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Original Contribution

Exposure to Neighborhood Foreclosures and Changes in Cardiometabolic Health: Results From MESA

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Home foreclosures can precipitate declines in health among the individuals who lost their homes. Whether home foreclosures can "spillover" to affect the health of other neighborhood residents is largely unknown. Using longitudinal data from the Multi-Ethnic Study of Atherosclerosis that were linked to foreclosure data from 2005 to 2012, we assessed whether greater exposure to neighborhood foreclosures was associated with temporal changes in 3 objectively measured cardiometabolic risk factors: body mass index, systolic blood pressure, and fasting glucose level. We used fixed-effects models to estimate mean changes in cardiometabolic risk factors associated with changes in neighborhood foreclosures over time. In models in which we controlled for time-varying income, working status, medication use, neighborhood poverty, neighborhood unemployment, and interactions of age, sex, race, and state foreclosure laws with time, a standard-deviation increase in neighborhood foreclosures (1.9 foreclosures per quarter mile) was associated with increases in fasting glucose (mean = 0.22 mg/dL, 95% confidence interval: −0.05, 0.50) and decreases in blood pressure (mean = −0.27 mm Hg, 95% confidence interval: −0.49, −0.04). Changes in neighborhood foreclosure rates were not associated with changes in body mass index. Overall, greater exposure to neighborhood foreclosures had mixed associations with cardiometabolic risk factors over time. Given the millions of mortgages still in default, further research clarifying the potential health effects of neighborhood foreclosures is needed.

blood glucose; blood pressure; body mass index; foreclosure; neighborhoods; social environment

Abbreviations: BMI, body mass index; CI, confidence interval; MESA, Multi-Ethnic Study of Atherosclerosis.

From December 2007 to June 2009, the United States experienced its largest financial crisis since the Great Depression. Alongside the bankruptcy of financial institutions and increases in unemployment, the collapse of the housing market drove millions of mortgages into default, with more than 12.5 million mortgages going through the foreclosure process between 2007 and 2012 (1).

Given the magnitude of the crisis, researchers have taken an interest in the possible health effects of foreclosure (2). Foreclosure is a disruptive and stressful life event, and in previous studies, investigators have found that individuals going through foreclosure experience poorer health outcomes, including depression, anxiety, posttraumatic stress disorder, and lower self-rated health (3–5). More recently, researchers have conceptualized foreclosure as a community-level risk factor that can alter the health of residents who do not directly experience foreclosure (6–11). Foreclosures can "spillover" to affect the surrounding neighborhood environment, lowering neighboring home values (12–15), disrupting social networks (16), increasing the crime rate (17, 18), and eroding neighborhood aesthetic quality. These neighborhood changes may in turn be related to increased stress, decreased physical activity, and coping behaviors that are risk factors for a variety of diseases. A growing body of work has shown that living near foreclosed properties is associated with higher hospital admission rates (8), body mass index (BMI) (7), systolic blood pressure (6), and depressive symptoms (10).

Current research on the health effects of the foreclosure crisis is limited in several ways. Most research has been focused on the health of individuals undergoing foreclosure, without considering potential effects on residents who live nearby (3–5). The few studies in which researchers have assessed the effects of neighborhood-level foreclosure have been cross-sectional (9), lacked individual-level data (8), focused on foreclosure at large geographic scales (e.g., zip codes) (10), and used geographically limited samples that may fail to capture a broad range of foreclosure exposures or sociodemographic attributes (6, 7). Thus, further research using longitudinal data on foreclosures at relevant spatial scales and individual-level outcomes is warranted.

Using longitudinal data from the Multi-Ethnic Study of Atherosclerosis (MESA) linked to foreclosure data, we assessed whether living near foreclosed properties was associated with temporal changes in 3 objectively measured cardiometabolic risk factors: BMI, systolic blood pressure, and fasting plasma glucose level. We hypothesized that residing in a neighborhood in which there were more foreclosures would lead to greater temporal increases in cardiometabolic risk factors compared with residing in a neighborhood with less foreclosure activity.

