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Original Research

Mortgage possessions, spatial inequality, and obesity in large US metropolitan areas

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ABSTRACT

Objectives: As social determinants of health, mortgage possessions (primarily foreclosures in the US context) and housing instability have been associated with certain mental and physical health outcomes at the individual level. However, individual risks of foreclosure and of poor health are spatially patterned. The objective of this study is to examine the extent to which area-specific social and economic characteristics help explain the relationship between mortgage possessions and obesity prevalence in 75 of the 100 most populous US metropolitan areas.
Study design: This is a cross-sectional study.
Methods: The study relies on three sources of data: the Selected Metropolitan/Micropolitan Area Risk Trends (SMART) project, RealtyTrac foreclosure data, and the American Community Survey. Focal social and economic characteristics include foreclosure rates, levels of racial residential segregation, and poverty. Obesity prevalence and several control measures for each metropolitan area are also used. Ordinary least squares regression, weighted using the SMART project data, is used, and statistical significance is set at 0.05.
Results: The results suggest that mortgage possessions are independently associated with higher obesity prevalence and that foreclosures operate through the specific channel of racial residential segregation and its tie to the racial composition of a metropolitan area. Socio-economic status of an area, and not poverty, is related to foreclosures and obesity prevalence.
Conclusion: Mortgage possessions not only are socio-economic but also have negative health consequences, such as obesity. The findings provide an empirical base for other researchers to uncover the relationships between segregation, mortgage possessions, and obesity at the individual level of analysis. The public health community should be engaged in addressing the issue of foreclosures in the US because the failure to engage may have broad financial and health consequences across large cities.

Introduction

The 2007–2008 global financial crisis drastically altered the economic stability of families and households worldwide. As housing is an integral part of the economy because of its tie to wealth access and accrual, mortgage possessions (specifically called foreclosures in the US context) were both precursors to and endemic of the market crashes that found millions of individuals losing their jobs.[1] Although the process differs by country, the mortgage possession process generally involves a mortgage lender terminating a borrower's 'right of redemption' by legal means.[2] Although the prevalence of mortgage possessions and mortgage arrears (i.e. where individuals have missed mortgage payments -before foreclosure) varies by country,[3] most countries experienced an uptick in them in 2008,[4] with the US seeing the most dramatic increases.

Mortgage possessions (foreclosures) in the US are tied to social inequality, in that, it is the primary mechanism through which low-income and racial/ethnic minorities lose possession of their purchased home.[5] The global financial crisis was, in part, preceded by the surge in subprime mortgage lending, which disproportionately affected racial and ethnic minority groups in the US. In 2006, when subprime lending was at its peak, 53.7% of the black population

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received high-priced loans, compared with 46.6% of the Hispanic population and just 17.7% of the white population. In predominantly non-white neighborhoods, 46.6% received such loans, compared with 21.7% of borrowers in the majority-white areas. Furthermore, these gaps were not attributable to various credit and financial characteristics of borrowers.[6]

Foreclosures followed a similar pattern. Among borrowers who received mortgage loans between the years 2004 and 2008, 11% of blacks, 14% of Hispanics, and 6% of non-Hispanic whites lost their homes.[7] Although the recession may have officially ended in 2009, the consequences (financial and otherwise) continue to this day, along with organizing and advocacy efforts to address these issues.[8,9] In August 2019, 385,675 properties were in some stage of mortgage possession (e.g. default, auction, bank-owned).[10] These numbers are better than those in the year 2010, when foreclosures were the highest over several decades.[11]

