Suburbanization of Poverty, Gentrification, and Health: Changing Geographic Inequalities and Implications for Health Care Access and Health Equity

SUBURBANIZATION OF POVERTY, GENTRIFICATION, AND HEALTH:

CHANGING GEOGRAPHIC INEQUALITIES AND IMPLICATIONS FOR HEALTH CARE ACCESS AND HEALTH EQUITY

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Abstract

Over the past two decades, patterns of affluence and poverty have shifted in many U.S. metropolitan areas. The prosperous are urbanizing, while poor and lower-middle class populations have moved or been subsequently pushed out to the suburbs. Little is known about the the health consequences of this changing geography of affluence and poverty, and associated reorganization of racial/ethnic segregation, and these shifts remain largely overlooked in public health literature and policy. In this dissertation I investigated how socio-spatial change in metropolitan areas -- specifically gentrification, urban development, and increasing suburban poverty-- impacted health care access and health equity.

In the first chapter we used descriptive statistics and multivariate regression of non-elderly adults (18-64 years) in the 2005-2015 Behavioral Risk Factor Surveillance Survey (BRFSS)- a nationally representative repeated cross-sectional study --to examine the differences in health care access and insurance coverage between suburban, urban, and rural areas, pre and post-the Affordable Care Act and between poor and non-poor respondents. We found that nearly 40% of the uninsured population lived in the suburbs, and more than one in three residents delayed care in the past year because of cost. These results suggest the need for increased research and policy attention to address these challenges for vulnerable populations living in the suburbs. In chapter two we conducted a systematic review to identify empirical studies that examined associations between gentrification, and similar but differently termed processes

(urban regeneration, urban development, neighborhood upgrading), and health. We found that 22 articles met inclusion criteria, and though the studies found evidence of significant associations between the neighborhood change exposures and health, the direction of these relationships was not consistent. Chapter three analyzed the relationship between gentrification and BMI and self-rated health using a quasi-experimental study design. Our study design represents a methodological improvement over other studies on gentrification and health, but we found no evidence of a significant effect in our population of survivors of Hurricane Katrina. Findings from this dissertation advance social epidemiology and inequality research and inform policy interventions designed to reduce health disparities in U.S. metropolitan areas.

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Introduction/Overview

Over the past two decades, the patterns of disinvestment and urban flight that took place in many U.S cities from 1960 to 1990 have begun reversing. Instead of the affluent fleeing the urban core for the sprawling suburbs, capital investment and the economically better off have flocked back to cities, while the poor and lower-middle class have moved or been pushed out to the suburbs (Hyra, 2014). This process, known as inversion (Ehrenhalt, 2012) or the "back-to-the-city movement" (Sturtevant & Jung, 2011), has contributed to two interrelated processes: gentrification of urban areas, and the suburbanization of poverty. While this shifting geography of affluence and poverty has been increasingly documented in the academic literature (Anacker, 2015; Gould Ellen & Ding, 2016), think tank reports (Kennedy & Leonard, 2001; Kneebone & Nadeau, 2016) and media (Badger, 2013; Florida, 2015; Kasperkevic, 2015; Stanton, 2015), we know little about its health consequences. Many in urban planning, sociology, and economics have, and continue to, study the social implications of this new alignment of spatial inequality. However, the public health field has been largely silent, and impacts and consequences for health remain under-examined and not fully understood.

A substantial body of literature in social epidemiology has sought to explain patterns of health and disease across geographic areas by examining the effects of places, particularly neighborhoods, on health (Diez Roux, 2001). This literature recognizes that health is influenced by peoples' residential contexts, as well as their individual characteristics (M. C. Arcaya et al., 2016; Oakes, Andrade, Biyoow, & Cowan, 2015). The reciprocal is also true - people influence and interact with their environments, thereby changing the contexts in which they live**.** Based in

ecosocial theory[1] (Krieger, 1994, 2001a), this dissertation sheds light on how social, political, economic, and geographic processes shape epidemiological profiles. Population patterns of health and disease follow patterns of deprivation and affluence, through embodiment of social conditions (Krieger & Smith, 2004). Therefore, shifts in these underlying distributions likely also shift population health.

This dissertation examines how recent geographic population configurations shape and reshape the distribution and patterning of disparities in health and access to health care. Most health research has assumed continued concentrations of poverty and resource deprivation in cities, and affluence in the suburbs. Thus, this dissertation will highlight the demographic shifts that have occurred and present potential pathways through which gentrification and the suburbanization of poverty may affect health. It will further provide empirical evidence for if and how rates of health coverage and access are patterned in the suburban, urban, and rural U.S. The first objective of this dissertation is to compare rates of health care access and insurance coverage between suburban, urban and rural areas of the U.S. between 2005 and 2015. The second objective of this dissertation is to contribute to the neighborhood effects literature by examining how changing neighborhood socioeconomics, in the form of gentrification, affects the health of low-income populations.

[1] Ecosocial theory was introduced by Nancy Krieger in 1994, and helps explain how patterns of population health are dependent on one's context, and how conditions of existence interact with biology across spatiotemporal scales and the lifecourse (Krieger, 2001a). It frames epidemiologic analysis in relation to historical, societal, biological, evolutionary and ecologic context, both of the population being studied and the scientists doing the research. Four core constructs 1) embodiment 2) pathways of embodiment 3) cumulative interplay between exposures, susceptibility, and resistance and 4) accountability and agency, which frame analysis on responsibility and causes for population patterns of, and social inequities in, disease and health (Krieger, 2001b).

Given these major population shifts, there is a need to study the changing geography of poverty in U.S. metropolitan areas, and to understand how such changes may perpetuate or mitigate inequities in health. It is unclear if movement by low-income populations to suburban areas; the socioeconomic decline of middle-income suburban families; and changes to the social, cultural, and economic environments of formerly impoverished neighborhoods shrink or widen health disparities. While these shifts break down historic patterns of residential racial segregation, whether they are beneficial or harmful to the health of those communities that suffer the consequences of segregation and concentrated poverty remains unknown. Further, we have limited knowledge about how these changes impact the protective neighborhood and individual factors that buffer against deleterious impacts of concentrated poverty or existing positive neighborhood factors in low-income racially segregated neighborhoods.

Critical gaps exist in the public health literature that examines recent changes in the geographic patterning of populations in the U.S. Documenting and explaining social inequalities in health is a central task of public health, and understanding the geography of inequality is a fundamental tenet of population health. Recognizing and documenting where the economically disadvantaged and the affluent reside, and how their contexts affect their health, aids in our understanding of the geographic distribution of health and wellness in the population. Overlooking these shifting geographic patterns hinders our ability to accurately assess changes in population health, identify causes of ill or good health, and develop interventions and policies to address inequities.

Health Care Access in the Suburbs

There are 16.9 million Americans living in poverty in the suburbs—more than in cities or rural communities. Despite recent increases in suburban poverty, the perception of the suburbs

as areas of uniform affluence remains, and there has been little research into health care barriers experienced by people living in these areas. This chapter provides the first comparison of patterns of insurance coverage and health care access in suburban, urban, and rural areas using national survey data from 2005 to 2015 and compare outcomes by geography before and after the Affordable Care Act took effect. We find that nearly 40% of the uninsured population lived in suburban areas. Though unadjusted rates of health care access is better in suburban areas, compared to urban and rural communities, this advantage is greatly reduced after income and other demographics are accounted for. Overall, a substantial portion of the US population residing in the suburbs lacks health insurance and experiences difficulties accessing care. Increased policy attention is needed to address these challenges for vulnerable populations living in the suburbs.

Gentrification, Neighborhood Change, and Population Health

Gentrification involves the process of low-income neighborhoods changing around residents, resulting in the displacement of some and, for those able to stay, shifts in the economic, social, cultural and political contexts of their neighborhood. All of these shifts have implications for population health and health disparities. Despite a proliferation of research on neighborhood effects on health, how neighborhood economic development affects health and well-being in the U.S. is poorly understood, and no systematic assessment of the potential health impacts has been conducted. Further, we know little about whether gentrification differs from urban development or urban regeneration in their impact on health. We systematically review empirical studies that examine associations between gentrification, and similar but differently termed processes (e.g., urban regeneration, urban development, neighborhood upgrading), and

health by searching five electronic databases: Pubmed, Sociological Abstracts, Web of Science, Academic Search Premier, and EconLit**.** Twenty-two articles meet inclusion criteria, which suggest that impacts of gentrification vary by health outcome, and exposure definition and operationalization. Our article helps to inform the debate on the impacts of gentrification and urban development for health, and suggests that these neighborhood change processes likely have both detrimental and beneficial effects on health. Given the influence of place on health and the trend of increasing gentrification and urban development in many American cities, we discuss how the health field can approach understanding and researching the impacts of these processes on health. We further consider how the health care safety-net can address gentrification to ensure programs and services target populations in need.

The Role of Gentrification in Predicting BMI and Self-Rated Health

Despite substantial debate about the impacts of gentrification on cities, neighborhoods, and their residents, there is limited evidence to demonstrate the implications of gentrification for health. In this chapter we examine the examines the impacts of gentrification on self-reported health and BMI using a unique individual-level longitudinal data set. We employ data from the Resiliency in Survivors of Hurricane Katrina (RISK) project, a study of low-income parents, predominantly non-Hispanic Black single mothers, who participated in a New Orleans-based study before and after Hurricane Katrina. After Katrina, all participants were displaced, at least temporarily, from New Orleans. Residents had little or no control over neighborhood placement immediately following the storm. This near-random displacement after Katrina created a natural experiment, which we exploit in our study design. We hypothesize that higher levels of gentrification will predict worse health outcomes for study participants; the risks of further

displacement, higher housing costs, neighborhood destabilization and breakdown of social fabric will exacerbate psychosocial stressors that outweigh the potential benefits of increased investment and influx of higher socioeconomic status residents. We find that many of the neighborhoods in the study underwent substantial gentrification and that on average, participants' health deteriorated during the study period. However, we do not find evidence of a significant effect of gentrification on BMI or self-rated health. The analysis employs a quasi-experimental design and has several additional unique features (homogeneous population, limited selection bias, longitudinal data collection) that improve our ability to draw causal conclusions about the relationship between gentrification and health. This work adds evidence and theory to the discussion about maintaining cities inclusive of residents across the economic spectrum, as well as understanding the causal effects of gentrification on health.

Chapter 1

Health Care in the Suburbs: An Analysis of Suburban Poverty and Health Care Access

Alina S Schnake-Mahl and Benjamin D. Sommers

Introduction

To many people, "suburbs" suggest sprawling post–World War II neighborhoods of predominantly white middle- and upper-class communities.[1] This narrative persists, despite some heterogeneity in suburban populations and community types that has always existed in the suburbs2 and despite recent shifts in the geography of poverty and affluence in the United States.[3,4] In fact, while rates of poverty are higher in cities, more poor Americans live in the suburbs than in cities or rural communities.[4] In the 2000s the number of poor residents in the suburbs of the largest metropolitan areas rose by 6.7 million, and by 2014 their number had reached 16.9 million—3 million more than the number of poor residents in urban areas.[5]

In the latter half of the twentieth century, the suburbs were home to predominantly white and relatively affluent populations. These residential patterns arose largely as a result of discriminatory housing policies and practices that incentivized whites' suburban homeownership and residence, to the exclusion of other racial groups.[1] However, in recent years the suburbs have become home to populations of increasing economic and racial/ethnic diversity, because of several factors: economic restructuring during and after the great recession, a "return to the city" trend among Millennials and empty nesters and subsequent pricing out of lower-income families, more affordable suburban housing options, and direct international immigration to suburban communities.2

Historically, rates of health insurance coverage have been higher in suburban areas than urban or rural areas,6 but the recent rapid uptick in suburban poverty has likely affected uninsurance rates in the suburbs, as people living below poverty are at high risk of being uninsured.[7]

Additionally, substantial suburban unemployment and the rising number of immigrants in suburbs may contribute further to coverage challenges among suburbanites.[7,8] Yet these issues have received little attention from health services researchers and policy makers.

Suburban residents, particularly those with lower incomes, may face unique barriers to health care access beyond simply lacking cover-age. Research has shown that residential context affects well-being and community health by shaping access and exposure to education, housing, social networks, transportation, employment, and health care.[9] However, knowledge of how suburban poverty affects health is limit-ed. While suburban poverty has become an area of increased policy interest, its implications for health remain unclear. To our knowledge, there has been limited research on the implications of the increasingly poor suburban population for health care access.

Other studies have highlighted the challenges of suburban poverty for social services, governance, institutions, and community-based pro-grams.[10,11] In particular, organizational resources targeted to the poor are more limited in suburban areas than elsewhere.[12] While suburban social service providers have to cover larger delivery service areas than in urban areas, they now also face increased demand for services, which has risen rapidly since the recession.[13] Additionally, despite substantial research on the impacts of the Affordable Care Act (ACA) for

insurance and health care access,[14,15] studies have not examined recent changes in these out-comes in suburban areas.

The objectives of this study were to compare patterns of insurance coverage and health care access in suburban, urban, and rural areas using national survey data from 2005 to 2015, and to compare outcomes by geography before and after the ACA took effect. We also conducted a subgroup analysis of these changes among low-income populations in these different geographies. We hypothesized that contrary to wide-spread assumptions about residents of suburbs, health care coverage and access to care are not substantially better in suburban areas than in rural or urban areas, though we hypothesized that these outcomes have improved in all three areas since the ACA's implementation.[14,15]

Study Data and Methods

STUDY POPULATION AND METHODS

Our study used data from the 2005–15 waves of the Behavioral Risk Factor Surveillance System (BRFSS), an annual national cross-sectional telephone survey of non institutionalized adults over age eighteen.[16] With support from the Centers for Disease Control and Prevention and conducted at the state level, the BRFSS is the only publicly available, nationally representative survey that has both state and sub-state geographic identifiers and questions on health insurance and access to health care. Details about its methodology are available elsewhere.[16]

SUBURBAN DEFINITION

There is no gold standard or official definition of the suburbs. The Census Bureau defines suburbs as municipalities with more than 2,500 people in a Metropolitan Statistical Area (MSA)

but located outside of census-identified "principal cities." Other research on suburban poverty has used variations of this definition.[2,3,17] Across definitions, the finding of a general trend of increasing suburban poverty at the national level holds.3 However, there are substantial inter suburban differences in levels of poverty, even in neighboring areas.[2]

The BRFSS data set includes an indicator for Metropolitan status code, which is based on MSAs, or regions that generally include a central city, its suburbs, and other economically or socially linked communities. The Metropolitan status code indicator includes the following categories: center city of an MSA; outside the center city of an MSA but inside the county containing the center city; inside a suburban county of the MSA; in an MSA that has no center city; and not in an MSA. Our definition, referred to as Definition 1, is similar to the census definition, defining urban as the center city only. Suburban includes areas outside the center city of an MSA but inside the county containing the center city, as well as areas inside a suburban county of the MSA. Rural areas are those not within an MSA.

SAMPLE

Our sample contained nonelderly adults ages 18–64 (n = 3,259,300) in all fifty states. We excluded elderly adults because 98.9 percent are covered by Medicare. Additionally, we excluded 1,929 observations (<0.001 percent) from 2005 to 2011 that were missing Metropolitan status codes, since it is the main variable of interest. Finally, we included only the landline sample from the 2011–15 waves, excluding 555,851 cell-phone observations. In 2011 the BRFSS changed its sampling methodology to include cell phones, but cellphone observations lack a geographic indicator for Metropolitan status code. The 2015 BRFSS wave contains 1,906

observations collected in early 2016, which we included as part of our 2015 estimates; all other estimates refer to the year in which the survey was conducted.

OUTCOME VARIABLES

Following previous research using data from the BRFSS,[18] we assessed access to health insurance coverage and access to health care using four measures: being uninsured, having no usual source of care (defined as lacking one or more personal doctors or health care providers), having an unmet care need due to cost in the past year, and having no receipt of a routine checkup in the past year. We modeled all of these outcomes as dichotomous, and all were defined so that higher values were worse (for example, percentage uninsured or without a usual source of care).

STATISTICAL ANALYSIS

We first compared the basic demographics of urban, suburban, and rural areas. Then we assessed changes over time in coverage and access for the three types of areas. Finally, we used logistic regression models to examine the association between the outcomes (access measures) and the three geographic areas, before and after adjustment for demographic factors (age, sex, race, ethnicity, marital status, education), employment, household income, survey year, and state of residence.

To estimate differential effects of the ACA associated with each of the three types of areas, we compared outcomes in the areas pre (2005–13) and post ACA (2014–15), also adjusting for a linear time trend and the additional covariates described above. For all regression analyses, we reported the odds ratio (OR) and p value. Analyses with associated 95% confidence intervals are in online Appendix Exhibits A1 and A2.[19] We also produced predicted probabilities,

calculated using Stata's "margins" command, for ease of interpretation. We stratified adjusted estimates into poor and nonpoor individuals (as described below), to assess for differential patterns by geography and poverty status.

We conducted additional analyses to test the sensitivity of our results to alternative definitions of suburban, as described in Appendix Exhibit A3.[19] Family income was calculated as a percentage of the federal poverty level, based on annual income and the number of people in each family. We created the following income categories: poor (under 100 percent of poverty), near-poor (100–199 percent), middle class (200–299 percent), upper middle (300–399 percent), upper (400 percent or more), and income missing (12.2 percent of the data set). Observations with missing outcome responses were omitted from the sample for that particular analysis.

For all analyses, urban geography was the reference group.

The data were analyzed using Stata/SE 13.1. Analyses accounted for the BRFSS's complex survey design and used nationally representative survey weights. We also tested the effect of using robust standard errors clustering at the level of state-geography (for example, suburban areas in Massachusetts would be one cluster) in lieu of BRFSS survey-based standard errors.

Limitations

Although our study provides important comparisons of health care access in suburban, urban, and rural areas, several limitations must be acknowledged. First, our sample included only nonelderly adults, while other research in this area has not been age restricted. This limits comparison of our work with other reports.

Second, though the study relied on survey data, previous research has found high levels

of reliability and validity for the BRFSS health care access questions.18 Third, our household income measure was imprecise, since it was self-reported and measured in income categories rather than exact amounts; in addition, 12.2 percent of our sample did not provide any response to the income question. In our data, those with those with missing income were significantly more likely than others to be uninsured and have no usual source of care ($p < 0:001$); thus, if anything, this omission may have led us to underestimate the suburban health care barriers in our sample.