METHODS

Study population and analytic sample

MESA is a longitudinal study of cardiovascular disease among white, black, Hispanic, and Chinese adults who were 45–84 years of age at baseline and were recruited from 6 locations (New York, New York; Baltimore, Maryland; Forsyth County, North Carolina; Chicago, Illinois; St. Paul, Minnesota; and Los Angeles, California) (19). People with clinical cardiovascular disease were excluded. A total of 6,814 individuals were recruited at baseline in 2000–2002, and there have been 4 follow-up examinations over 12 years. We used data from examination 4 (September 2005–May 2007) and examination 5 (April 2010–February 2012), which provided a time window that bookended the most severe period of the crisis. The analytic sample included those persons who had their home addresses geocoded (n = 6,191), completed examinations 4 and 5 (n = 4,567), had data available for at least 1 outcome and for all exposures and covariates (n = 4,406), and had foreclosure data available for a full year before examination 4 (n = 3,775). Excluded individuals did not differ significantly from the full study population at examination 4. Written informed consent was obtained from participants, and the study was approved by institutional review boards at each site.

Outcome variables

BMI was calculated as measured weight in kilograms divided by the square of measured height in meters. Systolic blood pressure was calculated as the average of the last 2 of 3 seated measurements, taken using an automated oscillometric device. Plasma glucose levels were obtained from 12-hour fasting blood samples and were measured using the glucose oxidase method on a Vitros analyzer (Johnson & Johnson, Rochester, New York). All outcomes were measured at both examinations 4 and 5.

Exposure variables

Geocoded foreclosure data for the years 2005–2012 were obtained from RealtyTrac (Irvine, California), an authoritative source for foreclosure information that collects foreclosure records from roughly 2,200 counties, covering more than 90% of households (10, 20). Consistent with previous research, we defined foreclosures as residential properties with mortgages in default that were issued a Notice of Trustee's Sale or a Notice of Foreclosure Sale indicating an upcoming auction of the property (i.e., properties in the foreclosure process) (8, 21). Because a property can have multiple filings for the same foreclosure event, properties with multiple filings within a year were counted as 1 occurrence. A count of the number of foreclosures within a quarter-mile Euclidean buffer around each MESA participant's residence was calculated for each year between examinations 4 and 5 using ESRI ArcGIS 10.1 (Redlands, California). The primary exposure of interest was change in foreclosure count from the year preceding examination 4 to the year preceding examination 5.

Covariates

Individual-level covariates included the time-invariant variables age at examination 4, race/ethnicity, sex, and years of education and the time-varying variables household income, employment status (working full/part-time vs. not working/retired), and medication use (antihypertensive or antihyperglycemic medication). An indicator of whether a participant moved between visits was also included to account for possible effects of moving per se. To control for area-level confounders, we included the time-varying percentage of individuals living in poverty and percentage unemployment at the census tract level, as well as population density. Percentages of poverty and unemployment were obtained from the American Community Survey 2005–2009 (22) for examination 4 and American Community Survey 2007–2011 (23) for examination 5. Population density, which was measured as number of persons per square mile within a quarter-mile buffer of each participant's address, was calculated based upon population counts from the 2010 Census. Because states have different laws regulating foreclosure that might influence the rapidity of home eviction after foreclosure documents are filed, we also controlled for the type of foreclosure process (judicial vs. nonjudicial) used in the participant's state (10).

Statistical analysis

We conducted descriptive analyses to examine participant characteristics and outcomes both overall and by tertile of change in foreclosure count between examinations 4 and 5. Tests of differences by tertiles were performed using unadjusted analysis of variance for continuous measures and χ^2 tests for categorical variables.