International research and some US governmental initiatives (such as Healthy People 2020) have shown a relationship between housing stability and health outcomes, suggesting that mechanisms such as stress, substance use, and access to primary (i.e. non-emergency) care may help in explaining that relationship.[12–18] However, these studies have mostly focused on foreclosure as either an individual risk factor or a spatial control variable. When testing the relationship at the individual level, research has indicated that a sizable percentage of individuals who are experiencing mortgage repossessions also experience negative mental health outcomes such as depression and anxiety[19–23] and lower levels of self-reported physical health.[24] Measures related to weight status such as obesity,[25,26] neighborhood walkability,[27] and food insecurity[28] are also linked to an individual's experience with foreclosure. However, most research studies also highlight the issue of reverse causality, such that health problems may also lead to financial difficulty and housing insecurity.[29–33] In turn, some studies suggest that although mortgage possessions may not affect every home, residing in an area that is experiencing numerous foreclosures may have cascading effects. These studies find no statistical relationship between what is going on in one's neighborhood regarding foreclosure rates (or in some cases, home affordability) and one's body mass index (BMI).[34–36] Thus, there are methodological and substantive issues with research on mortgage possessions and health.[37]

Given their ties to economic stability and strain,[38] mortgage possessions could be classified as a social determinant of health. They are linked to socio-economic status, as illness and medical bills contribute to about 62% of bankruptcies,[39] and these effects are heightened in racial/ethnic minority populations.[40] Foreclosures change the landscape of the larger area context as blighted properties and decay of neighborhood structures are likely to appear as individuals leave their property through the foreclosure process.[41,42] Consistent with social science theories, this change in the urban landscape is associated with crime, disruptive social networks, and ineffective social support systems.[43,44] Thus, foreclosures happening at the local level can change the social and economic profile of the neighborhood and the features present in the built environment, which have been found to be related to hospital/emergency room visits at the state level,[45] cardiovascular disease prevalence,[46] low insurance coverage at the metropolitan level,[47] and bipolar and depressive disorders at the zip-code level.[48]

Prior work demonstrates that spatial dimensions inform the relationship between foreclosures and metabolic outcomes. However, one can link the social, economic, and physical consequences of both foreclosures and health through the lens of spatial inequality. Spatial inequality shapes the kind of healthy environment that one can live in, and in fact, the uneven development that occurs in metropolitan areas often results in an obesogenic environment, where a person's community can lead to obesity.[49] Moreover, researchers have found that racial residential segregation (i.e. the physical and systematic separation of racial/ethnic groups into different neighborhoods) and concentrated poverty (i.e. the spatial density of impoverished individuals in extremely poor neighborhoods) are mediating components in the relationship between foreclosures and health.[46,50] In certain areas, such as the state of California, researchers have found no relationship between foreclosure exposure and weight gain,[25,36] but, to date, no studies have explored the relationship between foreclosures and obesity from a national perspective.

This research frames the relationship between mortgage possessions and health in a similar fashion as other previously- published research on foreclosures and health—that is, through the lens of social inequality. As a social determinant to health, mortgage possessions disproportionately affect individuals in socio-economically disadvantaged urban areas, racial and ethnic minorities, and the middle/lower- middle classes, which are often characterized in the literature as economically 'fragile.'[51] Jones et al.[46] found that foreclosures are actually consequences of the level of economic inequality that exists across places. Foreclosures, health challenges, and an array of social problems have long been concentrated in US communities with high rates of poverty, low incomes, and large racial/ethnic minority populations. This research uses the lens of inequality to suggest that mortgage possessions occurring in the US are associated with structural, systemic, and spatial changes to low-income and majority-minority communities. Such changes could include 'reverse redlining' (where communities have been inundated with predatory loan products that lead to repossessions), the emergence of alternative financial services such as payday lenders and other subprime lenders, and declining property values.[52] These changes may then result in a less favorable perception of the communities by potential homeowners searching for property, developers who are interested in maximizing returns for land and property investments, local governments who form public-private sector partnerships to stimulate city growth, and current city residents who may be reticent to visit these communities and patronize any businesses within them—any or all of which may result in economic divestment. Economic divestment may take the form of food deserts in low-income neighborhoods, an absence of healthcare facilities in those same communities, persisting high levels of joblessness, and a declining share of available jobs that offer health insurance and other benefits for area residents. These examples are universally recognized as contributors to health problems in urban communities.[53–55]