Fourth, we excluded cell-phone respondents from our sample because data on our primary exposure, the geographic indicator, is lacking for this group. Fortunately, even after we excluded cell-phone respondents, the overall trend in the insurance rate in our data was similar to those found in other surveys of national insurance rates.[7] Cell-phone use is more prevalent among low-income households.[20] Therefore, our use of the landline-only sample may also have led to an underestimate of poverty rates and barriers to care.

Fifth, our assessment of changes after ACA implementation in 2014 are largely descriptive. We could not determine whether these changes in coverage rates were related directly to the ACA's coverage expansions or were due to unmeasured confounders. However, we did control for several potential confounders, including income, age, state, and the pre-2014 time trend.

Finally, the percentage of Asian respondents in the BRFSS is smaller than their representation in the US population, and the BRFSS does not include questions for nativity or immigration status. This is a potentially important factor, given that the share of suburban immigrants living in the largest metro areas increased from 56 percent to 61 percent between 2000 and 2013— more than a 30 percent increase in the number of immigrants in the

suburbs[21]—and that immigrants experience greater access challenges than their native-born counterparts.[8] Though controlling for race, ethnicity, and other demographic factors should partially account for selective migration effects, future research on access challenges for immigrants in the suburbs would be informative.

Study Results

Our final data set included 2,701,520 observations. Table 1 presents our descriptive analyses for suburban, urban and rural areas. Most demographic characteristics were similar across geographic area types. The largest portion of the population lived in the suburbs, and the smallest in rural areas. Educational attainment was highest in suburban areas, followed by urban. Our data show a greater percentage of non-Hispanic whites in suburban and rural locations, a lower rate of married individuals in urban areas, and a lower poverty rate in the suburbs.

Table 1: Demographic characteristics in urban, suburban, and rural areas of the United States

	Urban	Suburban	Rural
Variable	(N = 1,036,189)	(N = 1,185,630)	(N = 478,507)
Total population	38.37%	43.91%	17.72%
Sex (male)	48.94	48.46	48.65
Age (years)			
18–24	13.37	12.50	13.07
25–34	20.23	18.32	18.43
35–44	22.86	23.89	20.89
45–54	23.65	25.06	24.69
55-84	19.89	20.24	22.92
Education			
Less than high school	12.12	9.34	12.44
High school diploma	25.01	26.47	36.35
College or more	62.30	63.75	51.00
DK/miss/ref	0.47	0.44	0.21
Marital status	55.60	63.89	62.92
Married	54.97	62.90	62.09
Widowed/divorced	17.27	15.28	18.13
Single	27.76	21.80	19.79
Working	66.17	68.83	65.80
Race			
White	67.77	79.95	85.38
Black	16.42	8.76	7.18
Asian	1.53	1.07	0.39
Other race	11.74	8.63	5.92
DK/miss/ref	2.61	1.59	1.14
Ethnicity			
Hispanic	19.78	13.26	6.68
Non-Hispanic	75.32	82.70	89.61
DK/miss/ref	4.90	4.04	3.71
Income level			
Poor	15.61	11.11	14.71
Near-poor	17.03	14.60	21.21
Middle class	12.50	12.78	16.56
Upper middle class	7.31	7.55	8.95
Upper class	35.32	42.06	25.62
DK/NS/miss/ref	12.22	11.87	12.94

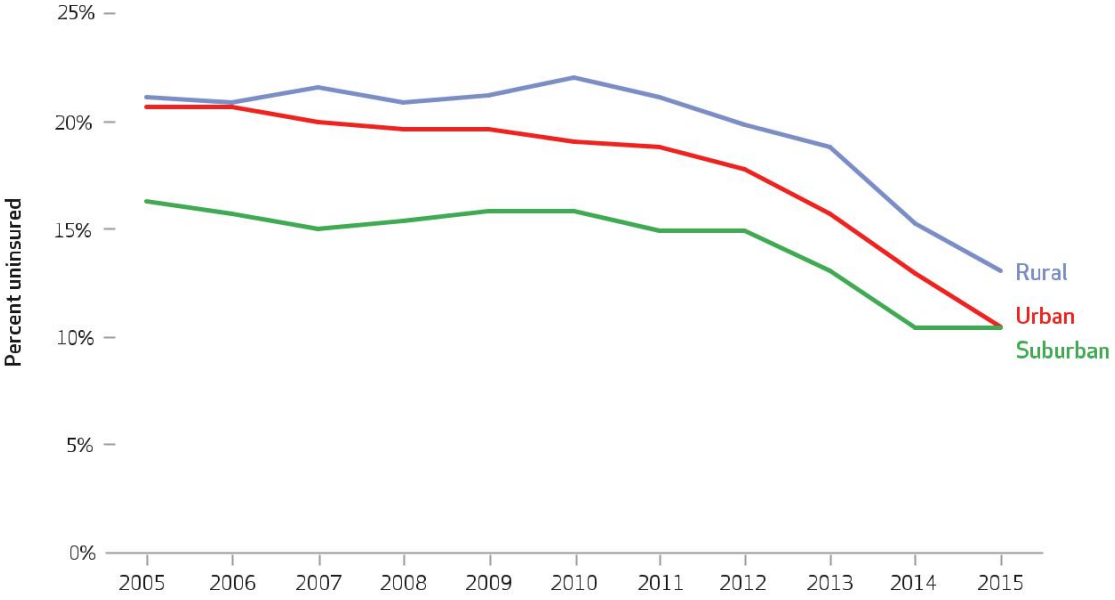
Table 1 (Continued)
SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text). NOTES Our definition of suburban is in the text. All results are significant ($p < 0:001$) using chi-square tests for differences in each demographic variable across the three types of geographic areas. DK/NS/miss/ref indicates Don't know/not sure/missing/refused.

URBAN, SUBURBAN, AND RURAL LEVELS OF COVERAGE AND ACCESS

We found that the suburbs were home to 43.9 percent of the population (Table 1) and 38 percent of the uninsured population, based on an uninsurance rate of 15 percent. Figure 1 presents time trends of the mean uninsurance rate in the three geographic area types. Across all three, the trend was essentially flat from 2005 to 2010, after which the rate decreased. The uninsurance rate was initially lower in the suburbs, though the gap narrowed over time; by 2015 the rate in suburban areas was essentially the same as in urban areas.

Appendix Exhibits A4–A6 contain the time trends for three of the four access measures: having no usual source of care, having an unmet care need due to cost in the past year, and not receiving a routine checkup in the past year.[19] For all three of these outcomes, the rates decreased across all geographic areas after 2014; by 2015 the gaps between urban and suburban areas had been eliminated for the first two measures.

Figure 1
Uninsurance rates among nonelderly adults in urban, suburban, and rural areas, 2005–15



SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text). NOTE Our definition of suburban is in the text.

REGRESSION RESULTS

Table 2 presents our unadjusted, adjusted, and income-stratified regression estimates. Unadjusted rates for the suburbs were significantly lower in three of the four outcomes—being uninsured, having no usual source of care, and delaying care because of cost—than in urban areas. Across most outcomes, outcome rates were highest (worst) in rural areas. Access rates and the size of the disparity between suburban and other geographic areas differed by outcome; for example, the absolute difference between urban and rural areas was 4.5 percentage points for lacking a usual source of care, compared to 2.4 percentage points for delaying care because of cost.

The adjusted predicted probability of being uninsured was high across all geographic areas: over 15 percent overall and over 40 percent among the poor. The adjusted probability of having no usual source of care in the suburbs was 20.1 percent, and for no receipt of a routine

checkup in the suburbs it was 34.7 percent. The suburban advantage for these outcomes was greatly attenuated after adjustment for income and other demographics; in fact, the odds of being uninsured were significantly higher for suburbs than urban areas after adjustment (OR: 1.027; $p < 0:05$).

Meanwhile, not surprisingly, access and coverage barriers were more common for poor adults than for higher-income adults, with odds ratios on "poor" ranging from 1.7 for no checkup to 8.14 for being uninsured. Among poor adults, the odds of the outcomes were close to 1.0 across geographic area types and were significantly higher in suburban areas for being uninsured. Thus, poor adults in the suburbs fared similarly to their poor counterparts in urban and rural areas. Overall, this indicates that sizable barriers to coverage and access exist among people in different income categories. After adjustment, 36.4 percent of low-income suburbanites had an unmet need due to cost, and 42.4 percent had not had a recent check-up, compared to 15.7 percent and 34.7 percent for the full suburban population, respectively.

Table 3 compares outcomes in each type of geographic region before and after implementation of the ACA. In all three types of areas, our coverage and access outcomes significantly improved in the post-ACA period. For suburban areas, there was a 3.8-percentage-point drop in the uninsurance rate in the post ACA period compared to the pre-ACA trend; for urban areas, the comparable estimate was 4.6 percentage points, and for rural areas, it was 4.2 percentage points.

Sensitivity analyses with alternative definitions for suburban are in Appendix Exhibits A7 and A8, and analyses with standard errors clustered by state-geography are in Appendix Exhibit A9.[19] Across these models, rates of coverage and access challenges remained high among low income adults in suburban areas, similar to those in urban and rural areas.

Table 2: Predicted probabilities and odds ratios for coverage and access-to-care barriers in urban, suburban, and rural areas of the United States

	Urban (ref)	Suburban		Rural	
	Predicted probability (%)	Odds ratio	Predicted probability (%)	Odds ratio	Predicted probability (%)
Uninsured					
Unadjusted	18.66	0.770****	14.99	1.117***	20.37
Adjusted[a]	16.83	1.027**	17.13	1.190****	18.88
Among the poor[a]	41.13	1.061**	41.24	1.024	41.66
No usual source of care					
Unadjusted	23.47	0.765****	19.01	0.859****	20.86
Adjusted[a]	22.68	0.936****	20.08	0.947****	19.81
Among the poor[a]	40.29	0.925**	38.64	0.805****	35.80
Unmet need due to cost					
Unadjusted	16.68	0.830****	14.16	1.072****	17.57
Adjusted[a]	15.54	1.011	15.68	1.032**	15.93
Among the poor[a]	33.65	1.035	36.39	0.978	35.15
No receipt of a routine checkup					
Unadjusted	34.11	0.993	33.96	1.147****	37.26
Adjusted[a]	33.96	1.035****	34.70	1.089****	35.77
Among the poor[a]	41.53	1.041	42.44	1.037	42.35

SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text). NOTE Our definition of suburban is in the text. [a]Analyses adjusted for year, education, employment, marriage status, age, race, ethnicity, state, and federal poverty level category. **p < 0:05 ***p < 0:01 ****p < 0:001

Table 3 Predicted probabilities and odds ratios for coverage and access, before (2005–13) and after (2014–15) implementation of the Affordable Care Act (ACA) in urban, suburban, and rural areas of the United States

	Urban		Suburban		Rural	
	Odds ratio	Predicted probability (%)	Odds ratio	Predicted probability (%)	Odds ratio	Predicted probability (%)
Uninsured						
Pre ACA	Ref	17.51	Ref	17.45	Ref	17.41
Post ACA	0.646****	12.89	0.702****	13.64	0.679***	13.29
No usual source of care						
Pre ACA	Ref	21.07	Ref	21.03	Ref	21.02
Post ACA	0.965	20.56	1.058**	21.85	1.147****	23.04
Unmet need due to cost						
Pre ACA	Ref	15.81	Ref	15.77	Ref	15.73
Post ACA	0.735****	12.47	0.774****	12.96	0.763****	12.77
No receipt of a routine checkup						
Pre ACA	Ref	34.66	Ref	34.63	Ref	34.63
Post ACA	0.937****	33.29	0.963**	33.82	0.919****	32.86

SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text). NOTES Our definition of suburban is in the text. Analyses adjusted for year, education, employment, marriage status, age, race, ethnicity, federal poverty level category, and pre-ACA trend. Odds ratios represent the odds of the outcomes, comparing post ACA to pre ACA, for each geographic area. **p < 0:05 ***p < 0:01 ****p < 0:001

Discussion

In this national study of patterns of health care access and insurance coverage, we found that people living in suburban areas encounter substantial barriers to care. Although the suburbs do have a small advantage over urban and rural areas for our unadjusted study measures, overall uninsurance rates there were not low, and access barriers were quite common, particularly for low-income adults. After adjustment for demographic differences by area, rates of access to care were similar across all geographic areas. This implies that living in the suburbs provides little if any protective effect, after income and other demographic features are taken into account.

Overall, nearly 40 percent of the uninsured population in the United States lives in the suburbs, and though the uninsurance rate is lower in suburban areas than in urban and rural locations, they are nonetheless substantial: Nearly one of every seven suburban residents is uninsured. Furthermore, as the overall uninsurance rate in the United States decreased and access improved in recent years, in large part because of the ACA,[14,15] we found that the coverage and access gaps between urban and suburban areas essentially disappeared by 2015. Our analysis comparing the pre- and post-ACA periods appears to show differential change post ACA across these geographic areas, wherein coverage gains were greater in urban than suburban areas for some access measures. Despite improvements in access and coverage after the ACA took effect, our results also suggest that sizable barriers remain and that, if anything, gains may have been more limited in suburban areas.

IMPLICATIONS FOR POLICY

Our results show a large affordability gap based on income, with substantially worse access rates for the poor than the nonpoor across all geographies. Poverty in the suburbs likely

poses unique challenges and consequences for residents, particularly for low-income and uninsured residents who seek care from the health care safety-net. Safety-net providers deliver care to uninsured, low-income, and other vulnerable populations, and as these populations increase in a geographic area, local need for these services also likely rises. Though our results do not enable us to comment directly on this issue, there is reason to suspect that unique nonfinancial barriers to care may exist in the suburbs, which may require different solutions than those needed in urban or rural areas. Previous research shows that even after area poverty rates are controlled for, services and publicly funded infrastructure targeted to the poor are scarce in many suburban areas.[22] For instance, there are important gaps in the availability of health care services such as mental health, substance abuse treatment, and hospitals in suburban areas.[23] And though care systems and provider networks are often and increasingly located in high-income suburban areas with large privately insured populations,[11] many suburban physicians are less willing than their urban counterparts are to treat the uninsured and Medicaid beneficiaries, leaving poor suburban residents with limited options for physician care.[23]

Most policy approaches to bolster the health care safety net overlook the suburbs, focusing on urban and rural areas, which historically have had the greatest need. Many expansive suburban areas with large poor populations have few community health centers (CHCs) and small free clinics available.[23] While some federally qualified health centers (FQHCs) are in some suburban areas, expanding FQHC capacity in areas with growing needs can be difficult. Location and funding for these health centers are dependent on Medically Underserved Area/Population (MUA/MUP) designation from the Health Resources and Services Administration, which is determined based on a metric combining area-level percentage of residents living in poverty

and other indicators of care access and need. There are reports that some suburban areas attempting to gain MUA/MUP designation or establish FQHCs have been unable to do so because poor areas were balanced out by more affluent areas in the same census tract or because there were several large hospitals in the areas, giving the statistical appearance of sufficient provider capacity.[23,24]

Given the lack of health centers in suburban areas, emergency departments are often the Even accessing hospital or emergency care can be difficult for this population because of insufficient availability of safety-net hospitals, especially in high-poverty suburbs.[11] Because fewer suburban providers appear to be willing to treat uninsured patients, suburban patients often must travel long distances to urban safety-net providers.[25] On a broader scale, limited public transportation systems and sprawl in the suburbs may present unique barriers to low-income patients, given the long distances they must travel to obtain care.

Current policies that identify areas of medical need and determine safety-net location have not adapted to shifts in the geography of poverty, which makes it difficult to locate services and providers in suburban areas with high levels of need for free or low-cost care. Recent proposals by some states to limit medical transportation services in Medicaid[26] in particular could hamper access to care for suburban populations.

More generally, access and insurance gains post ACA were more limited in states that chose not to expand Medicaid.[15] We found that 68 percent of the suburban population resided in expansion states, compared to 54 percent among rural populations and 42 percent among urban populations. The larger representation of suburban areas in expansion states indicates the importance of the ACA Medicaid expansion for the suburban population, along with the potential coverage and access losses if the expansion is repealed. Despite this disproportionate

presence of suburbanites in expansion states, our findings indicate that the ACA has not differentially improved coverage and access for those in the suburbs.

IMPLICATIONS FOR RESEARCH

Most studies and reports on geographic disparities present urban-rural differences in health care access and outcomes, lumping suburban areas in with urban areas. For instance, a 2017 study comparing urban versus rural coverage rates in Medicaid expansion and non-expansion states found that expansion increased the likelihood of insurance for low-income populations in both areas.[27] Our study points to the need to consider suburban populations as well, particularly if the suburban poor population continues to increase. The potential technical differences in definition of suburban did not have a major impact on the trends identified in our analysis. Thus, which definition is used appears to be less critical than ensuring the identification of the suburbs as a geography independent of urban or rural areas. Such disaggregation by geography in survey design and data analysis is imperative for identifying, monitoring, and attempting to eliminate health disparities between populations living in different types of geographic areas. Given the heterogeneity that exists between types of suburbs, and the importance of census tract or area poverty level on service availability,[22] future research should also consider how differences in income levels within suburbs may affect access to care. Given our data set, our analysis was able to examine only family-level poverty in assessing barriers to care. But poor neighborhoods themselves have critical implications for health and care access. Areas of concentrated poverty (that is, with poverty rates exceeding 40 percent) are beginning to present challenges to suburbia.[28] Patterns of racial inequality typically seen in cities

are being replicated in the suburbs, with suburban low-income communities of color facing low-performing schools, poor public transport, limited economic opportunity, and minimal municipal capacity or motivation to address poverty.[4] These worrisome patterns reveal that more research is needed on the implications of concentrated suburban poverty and differential effects of suburban poverty by individual and community racial/ethnic composition.

Conclusion

This article contributes to a preliminary understanding of patterns of insurance coverage and access to care across suburban, urban, and rural areas of the United States. Our findings that nearly 40 percent of the uninsured live in the suburbs and that almost one in seven suburban residents is uninsured highlight the need for additional research in this area. We have shed some light on the large and growing number of poor Americans living in the suburbs, many of whom lack health insurance and experience difficulty gaining access to care. Overlooking the challenges faced by some residents of suburban areas—in particular, those with low incomes—ignores a large segment of the population. Increased attention to these issues will be critical to identifying the unique features of the suburbs that may present challenges to the health care safety net in serving vulnerable populations.

