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Foreclosures and weight gain: Differential associations by longer neighborhood exposure

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ABSTRACT

While home foreclosure can lead to mental and physical health declines in persons experiencing the foreclosure, whether neighborhood foreclosures can affect the health of other residents is debatable. Using a racially/ethnically diverse sample of Chicago metropolitan area residents linked to foreclosure data from 2008 to 2014, we assessed whether exposure to neighborhood foreclosure fillings was associated with changes in objectively measured body mass index (BMI) over time. Using a retrospective longitudinal design, we employed fixed-effects regression models that controlled for individual- and neighborhood-level covariates to test the association of neighborhood foreclosures and BMI in > 60,000 individuals and for individuals who did not move during the follow-up period. We also adjusted for the non-linear association of age and BMI and comorbidities and employed a series of sensitivity analysis to test for robustness. In fully adjusted models, a standard-deviation increase in neighborhood foreclosure filings within 500 m was associated with increases in BMI for individuals who did not move (nonmovers) (mean = 0.03 BMI units, 95% confidence interval: 0.01, 0.06). Neighborhood foreclosure rates were not associated with changes in BMI for the full sample. Given the potential deleterious effects of neighborhood foreclosure on individuals with longer exposure to the local vicinity, clarifying the potential health effects of neighborhood foreclosures would help policymakers when planning actions to prevent home losses, predatory home loans, and that aim to more efficiently return foreclosure properties to productive uses.

1. Introduction

The role of home foreclosures in health outcomes, including obesity, has only recently been explored as a potential social determinant of health (Arcaya et al., 2014; Arcaya et al., 2013; Pollack et al., 2011; Pollack and Lynch, 2009; Houle and Keene, 2015; Houle and Light, 2014; Houle, 1982; Currie and Tekin, 2015; Downing, 1982). During the last economic recession in the United States (2007–2012), 12.5 million homes were involved in foreclosure (Center for Responsible Lending, 2013). Similar problems are seen in other countries, such as Spain, where thousands of families were evicted from their homes (Vasquez-Vera et al., 2016). Evidence on the spillover effects of nearby foreclosures on weight gain, specifically, is limited and provides mixed results (Arcaya et al., 2013; Christine et al., 2017; Downing et al., 2016).

Living in neighborhoods distressed by higher rates of foreclosure may contribute to weight gain by reducing neighborhood-based physical activity and stress, two well-established risk factors for obesity (Chang et al., 2009; World Health Organization (WHO), 2004). First, neighborhood foreclosures may reduce neighborhood-based physical activity by increasing neighborhood deterioration and crime. Foreclosed residential units often sit vacant for extended periods and high neighborhood foreclosure rates can result in a lower neighborhood tax base, reducing local resources devoted to neighborhood upkeep. Ensuing unappealing aesthetics (e.g., poorly maintained buildings and lawns, litter) (Cui and Walsh, 2014; Payton et al., 2015; Arnio et al., 2012) may deter residents from engaging in physical activity in their neighborhoods (Evenson et al., 2012). Neighborhood deterioration also

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contributes to fear and perceived risk of crime (Perkins and Taylor, 1996). Second, neighborhood foreclosures can lead to declines in nearby property values, resident displacement, higher residential turnover, and deterioration, which may increase stress and repeated activation of response to stress among residents (Immerglucka and Smith, 2009; Kuo et al., 2008). Chronic exposure to stress can lead to physiological consequences that promote fat accumulation (Sinha and Jastreboff, 2013; Born et al., 2005). In addition, while some people eat less in response to stress, it can also lead to increased consumption of energy-dense food (Sinha and Jastreboff, 2013; Born et al., 2005; Tryon et al., 2013; Mozaffarian et al., 2011).

Moreover, effects of distressed neighborhoods on health can undoubtedly accumulate with long-term residence (Diez Roux and Mair, 2010). The relationship of collective measures with neighborhood ties are well established (Taylor, 1996; Keene et al., 2013). However, characteristics of community residents such as their length of residence and home ownership also contribute with building those ties (Keene et al., 2013).