This study provides evidence that areal social and economic characteristics help explain the relationship between mortgage possessions in many of the largest US metropolitan areas and obesity prevalence. A metropolitan area, as defined by the US Census Bureau, is a core area containing a large population nucleus together with adjacent communities that have a high degree of economic and social integration with that core.[56] Prior studies on foreclosure and health are individual- focused and neglect to discuss and test structural mechanisms related to place, or they use foreclosure as a control variable to approximate disadvantage. This study leverages data collected at the city level to isolate how foreclosures are related to obesity, acknowledging that foreclosures are tied to inequality but are not dimensions of inequality. There are two main hypotheses that guide this research inquiry. First, mortgage possessions will be positively associated with obesity preva-

lence, that is, more foreclosures in a metropolitan area will be associated with higher levels of obesity. US foreclosures during the economic crisis of 2007–2008 were primarily in low-income and racial minority communities. These communities are also disproportionately exposed to obesity risks. As such, the second hypothesis is that spatial disadvantage measures (i.e. racial residential segregation, concentrated poverty), will mitigate some of the effects of mortgage possessions on obesity prevalence. Furthermore, as an ancillary hypothesis, these spatial disadvantage measures will also have independent effects in predicting obesity prevalence, such that higher levels of segregation and concentrated poverty will be associated with higher obesity prevalence.

Methods

Data

This study relies on three sources of US data. First, health data come from the Selected Metropolitan/Micropolitan Area Risk Trends (SMART) project, which uses information from the 2010 Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a cross-sectional, telephone-based survey managed by the Centers for Disease Control and Prevention. Multistage cluster sampling and random digit dialing were used in the data collection efforts of the BRFSS to ensure a representative sample, and weights are included to adjust for potential selection bias and incomplete sampling frames. It is important to note that not all metropolitan statistical areas (MSAs) are represented in the SMART data, but the more populated MSAs are represented.

Second, mortgage possession data come from RealtyTrac, a leading foreclosure monitoring and marketing company that collects data from public records. RealtyTrac accesses all legal documents containing information about foreclosure auctions. It includes filings of a notice of trustee sales and a notice of foreclosure sale from real estate owned properties. Similar to prior work that uses these data,[50] we aggregate the individuals' foreclosures to the metropolitan level and rely on the 2006–2009 time frame, peak years of the foreclosure crisis.[57] Foreclosure data are notoriously expensive to obtain for all US metropolitan areas, so the mortgage possession data acquired are for the 100 most populous MSAs. Prior work has used these MSAs to study foreclosures[50] and health,[46] so this work is well- situated to be representative of places where foreclosures and health issues are substantial.

Third, metropolitan characteristics are derived from the American Community Survey (ACS), which is a monthly household survey developed by the US Census Bureau to provide annual estimates of characteristics for all geographies and populations of at least 65,000 people. Again, this research focuses on the most populated metropolitan areas because these areas are also more likely to have experienced severe impacts of the foreclosure crisis[46] and are more likely to have severe health problems,[58] than less populated metropolitan areas. Because the BRFSS SMART data do not provide estimates for all metropolitan areas, we restrict our analyses to 75 of the 100 most populous metropolitan areas (See Appendix Table A).

Measures

Dependent variable: obesity prevalence

Individuals in the BRFSS self-reported their height and weight measurements, which were used to calculate their BMI. Individuals were classified as obese if their BMI was 30 or higher. Obesity prevalence is thus calculated by taking the number of people in the year 2010 who were obese and dividing by the total population of the metropolitan area. To convert it to a percentage, the proportion is multiplied by 100.