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Appendix 1

Appendix Exhibit A1: Predicted probabilities and odds ratios for coverage and access to care barriers in urban, suburban, and rural areas of the United States (Including 95% CI)

		Urban (Ref)		Suburban		Rural	
		Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI
Uninsured	*Unadjusted*	1 (18.66%)	Ref	0.770****(14.99)	(0.756, 0.784)	1.117***(20.37%)	(1.097, 1.137)
	Adjusted [a]	1(16.83%)	Ref	1.027**(17.13%)	(1.005, 1.049)	1.190****(18.88%)	(1.164 ,1.214)
	Among the poor [a]	1(41.13%)	Ref	1.061**(41.24%)	(1.013, 1.112)	1.024(41.66%)	(0.979, 1.072)
No Usual Source of Care	*Unadjusted*	1(23.47%)	Ref	0.765****(19.01%)	(0.752, 0.778)	0.859****(20.86%)	(0.845, 0.874)
	Adjusted [a]	1 (22.68%)	Ref	0.936****(20.08%)	(0.919, 0.953)	0.947****(19.81%)	(0.929, 0.966)
	Among the poor [a]	1 (40.29%)	Ref	0.925**(38.64%)	(0.881, 0.971)	0.805****(35.8%)	(0.767, 0.846)
Unmet Need due to cost	*Unadjusted*	1 (16.68%)	Ref	0.830****(14.16%)	(0.815, 0.845)	1.072****(17.57%)	(1.054, 1.091)
	Adjusted [a]	1 (15.54%)	Ref	1.011(15.68%)	(0.988, 1.084)	1.032*(15.93%)	(1.012, 1.053)
	Among the poor [a]	1 (33.65%)	Ref	1.035(36.39%)	(0.988, 1.084)	0.978(35.15%)	(0.935, 1.022)
No Receipt of a Routine Checkup	*Unadjusted*	1 (34.11%)	Ref	0.993(33.96%)	(0.980, 1.006)	1.147****(37.26%)	(1.132, 1.163)
	Adjusted [a]	1 (33.96%)	Ref	1.035****(34.7%)	(1.021, 1.05)	1.089****(35.77%)	(1.073 1.105)
	Among the poor [a]	1 (41.53%)	Ref	1.041(42.44%)	(0.954, 1.086)	1.037(42.35%)	(0.991, 1.085)

SOURCE: Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text). NOTE: Uses Definition 1 of suburban, in the text [a] Analysis adjusted for year, education, employment, marriage status, age, race, ethnicity, state and Federal Poverty level category. CI is confidence interval. **p<0.5 ***p<.01 ****p<.001

Appendix Exhibit A2: Predicted Probabilities and Odds Ratios for Coverage and Access, Pre ACA (2005-2013) and Post ACA (2014-2015) Implementation, by Geographic Area (Including 95% CI)

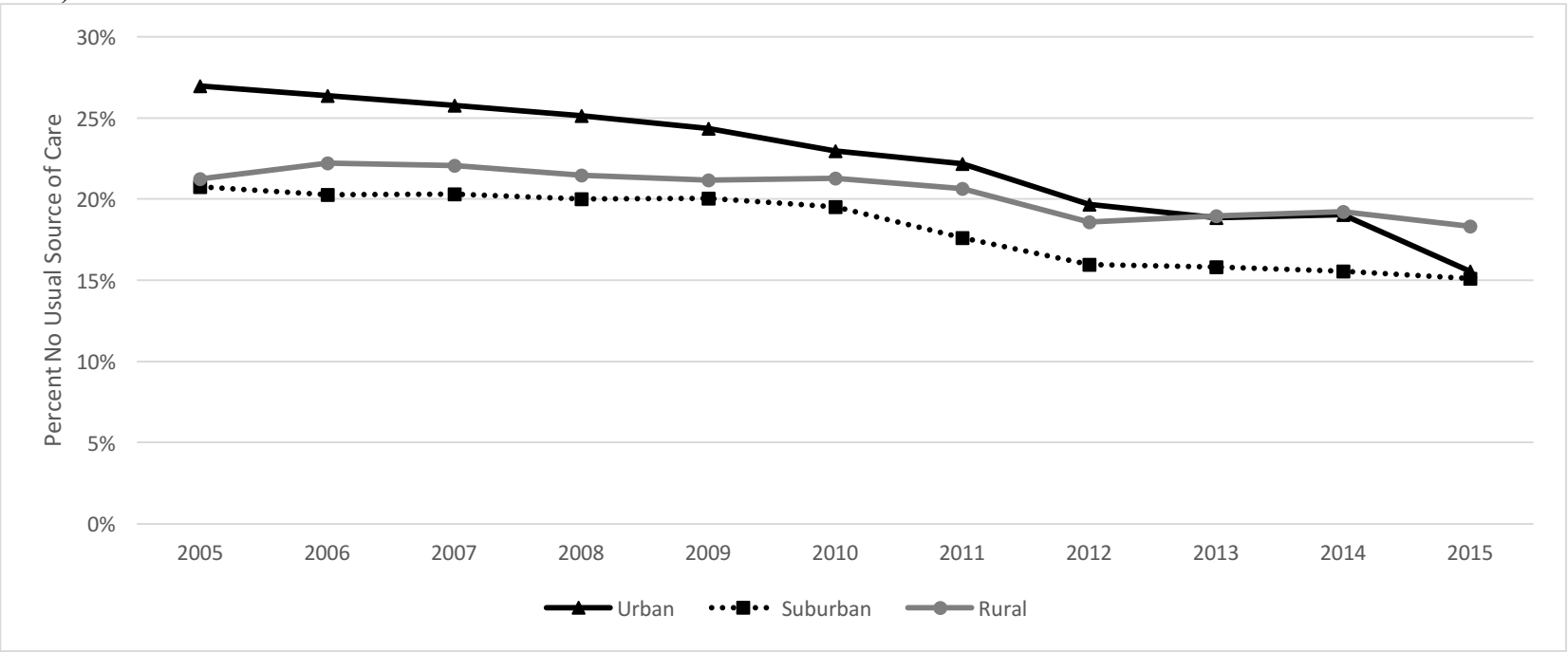
		Urban		Suburban		Rural	
		Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI
Uninsured	*Pre ACA*	1(17.51%)	Ref	1(17.45%)	Ref	1(17.41%)	Ref
	Post ACA	0.646****(12.89%)	(0.614,0.681)	0.702****(13.64%)	(0.663, 0.744)	0.679***(13.29%)	(0.642, 0.744)
No Usual Source of Care	*Pre ACA*	1(21.07%)	Ref	1(21.03%)	Ref	1(21.02%)	Ref
	Post ACA	0.965(20.56%)	(0.924, 1.007)	1.058**(21.85%)	(1.009, 1.110)	1.147****(23.04%)	(1.093, 1.204)
Unmet Need due to cost	*Pre ACA*	1(15.81%)	Ref	1(15.77%)	Ref	1(15.73%)	Ref
	Post ACA	0.735****(12.47%)	(0.702,0.769)	0.774****(12.96%)	(0.737, 0.814)	0.763****(12.77%)	(0.725, 0.802)
No Receipt of a Routine Checkup	*Pre ACA*	1(34.66%)	Ref	1(34.63%)	Ref	1(34.63%)	Ref
	Post ACA	0.937****(33.29%)	(0.907, 0.968)	0.963**(33.82%)	(0.930, 0.996)	0.919****(32.86%)	(0.886, 0.953)

SOURCE: Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text). NOTE: Uses Definition 1 of *suburban*, in the text. Analyses adjusted for year, education, employment, marriage status, age, race, ethnicity, Federal poverty Level category and pre ACA trend. Odds ratios represent the odds of the outcomes, comparing post ACA to pre ACA, for each geographic area. CI is confidence interval. **p<0.5 ***p<.01 ****p<.001

Appendix Exhibit A3: Alternative Definitions of Suburban Areas

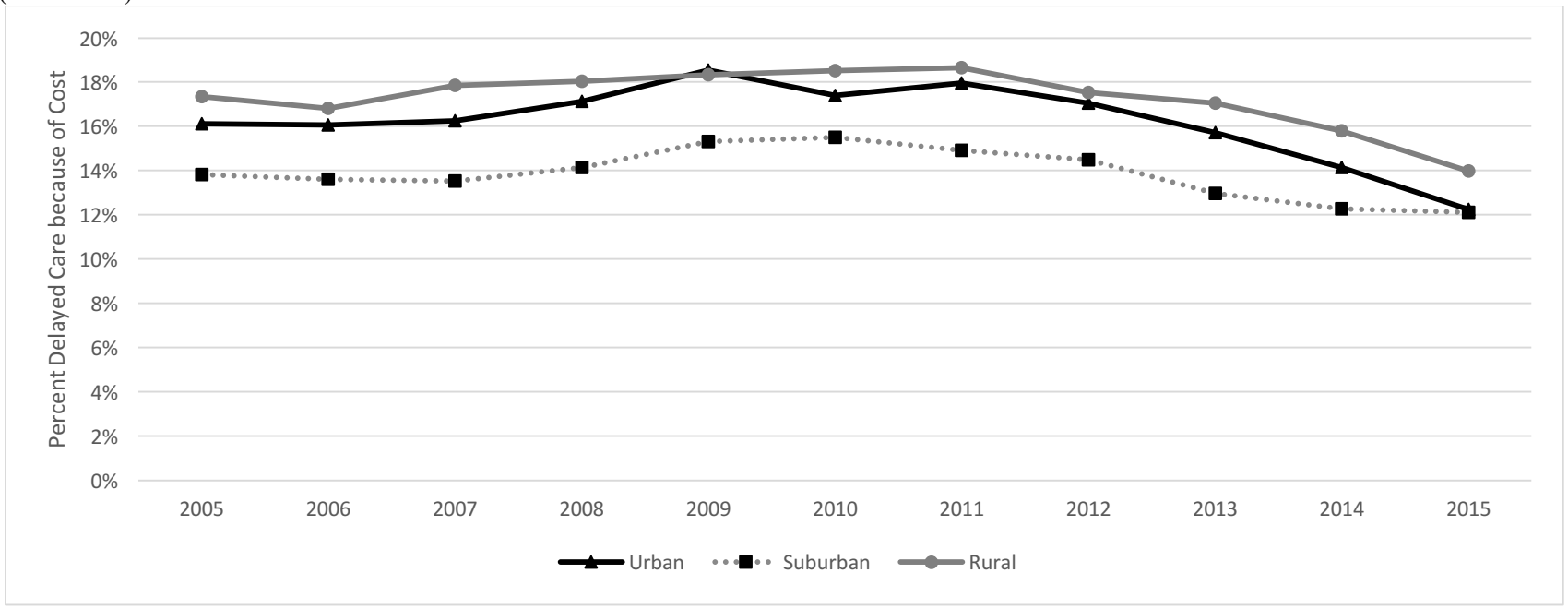
Definition 2: • "Urban" includes both the center city and area within a county with a center city that is urban. "Suburban" includes only suburban counties of an MSA (similar to definition by Allard and Roth). Rural" is defined as not within a MSA.
Definition 3: • Urban" is limited to the center city of an MSA, while the suburbs are divided into two categories – the inner suburb that is beyond the city center but with the county containing the center city, and the outer suburb, which is any suburban county of the MSA. Rural" is defined as not within a MSA.

Appendix Exhibit A4: Rate of No Usual Source of Care Among Non-Elderly Adults in Urban, Suburban and Rural Areas (2005-2015)



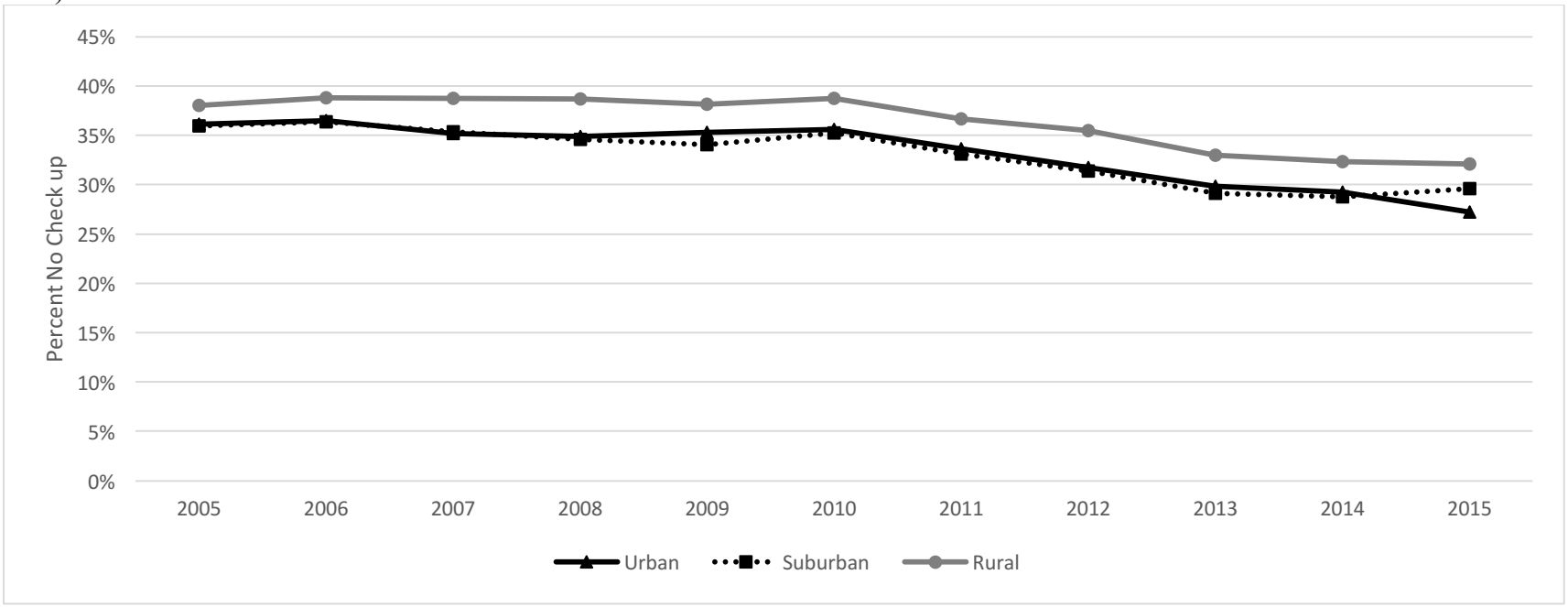
SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text).
NOTE Uses Definition 1 of *suburban*, in the text.

Appendix Exhibit A5: Rate of Delayed Care because of Cost in the Past Year Among Non-Elderly Adults in Urban, Suburban and Rural Areas (2005-2015)



SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text).
NOTE Uses Definition 1 of *suburban*, in the text

Appendix Exhibit A6: Rate of No Check up in the Past Year Among Non-Elderly Adults in Urban, Suburban and Rural Areas (2005-2015)



SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text).
NOTE Uses Definition 1 of *suburban,* in the text

Appendix Exhibit A7: Predicted Probabilities and Odds Ratios for Coverage and Access to Care Barriers, in urban, suburban and rural areas of the United States (Suburban Definition 2)

		Urban (Ref)		Suburban		Rural	
		Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI
Uninsured	*Unadjusted*	1 (17.20%)	Ref	0.822**** (14.58%)	(0.903, 0.840)	1.232**** (20.38%)	(1.212, 1.252)
	Adjusted [a]	1 (16.68%)	Ref	1.061**** (17.54%)	(1.035, 1.088)	1.19**** (18.91%)	(1.167 , 1.213)
	Among the poor [a]	1 (42.08%)	Ref	0.986* (41.75%)	(0.931, 1.044)	0.922(40.25%)	(0.885, 0.960)
No Usual Source of Care	*Unadjusted*	1 (22.00%)	Ref	0.737**** (17.21%)	(0.722, 0.752)	0.936**** (20.89%)	(0.922, 0.951)
	Adjusted [a]	1 (21.41%)	Ref	0.921**** (20.23%)	(0.900, 0.942)	0.93**** (20.40%)	(0.914, 0.946)
	Among the poor [a]	1 (40.24%)	Ref	0.866*** (37.21%)	(0.813, 0.923)	0.758**** (34.47%)	(0.725, 0.792)
Unmet Need due to cost	*Unadjusted*	1 (15.56%)	Ref	0.894**** (14.15%)	(0.876, 0.913)	1.157**** (17.57%)	(1.139, 1.175)
	Adjusted [a]	1 (15.54%)	Ref	1.033** (15.93%)	(1.009, 1.058)	1.035**** (15.95%)	(1.016, 1.054)
	Among the poor [a]	1 (35.83%)	Ref	1.042(36.76%)	(0.983, 1.01)	0.966**** (35.19%)	(0.928, 1.006)
No Receipt of a Routine Checkup	*Unadjusted*	1 (34.28%)	Ref	0.943*** (32.97%)	(0.929, 0.957)	1.139**** (37.27%)	(1.125, 1.153)
	Adjusted [a]	1 (34.13%)	Ref	1.057**** (35.31%)	(1.040, 1.075)	1.082**** (35.81%)	(1.067 1.097)
	Among the poor [a]	1 (41.75%)	Ref	1.06** (43.1%)	(1.001, 1.125)	1.03(42.41%)	(0.988, 1.074)

SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text). NOTE Analysis uses Suburban Definition 2 (see Appendix Exhibit A3). [a] Analysis adjusted for year, education, employment, marriage status, age, race, ethnicity, state and Federal Poverty Level category. CI is confidence interval ** p<0.5 *** p<.01 **** p<.001

Appendix Exhibit A8: Predicted Probabilities and Odds Ratios for Coverage and Access to Care Barriers, in urban, suburban and rural areas of the United States (Suburban Definition 3)