We modeled the association between neighborhood foreclosure activity and each cardiometabolic risk factor using individual-level econometric fixed-effects linear regression (24). These models tightly control for time-invariant characteristics and were used to evaluate whether within-person changes in neighborhood foreclosure rates were associated with within-person changes in the outcomes. We adjusted for all time-varying individual-level (household income, working status, and medication use) and area-level (percentage living in poverty, percentage unemployment, and population density for individuals who moved) covariates in a series of models and included a term for time since examination 4 in all models. To control for potential confounding of the temporal trends, we included interactions of examination 4 age, sex, race/ethnicity, and state foreclosure laws with time. We evaluated possible nonlinear relationships for continuous variables by testing squared terms, none of which were retained in the final models. All estimates of association were scaled to correspond to a 1-standard-deviation increase in foreclosures between examinations 4 and 5 (1.9 foreclosures).

We performed several sensitivity analyses. First, we ran complementary linear mixed models with random individual-level intercepts to account for repeated observations. These models may have more power to detect associations than fixed effects models because they utilize both within-person and between-person variability, but they are also susceptible to confounding by unobserved time-invariant covariates. We used the linear mixed models to estimate 4 associations of interest: 1) the association of each outcome with foreclosure count at examination 4; 2) the mean 5-year change in each outcome for individuals with no foreclosures at examination 4 and no change in foreclosures over time; 3) the modification of the 5-year change in each outcome by foreclosure count at examination 4; and 4) the modification of the 5-year change in each outcome by annual change in foreclosure count. The annual change in foreclosures was calculated by regressing yearly foreclosure counts on time for each participant and using the slope term as the yearly change. All linear mixed models controlled for the same covariates as the fixed-effects models, with additional controls for time-invariant age at examination 4, sex, race/ethnicity, and educational level. Adding site as a covariate produced similar results, and it was therefore excluded from the final models.

Second, because foreclosures beyond a quarter-mile buffer may influence neighborhood conditions, we re-ran all models using 1-mile buffers for foreclosure counts. Furthermore, both blood pressure and fasting glucose can be affected by medication use. Including medication use as a covariate is common but possibly unsatisfactory because of confounding by indication (25). Therefore, we used a nonparametric ad hoc imputation method to assign individuals on medication an "untreated value" and re-ran our models to assess the sensitivity of our results (Web Appendix 1, available at http://aje.oxfordjournals.org/). For systolic blood pressure, we assessed the sensitivity of this ad hoc approach by running models with multiply imputed blood pressure for those taking antihypertensive medication. We also ran models that were restricted to participants not taking antihypertensive or antihyperglycemic medications at either examination to evaluate whether medication use masks any associations. Because individual foreclosure data were not available for MESA participants, we ran additional models stratified by home ownership status at examination 3 (not available at examination 4) to verify that associations were also present among those who were not homeowners. Finally, given that time between a Notice of Trustee's Sale/Notice of Foreclosure Sale filing and actual repossession or sale of a home can vary, we also used 2- and 3-year time windows before examination 5 (rather than 1-year) to evaluate the sensitivity of our results.

RESULTS

Foreclosure activity increased dramatically throughout the study period, with considerable variability by site (Table 1). In 2005, the overall mean quarter-mile foreclosure count was 0.4, which increased to 4.2 by 2011. Study participants in California, Illinois, and Minnesota experienced the greatest exposure to neighborhood foreclosures, with Illinois residents peaking at a mean of 9.2 foreclosures within a quarter-mile buffer in 2010.

The mean follow-up period between examinations 4 and 5 was 4.61 years (Table 1). There were important differences in participant characteristics at examination 4 by tertiles of foreclosure change between examinations. Participants who resided in neighborhoods in the highest tertile of foreclosure change were more likely to be white or Hispanic and less likely to be black or Chinese, had lower annual household income and education levels, and were more likely to be currently working. Compared with neighborhoods in the lowest tertile of foreclosure change, those in the highest tertile had slightly higher levels of poverty and unemployment and considerably lower population densities. Participants in neighborhoods with higher foreclosure activity were also more likely to reside in states with a nonjudicial foreclosure process. BMI and blood pressure at examination 4 were not associated with changes in foreclosure activity. Fasting glucose levels at examination 4 were higher among persons in the middle tertile of foreclosure change compared with persons in the lowest and highest tertiles.