Focal independent variable: rate of mortgage possessions

The number of properties with at least one mortgage possession in 75 of the 100 most populous MSAs, for the years 2006 through 2009, is measured using RealtyTrac data. The years 2006 through 2009 were the peak years of the global economic crisis. The number of foreclosures is divided by the total number of housing units in the MSA from the previous year to derive a foreclosure rate that is sensitive to the housing stock. Housing stock information comes from the ACS data. Prior studies have also used this calculation.[46,50]

Mediating variable: spatial inequality

Based on the framework discussed in Introduction, measures of spatial inequality include two indices of racial residential segregation and one measure of concentrated poverty. Following research on measuring segregation,[59,60] it is measured using the dissimilarity index and the exposure index. The dissimilarity index measures the degree to which a racial/ethnic minority group is spatially distributed differently than whites across census tracts (administrative proxies for neighborhoods) in a metropolitan area. The index ranges from 0 to 100, with higher values corresponding to higher levels of segregation. The exposure index measures the degree of potential contact between whites and specific racial/ethnic minorities. It is computed as the minority-weighted average of the minority proportion in each metropolitan area so that higher values indicate higher levels of segregation.[61] Concentrated poverty is the proportion of census tracts within an MSA in which at least 20% of households have incomes below the federal poverty level. This percentage is typically used to indicate areas of concentrated poverty.[62,63]

MSA control measures

Eight measures from the ACS data are included as controls at the metropolitan level and are derived from the analysis by Jones et al.[46] from which the framework was derived. The percentage of minority is calculated by dividing the number of minorities (black, Hispanic, and Asian) by the total MSA population. The MSA population is also included in the analyses and is logged to correct for non-normality. The percentage of university-educated people is captured using the number of individuals aged 25 years and older with at least a university degree and dividing it by the total population of the MSA in the same age range. The percentage of working–age (those aged 18–64 years) individuals in a given MSA who are insured is also included. Median household income is logged in the analyses to make the variable normally distributed. The MSA poverty rate and the proportion of employed MSA residents are also included in the analyses. Finally, the US Census Bureau's definitions of the four major geographic regions (midwest, north, south, and west) are used to control for regions as foreclosures were not uniformly distributed across regions in the US.

Statistical analyses

Final population weights provided in the SMART BRFSS data are used to account for the complex sampling design. The multivariate models presented are additive. The first model isolates the spatial inequality measure (i.e. segregation or concentrated poverty). The second model includes foreclosure rates and the spatial inequality measures to test whether the previous relationships remain statistically significant. The third and final model is the full model including all measures. The analyses for this study were performed using Stata 15.1,[64] and a 0.05 alpha level was used for statistical significance.

Results

Table 1 presents descriptive statistics for all measures in this study. For this sample of MSAs, the mean obesity prevalence is 25.9%. For both segregation measures, black-white segregation is stronger than the other remaining racial pairings. For the dissimilarity index, black-white segregation averages 0.6, compared with 0.4 for Hispanic-white and for Asian-white. Similarly, black–white segregation averages 0.5, compared with 0.3 for Hispanics and 0.1 for Asians. The average percentage of census tracts that have concentrated poverty is around 22. From 2006 to 2008, the foreclosure rate uniformly increased from 0.7 to 2.0, but in 2009, the rate fell slightly to 1.9.

The control variables showcase MSAs that are not particularly disadvantaged. The average percentage of black residents is about 14.2, compared with 12.5% for Hispanic residents and 4% for Asian residents. The average number of people in these MSAs is more than 1.4 million. An average of 84.2% of working–age residents have health insurance. The median household income across the 75 MSAs averages just higher than $53,000, while the poverty rate is around 12.8% and the percentage of employed residents in each MSA is 75.8%. There are nearly identical distributions of MSAs in the northeast, midwest, and west (17.2–21.9%) regions but more representation in the south (42.2%) region.