		Urban (Ref)		Inner Suburb		Outer Suburb		Rural	
		Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI
Uninsured	*Unadjusted*	1(18.64%)	Ref	0.784**** (15.23%)	(0.767,0.801)	0.745**** (14.58%)	(0.767,0.801)	1.117**** (20.38%)	(1.097, 1.13)
	Adjusted[a]	1(16.81%)	Ref	1.009 (16.91%)	(0.984, 1.034)	1.065**** (17.54%)	(1.036,1.094)	1.194**** (18.91%)	(1.169, 1.219)
	Among the poor[a]	1(41.87%)	Ref	1.027 (42.45%)	(0.974, 1.083)	0.995 (41.74%)	(0.937, 1.058)	0.930*** (40.23%)	(0.890, 0.972)
No Usual Source of Care	*Unadjusted*	1(23.47%)	Ref	0.815**** (20.00%)	(0.9, 0.938)	0.678****(17.21%)	(0.663,0.692)	0.861**** (20.89%)	(0.847, 0.876)
	Adjusted[a]	1(21.84%)	Ref	0.927**** (20.75%)	(0.908,0.947)	0.893****(20.22%)	(0.872, 0.915)	0.903[1]*** (20.38%)	(0.886, 0.921)
	Among the poor[a]	1(40.92%)	Ref	0.915*** (39.03%)	(0.866,0.966)	0.84**** (36.23%)	(0.786, 0.897)	0.736**** (34.52%)	(0.701, 0.772)
Unmet Need due to cost	*Unadjusted*	1(16.58%)	Ref	0.830**** (14.16%)	(0.813,0.848)	0.829****(14.15%)	(0.811, 0.847)	1.072**** (17.577%)	(1.054, 1.091)
	Adjusted[a]	1(15.64%)	Ref	0.994 (15.57%)	(0.971,1.017)	1.021 (15.88%)	(0.996, 1.047)	1.016 (15.82%)	(0.996, 1.036)
	Among the poor[a]	1(35.61%)	Ref	1.027 (36.22%)	(0.975,1.084)	1.049 (36.77%)	(0.989, 1.113)	0.975 (35.18%)	(0.933, 1.018)
No Receipt of a Routine Checkup	*Unadjusted*	1(33.78%)	Ref	1.017** (34.51%)	(1.002,1.033)	0.95*** (32.97%)	(0.935, 0.964)	1.147**** (37.26%)	(1.132, 1.163)
	Adjusted[a]	1(33.94%)	Ref	1.021*** (34.37%)	(1.004,1.037)	1.067**** (35.32%)	(1.048, 1.086)	1.091**** (36.02%)	(1.075 1.108)
	Among the poor[a]	1(41.51%)	Ref	1.03 (42.17%)	(0.977,1.086)	1.052** (43.09%)	(1.008, 1.139)	0.980*** (42.40%)	(0.994, 1.089)

SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text). NOTE Analysis uses suburban Definition 3 (see Appendix Exhibit A3). [a] Analysis adjusted for year, education, employment, marriage status, age, race, ethnicity, state and Federal Poverty Level category. CI is confidence interval ** p<0.5 *** p<.01 **** p<.001

Appendix Exhibit A9: Predicted Probabilities and Odds Ratios for Coverage and Access to Care Barriers, in urban, suburban and rural areas of the United States, with Clustering

		Urban (Ref)		Suburban		Rural	
		Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI	Odds Ratio (Predicted Probability)	95% CI
Uninsured	*Unadjusted*	1 (18.66%)	Ref	0.770** (14.99%)	(0.611, 0.970)	1.117(20.37%)	(0.904, 1.379)
	Adjusted [a]	1 (16.99%)	Ref	0.973(16.67%)	(0.773, 1.225)	1.230** (19.52%)	(1.016 ,1.489)
	Among the poor [a]	1 (40.84%)	Ref	1.014(41.15%)	(0.695, 1.48)	1.187(44.81%)	(0.886, 1.59)
No Usual Source of Care	*Unadjusted*	1(23.47%)	Ref	0.765** (19.01%)	(0.591, 0.99)	0.859**** (20.86%)	(0.712, 1.042)
	Adjusted [a]	1 (22.03%)	Ref	0.878(20.15%)	(0.746, 1.034)	0.932(21.0%)	(0.805, 1.079)
	Among the poor [a]	1 (40.40%)	Ref	0.908(38.34%)	(0.744, 1.107)	0.815**** (36.11%)	(0.683, 0.973)
Unmet Need due to cost	*Unadjusted*	1 (16.68%)	Ref	0.830** (14.16%)	(0.716, 0.961)	1.072(17.57%)	(0.928, 1.239)
	Adjusted [a]	1 (15.76%)	Ref	0.991(15.51%)	(0.873, 1.126)	1.051(15.94%)	(0.931, 1.187)
	Among the poor [a]	1 (35.31%)	Ref	1.019(35.74%)	(0.805, 1.29)	1.081(37.17%)	(0.897, 1.301)
No Receipt of a Routine Checkup	*Unadjusted*	1 (34.11%)	Ref	0.993(33.96%)	(0.869, 1.134)	1.147** (37.26%)	(1.011, 1.302)
	Adjusted [a]	1 (34.31%)	Ref	0.985(34.17%)	(0.892, 1.088)	1.072(36.29%)	(0.97, 1.184)
	Among the poor [a]	1 (41.66%)	Ref	0.998(41.69%)	(0.878, 1.134)	1.060(43.46%)	(0.932, 1.205)

SOURCE Authors' analysis of data from the Behavioral Risk Factor Surveillance System, 2005–15 (see Note 16 in text) NOTE Analysis uses suburban Definition 1, in the text. [a] Analysis adjusted for year, education, employment, marriage status, age, race, ethnicity, state and Federal Poverty Level category. CI is confidence interval. Analysis used robust standard errors, with clusters at the state and geography level. CI is confidence interval. ** p<0.5 *** p<.01 **** p<.001

Appendix 2: Extended Definitions of Suburbs

We compared the demographic profiles of the sample using our three definitions of suburbs (see Appendix2 Exhibit A1). There was one notable difference between our main definition and the other two definitions: the percentage of the population in urban places is much larger for Definition 2 (66% of the population vs only 15% in suburbs). For Definition 3, the urban population is more evenly split between areas (38.4% urban, 28.2% inner suburb, 28.2% outer suburb, and 17.7% rural).

Appendix 2 Exhibit A3 displays the percentage of the population, uninsured rate, and proportion of the uninsured in urban, suburban, and rural areas, for all three geographic definitions. The share of uninsured Americans in the suburbs ranged from 13% to 40%, depending on which definition of suburbs was used, while the uninsured rate was close to 15% across all three definitions.

Appendix 2 Exhibit A1: Demographic Characteristics for Geography Definition 2

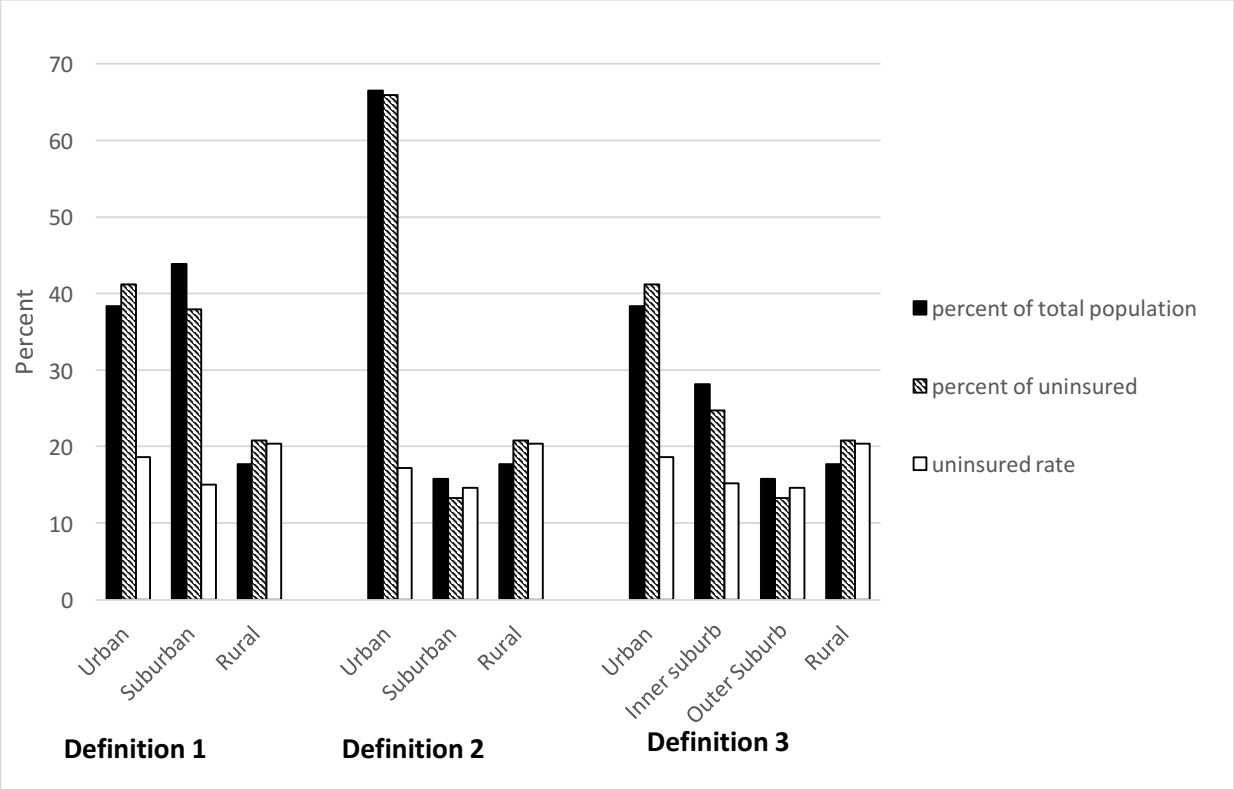
	Urban N= 1,796,895	**Suburban** N= 424,923	**Rural** N= 478,507	**P-value**
Variables				
Total Population	66.54%	15.74 %	17.72%	<0.001
Sex (Male)	48.51%	48.26%	48.65%	<0.001
Age				
18-24	13.14%	11.89%	13.07%	<0.001
25-34	19.48%	18.06%	18.43%	<0.001
35-44	23.27%	24.01%	20.89%	<0.001
45-54	24.17%	25.37%	24.69%	<0.001
55-65	19.94%	20.67%	22.92%	<0.001
Education				
Less than HS	11.25%	8.02%	12.44%	<0.001
HS	25.11%	28.64%	36.35%	<0.001
College Plus	63.14%	64.01%	51.00%	<0.001
DN/refus/miss	0.49%	0.32%	0.21%	<.0001
Married	58.86%	63.94%	62.92%	<0.001
Working	67.09%	69.69%	65.80%	<0.001
Race/Ethnicity				
White	60.59%	76.38%	81.00%	<0.001
Black	11.80%	9.38%	6.84%	<0.001
Hispanic	16.29%	6.69%	5.56%	<0.001
Asian	1.21%	0.62%	0.22%	<0.001
Other Race	7.10%	5.04%	4.73%	<0.001
DN/refus/miss	1.01%	1.05%	0.73%	<0.001
Income Level				
Poor	14.16%	9.27%	14.71%	<0.001
Near Poor	16.03%	14.50%	21.21%	<0.001
Middle class	12.45%	13.51%	16.56%	<0.001
Upper middle class	7.30%	8.01%	8.95%	<0.001
Upper class	38.16%	42.13%	25.62%	<0.001
DN/NS/Miss/Ref	11.91%	12.58%	12.95%	<0.001

Appendix 2 Exhibit A2: Demographic Characteristics for Geography Definition 3

	Urban N= 1,036,189	**Inner Suburb** N= 760,706	**Outer Suburb** N= 424,923	**Rural** N= 478,507	**P-value**
Variables					
Total population	38.37%	28.17%	15.73 %	17.72%	<0.001
Sex (Male)	48.46%	48.57%	48.26%	48.65%	<0.001
Age					
18-24	13.37%	12.84%	11.89%	13.07%	<0.001
25-34	20.23%	18.46%	18.06%	18.43%	<0.001
35-44	22.86%	23.82%	24.01%	20.89%	<0.001
45-54	23.65%	24.89%	25.37%	24.69%	<0.001
55-65	19.89%	20.00%	20.67%	22.92%	<0.001
Education					
Less than HS	12.12%	10.08%	8.02%	12.44%	<0.001
HS	25.01%	25.25%	28.65%	36.35%	<0.001
College Plus	62.40%	64.16%	63.01%	51.00%	<0.001
DN/refus/miss	0.47%	0.51%	0.32%	0.21%	<.0001
Married	55.60%	63.30%	64.94%	62.92%	<0.001
Working	66.17%	68.36%	69.69%	65.80%	<0.001
Race /Ethnicity					
White	55.44%	67.61%	76.39%	81.00%	<0.001
Black	15.12%	7.27%	9.38%	6.84%	<0.001
Hispanic	17.53%	14.59%	6.69%	5.56%	<0.001
Asian	1.33%	1.05%	0.62%	0.23%	<0.001
Other Race	7.33%	6.79%	5.04%	4.73%	<0.001
DN/refus/miss	1.10%	0.89%	1.05%	0.73%	<0.001
House Hold Income					
Poor	15.61%	12.18%	9.27%	14.71%	<0.001
Near Poor	17.03%	14.66%	14.50%	21.21%	<0.001
Middle class	12.50%	12.38%	13.51%	16.56%	<0.001
Upper middle class	7.31%	7.29%	8.01%	8.95%	<0.001
Upper class	35.32%	42.02%	42.13%	25.62%	<0.001
DN/NS/Miss/Ref	12.22%	11.47%	12.58%	12.95%	<0.001

SOURCE: Authors' Analysis of BRFSS data, https://www.cdc.gov/brfss/annual_data/annual_data.htm **NOTES:** P-values represent chi-square test for significant differences in each demographic variable across the geographic areas.

Appendix 2 Exhibit A3: Percent of the Population, Percent of the Uninsured and Uninsured Rate 2005-2015



SOURCE: Authors' Analysis of BRFSS data, https://www.cdc.gov/brfss/annual_data/annual_data.htm **NOTES:** Analysis adjusted for survey design and weights.

Chapter 2

Gentrification, Neighborhood Change, and Population Health: A Systematic Review

Introduction

Variation in health correlates strongly with the patterning of social inequality; worse neighborhood conditions are associated with worse health at the neighborhood and individual level (Pickett & Pearl, 2001; Stafford & Marmot, 2003). Many public health scholars argue that these underlying social and area-level factors play essential roles in producing area-level health variation and inequities (Diez-Roux 1998, Blakely and Woodward 2000). One such neighborhood factor is gentrification, a process where central urban neighborhoods that have undergone disinvestments and economic decline experience a reversal, reinvestment, and the in-migration of a relatively well-off population (Smith, 1998). Gentrification often includes increases in housing prices and amenities, and distinct shifts in the residential, social, cultural, and political context of a neighborhood.

Though the term gentrification was initially coined in London in the 1960s and refers to an influx of higher socioeconomic status (SES) residents to historically disinvested neighborhoods, gentrification of inner-city neighborhoods in the U.S. has attracted attention since the 1970's (Ellen, 2016). In the following decades, low-income, predominantly white neighborhoods in a small number of cities experienced reversals in SES decline, catalyzing a wave of research (Lance Freeman, 2009). Over the past two decades, the scope and scale of gentrification have increased dramatically and created more extreme neighborhood change (Hwang & Lin, 2016): prevalence, measured by the greater proportion of metro areas with at least one downtown tract experiencing gentrification, has increased (Hwang & Lin, 2016);

compositional shifts towards higher socioeconomic status (SES) residents have accelerated (Baum-Snow & Hartley, 2016 2236; Couture & Handbury, 2015); and the process has expanded into historically Black neighborhoods (Lance Freeman & Cai, 2015). Shifts in the composition of neighborhoods – increases in white, young, college-educated households in – rather than overall population growth and redevelopment of dilapidated housing, characterize these changes (Couture & Handbury, 2015; Guerrieri, Hartley, & Hurst, 2013). Notwithstanding such changes, historical patterns of neighborhood disadvantage continue, and the average downtown neighborhood continues to have lower SES compared to metro areas as a whole (Guerrieri et al., 2013).

Increased gentrification and urban redevelopment are parts of a more extensive process of metropolitan reorganization in the U.S., whereby higher-income populations are moving to back to cities, often to historically low-income communities of color. Conversely, less economically advantaged populations are moving, or are being pushed out, to suburbs (Hyra 2014). These changes have begun to invert the geographic patterns that predominated since World War II (Anacker, 2015; Gould Ellen & Ding, 2016), where, due to systematic housing discrimination, many U.S. metropolitan areas have racially segregated low-income urban neighborhoods and higher-income suburbs. However, by 2014, three million more low-income individuals lived in the suburbs than in urban areas (Allard 2017). By 2010, more than half of all large U.S. cities had at least one gentrifying neighborhood (Hwang & Lin, 2016), creating new geographic distributions of neighborhood and metropolitan area inequity.

The increased incidence and virulence of gentrification and other neighborhood change processes- significant shifts in neighborhoods' demographic characteristics over time - have provoked a renewed interest in these processes. Various social science disciplines have produced

numerous works on gentrification, but most focus on causes and trends, with limited investigation of gentrification's consequences beyond the debate on displacement (Newman and Wyly 2006, Freeman 2005, Ding, Hwang, and Divringi 2015, Desmond and Gershenson 2017), crime (Papachristos et al., 2011) (Lee 2010, Barton 2016b), and a small number of studies on economic impacts (Dastrup and Ellen 2016, Ding and Hwang 2016, Ellen and O'Regan 2011, McKinnish, Walsh, and White 2010). Studies of gentrification and urban development, media sources (Schumaker 2018), and affected communities (Justa 2014, NextShift 2018) suggest that these processes likely impact health. However, there is limited evidence of how the process impacts population health, health behaviors, and access to health care in the U.S. To our knowledge there have been no systematic efforts to scope the existing literature on the subject.

Researchers have hypothesized both beneficial and detrimental health consequences of gentrification, particularly for low-income populations (Venis Wilder, Makoba, and Arniella 2017, Mehdipanah et al. 2017, Formoso, R, and M 2010). For populations able to stay in gentrifying neighborhoods, substantial health benefits may accrue from poverty de-concentration; reduced segregation;, enhanced safety; and improved resources, amenities (e.g., public parks), and economic opportunities (Byrne 2002), as suggested by the vast body of literature examining the adverse health effects of exposure to concentrated poverty and residential segregation (Kramer & Hogue, 2009 ; Williams & Collins, 2001). However, the evidence on the economic risks and benefits to individuals and neighborhoods is limited (Lees 2008, Walks and Maaranen 2008), and debate remains about the direction of the relationship between gentrification and crime (Lee 2010, Papachristos et al. 2011, Barton 2016b).