We, therefore, examined the longitudinal associations between neighborhood foreclosure filings and weight gain, measured using body mass index (BMI), in a racially/ethnically diverse sample of individuals living in a large metropolitan area and who were served by a large integrated healthcare delivery system. We hypothesized that living in a neighborhood with greater exposure to foreclosed properties would lead to higher BMI change, and that such associations would be stronger among those with longer exposure to their neighborhood.

2. Methods

2.1. Design

The study employed a 6-year retrospective longitudinal cohort design linking electronic health record data to foreclosure fillings.

2.2. Setting

We studied individuals living in 6 counties in the Chicago metropolitan area between 2009 and 2014. The annual county-level rate of foreclosures in this region reached its peak in 2010 (3.1 foreclosures filings/100 residential parcels), and had the lowest rate (1.1 foreclosures filings/100 residential parcel) in 2014.

2.3. Sample

This study drew on data of the Weight and Veterans' Environments Study (WAVES) (Zenk et al., 2018). The sample comprised individuals receiving primary health care in a Veterans Health Administration (VA) facility and therefore enjoyed healthcare access through a federal government system. The VA is the largest integrated health care system in the United States, providing care at 1245 health care facilities (170 VA Medical Centers and 1065 outpatient clinics), serving > 9 million individuals each year (Veterans Health Administration, 2017). Once enrolled for VA care, individuals generally remain enrolled over their lifetime. Sample inclusion criteria were aged 20–80 years at baseline, residence in six counties in metropolitan Chicago (Cook, DuPage, Kane, Lake, McHenry, and Will) between 2009 and 2014, at least one height and two weight measurements during the study period, and at least one VA healthcare encounter in the two years prior to baseline year (2009 or first year in which the individual met study eligibility criteria). Residence in the 6-county area was determined by individuals' geocoded addresses. Exclusion criteria included long-stay nursing home residence at baseline (0.11% of the nationwide sample of VA users from which our sample was drawn), and no home address, PO Box address, or address that was non-geocodable to the street or ZIP + 4 level. In addition, 5% of individuals had implausible BMI values ($< 15.0\,kg/m^2$ or $> 75.0\,kg/m^2$) and were excluded from the analysis.

2.4. Outcome

BMI was measured based on height and weight assessed during healthcare encounters and obtained from the VA Corporate Data Warehouse, a repository of clinical and administrative data from the electronic health record and other sources. We used the most frequent height value measured in all available study years to calculate BMI. For each year (2009–2014), we averaged individuals' weight values obtained during encounters in the second half of the calendar year (July–December). If no weight measurements were available for that timeframe, we took the average weight value for the first half of the calendar year. We prioritized the second half of the calendar year (July–December) because of the timing of home address information updates (September 30 of each year).

2.5. Exposure

We used data on all address-level foreclosure filings in the six-county region from July 2007 to June 2014. Foreclosure filings data, including geographic coordinates of properties, were provided by the Institute for Housing Studies (IHS) at DePaul University and were collected from County Circuit Courts and County Assessor's Offices by Property Insight and Record Information Services. We opted for foreclosure filings to capture the overall distressed housing market, and each deed's filing was used to construct time-varying measures of exposure to neighborhood foreclosure activity. Because a property can have multiple filings for the same foreclosure event, properties with multiple filings within a year were counted once. We constructed four individual exposure variables: number of foreclosure filings within 100, 200, 500, or 1000 m of individual's home location in the 12 months preceding the BMI measurement. For instance, 2009 mean BMI measures were examined in relation to foreclosures filed between July 2008 and June 2009. We selected different distances based on previous studies (Arcaya et al., 2013).

2.6. Covariates

Individual-level covariates included time-constant gender, age at baseline and race/ethnicity, and time-varying marital status and comorbidities that, based on previous studies (Downing, 1982; United States Census Bureau, 2011), would potentially confound the association of neighborhood foreclosure filings and BMI. VA Corporate Data Warehouse provided those data.

Neighborhood-level covariates included census tract socioeconomic characteristics (median household income and percent home ownership) and population density (number of residents). Data were based on 5-year estimates of the American Community Survey (ACS) (United States Census Bureau, 2011). Given the delay in annual releases of 5-year ACS estimates, a 2-year lag based on the ACS 5-year midpoint for linking patient measures to ACS measures was used (e.g., 2009 patient BMI linked to 2005–2009 ACS data, midpoint 2007; 2014 patient BMI linked to 2010–2014 ACS data).