Tables 2–4 present the ordinary least squares regression models predicting obesity prevalence using the segregation and concentrated poverty measures. In each of the tables, model 1 isolates a spatial inequality measure (i.e. segregation or concentrated poverty), model 2 includes foreclosure rates and the spatial inequality measures to test whether the previous relationships remain statistically significant, and model 3 is the full model including all measures. Table 2 focuses on relationships among three key variables: mortgage possessions (foreclosures), dissimilarity as one measure of racial residential segregation, and obesity prevalence. In model 1, only one of the three dissimilarity indices is statistically significant: higher values of the Hispanic-white dissimilarity index are associated with a 0.85 decrease in metropolitan obesity prevalence. When adding the foreclosure measures in model 2, this statistical relationship falls to 0.73, with a one-unit increase in the 2009 foreclosure rate associated with a 0.68-point increase in the 2010 obesity prevalence. In the full model (model 3), there is a further weakening of these relationships: higher values of the Hispanic-white dissimilarity index are associated with a 0.4 decrease in metropolitan obesity prevalence, and a unit increase in the foreclosure rate is associated with a 0.37-point increase in the 2010 obesity prevalence, net of other control variables. Among the control variables, a 1% increase in the Asian population is associated with a 0.64 decrease in the metropolitan obesity prevalence, and a 1% increase in the university-educated population is associated with 1.53% decrease in obesity prevalence.

Table 3 focuses on the exposure index, a different dimension of racial residential segregation. In model 1, two of the three exposure indices are statistically significant: higher values of the black-white exposure index are associated with a 0.25 increase in metropolitan obesity prevalence, whereas higher values on the Asian-white exposure index are associated with a 0.51 decrease. When adding the mortgage possession measures in model 2, the effect of the black-white exposure index is attenuated, and the Asian-white effect of exposure falls modestly to 0.48, whereas a one-unit increase in the 2009 foreclosure rate is associated with a 0.57-point increase in 2010 obesity prevalence. In the full model, there is a reversal in the effect from the previous model: The black-white exposure index now becomes statistically significant once again ($\beta = 0.43$), while the Asian-white exposure index coefficient is attenuated in

Table 1
Descriptive statistics for all study measures.

Measures	Mean/%	SD
2010 MSA obesity rate	25.91%	–
Dissimilarity index		
Black–white	0.57	0.12
Hispanic–white	0.44	0.10
Asian–white	0.38	0.07
Exposure index		
Black–white	0.45	0.19
Hispanic–white	0.28	0.22
Asian–white	0.11	0.12
Concentrated poverty	21.95%	–
Foreclosure rate		
2006	0.67	0.47
2007	1.14	0.87
2008	1.95	1.63
2009	1.88	1.98
Controls		
Percentage of black residents	14.23%	–
Percentage of Hispanic residents	12.46%	–
Percentage of Asian residents	3.99%	–
Population	14,99,356	11,16,826
Percentage of University-educated residents	28.37%	–
Percentage of Working-age insured population	84.21%	–
Median household income	$53,920.72	$9149.89
Poverty rate	12.75%	–
Proportion of employed MSA residents	0.76	–
Region		
Northeast	17.19%	–
Midwest	21.88%	–
South	42.19%	–
West	18.75%	–

$^{*}P < .05$; $^{**}P < .01$; $^{***}P < .001$.
$n = 75$ MSAs.
MSA, metropolitan statistical area; SD, standard deviation.

Table 2
OLS regression estimates for foreclosures, racial dissimilarity index, and obesity.

Measures	Model 1	Model 2	Model 3
Dissimilarity index			
Black–white	0.22	−0.32	−0.33
Hispanic–white	−0.85***	−0.73***	−0.40**
Asian–white	0.49	0.30	0.32
Foreclosure rate			
2006		−0.19	−0.11
2007		−0.09	−0.03
2008		0.01	−0.01
2009		0.68***	0.37*
Controls			
Percentage of black residents			0.14
Percentage of Hispanic residents			0.02
Percentage of Asian residents			−0.64***
Log population			0.02
Percentage of university-educated residents			−1.53**
Percentage of working-age insured population			0.00
Log median household income			0.13
Poverty rate			0.00
Proportion of employed MSA residents			0.00
Region (Northeast)			
Midwest			0.06
South			0.06
West			−0.05
Constant	−0.93***	−0.61**	−2.33

$^{*}P < .05$; $^{**}P < .01$; $^{***}P < .001$.
Contrast categories are given in parentheses.
MSA, metropolitan statistical area; OLS, ordinary least squares.