These same change forces can create neighborhoods of extreme income inequality (Chapple 2017) and exacerbate income polarization and inequality (Walks and Maaranen 2008);

break down social cohesion and organizations; and displace culture, businesses and political power, all of which can have potential negative health effects (Kawachi, Berkman, and Glymour 2014). Some low-income families may be displaced (Formoso, R, and M 2010), creating financial strain from moving and possible eviction, change in neighborhood resources (e.g., schools), exposure and responses to discrimination and social marginalization, and disruption of protective social connections in prior neighborhoods and resiliency strategies (Betancur 2011). For low-income populations who remain in changing neighborhoods, perception and anticipation of displacement can present a substantial psychosocial burden, which acts as risk factors for a range of adverse outcomes (Shmool et al. 2015). Additionally, higher rent, a common side effect, and indictor of gentrification, reduce available income for required medication or health care, healthy food, and leisure activities (Newman and Holupka 2014). These factors impact families' ability to achieve health.

We also do not fully understand whether the health effects of gentrification differ from those related to urban development and other neighborhood change processes involving economic increases and if such processes are protective or detrimental to health. This review draws explicitly on Ecosocial theory (Krieger, 2001a) in framing how to examine gentrification and health, and situates gentrification in its historical context, as a recent manifestation of multi-generational patterns of residential segregation and economic divestment (Hwang and Sampson 2014).

Here, we present an original systematic search assessing the quantitative effects of gentrification, urban development, and neighborhood change on health in the U.S. Such an analysis can aid in better understanding how these neighborhood socioeconomic and cultural changes impact equity, specifically disparities in health and health care access.

Methods

LITERATURE SEARCH

We conducted our systematic review according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al. 2015).

SEARCH STRATEGY

To identify empirical studies that examine associations between gentrification, and other differently termed but similar neighborhood change processes, and health outcomes published between January 1, 2000, and March 31, 2018, we performed a literature review in five electronic databases: Pubmed, Sociological Abstracts, Web of Science, Academic Search Premier, and EconLit. These databases index journals from each of the major fields that have produced articles on neighborhood effects research.

We compiled a list of exposure terms from the authors' knowledge of the literature, previous searches on the topics, and term review by topic experts. These included gentrification, as well as similar processes of socioeconomic assent, community development/revitalization, and neighborhood change. We expand our search beyond just gentrification because the term is contentious, and authors use multiple terms to describe the same process/phenomena. We explicitly did not include words such as eviction or displacement, as they represent possible consequences of gentrification, or mediators in the relationship between gentrification and health.

Health outcomes were based on outcomes previously examined in neighborhood effects research (Arcaya et al. 2016). The search terms fell into three broad categories: geography, exposures, and health outcome/behavior terms (See Appendix 3 Exhibit 1 for search terms

according to groups). We combined terms within the first two broad categories with the Boolean operator "AND", then combined these with the health outcomes. We searched title and abstracts in all databases, and if available by the database, additionally searched MESH terms and keywords. See Appendix 3 Exhibit 2 for an example of search terms used in PubMed.

We also examined the reference lists of included articles, referred to as the "snowball search," and searched the grey literature on Google using a series of search terms. We additionally searched Google for grey literature (government, Think-Tank, Non-profit reports, etc) using various search terms combining the exposure and outcome terms from Exhibit 2, combined with the name of large cities (E.g., New York, Chicago, San Francisco). Though the search identified a number of reports, none included quantitative estimates of the relationship between gentrification and health. We, therefore, exclude the details of this search strategy We did not perform a formal meta-analysis on included studies because of the diversity of outcomes assessed in the various included articles.

INCLUSION/EXCLUSION CRITERIA

To be included, studies had to be the primary analysis, of any study that described the empirical relationship(s) between gentrification, or similar processes, and health at the neighborhood or community level. We limited our search to English-language articles with a U.S. study population, because the context, drivers, and thus implications of gentrification and neighborhood change in other countries differ substantially from the U.S., given the history and legacy of residential racial segregation in the U.S, which created unique neighborhoods of concentrated poverty, and consequential opportunity for reinvestment in previously disinvested communities (Massey and Denton 1993).

During the second round of full text assessment we excluded studies on general crime as an outcome, but included studies that assessed homicide or violent crime specifically, as general crime is not a health outcome. Additionally, we excluded articles that evaluated stagnant neighborhood poverty and increasing neighborhood poverty; articles that did not identify the direction of neighborhood socioeconomic change; or studies in which participants moved, but neighborhoods did not undergo change, because they did not meet our definition of gentrification and related neighborhood processes. Finally, we also excluded articles in which there was no quantitative assessment between the exposure and health outcome were also excluded.

STUDY SELECTION AND DATA EXTRACTION

Once all identified bibliographic records from the electronic databases were compiled, titles and abstracts were reviewed by ASM and JJ using the above eligibility criteria. The same authors then reviewed and cross-checked the abstract and full articles to verify inclusion criteria. This process was then repeated by ASM, and any disagreement on inclusion was resolved through discussion. A second full-article review was then conducted by both authors during the data extraction process, and additional articles were excluded. To quantitatively assess how gentrification affects health, only data from empirical studies were extracted and entered into a database (see Appendix 3 Table 3).

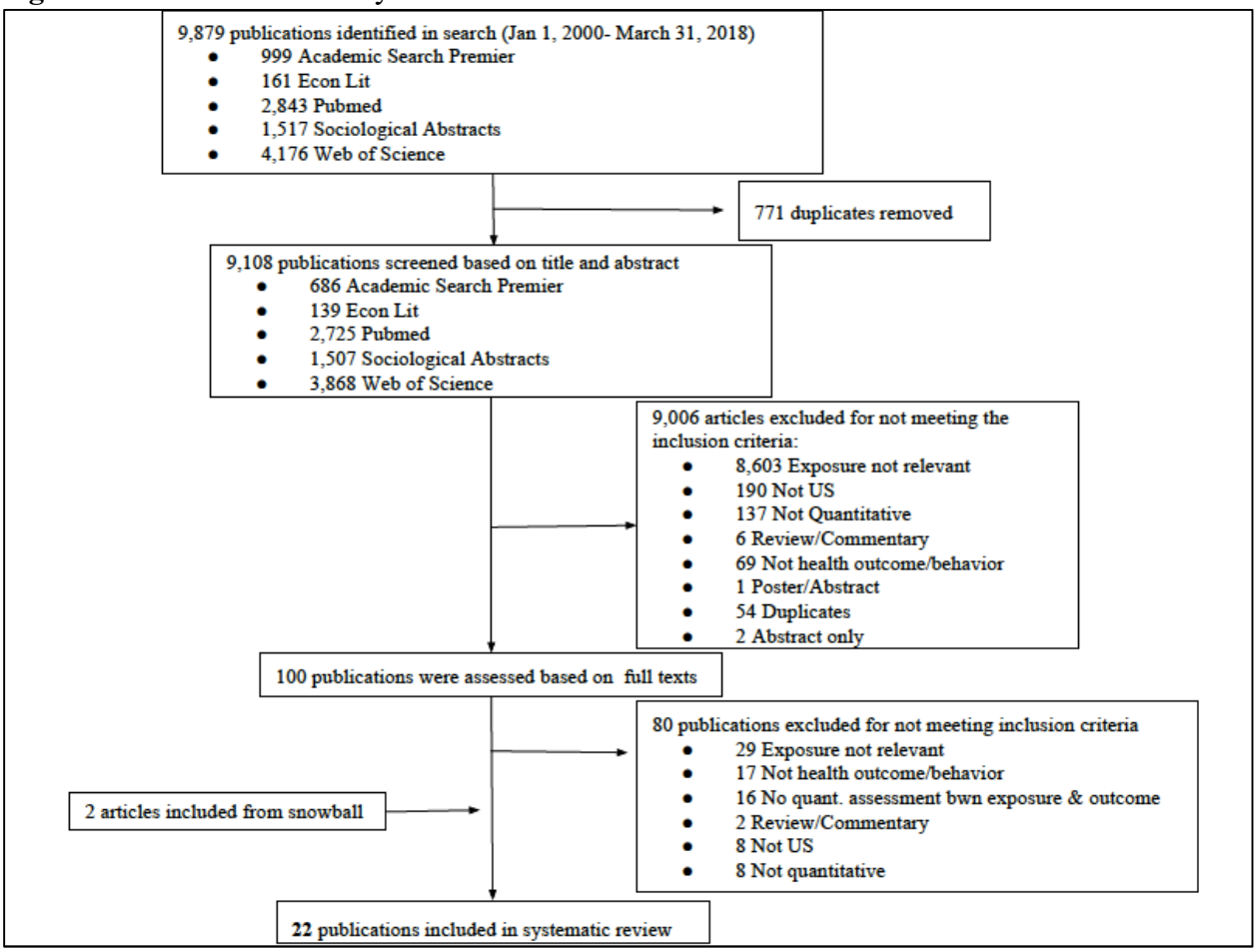
To understand how gentrification has been conceptualized and operationalized, we recorded how the exposure was named and measured, and the description of the construct. Additionally, we report the main results and findings, and direction of results, as related to the effects of gentrification on health. Table 4 also displays the author(s), title, year, hypothesized effect and direction, and effect estimate and direction. Though not shown in Table 4, we also extracted information on discipline of publishing journal, explicit mention of guiding

theory/framework and theory/framework name, stated article purpose, neighborhood definition, connections between gentrification and health, dataset used, years studied and study location, study design, covariates assessed, and mediators and moderators considered. We additionally assessed if studies took a historical perspective on the process of gentrification (examining the history of community development policy or disinvestment in that area), if race/ethnicity was explicitly mentioned or operationalized in the definitions of the exposure (i.e., defining gentrification as a process including racial/ethnic demographic change), and whether the study required that neighborhoods were low-income or disinvested in the base year to be eligible for gentrification. These three areas are major areas of controversy in the gentrification literature, and therefore we sought to understand how health-related assessments of gentrification considered these questions.

Results

See Figure 2 for study selection flow-chart. The five database search yielded 9,879 articles. After removing duplicates, 9,108 articles remained. The majority of these articles (8,603) were excluded because they did not study a gentrification-relevant exposure, and an additional 190 articles did not examine U.S. populations. We included 100 articles in our first full-text review, but excluded an additional 83 publications during the data extraction phase, again primarily because they did not examine a gentrification-relevant exposure, leaving 20 articles that met inclusion criteria. We included an additional 2 articles from the snowball search strategy, for a total of 22 included articles.

Figure 2: Flowchart for Study Selection



Appendix 3 Exhibit 3 shows the author and publication year, primary exposure name, exposure definition, hypothesized effect and direction of the effect, and the resulting estimated effect and direction of the effect of the 22 included studies.

Table 4 summarizes the publication year of the included articles, study population geographic location, exposure definition, and outcome(s). Study publication was concentrated in the years after 2005, and only one article was published before 2005, using data from the 1980s and 1990s. The remaining articles were approximately evenly split between 2005 and 2018. Articles focused on various areas across the country, though nearly a third of articles examined

East coast cities (New York and Philadelphia specifically); and, a number of articles (three) also examined Chicago and St Louis.

Table 4: Characteristics of 22 empirical quantitative studies of neighborhood change and health

	No. of studies	% of total studies
Year Published		
2000-2004	1	4.5%
2005-2009	8	36.4%
2010-2014	6	27.3%
2015-2018	7	31.8%
Location		
National[b]	1	4.6%
Multicounty (CA, Kansas, Oregon)	3	13.6%
West Coast County (Cook County, WA; San Diego, CA)	2	9.1%
East Coast City (New York City, NY; Philadelphia, PA)	7	31.8%
Midwest City (Chicago,IL ; St Louis, MI)	5	22.7%
West Coast City (Los Angeles [b,] Seattle, Santa Ana CA)	3	13.6%
Southern City (Birmingham, AL; Dallas, TX; West Wabasso, FL)	3	13.6%
Exposure Name		
Gentrification	9	40.1%
Community/Neighborhood Change/Trajectory	5	22.7%
Neighborhood Context (affluence/gentrification)/Neighborhood position	2	4.5%
Revitalization/Improvement/Renewal/Development	4	18.2%
Other (Renovation, instability)	1	9.1%
Outcome		
Homicide/violence/safety/mortality	8	26.3%
Birth Outcomes	3	13.6%

Table 4 (Continued)		
Health behavior (physical activity, health care access, children's behavioral health)	3	13.6%
Chronic disease (cancer, weight gain, hypertension)	3	13.6%
Self-Rated Health/general illness	2	9.1%
Mental Health	2	9.1%
Other (blood lead levels)	1	4.6%

[a]One study included both a longitudinal and cross-sectional study design
[b] One study included both a national and LA specific analysis

EXPOSURES AND OUTCOMES

More than a quarter (eight) of the articles examined homicide, violence, safety or mortality as a primary outcome. Nine other articles (40%) assessed birth outcomes, health behaviors, and chronic diseases. Only two studies directly examined mental health (depressive symptoms and depression scale), and measured their relationship with either neighborhood change (Mair, et al. 2015) or community development (Semenza, March, and Bontempo 2007).

Though all included articles measured some type of neighborhood change related to socioeconomic gain, the exposure title differed by article. Looking at the exposure definition in more detail, nine (>40%) of the included articles looked explicitly at gentrification as an exposure, and an additional five (22%) referred to their exposure as community change, neighborhood change, or neighborhood trajectory. Though the terminology differed, 13 out of 14 articles that examined gentrification or neighborhood/community change defined the exposure as a process of neighborhood change that included a shift towards higher socioeconomic status (see Appendix Table 3 for exposure definitions); the Morenoff et al, 2007 defined gentrification as, "a residentially mobile population consisting of young adults and few children under the age of 18." The remaining nine articles were approximately evenly split regarding their exposure name

between urban/ community development, revitalization/improvement, neighborhood context/position and other, including renovation or instability.

As shown in Appendix Table 3, seven articles (~33%) lacked an a priori hypothesis about the direction of the relationship between the exposure and health outcome of interest. Another eight articles (33%) hypothesized a protective relationship, and five articles (~25%) included both protective and detrimental hypothesis. Three articles (14%) (English et al. 2003, Rabito et al. 2007, Lim et al. 2017) hypothesized that the relationship between the exposure and the outcome would be detrimental to the health of individuals exposed, and only the Lim et al. article examined gentrification specifically.

Almost 90% of studies (19 articles) reported a significant effect of the exposure on health, when including subgroup effects. One-third (eight articles) of the included articles reported significant health improvements associated with the exposure, another third (eight articles) found both significant protective and detrimental effects, and 20% (four articles) found significant harmful effects, and the remainder (two articles) reported no significant effects.

Gentrification and Health

We observed conflicting results about the effect of gentrification on health. Six of nine articles (67%) found a significant overall effect of gentrification on health, and all but one (Lee 2010) found a significant effect in low-income neighborhoods after assessing for subgroup effects. For example, using a cross-sectional dataset, Gibbons found only a marginally significant effect ($p<.10$) for the overall association between gentrification and health, but significantly higher odds of poor self-rated health for Blacks compared to Whites. Of note, this was the only study that included a self-reported outcome. Lim et al 2017, found that for low-

income groups remaining in gentrifying neighborhoods, residents experienced significantly higher rates of Emergency Department (ED) utilization, lower rates of hospitalizations, and no significant effect on mental health related visits, in comparison to low-income residents in non-gentrifying neighborhoods (Lim et al. 2017). However, the Lee article which found no significant effect for low-income neighborhoods, found an increase in assaults in moderate-income neighborhoods undergoing gentrification, and used a quasi-experimental design, so can make the strongest causal claims about the significance of the relationship between gentrification and health.

There were additional contrasting results in terms of the protective or detrimental effects of gentrification on health. Four of the studies (44%) on gentrification found protective effects--all but one examined violence-one (11%) found only harmful associations, and four (44%) found both protective and detrimental associations, depending on the subgroups, intervention groups, and outcomes analyzed.

Specifically, studies on violence and crime (six of the nine articles) produced conflicting results, with some documenting a decrease (Smith 2014, Papachristos et al. 2011, Barton 2016b, Kreager, Lyons, and Hays 2011) and others an increase in violence associated with gentrification (Lee 2010 , Williams). The majority of studies that examined violent crime or homicide found an overall association between increasing gentrification and decreasing violence/homicide (Papachristos et al. 2011, Smith 2014, Barton 2016b, Kreager, Lyons, and Hays 2011). Though, notably, Williams found that between 2000 and 2009 gentrification was associated with 52 (SE: 13.56, $p<.01$) additional violent crimes than other areas, and Lee found that in moderate-income neighborhoods each additional gentrifying household per 1000 led to annual average of 2.2 (SE 1.09 $P<.05$) more assaults per 1,000. Kreager et al summarized earlier work, and the findings

suggest a curvilinear relationship between gentrification and crime/violence, suggesting that early stage gentrification -during the 1970s and 1980s- is associated with increases in crime, while crime rates decline during the 1990s. The articles on violence, however, cannot be directly compared, as they focus on different cities and periods, and include various measures of gentrification, and all but one used observational data so cannot show that gentrification caused changes in violence.

Of the gentrification articles that found multi-directional relationships, one differed by outcome (Lim et al. 2017), another by how the exposure was measured (Smith 2014), one by decade assessed (Williams), and the final two found evidence of differential effects by participant racial category (Huynh and Maroko 2014, Gibbons, Barton, and Barton 2016). Three articles (Papachristos et al. 2011, Huynh and Maroko 2014, Mair et al. 2015) specifically mentioned displacement of lower-income households as part of the exposure definition. For example, English et al. measured neighborhood instability with census variables also commonly considered to indicate gentrification, but termed their exposure "neighborhood instability."

STUDY DESIGN AND ANALYSIS METHODS

Regarding study design, the vast majority of articles (90%) were observational, and only two (9%) articles used quasi-experimental designs, one instrumental variable (Lee 2010), and one longitudinal pre-post with a control group (Semenza, March, and Bontempo 2007) (see Table 5). Of those 20 observational articles, one article used both a longitudinal and cross-sectional study design (Jackson and Mare 2007), and another eight (36%) used only a longitudinal design. Of the nine studies that examined gentrification, one (5%) used a quasi-experimental design, four (18%) used longitudinal designs, and the remaining employed cross-sectional or repeated cross-sectional designs. The single study using a quasi-experimental design

by Lee 2010, exploited the 1994 Northridge earthquake in Los Angeles as an instrument to control for bias due to neighborhood selection, and found that in the short term gentrification increased crime. Overall however, studies using designs with lower risk of bias (quasi-experimental, longitudinal) did not appear to differ concerning the likelihood of reporting either a positive or negative relationship between the assessed exposure and health.