3. Statistical analysis

In the first set of analyses we described individual- and neighborhood-level covariates of the full sample living in the study area and the group of individuals who lived in the same location during the 6 years of follow up. We also described trends in foreclosure filings in the Chicago metropolitan area between 2009 and 2014 using foreclosure rates per 100 residential parcel (calculated as an absolute number of foreclosures in the area per 100 residential parcel) and foreclosure filings around participants' homes.

We then employed regression models with time- and person-fixed effects with annual BMI measures nested within individuals. We accounted for the clustering of individuals in census tracts of residence at

baseline. Models included individual-level covariates (marital status and comorbidities) and neighborhood-level covariates (household income, percent home ownership, and population density). Neighborhood unemployment rates were highly collinear with neighborhood household income and therefore dropped out of the model after VIF testing. We controlled for year trends, included an interaction term between age at baseline and time since baseline to adjust for the non-linear association of age and BMI, and an interaction term between race and year to control for potential time-varying race effects. The F-tests showed the superiority of fixed-effect models as compared with ordinary least square models.

A type of attrition occurred because a third of the sample moved at least once during the study period. If an individual's reason for moving was related to health status and exposure to foreclosures, our estimates might be biased. After finding that an interaction term between moving status and obesity in the fully adjusted models for those who moved was statistically significant, we re-estimated our models with those who did not move in the 6 years of the study (71% of the total sample). We determined an individual to have moved if his or her home location was > 400 m from the home location of the previous year.

Because neighborhood foreclosures may have impacted low-income areas and areas with greater proportion of racial/ethnic minorities (who have been disproportionally affected by the housing crisis (Downing et al., 2017)), we included interaction terms between exposure to foreclosures and neighborhood-level median income and individual-level race. We also tested whether health conditions potentially related to both neighborhood foreclosures and BMI (hypertension, substance use disorder, and depression) would change the results by first estimating the foreclosure-BMI relationship without accounting for these health conditions and then re-estimating it controlling for them.

4. Sensitivity analysis

We conducted a series of sensitivity analyses to examine the consistency of our results. First, we ran 3-level linear mixed-effect models with annual BMI measures (level 1), nested within individuals (level 2) and census tracts (level 3) adjusting for the same set of individual- and neighborhood-level covariates used in the fixed effect models. Fixed-effect models had, however, a better fit than mixed-models which were compared with Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) estimators.

We then tested whether the foreclosure-BMI exposure relationship varied across census tracts. We thus included a random slope for each census tract. We did not find any difference in the results and thus report results for models without the random slope for each census tract.

Because not all individuals have clinical measurements for all years, we were concerned that our models might be biased if an unobserved factor that caused an individual to skip an outpatient visit was correlated with their exposure to foreclosures. We therefore re-estimated our models including only individuals with BMI measurements in all follow-up years to investigate whether missing data would bias our results (complete cases analysis).

Since we had no prior knowledge about the appropriate lag period, we also employed a two-year lag specification previously tested in similar studies (Arcaya et al., 2013; Leonard et al., 2017). We hypothesized that the foreclosure–BMI relationship would be weakened in larger time windows (2 years).

Finally, we ran stratified fixed-effect models by quartiles of changes in neighborhood foreclosure rates expressed as the difference between neighborhood foreclosures at baseline and in the last year of follow-up period as well as by yearly within-person variation in neighborhood foreclosures in order to test whether our associations would hold among those with a larger change in the exposure to neighborhood foreclosures.

Statistical analyses were performed using Stata 14.1.

Table 1
Baseline sample characteristics, six counties in Chicago Metropolitan Area, 2009.