Table 3
OLS regression estimates for foreclosures, racial exposure index, and obesity.

Measures	Model 1	Model 2	Model 3
Exposure index			
Black–white	0.25**	−0.08	0.43**
Hispanic–white	−0.13	−0.11	−0.21
Asian–white	−0.51**	−0.48**	0.49
Foreclosure rate			
2006		−0.13	−0.04
2007		−0.12	−0.04
2008		0.02	0.00
2009		0.57*	0.24
Controls			
Percentage of black residents			0.55*
Percentage of Hispanic residents			0.11
Percentage of Asian residents			−0.88*
Log population			0.03
Percentage of university-educated residents			−1.39**
Percentage of working-age insured population			0.01
Log median household income			−0.02
Poverty rate			0.01
Proportion of employed MSA residents			0.00
Region (Northeast)			
Midwest			0.12*
South			0.15*
West			−0.04
Constant	−1.00***	−0.87	−1.40

*$P < .05$; **$P < .01$; ***$P < .001$.
Contrast categories are given in parentheses.
MSA, metropolitan statistical area; OLS, ordinary least squares.

effect size. In supplemental analyses, the addition of both the percentage of black and Asian residents contributed to these findings. When controlling for metropolitan characteristics (specifically the percentage of university-educated residents), the foreclosure effect is no longer statistically significant. However, there are independent effects of several control variables on obesity prevalence. A 1% increase in the black population is associated with a 0.55 increase in the metropolitan obesity prevalence, but a 1% increase in the Asian population is associated with a 0.88 decrease. A 1% increase in the university-educated population is associated with a 1.39 decrease in obesity prevalence. In this model, there are regional effects that are statistically significant—compared with the north region, the midwest region has a 0.11 higher obesity prevalence, whereas the south region has a 0.15 higher obesity prevalence, net of other control variables.

Table 4
OLS regression estimates for foreclosures, concentrated poverty, and obesity.

Measures	Model 1	Model 2	Model 3
Concentrated poverty	0.63***	0.53***	0.02
Foreclosure rate			
2006		−0.01	0.02
2007		−0.10	−0.05
2008		0.01	0.00
2009		0.40	0.10
Controls			
Percentage of black residents			0.18
Percentage of Hispanic residents			−0.17
Percentage of Asian residents			−0.33
Log population			0.02
Percentage of university-educated residents			−1.72**
Percentage of working-age insured population			0.00
Log median household income			0.13
Poverty rate			0.01
Proportion of employed MSA residents			0.00
Region (Northeast)			
Midwest			0.12*
South			0.19**
West			0.06
Constant	−1.12***	−1.13***	−2.95

*$P < .05$; **$P < .01$; ***$P < .001$.
Contrast categories are given in parentheses.
MSA, metropolitan statistical area; OLS, ordinary least squares.

Table 4 presents the regression estimates for concentrated poverty, mortgage possessions, and obesity prevalence. In model 1, concentrated poverty is statistically associated with metropolitan obesity prevalence. A one-unit increase in the percentage of census tracts that have concentrated poverty within them is associated with a 0.63-point increase in obesity prevalence. This result is reduced to 0.53 in model 2 when the annual foreclosure rates are added. However, none of the foreclosure indicators are statistically related to obesity prevalence, net of concentrated poverty. In model 3, the effect of concentrated poverty is attenuated because of the addition of the percentage of university-educated residents to the model. Similar to the previous table, the percentage of university-educated residents and region of residence are both statistically significant in consistent ways ($\beta = -1.72$ for university-educated residents, $\beta = 0.12$ for midwest region, and $\beta = 0.19$ for south region).

Discussion

Prior research failed to uncover any statistically significant relationship at the individual level between experiencing foreclosures and weight gain. This research surmises that mortgage possessions are unique structural contributors to spatial inequality, and thus, this study identified the ways in which mortgage possessions (i.e. foreclosures) and spatial inequality at the metropolitan level affect obesity prevalence in 75 of the 100 most populous MSAs in the US.