Table 2 shows the association between within-person change in neighborhood foreclosure activity and within-person changes in BMI, blood pressure, and fasting glucose levels. In models adjusted for time between examinations and medication use (model 1), changes in neighborhood foreclosure were unassociated with changes in BMI (per standard-deviation increase in foreclosure count, mean difference in BMI = 0.02, 95% confidence interval (CI): −0.01, 0.04). However, changes in neighborhood foreclosure were related to changes in both blood pressure and fasting glucose level: A standard-deviation increase in foreclosure count between examinations was associated with a mean decrease of 0.24 mm Hg (95% CI: 0.04, 0.46) in blood pressure but a mean increase of 0.26 mg/dL (95% CI: −0.01, 0.53) in fasting glucose level. Estimates of association were largely unchanged after adjustment for individual- and area-level time-varying covariates (models 2 and 3).

Table 1. Participant Characteristics at Examination 4, Overall and by Tertile of Change in Foreclosures Within a Quarter Mile of the Participant's Residence, Multi-Ethnic Study of Atherosclerosis, 2005–2012

Characteristic	Overall (*n* = 3,775)		Foreclosure Tertile[a]						*P* Value[b]
			Low (*n* = 1,183)		Middle (*n* = 1,332)		High (*n* = 1,260)		
	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	
Age, years	65.39 (9.46)		65.75 (9.55)		65.41 (9.33)		65.02 (9.52)		0.16
Male		47.13		48.01		48.57		44.76	0.12
Race/ethnicity									<0.001
White		36.98		38.29		34.38		38.49	
Chinese		12.87		11.92		15.84		10.63	
Black		28.19		29.16		29.05		26.35	
Hispanic		21.96		20.63		20.72		24.52	
Income in thousands, $	52.21 (34.58)		53.39 (34.41)		54.09 (34.67)		49.12 (34.46)		<0.001
Years of education	13.48 (3.84)		13.64 (3.75)		13.63 (3.69)		13.18 (4.07)		<0.01
Currently working		52.61		48.69		55.26		53.49	<0.01
Site									<0.0001
Forsyth County, North Carolina		15.87		20.79		20.80		6.03	
New York, New York		17.27		29.84		19.37		3.25	
Baltimore, Maryland		14.54		14.29		15.99		13.25	
St. Paul, Minnesota		16.50		9.81		12.76		26.75	
Chicago, Illinois		19.66		16.74		16.07		26.19	
Los Angeles, California		16.16		8.54		15.02		24.52	
Moved between examinations		14.12		16.40		13.36		12.78	0.02
Years between examinations	4.61 (0.32)		4.63 (0.32)		4.63 (0.32)		4.58 (0.32)		<0.001
Census tract poverty, %	15.58 (11.40)		15.87 (12.11)		14.34 (11.58)		16.61 (10.36)		<0.0001
Census tract unemployment, %	8.34 (4.85)		8.46 (5.17)		7.75 (4.68)		8.86 (4.66)		<0.0001
Population density per 1,000 persons[c]	23.11 (33.42)		28.84 (39.59)		23.36 (36.91)		17.46 (19.30)		<0.0001
Foreclosure law[d]									<0.0001
Judicial		51.47		60.78		51.58		42.62	
Nonjudicial		48.53		39.22		48.42		57.38	
Cardiometabolic risk factors									
BMI[e]	28.45 (5.57)		28.40 (5.58)		28.49 (5.52)		28.44 (5.62)		0.92
Systolic blood pressure, mm Hg	123.36 (20.17)		123.33 (19.71)		123.44 (19.90)		123.30 (20.89)		0.98
Taking antihypertensive medication		46.94		49.21		47.84		43.86	0.02
Fasting plasma glucose, mg/dL	100.45 (26.85)		99.93 (22.89)		102.02 (31.14)		99.27 (25.27)		0.03
Taking antihyperglycemic medication		13.99		14.29		13.89		13.81	0.94
Foreclosure exposures									
Count of foreclosures at examination 4	0.90 (1.88)		1.14 (2.34)		0.48 (1.32)		1.13 (1.83)		<0.0001
Change in foreclosure count between examinations 4 and 5	3.49 (5.60)		−0.52 (1.18)		1.80 (0.80)		9.04 (6.54)		<0.0001