	All participants		Non-movers	
	n	%	n	%
Male	43,465	95.31	30,858	96.55
Age (years)				
20–29	1429	3.20	466	1.49
30–39	1659	3.71	673	2.16
40–49	3433	7.68	1692	5.42
50–59	8226	18.41	4716	15.12
60–69	15,479	34.65	11,570	37.09
70–80	14,450	32.34	12,077	38.72
Race/ethnicity				
Non-Hispanic white	25,083	59.31	18,613	63.87
Non-Hispanic black	15,014	35.50	9163	31.44
Hispanic	1533	3.62	916	3.14
Other	660	1.56	450	1.54
Marital status				
Married	21,903	48.26	17,484	54.91
Separated/divorced	10,643	23.45	6498	20.41
Widowed	2434	5.36	1796	5.64
Single	10,410	22.93	6062	19.04
BMI (kg/m^2) (mean;95%CI)	29.70 (29.64,29.75)		29.71 (29.65,29.78)	
Obesity (BMI ≥ 30 kg/m^2)	19,176	42.05	13,483	42.18
Substance use disorder	3705	8.12	1925	6.02
Hypertension	27,226	59.70	20,324	63.59
Depression	6249	13.70	3682	11.52
Median annual household income (median;IQR)	57,150 (43,365;74,375)		59,080 (45,217;76,475)	
Population density (in 1000 residents) (median;IQR)	5.02 (2.35;11.07)		4.81 (2.17;10.47)	
Percent of home owners (median;IQR)	74.39 (55.27;87.46)		76.49 (57.76;88.48)	

Abbreviations: CI, confidence interval, IQR, interquartile range.
Values are n (%) unless indicated otherwise.

5. Results

Across the observation period, 59,854 unique individuals met study inclusion. Table 1 shows characteristics in the baseline year (2009) for the entire sample of individuals and for non-movers, which comprised 71% of the sample. Most subjects were male (95.3%), 60 years or older (67.0%), non-Hispanic white (59.3%), and married (48.3%). Non-Hispanic black were 35.5%. Those participants who did not move during the follow-up period were in general slightly older, more likely to be non-Hispanic white and married, and less likely to have a diagnosis of substance use disorder and depression. Non-movers also lived in neighborhoods with higher median household income, lower population density, and higher proportion of home ownership as compared with neighborhoods where movers lived. Mean BMI went from 29.7 kg/m^2 in 2009 to 29.5 kg/m^2 in 2014.

Exposure to neighborhood foreclosures was highest in 2010 reflecting the nationwide foreclosure crisis (Table 2). In the July 2008–June 2009 period, the mean number of foreclosures were 1.14 within 100 m of a participant's home, 21.60 m within 500 m of a participant's home, and 75.53 m within the 1-km buffer. The within-person standard deviations were 1.85 for the 100-m buffer, 21.14 for the 500-m buffer, and 69.75 for the 1-km buffer.

In adjusted analyses, foreclosure activity within 100 or 200 m of individuals' home locations was not associated with BMI (not shown). Since results for models using foreclosures within 500 and 1000 m of individuals' home locations produced similar results, we present results for the 500-m buffer only. Results for the entire sample and non-movers are shown in Table 3. We did not find an association of neighborhood

Table 2
Foreclosure filing activity during follow-up period, six counties in Chicago Metropolitan Area, 2009–2014.

	2009	2010	2011	2012	2013	2014
Foreclosure filings per 100 residential parcel	2.80	3.10	2.50	2.60	1.60	1.10
Foreclosure filings within 500 m of individuals' home location, mean (SD)	21.60 (21.14)	27.97 (25.22)	24.43 (21.00)	22.65 (18.78)	18.30 (15.06)	10.78 (8.93)

Abbreviation: SD, standard deviation.

Table 3
Associations of neighborhood foreclosures within 500 m of participants' home and body mass index, Chicago Metropolitan Area, 2009–2014.

Models	Number of observations	Number of individuals	Coefficient	95% CI	
1: All participants[a,c]	202,194	52,323	−0.002	−0.021,	0.018
2: Non-movers[b,d]	142,131	34,531	0.034	0.006,	0.061
3: All participants[a,e]	202,194	52,323	−0.002	−0.021,	0.017
4: Non-movers[b,f]	142,131	34,531	0.033	0.006,	0.061

Abbreviation: CI, Confidence Interval.
[a]All participants living in the Chicago metropolitan area.
[b]Only participants who did not move to a new address in the 6-year follow-up.
[c,d]Model 1 and 2 include a term for time; an interaction term between age at baseline and time; and are adjusted for marital status + interaction term of race and year + neighborhood-level variables (median household income, percent of home owners, and population density) + yearly counts of foreclosure filing activity at the county level.
[e,f]Models 3 and 4 include all covariates in models 1 and 2 + comorbidities (hypertension, depression, substance use disorder).