The first hypothesis— that more foreclosures in a metropolitan area will be associated with higher levels of obesity— was supported. The results suggest that these possessions are independently associated with increased obesity prevalence. At the individual level, prior work has argued that foreclosures are stressful life events that have enduring and variable effects,[58] which can lead to the biophysiological response of fat accumulation in the body.[25] Although these mechanisms can aggregate to create a spatial relationship at the metropolitan level, there are specific spatial mechanisms that could also be used to explain foreclosure and obesity prevalence.

The second hypothesis that measures of spatial disadvantage will mitigate some of the effects of mortgage possessions on obesity prevalence was also supported. The analysis found that mortgage possessions operate through the specific channel of racial residential segregation and its tie to the racial composition of an area. Black-white segregation was associated with increased obesity prevalence after controlling for foreclosure rates during the study period. Conversely, Hispanic-white and Asian-white segregation were associated with diminished obesity prevalence. However, these relationships were in part affected by the percentage of racial/ethnic minorities in the MSAs. Specifically, the black-white segregation effect was enhanced by the percentage of blacks present in the MSA, whereas Hispanic-white and Asian-white segregation effects were diminished (and even attenuated) by the percentages of Hispanics and Asians, respectively, in the MSA. Race and foreclosures have been shown to be related in prior research.[65] Blacks

and Hispanics were highly impacted by subprime mortgages that preceded the foreclosure crisis in the mid-2000s, which led to the groups having an elevated risk of losing their homes to foreclosure, although the largest number of foreclosures was for white homeowners.[65] Furthermore, subprime mortgages were targeted in areas that were racially segregated,[66] thus providing a connection between segregation and foreclosures. Some studies have also linked segregated areas to poor health outcomes,[67] including obesity,[68] and the findings from this study provide an empirical base for future research to uncover the relationships between segregation, mortgage possessions, and obesity at the individual level of analysis.

Another major finding from this research is that the socioeconomic status of an area is related to mortgage possessions and obesity prevalence. Again, at the individual level, housing instability (through the foreclosure process) is linked to economic instability. At the metropolitan level, this study found that foreclosures do not seem to be related to concentrated poverty, but concentrated poverty is related to obesity prevalence. In addition, the proportion of university-educated residents has a protective health benefit to residents in metropolitan areas as it is associated with a decrease in obesity prevalence. Concentrated poverty has been found to be related to population health outcomes net of foreclosures in prior work,[46] but the lack of statistical significance in this work may be due to the observation period. Although the subprime foreclosure crisis started in the 1990s, the crisis peaked toward the end of the first decade of the 21st century; however, during this window of time, the level of extreme concentrated poverty actually declined,[69] making it less likely to be a factor that affects the foreclosure/obesity relationship, which this study addressed. It would be worthwhile for future research to test whether the foreclosure/obesity relationship is strong during this time in metropolitan areas, where there was still a high level of concentrated poverty, to provide more convincing evidence that spatial poverty is linked to population health. Moreover, the presence of university-educated residents was associated with lower obesity prevalence in these most populous metropolitan areas. Nearly 90% of university-educated individuals live in urban countries,[70] and as a result, the density of highly- educated persons may result in healthier food options, more parks, and higher- quality recreation centers. These amenities are associated with increased activity and decreased calorie consumption.[71,72] In addition, a highly- educated population may result in higher levels of civic engagement, which has been linked to lower levels of obesity in prior work.[73,74] Future studies could provide further evidence of the effect of university-age populations on mortgage possessions and obesity.

The study has several important limitations. By design, the data used cannot imply causality as they can only describe associations between the measures used. Obesity in this research is based on self-reported height and weight over the phone. Thus, the study participants may not have given valid and reliable measurements, which could bias the estimates for obesity prevalence in a metropolitan area. Related to data collection, individuals who are undergoing foreclosure may not be captured accurately because the telephone-based survey may have skewed the sample to interview more residentially stable and/or socio-economically higher households. This study focused on 75 of the top 100 most populous metropolitan areas, but the BRFSS does not collect data from all metropolitan areas, so the findings are not necessarily generalizable across all MSAs.