Abbreviations: BMI, body mass index; SD, standard deviation.

[a] Tertile of change in the number of foreclosures within quarter-mile buffer around each participant's residence between examinations 4 and 5, calculated by subtracting the number of foreclosures in the year preceding examination 4 from the number of foreclosures in the year preceding examination 5. Tertile ranges are as follows: low, −10–0; middle, 1–3; high, 4–81.

[b] Two-sided *P* value from unadjusted analysis of variance models for continuous variables and χ^2 test for categorical variables.

[c] Population density, measured as persons per square mile within a quarter-mile buffer of the participant's address, was calculated based on block-level census population.

[d] States that have both judicial and nonjudicial foreclosures were classified according to the most common form of foreclosure.

[e] Weight (kg)/height (m)^2.

Table 2. Associations of Within-Person Changes in Foreclosure Counts With Within-Person Changes in Cardiometabolic Risk Factors Between Examinations 4 and 5, Multi-Ethnic Study of Atherosclerosis, 2005–2012[a]

Cardiometabolic Risk Factor	Model 1[b]		Model 2[c]		Model 3[d]	
	Mean Difference	95% CI	Mean Difference	95% CI	Mean Difference	95% CI
BMI[e]	0.02	−0.01, 0.04	0.01	−0.01, 0.03	0.01	−0.01, 0.03
Systolic blood pressure, mm Hg	−0.24	−0.46, −0.03	−0.27	−0.49, −0.06	−0.27	−0.49, −0.06
Fasting plasma glucose, mg/dL	0.26	−0.01, 0.53	0.23	−0.04, 0.51	0.22	−0.05, 0.50

Abbreviations: BMI, body mass index; CI, confidence interval.

[a] Model estimates are derived from fixed effects models. Mean differences correspond to a standard-deviation increase in exposure (1.9 foreclosures).

[b] Adjusted for time between examinations and time-varying medication use (for blood pressure and fasting glucose).

[c] Adjusted for the variables in model 1 and time-varying income, working status, moving status, and interactions of time-invariant age, sex, and race/ethnicity with time.

[d] Adjusted for the variables in model 2 and time-varying census tract-level percent poverty, percent unemployment, population density, and state foreclosure law by time interaction.

[e] Weight (kg)/height (m)^2.

Table 3 shows the associations of foreclosure count at examination 4 and over time with each outcome using linear mixed models. In fully adjusted models (model 3), a higher foreclosure count at examination 4 was inversely associated with BMI at examination 4 (per each standard-deviation increase, mean difference = −0.27, 95% CI: −0.43, −0.11). The mean 5-year change in BMI was negligible (for individuals in neighborhoods with no foreclosure activity at examination 4 and no annual change in foreclosure activity, mean 5-year change = −0.05, 95% CI: −0.14, 0.04), and the temporal trend was not modified by either examination 4 foreclosures or annual changes in foreclosure activity. In fully adjusted models for systolic blood pressure, higher levels of foreclosure at examination 4 were associated with higher blood pressure (per standard-deviation increase, mean difference = 0.60, 95% CI: 0.00, 1.19). Blood pressure increased between examinations (for individuals in neighborhoods without foreclosures at examination 4 and no annual change in foreclosure activity, mean 5-year change = 1.58, 95% CI: 0.70, 2.46), but temporal changes were not strongly associated with foreclosure exposure (e.g., for a standard-deviation increase in foreclosure activity between examinations 4 and 5, mean difference in 5-year change in blood pressure = −0.48, 95% CI: −1.14, 0.18). For fasting glucose, examination 4 foreclosure counts were associated with slightly lower glucose levels in fully adjust models (mean difference per standard-deviation increase = −0.40, 95% CI: −1.13, 0.34). The mean glucose level decreased modestly over time (mean 5-year change for individuals in neighborhoods without foreclosures at examination 4 and no annual change in foreclosure = −0.98, 95% CI: −2.14, 0.17), but this trend was modified such that greater annual change in foreclosure activity was associated with temporal increases in fasting glucose (per standard-deviation increase in annual foreclosure count, mean difference in 5-year change = 1.23, 95% CI: 0.36, 2.10).