foreclosure filings and BMI for the entire sample. For non-movers, however, we found that for each additional foreclosure filing standard deviation (SD) (20 filings), BMI was on average 0.03 units higher over time (95% confidence interval – 95%CI 0.01, 0.06) (Table 3; Model 2). This represents a 0.19-pound (0.09-kg) weight gain for an individual whose height is 5 ft 7 in. (170 cm). Our results were consistent when models were controlled for related health conditions (Table 3; Model 4). Models without interaction terms between race and year trends and as well as without interaction terms between year trends and age produced similar results. We did not find effect modification by neighborhood median household income or individual-level race/ethnicity, and models using the 2-year lagged variables led to similar though weaker or non-significant associations (not shown).

Sensitivity analyses using mixed-effect models (Table 4; Models 1–2) produced similar results. The complete cases analysis also produced similar results (Table 4; Models 3–4). When we ran stratified models by quartiles of change in the neighborhood foreclosure rates – expressed by the difference between the last year of follow-up and the baseline year of each participant as well as by yearly changes in neighborhood foreclosure – and found results in the same direction among non-movers in the top quartile of neighborhood foreclosure change with both approaches but with wider confidence intervals, thus not statistically significant (0.042; 95%CI −0.001, 0.084; 0.034 −0.006, 0.074, respectively).

6. Discussion

Using electronic health records of almost 60,000 individuals living in the Chicago metropolitan area between 2009 and 2014, we found no evidence of an association between neighborhood foreclosures in the prior year and BMI for the full sample. However, when we limited the sample to those who lived in the same location for the entire observed period (6 years), we found that more foreclosures were associated with BMI increase. These findings were consistent when we addressed potential confounding effects such as comorbidities and remained robust when we employed different analytical approaches (fixed- and mixed-effects models).

Previous studies that explored the association of neighborhood foreclosure and BMI found either a positive (Arcaya et al., 2013) or a null association (Christine et al., 2017; Downing et al., 2016). However, they all differed in terms of period (before or after the mortgage crisis), follow-up length, characteristics of the study population and how foreclosure filings were measured. Although our sample included a large proportion of racial minorities (35–40%), our group of non-movers was disproportionately white and living in comparatively higher income areas. In fact, a sample of non-movers from Dallas were also older, more likely to be white males, had more education, and higher income than participants that had moved to a new address. (Leonard et al., 2017) Racial/ethnic minorities generally experienced a disproportionate impact from housing crisis (Downing et al., 2017), however they were also more likely to have been living in distressed neighborhoods prior to the crisis as previous work that used national data from 2005 to 2009 has shown. (Hall et al., 2015) Residents in those distressed neighborhoods were probably less likely to perceive the incremental increase in neighborhood decay resulting from foreclosures. This raises the question of whether our non-movers group were more sensitive to foreclosure exposure and whether it was the heightened sensitivity rather than longer tenure itself. However, previous differential findings between movers and non-movers strengthen our findings regarding longer exposure to the neighborhood (Leonard et al., 2017). Additional studies in racially/ethnically and socioeconomically diverse areas, however, are needed to confirm our findings.

Previous studies that investigated the longitudinal associations of neighborhood foreclosures on weight (Downing et al., 2016) or HbA1c levels (Leonard et al., 2017) in an insured population living in the San Francisco Bay Area did not find significant associations between these measures and neighborhood foreclosure. A greater number of foreclosures in the Chicago Metropolitan Area as compared with the San Francisco Bay Area, (Downing et al., 2016; Leonard et al., 2017) as well

Table 4
Associations of neighborhood foreclosures within 500 m of participants' home and body mass index using mixed models and complete cases analysis, Chicago Metropolitan Area, 2009–2014.