Limitations notwithstanding, the present study embodies the perspective that housing policy is health policy. Thus, addressing the ways in which mortgage possessions (which affect an already-vulnerable population) can exacerbate health disparities across metropolitan areas can be beneficial from a public health perspective. Healthcare organizations may be able to partner with mortgage counseling agencies to provide comprehensive assistance in terms of linking people to resources to help keep individuals and families healthy in their purchased homes.

Author statements

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Ethical approval

This study relied on de-identified data aggregated at the metropolitan level, and therefore, it is exempt from institutional review board approval.

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Competing interests

None declared.

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Appendix

Table A
List of all US metropolitan statistical areas (MSAs) used in the study.

Akron, OH	Minneapolis-St. Paul-Bloomington, MN-WI
Albuquerque, NM	Nashville-Davidson–Murfreesboro–Franklin, TN
Allentown-Bethlehem-Easton, PA-NJ	New Haven-Milford, CT
Atlanta-Sandy Springs-Roswell, GA	New Orleans-Metairie, LA
Austin-Round Rock, TX	New York-Newark-Jersey City, NY-NJ-PA
Baltimore-Columbia-Towson, MD	North Port-Sarasota-Bradenton, FL
Baton Rouge, LA	Oklahoma City, OK
Birmingham-Hoover, AL	Omaha-Council Bluffs, NE-IA
Boston-Cambridge-Newton, MA-NH	Orlando-Kissimmee-Sanford, FL
Bridgeport-Stamford-Norwalk, CT	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD
Buffalo-Cheektowaga-Niagara Falls, NY	Phoenix-Mesa-Scottsdale, AZ
Charleston-North Charleston, SC	Pittsburgh, PA
Charlotte-Concord-Gastonia, NC-SC	Portland-Vancouver-Hillsboro, OR-WA
Chicago-Naperville-Elgin, IL-IN-WI	Providence-Warwick, RI-MA
Cincinnati, OH-KY-IN	Raleigh, NC
Cleveland-Elyria, OH	Richmond, VA
Columbia, SC	Riverside-San Bernardino-Ontario, CA
Columbus, OH	Rochester, NY
Dallas-Fort Worth-Arlington, TX	Sacramento–Roseville–Arden-Arcade, CA
Dayton, OH	Salt Lake City, UT
Denver-Aurora-Lakewood, CO	San Antonio-New Braunfels, TX
Detroit-Warren-Dearborn, MI	San Diego-Carlsbad, CA
El Paso, TX	San Francisco–Oakland–Hayward, CA
Greensboro-High Point, NC	San Jose-Sunnyvale-Santa Clara, CA
Greenville-Anderson-Mauldin, SC	Scranton–Wilkes-Barre–Hazleton, PA
Hartford-West Hartford-East Hartford, CT	Seattle-Tacoma-Bellevue, WA
Indianapolis-Carmel-Anderson, IN	Springfield, MA
Jacksonville, FL	St. Louis, MO-IL
Kansas City, MO-KS	Tampa-St. Petersburg-Clearwater, FL
Knoxville, TN	Toledo, OH
Las Vegas-Henderson-Paradise, NV	Tucson, AZ
Little Rock-North Little Rock-Conway, AR	Tulsa, OK
Los Angeles-Long Beach-Anaheim, CA	Urban Honolulu, HI
Louisville/Jefferson County, KY-IN	Virginia Beach-Norfolk-Newport News, VA-NC
McAllen-Edinburg-Mission, TX	Washington-Arlington-Alexandria, DC-VA-MD-WV
Memphis, TN-MS-AR	Wichita, KS
Miami-Fort Lauderdale-West Palm Beach, FL	Worcester, MA-CT
Milwaukee-Waukesha-West Allis, WI	