Eight studies (36%) used a multilevel modeling approach, most nesting individuals within neighborhoods or communities, and another six studies used a fixed effects approach, though there was no difference in the direction or likelihood of significance for multilevel models versus fixed effects approaches. Common individual-level covariates included age, sex or gender, race/ethnicity, measures of socioeconomic status (income, education, wealth), a housing tenure-related measure, insurance status, marital status, and outcome at baseline. Common neighborhood-level measures included population count, neighborhood racial composition, percent foreign-born/immigrant population, and indices of concentrated disadvantage.

A number of studies augmented census data with measures intended to capture more subtle cultural process of neighborhood change not evident in census data. Half of all studies (11) relied on administrative data to operationalize the exposure, primarily data derived from either the decennial census or American Community Survey (ACS), and another almost quarter (five) of the studies employed various types of observational data, such as the count of coffee shops or analysis of property appraisals. Six studies (27%) used a longitudinal or repeated cross-sectional study design, and measured the pre-post design as the exposure (e.g., before and after a development project).

Slightly fewer than half (45%) of the studies tested whether the magnitude of the effect differed depending on a third variable. Most (70%) of those articles examined whether the magnitude or direction of the effect differed depending on respondents' race/ethnicity. In addition, five of the twenty-two included articles explicitly mentioned race in their definition or operationalization of the exposure, and all but one (Morenoff et al. 2007) assessed if the effect changed depending on either by neighborhood racial composition (Papachristos et al. 2011), a composite measure representing mobile White population versus other populations (Smith 2014), or individual race/ethnicity (Gibbons, Barton, and Barton 2016). Though Williams found that the interaction between baseline neighborhood racial composition and gentrification failed to reach significance in any of the models (Williams), the three remaining studies found support for differential effects either by individual or neighborhood race/ethnicity, generally with non-White populations experiencing worse outcomes than White populations.

Whether a neighborhood must be poor or low-income to be eligible for reinvestment and therefore considered able to gentrify or revitalize is a major debate in the literature. Less than half of the included studies required such a condition in the base year of analysis, and how studies operationalized this variable varied: some measured neighborhoods eligible for reinvestment in the base year as those with below average median family income for the city (Gibbons, Barton, and Barton 2016, Barton 2016b), neighborhoods where ≥50% of the residents live below 1.5 times the federal poverty level (Althoff et al. 2009), neighborhoods with higher than average poverty level (Kreager, Lyons, and Hays 2011), or defined by a principal component analysis of multiple neighborhood-level characteristics (Lim et al. 2017). Among these same studies, five (23%) found both protective and detrimental relationships between

gentrification and health, three (14%) found a protective relationship for violence as an outcome, and one (5%) found a detrimental relationship.

Table 5: Study design and exposure measurement in studies of neighborhood change and health (N=22)

	No. of studies	% of studies
Study Design		
Observational		
Cross-sectional	5	22.7%
Ecological (repeated cross-sectional)	7	31.8%
Cohort (longitudinal)[a]	9	40.9%
Quasi Experimental		
Instrumental Variable	1	4.6%
Pre-Post (with control)[a]	1	4.6%
Exposure Measurement Category		
Administrative Data	11	50%
Development/demolition activities	2	9.1%
Observational (coffee shops, property appraisal data, home loans)	5	22.7%
Survey-Based	5	22.7%
Pre/Post	1	4.6%
Explicit mention of Race in Definition/Operationalization		
Yes	5	22.7%
No	17	77.3%
Prior Disinvestment (low-income in base year)		
Yes	10	45.5%
No	12	55.5%

a. Only longitudinal studies that included a control group were considered quasi-experimental

ARTICLE FRAMING

Almost 60% (13) of the included studies explicitly mentioned or described a theory in the article text (Table 6). Most of those theories either fell into the category of Ecological theories (social-ecological, ecological dissimilarity, human ecology, social disorganization, and relative deprivation) or social capital theories (social disorganization and collective efficacy). No included studies explicitly employed a participatory framework or approach.

We also examined if the presence of theory or historical assessment suggested the directionality of the hypothesized relationship between the exposure and outcome. No clear relationships emerged, though studies including a historical or theoretical perspective were more likely to hypothesize a protective directionality, and no studies that included a historical perspective assumed a detrimental impact: eight (36%) studies hypothesized a protective effect, three (14%) hypothesized detrimental, seven (32%) lacked an a priori hypothesis, and four (18%) hypothesized that there would be both protective and detrimental impacts. Conversely, nearly one-third of studies that lacked a historical perspective of the exposure or neighborhood also lacked an a priori hypothesis. Among articles published in public health journals, 50% (five of ten articles) were both a-theoretical and ahistorical, and the remaining five were either ahistorical or a-theoretical; no studies published in public health journals explicitly addressed both theory or history.

Table 6. Theory and Historical Framing, by direction of Hypothesis, in studies of neighborhood change and health (N=22)

		Hypothesis Direction			
	Total *N(percent)*	Protective *N(percent)*	Detrimental *N(percent)*	Protective & Detrimental *N(percent)*	No a priori hypothesis *N(percent)*
Theory					
Theoretical	13(59.1%)	5(22.6%)	1(4.5%)	4(18.2%)	3(13.6%)
A theoretical	9(40.9%)	3(13.6%)	2(9.1%)	0(0.0%)	4(18.2%)
Historical					
Historical Perspective	8 (36.4%)	5(22.6%)	0(0.0%)	3(22.6%)	0(0.0%)
Ahistorical[a]	14(63.6%)	3(13.6%)	3(13.6%)	1(4.5%)	7(31.8%)

a. Studies were defined as ahistorical if they did NOT include include any description of the history of the exposure measure or history of the study neighborhoods

Discussion

This review provides a summary of how research has measured the relationship between neighborhood change/gentrification and health since the turn of the century. Our results reveal limited literature on these topics, and although we find evidence of associations between these exposures and health, the direction of these relationships is not consistent. One intention of this review was to provide readers with an understanding of how the processes of neighborhood change impact health from a quantitative perspective. We find that there is a plurality of definitions, measures, and outcomes of neighborhood change, and caution against assuming a uniform relationship between these exposures and health.

Debates on gentrification and other neighborhood change processes are often framed as questions about whether gentrification is harmful or protective (Vigdor, Massey, and Rivlin 2002). Our results cannot provide a definite conclusion to this question, and further whether such processes likely exacerbate or shrink disparities in health. Instead, our results suggest that gentrification, neighborhood change, and urban development appear to both both detrimentally and beneficially affect health.

The effects of these neighborhood change processes likely differ due to contextual differences in the preexisting spatial and racial inequity in cities, policy efforts underway, the level of affordable housing and community organizing present, speed at which the change process occurs, whether the cause of the change is exogenous (Lee 2017), as well as the health outcome of interest. The studies' differential outcomes are also likely due to methodological differences in study design, exposure measurement, and etiologic and decade studied. And for many of the included studies, aggregate results appeared to mask heterogeneity in the health effects across subpopulations of those exposed to various neighborhood change processes.

Notably, studies with stronger causal designs did not appear to make a clear impact on the significance or direction of findings, though we note that only one study employed a quasi-experimental design. Thus, while the literature is incomplete, studies on urban change and health represent a promising area of study about how place effects health.

The literature, both those articles reviewed, and the larger body of literature on gentrification and urban development, have failed to arrive at a consensus on the definition or measurement of these processes (Kennedy and Leonard 2001, Barton 2016a). All definitions, however, involve changes in economic status, changes to the built environment, and often, change in racial diversity (Lee 2017). With respect to gentrification specifically, there is substantial debate in the literature about how to define and measure gentrification: whether displacement is a feature or consequence of gentrification (and if displacement rates are higher in gentrifying than low-income neighborhoods) (Ellen 2017), whether a neighborhood must experience prior disinvestment, economic decline, or low-income prior to socioeconomic transformation (Wyly and Hammel 1999, Curran 2004), and if gentrification is an inherently racialized process (Papachristos et al. 2011). The ecological dissimilarity hypothesis- which posits that residential segregation creates differential exposures and contexts for majority Black versus majority non-Black neighborhoods –suggests that gentrification and urban development produce divergent processes and outcomes depending on the prior racial/ethnic composition of the neighborhood and the gentrifiers (Sampson et al. 2006). We add to this debate by identifying that the definition and operationalization of the exposure process also impact the health effects estimated.

Rather than advocating for a single definition, we instead suggest researchers present a clear theoretical basis for their definitional and operational choices, so that readers can

transparently assess the position from which researchers are approaching their questions (Krieger 1994). The included studies also considered various control groups, and we suggest that more explicit consideration of the study population and control group, as well as addition of sub group analysis, particularly by individual and neighborhood racial composition, will improve our ability to assess the effect of these processes on health and disparities in health. Further, no studies on gentrification examined self-reported mental health, though mental may show more immediate changes in the face of neighborhood change than physical health outcomes.

Neighborhood effects research tends to frame low-income neighborhoods as universally detrimental to health and argues that the de-concentration of poverty is de facto positive for low-income residents remaining in gentrifying areas (Byrne 2002). However, such frames often fail to recognize the positive and protective individual and neighborhood factors that exist in low-income neighborhoods before an influx of higher income individuals, and that neighborhood change can disrupt these protective factors. A myopic focus on the detrimental impacts of economically deprived neighborhoods, and discounting of the positive factors, overlooks protective health factors (e.g,. collective efficacy, micro-economies, social networks) that likely break down when neighborhoods change and long-term residents are forced to move. This work often frames increasing social and racial mixing as de-facto positive because it de-concentrates poverty (Crump 2002, Fraser et al. 2003), despite the limited evidence for economic benefits to low-income populations or actual social overlap between populations of different SES *within* gentrifying neighborhoods (Lees 2008, Walks and Maaranen 2008). Instead, applying an asset-based framing (Foot and Hopkins 2010), which suggests that both positive and protective neighborhood factors should be considered when examining low-income racially segregated

neighborhoods, can help to identify mediating factors that may protect health as neighborhoods change.

The included studies rarely considered power, yet political and economic power (i.e. developers, zoning regulation) are central components of why certain neighborhoods undergo gentrification and how neighborhood change impacts working-class communities and individuals. Many studies and communities have expressed the absence of low-and working-class voices in research on neighborhood change (Powell, Slater, and Chaloupka 2004). A deeper understanding of these neighborhood change processes requires listening to those directly impacted; Participatory Action Research (PAR) and Community Based Participatory Action Research (CBPAR) offer frameworks for inclusion. Promising work in this area, such as the Healthy Neighborhood Study (HNS), provides a platform to include residents in the research study, definition of outcomes, and mediators of the relationship between neighborhood development and health (Arcaya, 2018). We can learn lessons about the importance, mechanisms, and consequences involved in gentrification from the HNS project, and PAR generally. Other participatory research by the authors identified gentrification and displacement as the second most important neighborhood challenge impacting residents in Central Brooklyn in 2017 (NextShift 2018), and in research conducted with communities across New York found gentrification was among the top three most commonly identified structural psychosocial stressors (Shmool et al, 2015). We can learn lessons about the importance, mechanisms, and consequences involved in gentrification from these projects, and PAR generally. While community organizing and activism are often pitted as enemies of development and rezoning processes, PAR offers opportunities to bring community members, developers, and policymakers to the same table to create understanding and plans for inclusive development.

It is unclear whether low-income populations are benefitting from the spatial realignment associated with gentrification and urban redevelopment, and if poverty is re-concentrating in new areas. The limited research on this topic suggests the latter, that low-income residents directly displaced by gentrification or who move out of gentrifying neighborhoods often move to even lower-income neighborhoods (Hwang & Sampson, 2014) or neighborhoods further from cities' economic cores. But, on average rates of displacement are not higher in gentrifying than non-gentrifying low-income neighborhoods (Freeman 2005, Freeman and Cai 2015 , McKinnish, Walsh, and White 2010, Vigdor, Massey, and Rivlin 2002) because low-income people tend to live in poor housing conditions and move at high rates in all types of neighborhoods (Ellen 2017, Desmond and Gershenson 2017). Other research suggests that low-income households are often locked out from moving into gentrifying neighborhoods because of rental prices, and when low-income households move in gentrifying neighborhoods they are often replaced by higher income households, which creates much of the turnover observed in gentrifying neighborhoods (Ellen 2017). Health consequences, however, are not limited to physical displacement or lockout; the fear of these two outcomes can itself detrimentally impact residents.

In part as a consequence of these changing residential configurations, patterns of economic and racial segregation prevalent in cities are replicating in the suburbs (Kneebone & Berube, 2013). Our work indicates that between 2005 and 2015 the suburbs had on average lower rates of uninsurance and barriers to health care, but this advantage relative to urban areas fell over the study period and had disappeared by 2015. Nearly 40% of low-income suburban residents had an unmet care need due to cost in past year, suggesting that if low-income residents move out of or are displaced to the suburbs, they likely face substantial barriers accessing care (Schnake-Mahl and Sommers 2017). Only one article included in our study examined access to

health care, and they found that while ED admissions were slightly higher in gentrifying neighborhoods than a non-gentrifying poor neighborhood, hospitalizations were lower in gentrifying neighborhoods (Lim et al. 2017). Further research on how neighborhood change impacts access to health care can assist health departments and providers, particularly safety-net providers, in understanding how to distribute resources and services to better address care needs.

LIMITATIONS

We did not conduct a meta-analysis given the heterogeneity of the study designs, outcomes, data sources, and exposure definitions, and so do not present the range of estimated magnitudes for any outcomes.

We recognize, but intentionally avoid, the larger debates on causes of gentrification (Hyra 2016, Gould Ellen and Ding 2016) and debates on new urbanism. The literature suggests that a host of both supply and demand factors, as well as geopolitical and historical trends, drive gentrification and urban investment and that these factors are likely location specific in the degree to which they explain gentrification (Ding, Hwang, and Divringi 2015, Slater 2006). Researches have produced numerous works on these subjects, and we find it beyond the scope of this work to engage further in this debate because no studies relate these factors to health outcomes, but acknowledge their importance for understanding the larger implications of processes of divestment, investment, and gentrification. We suggest that future research on the subject consider the mediating factors, both between the upstream sociopolitical factors affecting the prevalence and intensity of neighborhood change processes, but also those factors that mediate the relationship between gentrification and health. For example, by examining the level of social support and cohesion, factors that may both confound and mediate the relationship

between gentrification and population health. Additionally, a body of literature, produced mostly in Europe, explores how urban renewal and regeneration can contribute to gentrification and other neighborhood change processes, and how in turn these impact health equity (Mehdipanah et al. 2015, Arbaci and Tapada-Berteli 2012, McCartney et al. 2017). We limited the scope of our search to studies directly assessing the relationship between neighborhood change processes and health, but recent work in systems thinking offer methods of evaluating these dynamic interrelations and identifying the multiple complex causal processes at play in urban environments (Galea, Riddle, and Kaplan 2010, Boone-Heinonen et al. 2013).

CONCLUSION

Critical gaps exist in the public health literature examining recent changes in the geographic patterning of populations in the U.S. Documenting and explaining social inequalities in health is a central task of public health, and understanding the geography of inequality is a fundamental tenet of population health. Public health and the healthcare field have primarily remained on the periphery of the public debate on gentrification and neighborhood change, but these processes impact these fields. We need further research to address this gap, particularly study designs that allow for a causal interpretation of effects- experimental, natural, and quasi-experimental-longitudinal designs that follow people across and within neighborhoods, and participatory studies that include the voices of impacted communities.

This review underscores the relevance of considering neighborhood change to accurately determine prevalence and incidence of area-level health outcomes. Recognizing and documenting where the economically disadvantaged and the affluent reside, and how their contexts affect their health, aids in our understanding of the geographic distribution of health and

wellness in the population. Overlooking these shifting geographic patterns hinders our ability to accurately assess changes in population health, identify causes of ill or good health, and develop interventions and policies to address inequities.