Model	Number of observations	Number of individuals	Coefficient	95% CI	
1: All participants[a,c]	202,194	52,323	0.019	−0.004	0.041
2: Non-movers[b,d]	142,131	34,531	0.032	0.005	0.060
3: All participants[a,e]	125,967	23,039	−0.002	−0.030	0.022
4: Non-movers[b,f]	97,702	17,868	0.038	0.005	0.072

Abbreviation: CI, Confidence Interval.
[a]All participants living in the Chicago Metropolitan Area.
[b]Only participants who did not move to a new address in the 6-year follow-up.
[c,d]Models 1 and 2 have a mixed models' specification; include a term for time; and are adjusted for age at baseline, sex, marital status, race, comorbidities (depression, hypertension, substance use disorder), median household income, population density, percent of home owners, and yearly counts of foreclosure filing activity at the county level.
[e,f]Models 3 and 4 use complete cases using a fixed-effect model specification; include a term for time; an interaction term between age at baseline and time; and are adjusted for marital status + interaction term of race and year + neighborhood-level variables (median household income, percent of home owners, and population density) + yearly counts of foreclosure filing activity at the county level + comorbidities (hypertension, depression, substance use disorder).

as different time periods and follow-up lengths may have driven the differential findings.

The use of fixed-effects models allowed us to investigate whether a within-person change in the neighborhood foreclosure filings was related to a within-person change in BMI while tightly adjusting for the time-invariant person characteristics that could confound associations of neighborhood foreclosures and BMI. Fixed-effects models, however, rely on within-person variability and can be inefficient when within-person variability in exposures or outcomes is very low. Peaking in 2010, foreclosure rates dropped to almost a third four years later; mean BMI, however, remained the same during the observed period (BMI varied from 29.7 to 29.5 kg/m^2 between 2009 and 2014). Although statistical tests pointed to a preferred use of fixed effect models, to rule out possible problems with low within-person variability, we ran sensitivity analysis using mixed models – which are less constrained by small variability in BMI overtime – and found similar results.

The strengths of our findings include a large racial/ethnically diverse sample with uniform access to an integrated health-care delivery system – a potential confounder that deserves to be further explored considering the possible buffering effect integrated health-care delivery systems can have on patients under socioeconomic stressors (Institute for Housing Studies, 2017)– and the availability of objectively measured data captured from electronic health records that we were able to precisely link to neighborhood-level data. Also, our foreclosure measures were more accurately specified than previous studies that used standardized national data sources of foreclosure activity (Christine et al., 2017).

The timing of our study incorporated the period during which the foreclosure crisis peaked and then began to drop, providing temporal variability that improves our ability to detect relationships with foreclosure exposure. We tested the robustness of our results using different modelling approaches.

Our study has, however, several limitations. We were unable to measure individual-level foreclosure experience, job status, and income; thus, unmeasured residual confounding might persist. By adjusting for neighborhood-level median household income, we believe we captured some of the variance due to individual-level income and job status.

Secondly, because patient geocodes were not available until 2009, we were not able to study years when foreclosure rates were beginning to rise among some of the most affected communities in metropolitan Chicago (Institute for Housing Studies, 2017). If the impact of foreclosure exposure on BMI was greatest – particularly among more socially vulnerable groups – when foreclosures begin to rise, we may have been able to detect a stronger association if an earlier period was included in the study (2006–2008). However, we include a later period in the foreclosures and financial crises – when middle-income neighborhoods were also hit (Zenk et al., 2017) – as well as the recovery period (Arcaya et al., 2014; Zenk et al., 2017).

Thirdly, we could not exclude pregnant women and participants with advanced cancer diagnosis from our sample due to inaccurate data on pregnancy status and on the stage of cancer. Still, by excluding all participants with any diagnosis of cancer (approximately 13% of the sample) we could have reduced the generalizability of the sample. We were however able to control our models by three conditions (substance use disorder, depression and hypertension) that are knowingly associated with weight change at baseline or that were diagnosed throughout the follow-up period. We did not have information on other conditions that may associated with weight change at baseline.

Moreover, we used information on weight and height available on the VA Corporate Data Warehouse. Thus, we were not able to control for potential mismeasurement during health encounters. Also, by deciding to use a yearly averaged value of weight, we may have smoothed out our associations if important weight change occurred within one year.