Sensitivity analyses utilizing a 1-mile buffer for neighborhood foreclosure produced similar results to the quarter-mile buffer in both fixed-effects and linear mixed models (Web Tables 1 and 2). Analyses using ad hoc imputation of blood pressure and glucose values for those on medication produced results that were largely consistent with those shown in Tables 2 and 3, as did models restricted to individuals not taking medication (Web Tables 3 and 4). Results using the ad hoc imputation method for systolic blood pressure were also consistent with those using multiply imputed blood pressure (data not shown). In models stratified by homeownership status, the observed associations were strongest for renters and homeowners with mortgages and weaker or null for individuals who owned their homes "free and clear" (Web Table 5). Finally, the observed associations were moderately strengthened when using 2- and 3-year windows for foreclosure exposure before examination 5 rather than a 1-year window (Web Table 6).

DISCUSSION

In the present longitudinal, geographically diverse sample, greater exposure to proximate foreclosure activity had minimal associations with cardiometabolic risk factors over a 5-year period. Using within-person fixed-effects models, increases in neighborhood foreclosures were associated with small increases in fasting glucose levels. However, contrary to our hypothesis, increases in foreclosure were also associated with small decreases in systolic blood pressure and were unassociated with changes in BMI. These results indicate that the short-term cardiometabolic health implications of neighborhood foreclosures may be more complicated than hypothesized or may be inadequately captured by our measures. They may also indicate that neighborhood foreclosures have relatively few short-term cardiometabolic consequences.

The inverse association between foreclosure and blood pressure, although small in magnitude, is especially puzzling. It does not appear to be driven by the initiation of antihypertensive medications. Selective loss to follow-up could be an explanation if individuals who lived in neighborhoods with

Table 3. Mean Differences in Cardiometabolic Risk Factors Associated With Foreclosure at Examination 4 and With Changes in Foreclosure Between Examinations 4 and 5 From Linear Mixed Models, Multi-Ethnic Study of Atherosclerosis, 2005–2012[a]