Appendix 3

Appendix 3 Exhibit 1: Example Search Terms

- **Exposure:** ((((("Residence Characteristics"[Mesh:NoExp] OR neighborhood*[tiab] OR community[tiab] OR communities[tiab] OR neighborhood change*[tiab] OR gentrif*[tiab]) AND ("Social Change"[Mesh:noexp] OR "Urban Renewal"[Mesh] OR redevelopment[tiab] OR revitalization[tiab] OR renewal[tiab] OR transformation[tiab] OR neighborhood change*[tiab] OR gentrif*[tiab] OR ascent[tiab] OR upgrading[tiab] OR up-and-coming[tiab] OR turnover[tiab] or regeneration[tiab]))
- **Health:** (("Body Mass Index"[Mesh] OR "Overweight"[Mesh] OR overweight[tiab] OR obesity[tiab] OR "Mental Health"[Mesh] OR "Depression"[Mesh] OR "Depressive Disorder"[Mesh] OR depression[ti] OR mental health[tiab] OR self rated health[tiab] OR "Homicide"[Mesh] OR homicide*[tiab] OR "Suicide"[Mesh] OR suicide*[tiab] OR "Life Expectancy"[Mesh] OR life expectancy[tiab] OR "Mortality"[Mesh] OR mortality[tiab] OR "Hospitalization"[Mesh] OR hospitalization*[tiab] OR hospital admission*[tiab] OR "Emergency Service, Hospital"[Mesh] OR emergency room*[tiab] OR emergency department*[tiab] OR acute care[tiab] OR mental health[tiab] OR self rate*[tiab] OR "Wounds and Injuries"[Mesh] OR injury[tiab] OR injuries[tiab] OR "Cardiovascular Diseases"[Mesh] OR cardiovascular disease*[tiab] OR "Respiratory Tract Diseases"[Mesh] OR chronic obstructive pulmonary disease[tiab] OR asthma[tiab] OR "Exercise"[Mesh] OR physical activit*[tiab] OR "Pregnancy in Adolescence"[Mesh] OR teen pregnanc*[tiab] OR teenage pregnanc*[tiab] OR adolescent pregnanc*[tiab] OR teen birth*[tiab] OR "Infant, Low Birth Weight"[Mesh] OR "Infant, Premature"[Mesh] OR low birth weight[tiab] OR preterm birth*[tiab] OR Pressure, Blood[tiab] OR Blood Pressure[tiab] OR "Hypertension"[Mesh] OR "Hypotension"[Mesh] OR "Smoking"[Mesh] OR "Alcohol Drinking"[Mesh] OR "Substance-Related Disorders"[Mesh] OR "Drug Overdose"[Mesh] OR "Pregnancy, Unplanned"[Mesh] OR "Sexually Transmitted Diseases"[Mesh] OR "HIV"[Mesh] OR “Health Status”[Mesh] OR self rated[Other Term]))

Appendix 3 Exhibit 2. Search Terms According to Group

Group	Terms		
Group 1: Geography	Residence characteristics	Neighborhood	Community/communities
	Neighborhood change	Gentrif*	
Group 2: Exposure	Social Change	Urban Renewal	Redevelopment
	Renewal	Transformation	Neighborhood change
	Gentrification	Regeneration	Ascent
	Upgrading	Up-and-coming	Turnover
Group 3: Health Outcomes	Body Mass Index	Overweight	Obesity
	Mental health	Depression	Depression disorder
	Self-rate/self-rated health	homicide	Suicide
	Life expectancy	Mortality	Hospitalization
	Hospital admission	Emergency service, hospital	Emergency room/department
	Acute care	Wounds and injuries	Injury/injuries
	Cardiovascular disease(s)	Respiratory tract diseases	Chronic obstructive pulmonary disease
	Asthma	Exercise	Physical activity
	Pregnancy in adolescence	Teen pregnancy	Adolescent pregnancy
	Teen birth	Infant, low birth weight	Infant, premature
	Low birth weight	Preterm birth	Blood pressure
	hypertension	Hypotension	Smoking
	Alcohol drinking	Substance-related disorders	Drug overdose
	Pregnancy, unplanned	Sexually transmitted diseases	HIV
	Health status		

Appendix 3 Exhibit 3: Summary of included studies

Author/Year	Exposure Name	Construct Description	Hypothesized Effect & (Direction)	Effect Estimate & Direction
Lim et al, 2017(Lim et al. 2017)	Gentrification	Process through which deprived neighborhoods are revitalized by economic development, typically resulting in an influx of new residents of higher socioeconomic status	Residents living in the gentrifying neighborhoods were more likely to visit ED and/or get hospitalized than residents living in non-gentrifying, poor neighborhoods if gentrification itself had a negative impact on health. (Detrimental)	Residents of gentrifying neighborhoods, as opposed to those of non-gentrifying poor neighborhoods, had significantly higher rates of **ED visits** (RR: 1.1, 95% CI: 1.0±1.1), but rates of **hospitalization** were lower (RR: 0.95; 95% CI: 0.91±0.98). The rates of **mental health-related ED visits** were not significantly different between these two groups.
Papachristos et al, 2011 (Papachristos et al. 2011)	Gentrification	A process that changes the character and composition of a neighborhood, resulting in the direct and indirect displacement of lower income households with higher income households	Crime rates (including **homicide**) will decline at a greater rate in gentrifying neighborhoods as population shifts stabilize. Any crime-reducing effect associated with gentrification will be lower in Black neighborhoods as compared to non-Black neighborhoods. (Protective)	Neighborhoods that experienced gentrification (as measured by coffee shops also experienced a greater than expected decline in **homicide** (b=-0.182 SE:0.039 p<.001)**,** though the effect of coffee shops (b=−0.077; SE=0.04 p<.10) became insignificant at the 0.05 level after controlling for census factors. The effect of coffee

Appendix 3 Exhibit 3: Summary of included studies (Continued)

				shops on homicides was larger for White (b= -0.121 p ≤.001) as compared to Hispanic (-0.055 p>.05) and Black neighborhoods (b=-0.047 p>.05), but the effect was negative (increasing coffee shops, decreasing homicide) for all groups.
Smith, 2014 (Smith 2014)	Gentrification	Temporal and spatial churning process of higher income households directly and indirectly displacing lower income households changing the character and composition of a neighborhood	Gentrification in the form of demographic change and coffee shops has a negative effect on **gang homicides** over time. Hypothesis 2: Gentrification in the form of public housing demolition has a positive effect on **gang homicides** over time. (Protective & Detrimental)	As neighborhood mobile White population and SES increased, the number of **gang homicides** significantly decreased per neighborhood cluster over time, before (mobile white: b=-0.53 SE: 0.05; SES b=-0.47 SE 0.05) and after adding control variables (mobile white: b=-0.52 SE:0.06, SES: b=-0.48 SE:0.05). Lagged coffee shops also had a negative effect on the number of gang homicides over time (b=-0.08, SE:0.04), but the effect was only marginally significant (p

Appendix 3 Exhibit 3: Summary of included studies (Continued)

				≤.01). The overall public housing demolition indicator variable had a positive and significant effect on gang homicide (b=0.36, SE: 0.16, p<.01), though the effect was only marginally significant after controlling for prior gang homicide (b=0.31 SE 0.18, p ≤.1).
Gibbons et al, 2016 (Gibbons, Barton, and Barton 2016)	Gentrification	The process by which higher income households displace lower income households of a neighborhood, changing the essential character and flavor of that neighborhood.	(H1) Improvements in quality of life associated with gentrification will be associated with increased **self-rated health** regardless of race. (H2) Nonwhite racial minorities living in a neighborhood that is gentrifying have **poorer health** than those residing in a neighborhood that is not gentrifying. (H3) Non-Hispanic Blacks living in a neighborhood that is gentrifying have **poorer health**	Gentrification had a marginally (p ≤0.10) significant negative relation to **poor/fair SRH** (b=0.806). Gentrification caused by the influx of affluent whites was not significant. In the fully adjusted models, Blacks who lived in a gentrifying neighborhood were almost 75% more likely (b=1.732 p<.01) to report **poor/fair SRH** than their counterparts who lived in other types of neighborhoods. No CI or SE reported

Appendix 3 Exhibit 3: Summary of included studies (Continued)

			than those residing in a neighborhood that is not gentrifying. (H4) Non-Hispanic Blacks living in a neighborhood that is experiencing gentrification by affluent Blacks will have similar health outcomes to those in neighborhoods experiencing gentrification as a result of an influx of affluent Whites. (Protective and Detrimental)	
Williams, 2014 (Williams)	Gentrification	Reinvestment occurring after a period of community decline, marked by both compositional and economic change and quantified by the extent of reinvestment activity taking place during the gentrification between 1990 and 2000	H1: Gentrification in the 90's resulted in decreases in property and **violent crimes** in gentrifying communities. H2: Gentrification in the 90's resulted in decreased property and violent crimes in gentrifying non-Black communities but increased property and **violent crimes** in gentrifying Black	Gentrifying neighborhoods were predicted to experience 132 (b= -131.99 SE:44.35, P<.01) fewer **crime** incidents, and 1.45 (b-1.45, SE: 0.589,P<.05) fewer **violent crimes** between 1990 and 2000 than their non-gentrifying counterparts. In 2000-2009, gentrifying neighborhoods were associated with higher rates of **violence** (b=51.99 SE: 13.56, p<.01)

Appendix 3 Exhibit 3: Summary of included studies (Continued)

			communities. H3: Gentrification in the 90's resulted in decreased property and **violent crimes** in gentrifying communities not characterized by concentrated disadvantage at the onset but increased property and **violent crimes** in disadvantaged gentrifying communities. H4: Gentrification resulted in initial property and **violent crime** increases followed by eventual property and violent crime declines. (Protective and Detrimental)	than other areas, and violent crime rates were higher in gentrifying than in appreciating or depreciating areas. Additionally, when gentrification was measured as a continuous exposure, higher levels of gentrification, were associated with higher levels of **violent crime** (b=392.32 SE 166.37p<.05). The gentrification-racial composition interaction term failed to reach significance in the models for both violent and property crime in both decades.
Huynh & Maroko, 2014 (Huynh and Maroko 2014)	Gentrification	Economic and social changes that are a result of an influx of higher income residents and housing investment. Also characterized by the displacement of lower income residents as housing stock values rise.	No explicit hypothesis	In the overall sample, gentrification was not associated with low birth weight. However, when stratified by race/ ethnicity, very high gentrification was a significant predictor of **low birth weight** for non-Hispanic

Appendix 3 Exhibit 3: Summary of included studies (Continued)

				Blacks in the fully adjusted model (AOR=1.16; 95 % CI 1.01–1.33), and very high gentrification was protective for non-Hispanic Whites (AOR=0.78; 95 % CI 0.64–0.94).
Barton, 2016 (Barton 2016b)	Gentrification	No Explicit definition	Decline in **crime** in New York City associated with gentrification after a "tipping point." (Protective)	Each percent increase in the percent gentrified census tract in a sub-borough was associated with a 0.008 (SE 0.001, P<.001) reduction in the **homicide** index in the unadjusted model, and 0.007 (SE 0.001, p<.001) reduction in the fully adjusted model. This association remained after controlling for variation across time and within traditional predictors of crime.
Kreager et al, 2011 (Kreager, Lyons, and Hays 2011)	Gentrification	The class transformation of those parts of the city that suffered from systematic outmigration, disinvestment, or neglect in the midst of rapid economic growth and suburbanization.	Gentrification in the 1980's was positively related to **crime** change, but then reversed in the 1990's in Seattle. (Protective and Detrimental)	Gentrification predicts 147 (SE:42.76 P<.001) **fewer crimes** than other tracts between 1990 and 2000. In gentrifying compared to non-gentrifying but poor tracts, there

Appendix 3 Exhibit 3: Summary of included studies (Continued)

		Process that only applies to urban areas that underwent substantial neglect.		was a predicted −104.77 (SE: 47.62 p<.05) fewer crimes. Adding covariates including net migration, household income, foreign born population, mean mortgage investment, percent black population, and a spatial error term slightly increased the magnitude of the observed relationship between gentrifying neighborhoods and declining **crime** (b=-117.54 SE:41.91, p<.05), in comparison to poor but not gentrifying neighborhoods.
Lee, 2010 (Lee 2010)	Gentrification	When middle- and upper-income individuals purchase homes in lower income neighborhoods	In the short term, when middle- and upper-income individuals purchase homes in lower income neighborhoods, neighborhood crime decreases. (Protective)	The OLS and IV estimates showed no significant effect of gentrification on **crime** or **violent crime** in low-income tracts. In moderate income neighborhoods, there was a significant positive gentrification effect (+2.2 assaults per year; SE 1.09 P<.05). In

Appendix 3 Exhibit 3: Summary of included studies (Continued)

				moderate income neighborhoods- including lagged effects- an increase in one gentrifying household leads to an average yearly increase in the following year of 3.1 assaults per 1,000.(SE:1.41, p<.05).
Morenoff et al, 2007 (Morenoff et al. 2007)	Neighborhood context, affluence and gentrification	Neighborhood-level variables that characterize the sociodemographic structure of neighborhoods. Gentrification specifically defined as a residentially mobile population consisting of young adults and few children under the age of 18.	No explicit hypothesis specific to gentrification	Significantly lower odds of **hypertension prevalence** (OR 0.7, CI: 0.6 to 0.9, p<.05) in gentrifying/affluent neighborhoods. No evidence of effect modification by race after adjusting for neighborhood level characteristics.
Althoff et al, 2009 (Althoff et al. 2009)	Neighborhood Socioeconomic Position	Neighborhoods with public housing residents, residents of low-income neighborhoods without public housing, and residents of higher-income neighborhoods without public housing, excluding neighborhoods with a mixture of public and private residential units and neighborhoods undergoing gentrification (a	No explicit hypothesis specific to gentrification, as the study excluded all gentrifying neighborhoods from the analysis	Age-adjusted, **all-cause mortality** in NYC neighborhoods decreased from 1989–1991 to 1999–2001, with the greatest decrease in residents of low-income neighborhoods (28%) and the smallest decrease in residents of public housing (16%). Found a narrowing mortality disparity

Appendix 3 Exhibit 3: Summary of included studies (Continued)

		decrease from ≥50% to <50% living below 1.5 times the FPL from 1990-2000)		between non-gentrifying low-income and higher-income neighborhoods.
Mair et al., 2015 (Mair et al. 2015)	Neighborhood Change	The displacement of lower-income residents in a neighborhood by higher income households.	Individuals living in neighborhoods with increasing levels of social cohesion and safety, decreasing violence and stress, and improving aesthetic environments would have improved reports of **depressive symptoms** compared to those living in neighborhoods undergoing the opposite types of neighborhood change. (Protective, compared to neighborhoods with decreasing higher income households)	An increase in neighborhood social cohesion was marginally associated with a 2.82-unit **decrease in depressive symptoms** score (95% CI −6.10, 0.46); P=0.09), after adjustment for individual covariates.
Jackson & Mare, 2007 (Jackson and Mare 2007)	Neighborhood Change	Socioeconomic position of neighborhoods, and change over time in SES.	No explicit hypothesis	Both the cross-sectional and longitudinal measures produced similar estimates of the association between neighborhood and **child well-being**.

Appendix 3 Exhibit 3: Summary of included studies (Continued)

Barrett et al, 2008 (Barrett et al.)	Neighborhood Change	Rapid residential area economic change (change in SES between 1990 and 2000)	No explicit hypothesis	Residential area socioeconomic upward change was significantly associated with the probability of **distant metastasis at diagnosis of breast cancer**. Specifically, for each unit increase (about one SD) in the rate of neighborhood change, the odds of distant metastasis at diagnosis increased by 9% (OR = 1.09, CI:1.01 to 1.18, p= 0.029).
Margerison-Zilko et al, 2015 (Margerison-Zilko et al.)	Longitudinal trajectories of neighborhood poverty (early poverty increase and late poverty increase)	Early poverty increase: tracts that were low or moderate income in 1970, became high or moderate income *by 1990 or earlier*, and remained high or moderate after that; Late poverty increase: tracts that were low or moderate income in 1970, became high or moderate *after 1990* and remained high or moderate after that.	No explicit hypothesis.	Neighborhoods that experienced early poverty increases were associated with a 37% increase in odds of **pre-term birth** (95% CI=1.09, 1.72), compared with long-term low-poverty neighborhoods. Later poverty increase and poverty decrease were not significantly associated **with pre-term birth.**
Leonard et al, 2017 (Leonard et al. 2017)	Changes in the Neighborhood Environment	Changes in the quality of the physical neighborhood	(H1) neighborhoods that homebuyers prefer more will	A one standard deviation increase in average homebuyer

Appendix 3 Exhibit 3: Summary of included studies (Continued)

		environment. Measure in relative terms how desirable a neighborhood was compared to the average neighborhood in the county.	be associated with less **weight gain**, and (H2) the effects will be similar for both movers and non-movers. (Protective)	neighborhood preference was related to 0.7 (B=-−0.651 SE: 0.337, p<.10) fewer **kilograms gained** adjusting for adjusting for individual socio-demographic characteristics, mover status, the Heckman Correction factor, and neighborhood housing structures. In stratified analysis, a one SD increase in neighborhood condition was associated with 0.5 (S:.0.0432 p>.10) and 1.4 (SE: 0.573 p<.05) **fewer kilograms gained** for movers and non-movers. The effect was stronger for both movers (b=-1.46, SE: 0.528 p<.05) and non-movers (b=-1.872 SE: 0.786, p<.05) after propensity score matching to account for non-random assignment to mover status.
English et al, 2003 (English et al. 2003 6687)	Neighborhood Measures of Instability	Communities that experience rapid change including high population growth, population	Communities that experience rapid change have poorer **reproductive**	In the model examining only neighborhood level measures: a 1% increase in the

Appendix 3 Exhibit 3: Summary of included studies (Continued)

		mobility, social discord, and economic pressure	**outcomes** than stable neighborhoods, and neighborhood measures of instability are related to local increases in poor reproductive outcomes. (Detrimental)	percent of the following variables were associated with increases in **term and pre term low birth weight** between 1980 and 1990: non-Hispanic African–American race/ethnicity (b=0.099, p=0.024), percent of residents with a college education (b=0.124, p= 0.032), and increasing rent-to-income ratio (b=0.037, p=0.026). While the following variables were protective against increases in **low birth weight**: percent of people living in the same house (b= 0.048 p=0.011) and the same county (b=0.073, p=0.010) for the last five years. In the model controlling for both neighborhood and individual variables, only an increase in the percent living in the same county for the last 5-years was significant. For **preterm low birth weight**, only

Appendix 3 Exhibit 3: Summary of included studies (Continued)

				percentage of college graduates (b=0.105 p=0.039) and increase in the rent-to-income ratio (b=0.029 p=0.031) were significant, and stayed significant after adjustment for individual characteristics.
Semenza et al, 2007 (Semenza, March, and Bontempo 2007)	Community Development	Creation of a community-designed, environmentally beneficial gathering places	Community development intervention will improve community depression score. (Protective)	There was a consistent decline between the first and the second survey in the estimated marginal mean for the **depression scale** (b=1.95, p=0.03).
Harduar-Morano et al., 2008 (Harduar-Morano et al. 2008)	Community Improvements	Removal of abandoned homes; establishment of bus routes; installation of streetlights, new septic systems, water mains, and connections; construction of new homes and sidewalks and repair of existing homes; and improvements to parks	No explicit hypothesis.	62% of survey participants responded positively when asked if their children missed **fewer school days due to illness** after compared to before the intervention. Of respondents who reported improvements across all community improvement categories, 99% responded positively when asked if improvements in their community positively affected their **mental and**

Appendix 3 Exhibit 3: Summary of included studies (Continued)

				physical health. All but three of the seven community improvement issues, when examined separately, were significantly associated with respondents' increased **mental and physical health.**
Day et al, 2007 (Day et al. 2007)	Renovation	Renovation of inside apartments, street renovation, streets converted to one way, and improvements to the appearance of the built environment	Renovation associated with 1) increased **perceived pedestrian safety and increased actual pedestrian safety** for residents of the renovated street; 2) improved perceived and actual safety from crime on the renovated street, and 3. increased **walking** on the renovated street. (Protective)	The renovation was associated with a significant increase in the **perceived safety of children**; **perceived pedestrian safety** from traffic was also higher post-intervention. The perception of the renovated street as safe from crime was lower in post surveys, although this finding was not statistically significant ($p=0.056$). Post survey respondents also reported that they **walked to the grocery store** more often ($p <0.001$), compared to the pre-surveys.

Appendix 3 Exhibit 3: Summary of included studies (Continued)

Dulin-Keita et al, 2015 (Dulin-Keita et al. 2015)	Revitalization	Replacing distressed public housing, improving surrounding neighborhoods, reducing the concentration of low-income families, and building sustainable communities	Residents who lived closer to HOPE VI would experience increases in **physical activity.** (Protective)	The analysis tested the relationship between various independent variables associated with HOPE VI, but not the impact of exposure to HOPE VI directly. They found no significant differences in the proportion of residents who changed their **physical activity** 1.21 (95% CI: 0.72-2.03, p=0.464) based on their distance from HOPE VI projects.
Rabito et al, 2007 (Rabito et al. 2007)	Urban Renewal (demolition activities)	Individual exposure to demolition activity	Demolition activities associated with urban renewal will increase **blood lead levels** in children (Detrimental)	Exposure to multiple demolitions was found to have a significant effect on children's **blood lead levels** (adjusted coefficient: b=0.281; 95% CI:0.069, 0.493; P-value: 0.010; unadjusted coefficient: b= 0.096; 95% CI: 0.009, 0.183; P-value: 0.031).