This study sample is also not representative of the United States population. Our study population has disproportionately more African Americans and low-income individuals (Baker et al., 2014), both groups at higher risk for obesity (Diez Roux and Mair, 2010), than the general US population. Also, men who are served by the VA healthcare system are older and demographically different than women (Zenk et al., 2017), who comprise 5% of the sample. Our findings are thus not generalizable to women and young adults. However, although men enjoy more opportunities and privileges than women, these advantages do not translate into better health outcomes. They are less likely to seek preventive healthcare than women and engage in less desirable behaviors (Baker et al., 2014). Therefore, by including a large and racially/ethnically diverse sample of men with access to an integrated healthcare service delivery we contribute to the literature on men's health.

Finally, foreclosure filings are the initial legal process of selling a mortgaged property that is in default. Real-estate owned foreclosures refer to a class of property owned by a lender after an unsuccessful sale at a foreclosure auction (Roark, 2006). We did not distinguish foreclosure filings and real-estate owned foreclosures, which limits the comparability of our results with previous studies (Arcaya et al., 2013). By utilizing a broader definition of foreclosure fillings, we may have missed specificity but potentially captured more aspects of the foreclosure process that have been shown to be important in other studies (Houle and Light, 2014; Houle, 1982; Currie and Tekin, 2015; Downing, 1982; Center for Responsible Lending, 2013; Vasquez-Vera et al., 2016; Christine et al., 2017; Downing et al., 2016; Chang et al., 2009; World Health Organization (WHO), 2004; Cui and Walsh, 2014; Payton et al., 2015; Arnio et al., 2012; Evenson et al., 2012; Perkins and Taylor, 1996; Immerglucka and Smith, 2009; Kuo et al., 2008; Sinha and Jastreboff, 2013; Born et al., 2005; Tryon et al., 2013; Mozaffarian et al., 2011; Diez Roux and Mair, 2010; Park et al., 1925; Taylor, 1996; Keene et al., 2013; Zenk et al., 2018; Veterans Health Administration, 2017; Tsai, 2015; United States Census Bureau, 2011; Rugh and Massey, 2010; Downing et al., 2017; Leonard et al., 2017; Hall et al., 2015; Arcaya, 2017; Institute for Housing Studies, 2017; Zenk et al., 2017; Baker et al., 2014; Roark, 2006; Cagney et al., 2014).

Over 95 million households have lost home equity because of neighbors' foreclosures in the recent crisis in the United States (Center for Responsible Lending, 2013). Because foreclosure mitigation has largely focused on curbing financial and home losses to the individuals and families undergoing foreclosure, our results lend new evidence that mitigation efforts should extend to protecting public health. Although our results do not point to a clear relationship between foreclosure and BMI in the full sample, higher rates of neighborhood foreclosures were associated with higher BMI among non-movers. Thus, the health effects of the foreclosure crisis may be stronger with longer exposure to the problem. In fact, stronger effects of neighborhood characteristics on the health of long-term residents can be true for other neighborhood distressors (Leonard et al., 2017). Considering the potential mechanisms that link neighborhood conditions to individual-level health (housing conditions, walkability, safety, and social cohesion), it is plausible to believe that the effects would differ by the length of exposure to the neighborhood (Leonard et al., 2017). This research also adds to the literature on the direct and indirect costs of foreclosure. Previous research has shown that neighborhood foreclosures are associated with greater neighborhood degradation, increased crime, and declines in property values (Payton et al., 2015). For municipal governments, these impacts translate to documented costs ranging from demolition of foreclosed and blighted properties, to court fees, to loss of property values and the impact of declining values to the tax base. Taken together, the information provided by this study suggests that policymakers and those interested in housing issues should consider additional foreclosure-related costs stemming from obesity and obesity-related conditions.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

Ethics approval

This study was approved by both the University of Illinois at Chicago and the Edward Hines, Jr. VA Hospital Institutional Review Boards.

Contributors

ACD, SNZ, and ET conceptualized the study. ACD, SNZ, ET, JML, and MLB contributed with the study design. ACD analyzed the data and drafted the manuscript. SD and GS contributed with technical knowledge on the foreclosure data and process. All authors interpreted the data, revised the article critically for important intellectual content, and approved the final version of the submitted manuscript.

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