Cardiometabolic Factor and Exposures of Interest	Model 1[b]		Model 2[c]		Model 3[d]	
	Mean Difference	95% CI	Mean Difference	95% CI	Mean Difference	95% CI
BMI[e]						
Examination 4 foreclosure count	−0.17	−0.34, −0.01	−0.31	−0.47, −0.16	−0.27	−0.43, −0.11
Time, 5-year change	−0.02	−0.11, 0.06	−0.04	−0.12, 0.05	−0.05	−0.14, 0.04
Examination 4 foreclosure count × time[f]	−0.02	−0.09, 0.05	0.00	−0.07, 0.07	−0.01	−0.07, 0.06
Annual change in foreclosure count × time[g]	0.03	−0.04, 0.09	0.00	−0.07, 0.07	0.00	−0.06, 0.07
Systolic blood pressure, mm Hg						
Examination 4 foreclosure count	0.99	0.40, 1.59	0.45	−0.13, 1.04	0.59	0.00, 1.19
Time, 5-year change	1.33	0.49, 2.17	1.58	0.72, 2.45	1.58	0.70, 2.46
Examination 4 foreclosure count × time[f]	−0.37	−1.03, 0.29	−0.30	−0.96, 0.36	−0.30	−0.97, 0.36
Annual change in foreclosure count × time[g]	−0.42	−1.08, 0.24	−0.48	−1.14, 0.18	−0.48	−1.14, 0.18
Fasting plasma glucose, mg/dL						
Examination 4 foreclosure count	−0.67	−1.39, 0.05	−0.54	−1.26, 0.18	−0.40	−1.13, 0.34
Time, 5-year change	−1.12	−2.22, −0.02	−1.13	−2.28, 0.01	−0.99	−2.14, 0.17
Examination 4 foreclosure count × time[f]	0.25	−0.62, 1.12	0.47	−0.41, 1.35	0.49	−0.39, 1.37
Annual change in foreclosure count × time[g]	1.37	0.51, 2.23	1.26	0.39, 2.13	1.23	0.36, 2.10

Abbreviations: BMI, body mass index; CI, confidence interval.

[a] The sample size for linear mixed models was 4,406 because individuals were not required to have foreclosure data for a full year before examination 4, as in the fixed-effects analyses. Mean differences were calculated for a standard-deviation change in each foreclosure exposure (examination 4 foreclosure count: 2.2 foreclosures; annual change in foreclosure count: 1.3 foreclosures).

[b] Minimally adjusted linear mixed model including time-varying medication use (for blood pressure and fasting glucose), time (scaled for a 5-year change and corresponding to those with 0 foreclosure activity at examination 4 and no annual change in foreclosure activity), foreclosure count at examination 4, mean annual change in foreclosure count between examination 4 and 5, and interactions between foreclosure count at examination 4 and mean annual change in foreclosure count with time. All models include a random person-level intercept.

[c] Adjusted for the variables in model 1; time-invariant age at examination 4, sex, race, and education; interactions of age, sex, and race with time; and time-varying income, working status, and moving status.

[d] Adjusted for the variables in model 2, time-varying percent poverty, percent unemployment at the census-tract level, population density, and state foreclosure law.

[e] Weight (kg)/height (m)^2.

[f] Examination 4 foreclosure count × time interaction indicates the mean difference in 5-year change in the outcome per each standard-deviation increase in foreclosure count at examination 4.

[g] Annual change in foreclosure count × time interaction indicates the mean difference in 5-year change in the outcome per each standard-deviation increase in annual change in foreclosure count between examinations 4 and 5.

more foreclosures and who had greater increases in blood pressure were also more likely to drop out, although we found little evidence of this in additional analyses. It is also possible that foreclosures do not have purely detrimental effects and that neighborhoods with a high degree of resiliency and collective efficacy may actually rally in response to the threat of foreclosures (26, 27). Whether such a response could improve health is unknown, and research exploring the heterogeneity of foreclosure effects by neighborhood characteristics might help clarify these relationships.

Our results were robust to different modeling approaches and specifications. Results from linear mixed models largely confirmed the conclusions from the fixed-effects models. For fasting glucose in particular, we found that temporal trends were significantly modified by increases in foreclosure activity, such that higher annual rates of foreclosure activity were associated with an increase in fasting glucose over time. Results from the sensitivity analyses in which we used imputed outcomes for persons on medication and included only participants not on medication at either examination suggest that associations were not masked by medication use. The results also do not appear to be driven by individual experiences of foreclosure because the associations were also apparent in renters. Using a 1-mile spatial buffer to define neighborhood foreclosures produced similar results. This could imply that associations with health may extend beyond the immediate surroundings, or it could result from high spatial correlation of foreclosures (in our data, the correlation between quarter-mile buffer and a 1-mile buffer foreclosure measures were >0.7).

