neighborhood covariates are linearly related to the outcome, an assumption which we will test. Again we repeat the analyses for the restricted and expanded sets of individual-level covariates.

Finally, we expand our investigation of neighborhood effects to include characteristics of the surrounding neighborhoods. We first find the average level of each neighborhood-level covariate which borders the respondent's neighborhood. We calculate tertiles of each neighborhood-level covariate for both the neighborhood itself and for the surrounding neighborhoods. These two sets of tertiles form a matrix with nine levels, such that a neighborhood may have low, moderate, or high levels, and be surrounded by low, moderate, or high levels of affluence, deprivation, Hispanic foreign-born, or elderly presence. We then combine categories to ease interpretation and increase the number of neighborhoods in a given category. The omitted category of affluence, for instance, is highly affluent neighborhoods surrounded by highly affluent neighborhoods. Other categories include the low-low, low-moderate/high, moderate-low, moderate-moderate, moderate-high, and high-low/moderate neighborhoods. We are continuing to refine these categorizations.

PRELIMINARY RESULTS AND FURTHER WORK

Preliminary results show that blacks have significantly higher HbA1c than do blacks, with a gap of .0055%. Neither Hispanics nor non-Hispanic persons of other race have significantly different HbA1c than do whites. Neighborhood deprivation and Hispanic foreign-born presence are related to HbA1c and diabetes. Characteristics of surrounding neighborhoods appear to influence HbA1c and diabetes even when characteristics of respondent's own neighborhood are controlled, and this characterization reduces black-white disparities.

Future work will finalize results from the models detailed above. In addition, we will continue to refine our spatial conceptualization of the sociodemographic characteristics of the surrounding neighborhoods as they explain black-white disparities.

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Table 1. Summary Statistics for Sample

Covariate	CCAHS Focal Sample (n=628)				CCAHS Full Sample (n=3,105)		
	Frequency (unweighted)	*Percent (weighted)*	Mean HbA1c (weighted)	Percent Diabetic (weighted)	Frequency (unweighted)	*Percent (weighted)*	Percent Diabetic (weighted)
Sex							
Male	254	44.70	0.056	7.93	1235	47.4	5.88
Female	374	55.30	0.055	8.15	1870	52.6	10.17
Age							
Age 18-29	151	24.50	0.059	16.66	800	27.5	1.60
Age 30-39	144	21.45	0.062	21.58	748	22.7	2.70
Age 40-49	134	19.87	0.059	18.87	608	18.7	7.90
Age 50-59	90	15.58	0.057	7.43	402	12.9	16.10
Age 60-69	58	7.37	0.052	3.32	286	9.0	22.35
Age 70+	51	11.24	0.051	0.55	261	9.2	16.54
Race/Ethnicity							
Non-Hisp. White	212	34.05	0.054	12.79	983	38.4	4.41
Non-Hisp. Black	227	39.26	0.055	5.81	1240	32.1	11.11
Hispanic	174	22.06	0.059	12.92	802	25.8	9.86
Non-Hisp. Other	15	4.63	0.053	4.90	80	3.8	8.93
Immigrant Status							
1st Generation	140	63.10	0.056	5.57	773	26.9	8.69
2nd Generation	95	16.70	0.054	5.36	378	13.7	5.36
3rd + Generation	393	20.20	0.056	5.57	1954	59.4	8.52
Education							
<12 years of education	155	21.90	0.053	5.93	792	23.4	15.80
12-15 years of education	315	48.04	0.055	8.03	1576	48.7	7.15
16+ years of education	158	30.06	0.060	10.70	737	27.9	3.43
Income							
LT$10K	82	10.54	0.055	10.69	365	10.1	11.09
$10K-LT$30K	172	24.47	0.054	5.81	876	26.2	11.39
$30K-LT$50K	122	18.33	0.055	4.53	581	18.4	6.00
$50K+	159	33.07	0.057	9.47	698	26.5	5.14
Income Missing	93	13.60	0.057	12.60	585	18.8	8.33
Marital Status							
Currently Unmarried	421	59.38	0.055	8.68	1091	58.2	7.32
Currently Married	208	40.62	0.056	7.05	2013	41.8	9.28
Waist to Hip Ratio							
First quartile	147	23.26	0.052	3.61	771	24.1	4.37
Second quartile	168	25.65	0.054	4.82	780	24.7	5.09
Third quartile	153	23.94	0.056	8.95	781	25.3	9.46

Fourth quartile	160	27.15	0.059	14.70	773	26.0	13.24
Physical Activity							
In bed/chair	80	13.34	0.058	7.96	527	16.6	9.68
Never Exercise	27	3.29	0.061	31.21	122	3.8	27.61
Light	113	16.60	0.056	12.82	511	15.6	8.31
Light/Moderate	129	20.79	0.057	6.41	638	20.3	6.83
Moderate or Moderate/Heavy	279	45.97	0.053	5.22	1,307	43.7	6.42
Eats Some Fruits and Vegs.							
No	38	4.52	0.062	11.23	182	5.2	4.45
Yes	590	95.48	0.055	7.90	2923	94.8	8.34
Smoking							
Never Smoker	340	55.83	0.055	5.97	1675	54.5	7.63
Current Smoker	109	27.16	0.056	7.68	815	25.3	7.26
Former Smoker	179	17.00	0.058	15.67	615	20.3	10.60
Drinking							
Never-drinker	245	35.24	0.058	14.52	1239	37.7	13.58
0-13 drinks/month	228	41.48	0.054	4.59	1136	36.1	6.77
14-89 drinks/month	131	20.32	0.052	3.42	632	22.8	1.67
>=90 drinks/month	24	2.96	0.056	7.37	98	3.4	5.73
Sleep							
<7 hours sleep	309	49.65	0.055	6.14	1569	51.1	6.80
7-8 hours sleep	283	44.27	0.056	10.57	1314	41.4	9.72
>8 hours sleep	37	6.09	0.055	7.06	222	7.6	8.50