Using data from the Framingham Offspring Study linked to foreclosure data from the 1980s through the mid-2000s, Arcaya et al. (6, 7) found that area-level foreclosure rates were associated with increased BMI and systolic blood pressure over time. Similarly, using zip code–level foreclosure counts matched to hospital discharge data, Currie and Tekin (8) found that higher foreclosure counts were associated with increases in the number of medical visits for hypertension, heart attacks, and strokes. Our results do not match those of previous studies, because we found no relationship of area-level foreclosure rates with BMI change and a small inverse relationship with systolic blood pressure. The reason for these differences could include alternative measures of foreclosure, different statistical methods (e.g., residual confounding in previous studies that did not use fixed-effects models), the short-term nature of our study, or true variation in the relationship between foreclosure and cardiometabolic outcomes in different locations. It is also possible that the stigma associated with foreclosure changes over time, particularly when foreclosure becomes ubiquitous, as in the housing crisis. Therefore, neighborhood foreclosures could elicit different responses and behaviors from residents over time.

To our knowledge, there has been no previous study in which investigators evaluated the relationship between neighborhood foreclosure and fasting glucose level. As a risk factor for cardiovascular events that changes over short periods of time because of behavioral changes and stress, fasting glucose is a plausible outcome to track when examining the possible health implications of neighborhood foreclosures. Our finding that an increase in neighborhood foreclosures between examinations was associated with increases in fasting glucose levels is in line with our hypothesis that foreclosures may alter neighborhood characteristics in ways that decrease physical activity and increase stress, although the small magnitude of the association is of questionable importance. Foreclosure activity has been linked to increases in property and violent crime both on the immediate neighborhood block and in the surrounding area (17, 28, 29), which may deter physical activity (30, 31) and increase stress levels (32), thereby increasing blood glucose (33, 34). Foreclosures can also decrease property values and erode neighborhood social networks, which could similarly alter behaviors and stress levels (12, 16). Why such dynamics would increase blood glucose levels but decrease blood pressure in our sample is not clear, although further research into the mechanisms linking neighborhood foreclosures and health outcomes may help clarify such findings.

Our study has several strengths. We utilized a geographically distributed sample with foreclosures directly linked to residential addresses at multiple spatial scales. Doing so allowed us to explore possible associations between foreclosure activity and health outcomes across a greater spectrum of neighborhoods and spatial scales than prior studies (6–8). The timing of the 2 study waves serendipitously incorporated the period during which the foreclosure crisis began and peaked, providing temporal variability that strengthens our ability to detect relationships with foreclosure exposure. Finally, we used fixed-effects models that tightly control for time-invariant confounders and included sensitivity analyses to test the robustness of our results.

Our study also has limitations. First, we had no data on individual foreclosure experiences. We were therefore unable to evaluate the association between individual foreclosures and participant cardiometabolic health or to control for such exposures in our analyses. Second, we utilized a single definition of foreclosure that may have failed to capture all aspects of the foreclosure process that have been shown to be important in other studies (10, 11). Third, we lacked data to look at changes in health behaviors like physical activity or diet that may drive the temporal changes in cardiometabolic profiles. Finally, because of the absence of comparable data across study sites before 2005, we were unable to evaluate the longer-term associations between foreclosures and cardiometabolic risk factors, which may not change rapidly.

The foreclosure crisis has resulted in the loss of over 6 million homes (35). Although our results do not point to clear short-term health consequences of neighborhood foreclosure, we note that the most profound social and health effects of the foreclosure crisis are likely to be felt far in the future. Home equity forms the bulk of low- and moderate-income homeowners' family wealth (36). Foreclosure thus represents not only a loss of immediate wealth, but also a loss of inheritance for future generations, with ramifications for wealth accumulation and social mobility (37, 38). With millions of mortgages still in the "foreclosure pipeline," further research clarifying the potential health effects of neighborhood foreclosures, as well as the policies that have been implemented to prevent them, could help guide decisions on how best to stabilize communities to maintain health now and mitigate future harms.

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