Chapter 3

The Role of Gentrification in Predicting BMI and Self-Rated Health Among Survivors of Hurricane Katrina

Introduction

Socioeconomic and racial disparities in health in the US are geographically patterned (Diez Roux, 2001; S. Macintyre, Ellaway, & Cummins, 2002). Exposure to neighborhood disadvantage, particularly concentrated poverty and segregation, contribute to a broad range of negative health outcomes, including elevated BMI (Corral et al., 2015), self-rated health (Gibbons & Yang, 2014) blood pressure (Chaix, Merlo, Evans, Leal, & Havard, 2009), heart disease (Jones, 2013), preterm birth (Britton & Shin, 2013), and premature mortality (S. V. Subramanian, Chen, Rehkopf, Waterman, & Krieger, 2005). As a result, many poverty scholars have argued for the deconcentration of poverty (Wilson, 1987), by mixing households of different SES, which many expect to reduce or ameliorate these risks.

Though research has established robust associations between area economic deprivation and unhealthy residents (Robert, 1999; S. V. Subramanian et al., 2005), there is limited research about how changes in the demographic, social, and cultural context of a neighborhood affect health outcomes (Schnake-Mahl et al. 2018). Previous literature has explored contemporaneous and lagged health effects of neighborhoods (Ellen, Mijanovich, & Dillman, 2001), how individuals' changing neighborhoods affects their health (Ludwig et al., 2011), how individual economic position affects neighborhood of residence, and how health can impact neighborhood selection (M. C. Arcaya, Subramanian, Rhodes, & Waters, 2014; James et al., 2015). However,

there is limited knowledge of how socioeconomic and cultural changes *within* a neighborhood causally affect residents' health. In part, because it is difficult to show that neighborhood changes *cause* changes in health, as low-income populations are likely to have poorer health to begin with, and to live in more resource-deprived neighborhoods than more affluent populations (Ellen and Glied 2015).

Gentrification – a process of demographic, social, cultural and political change resulting from an influx of new amenities, higher socioeconomic status (SES) residents, investment and increased housing prices – is one form of neighborhood change, and has increased in scope and scale across many U.S. metropolitan areas in the past two decades (Hwang and Lin 2016). However, there is limited evidence to demonstrate the implications of gentrification for health (Venis Wilder, Makoba, and Arniella 2017), and the available literature is mostly from observational studies lacking the methodological rigor to draw causal inferences (Schnake-Mahl et al. 2018). In this article, we improve upon previous work on gentrification and neighborhood change and health by conducting a quasi-experimental multivariate hierarchical analysis to test various associations between neighborhood gentrification, and self-rated health and BMI.

This study uses data from the Resilience in Survivors of Katrina (RISK) project, geocoded to census tracts, and merged with a census-derived measure of neighborhood gentrification. The RISK project is a longitudinal study of low-income parents, predominantly non-Hispanic Black single mothers, who participated in a New Orleans-based study before and after Hurricane Katrina. Our study uses three waves of the RISK dataset, from 2003-2004 before Katrina, and 2006-2007 and 2008-2009, after Katrina (2005) to track participants across neighborhoods. Katrina displaced all participants, at least temporarily, from New Orleans, though about half returned to their pre-Katrina parish. Residents had little or no control over

neighborhood placement immediately following the storm. This near-random displacement after Katrina created a natural experiment, which we exploit in our study design.

Though gentrification began in New Orleans well before the storm, the rebuilding of the city exacerbated existing trends in gentrification and spatial inequity (Seicshnaydre and Collins 2018, Orleans 2016). To identify how health outcomes would have evolved in the absence of gentrification, we examine BMI and self-rated health by comparing outcomes among those displaced into neighborhoods that underwent gentrification between 2000 and 2005-2009, to those displaced in low-income communities that did not experience gentrification, both before and after Katrina.

We employed a difference-in-differences approach similar to that used in a recent quasi-experimental study by Deryugina & Moliter 2018, which found that eight years after Katrina, elderly and disabled Katrina victims that moved to low-mortality regions had significantly lower mortality rates than those who moved to high-mortality regions (Deryugina and Molitor 2018). However, the Deryugina and Moliter study was potentially subject to bias from voluntary neighborhood selection. Our research aims to contribute to the urban health literature by assessing the causal effect of place on health, using a quasi-experimental design, examining health outcomes other than mortality, and focusing on a low-income population who are the most exposed and vulnerable to effects of gentrification.

We hypothesize that being assigned to a neighborhood with a higher level of gentrification will predict worse health outcomes; the risks of further displacement, higher housing costs, neighborhood destabilization and breakdown of social networks will outweigh the potential benefits of increased investment and influx of higher SES residents. There is also limited scholarship on gentrification that considers the role of racial stratification in shaping the

trajectory and implications of gentrifying neighborhoods (Anderson and Sternberg 2013, Hwang and Sampson 2014). We address this gap by including tests of effect modification by individual race and neighborhood majority racial composition.

Methods

STUDY DESIGN

We took advantage of the near random assignment to neighborhoods post-Katrina, and employ a quasi-experimental Intent-To-Treat (ITT) approach, that looked at neighborhood of assignment post-Katrina (2006). Using an ITT approach, participants were analyzed based on their 2006 neighborhood assignment, regardless of whether they voluntarily stayed long-term or moved after assignment. We included data from the second follow-up wave, but participants' exposure remained in the first wave assigned neighborhoods. This study design avoids selection into neighborhoods in a non-random way, which would bias our estimate of the relationship between gentrification and health, and controls for unmeasured time-in varying confounders. Our primary analysis employed a difference-in-difference (DD) method to compare self-rated health and BMI among those assigned to a gentrified neighborhood versus assigned to an impoverished neighborhood (first difference) before and after Katrina (second difference).

DATA SOURCE

Data comes from the RISK project, a longitudinal study of 1,019 young, low-income predominantly African-American parents who survived Hurricane Katrina and lived in New Orleans or a surrounding parish in 2003. Data were collected initially in 2003-2004 (baseline) on participants living in New Orleans or a surrounding parish, as part of the Opening Doors Evaluation, a program designed to increase academic persistence in community colleges. All

participants were between 18 and 34 years old, the parent of at least one dependent child, had an income below 200% FPL, and had a high school diploma or equivalent. After Hurricane Katrina hit in August of 2005 during follow-up data collection, the study was redesigned to be the RISK project. Two follow-up waves have been conducted since then, one in 2006-2007 that surveyed 711 of the original respondents, and again in 2009-2010 with 752 respondents. We refer to the 2003-2004 data as "baseline," the 2006-2007 as "first follow-up wave," and 2009-2010 as "second follow-up wave." All data are self-reported, and the study was approved by the Princeton and Harvard Institutional Review Boards.

MEASURES

We conduct a multilevel analysis with neighborhood as our level-two geographic variable, because it represents an administrative, economic, and social membership that likely influences BMI at the individual level (level-one). Clustering due to shared context at the neighborhood level creates statistical dependence that, if not appropriately accounted for in analysis, can result in incorrect statistical estimates. We operationalize census tracts as neighborhoods because participants were geocoded to this census geography, they are relatively small geographic units (approximately 4,000 people), and data are available at the tract level over our study period. Though imperfect representations of neighborhoods, census tracts are the most commonly used administrative unit in multilevel neighborhood health studies (M. C. Arcaya et al., 2016), and there is evidence suggesting these geographies perform well for health research (Krieger et al., 2003). Further, many other studies of gentrification have used census tracts (Ellen & O'Regan, 2008; Hwang & Sampson, 2014; McKinnish, Walsh, & White, 2010).

EXPOSURE

Our primary exposure is an indicator of gentrification, based on the change in the ratio of the median household income in the census tract to the county median, among previously low-income census tracts (Ellen & O'Regan, 2011). Following a number of other studies, we utilized this relative measure of income to account for differences in wage levels across MSAs and years (Rosenthal 2008, Ellen and O'Regan 2008). Though researchers have operationalized gentrification in various manners- including increases in household income, housing cost, percentage white, and education in formerly low-income neighborhoods- we followed several other studies in the literature and choose a metric based solely on income growth (Ellen & O'Regan, 2008; McKinnish et al., 2010, Landis 2016), because it uses administrative data that is available across the U.S. at the census tract level. Other studies found that this index correlated well with other metrics including, educational up-skilling, racial turnover, and housing rents (Sanghoon Lee & Lin, 2013), and produces similar results to more complex indices (Bostic & Martin, 2003; Ding et al., 2015).

For pre-Katrina (baseline), we measured the "gentrification index" as the change in census tract to county household median income from decennial Census 1990 to 2000. For the 2006-2007 wave we measure the difference in index between 2000 and 2005-2009 American Community Survey (ACS) 5-year estimates. We also consider whether the neighborhood was low-income, and therefore eligible for reinvestment, in 2000. We define previously low-income census tracts as those with household median incomes in the bottom 40th percentile of county median incomes, and categorize all other census tracts as "affluent," though many of these neighborhoods were either moderate income. All participants were geocoded to census 2000

tracts boundaries, and 1990 census tract boundaries were normalized to 2000 census tract boundaries using the Longitudinal Tract Base (Logan, Xu, & Stults, 2014).

Following a number of other studies, (Gibbons, Barton, and Barton 2016, Williams , Huynh and Maroko 2014, Ding, Hwang, and Divringi 2015), we categorized our gentrification index, and used a threshold of greater than five percentage point change in the census tract gentrification index to indicate substantial socioeconomic change (Ellen & O'Regan, 2011). Our categorical variable incorporates our measure of whether a neighborhood was eligible for reinvestment, helping to distinguish gentrifying neighborhoods from moderate- or high-income neighborhoods that experience further economic ascension. Additionally, categorizing the gentrification index creates a clear reference group, allowing us to easily compare the effects of gentrification to continuously low-income or declining neighborhoods.

The categorical variable, our *Treatment* variable, indicates whether between 2000 and 2005-2009 the post-Katrina assigned neighborhood gentrified, remained impoverished, appreciated, or depreciated. We defined these four mutually exclusive categories as follows: "Gentrifying" was defined as neighborhoods that were low-income in 2000, where the ratio of neighborhood to county household median income increased by five or more percentage points between 2000 and 2005-2009. "Impoverished" was defined as low-income in 2000, where the ratio of household to county income either decreased or increased by less than five percentage points. "Depreciated" was defined as not low-income (affluent) in 2000, where the ratio decreased or increased by less than five percentage points. "Appreciated" was defined as affluent in 2000, where the ratio increased by five or more percentage points. We refer to this variable as “neighborhood categories.” Our categorical variable incorporates our measure of whether a neighborhood was eligible for reinvestment, helping to distinguish gentrifying neighborhoods

from moderate or high income neighborhoods that experience further economic ascension. Additionally, a continuous measure assumes a linear relationship between the change in neighborhood economic status and resident health, while our categorical variable allows us to compare gentrifying neighborhoods to continuously low-income neighborhoods, our primary comparison of interest.

We also tested a three-level categorical variable that combined the appreciated and depreciated ("affluent" in 2000) categories. In all models, the impoverished category was the reference group. To test for sensitivity to the cut off threshold, we replicate our analysis including gentrification as a binary indicator based on greater than or less than 5% change among previously low income neighborhoods, a continuous measure of the census tract to county median household income, a ten percentage point increase, and any positive change in the gentrification index.

COVARIATES

We considered the racialized implications of gentrification using three variables, as evidence suggests the powerful impact of race in neighborhood selection and how race/ethnicity shapes patterns of segregation and risk of neighborhood disinvestment and investment (Charles 2003). Previous research has found neighborhood racial segregation predicts higher risk of neighborhood gentrification (Hwang & Sampson, 2014) and is associated with both BMI (Corral et al., 2015 2230) and self-rated health (Gibbons & Yang, 2014) among Blacks. We use racial composition to assess the potential differential effects of gentrification by racial segregation. We calculated our measure as the 2000 racial/ethnic composition for the follow-up neighborhoods, and categorized neighborhoods where greater than 50% of the population was part of a particular racial group as majority White, majority Black or any other racial composition, which includes

majority Hispanic and neighborhoods with no majority racial/ethnic composition (Papachristos et al. 2011) (Hwang & Sampson, 2014). We assess differences in neighborhood racial composition in 2000, the beginning of the gentrification window, for neighborhoods assigned post-Katrina. Our quasi-experimental design reduces the risk of neighborhood selection by race, so we do not adjust for potential confounding by residential segregation before Katrina. Instead, we run our adjusted models separately for each of our neighborhood composition categories to test for differential impacts of gentrification based on the racial composition in the neighborhood and to help identify the possible unequal consequences of reinvestment based on the racial composition of communities (Papachristos et al. 2011).

We also included individual race/ethnicity (White, Black, Other) as a covariate to adjust for baseline imbalance between the control and treatment groups. We then tested for effect modification by individual race by running adjusted models separately for each of our racial categories to examine the potential differential effects of gentrification on participants of different races.

INDIVIDUAL COVARIATES

In addition to individual race/ethnicity, we adjusted for several characteristics to account for any baseline imbalance between the various treatment groups post-Katrina. These variables include welfare and social support measured at baseline. There was no evidence of an imbalance in age at baseline, but including this variable controls for time-specific effects. We tested for imbalance along additional demographic characteristics of the full sample, between the treatment and control groups (N=1,019) but found no evidence of imbalance for these characteristics (see Table 7). Age was measured as continuous; race was measured as categorical (Non-Hispanic White, Non-Hispanic Black, Other race/ethnicity, which included Asian and Hispanic); and

social support was measured as continuous using a validated four-point scale of social support (Cutrona & Russell, 1987).

MODEL BUILDING

Statistical analysis

We used a multilevel data structure to make inference about the effects of an area-level exposure (gentrification) on individual level outcomes (BMI and self-reported health) over time. Our analysis used three waves of data for our quasi-experimental design, clustering observations within participants, and participants within neighborhoods. We clustered participants in baseline census tracts, as participants reported in qualitative data collection that neighbors were likely to board the same bus leaving New Orleans and resettle in the same area, return to the same New Orleans neighborhoods after Katrina, and to share sociodemographic profiles.

Using LR tests for nested models, and AIC/BIC for non-nested models, we tested the appropriateness of multilevel (one versus two, and two versus three level) data structure, and found the three-level model was the best fit for the data.

Our baseline model was a three-level model, with waves (i) nested within individuals (j) nested within neighborhoods (k). For interpretation, β_0 represents the average self-reported health pre-Katrina (2003) for participants living in an impoverished neighborhood in 2006. Bracketed terms represent random effects associated with neighborhood, individual participant, and waves. The term v_{0k} is the neighborhood-specific residual that gives each neighborhood its own average self-reported health, u_{0jk} is the individual-specific residual, and $e_{0ij}$is the wave-specific residual. Assuming residuals with a normal distribution and mean of zero, the model estimates σ_{v0}^{2} as the between neighborhood variation in self-reported health, σ_{u0}^{2} as the between individual, within neighborhood variation in self-reported health, and σ_{e0}^{2} as the within

neighborhood, within individual, between wave variation in self-reported health. We model the covariance as identity because we employ a single-level random effect.

We included a dummy variable for *Post*, where 1 indicated data from the 2006 and 2009 post-Katrina waves, and 0 indicated data from the pre-Katrina (2003) wave. We additionally tested creating an additional level for the 2009 wave. The *treatment* variable, the four-level categorical variable that indicated whether, between 2003 and 2006 the post-Katrina assignment neighborhood gentrified, stayed impoverished, appreciated, or depreciated, was included as three dummy variables with impoverished neighborhoods as the reference group.

Our main variable of interest was β_5, or the interaction term between the β_1 (Post) and $\beta_{,}$ (Gentrified). It can be interpreted as the average differential effect of being assigned to a gentrified neighborhood compared with the reference group (assigned to an impoverished neighborhood) post-Katrina. Our baseline model for the effect of gentrification on self-rated health is specified as follows.

$$
\begin{aligned}
Self - Rated\ Hlth_{,\,ijk} &= \beta_0 + \beta_1 Post_{ij} + \beta_{,}\, Gentrified_k + \beta_3 Depreciated_k \\
&+ \beta_4 Appreciated_k + \beta_5 Post_{ij} * Gentrified_k \\
&+ \beta_6 Post_{ij} * Depreciated_k + \beta_7 Post_{ij} * Appreciated_k + e_{0ijk} \\
&+ u_{0jk} + v_{0k}
\end{aligned}
$$

$$
\begin{aligned}
e_{0ijk} &\sim N(0, \sigma'_{e0}) \\
u_{0jk} &\sim N(0, \sigma'_{u0}) \\
v_{0k} &\sim N(0, \sigma'_{v0})
\end{aligned}
$$

Sensitivity Analysis

To look for evidence of selective attrition, we compared mean demographics at baseline, among the full sample, sample of participants in the survey at the first follow-up wave, and sample of participants in the survey at the second follow-up wave (Contoyannis, Jones, and Rice 2004). We then extended this analysis by performing a series of probit regressions where the

probability of remaining in the study at each wave is modeled as a function of the baseline values of the following predictors (Miller and Hollist 2007): age, race, social support, and whether the participant received welfare. To determine if non-response was missing completely at random (MCAR) we conducted Little's test (Little 1988) and then for variables for which the MCAR assumption did not hold, we ran bivariate tests between the dependent and predictor variables to assess which variables accounted for the non-random missingness. For our primary analysis, rather than conducting a complete case analysis, we used a repeated measure mixed model, which can account for unbalanced data or data with missing within-person data. However, to test the sensitivity of our results to missing observations we also conducted sensitivity analysis with only the participants with matched coordinates and outcome measures at the baseline and first follow-up wave and found that our results were substantively unchanged.

Previous analysis of the RISK dataset by Arcaya et al., found that at the first follow-up wave, residents were essentially randomized to neighborhoods with respect to county sprawl (Arcaya et al. 2014). We replicated this analysis with respect to gentrification by assessing the degree of neighborhood selection at the first follow-up wave and comparing the evidence of selection at follow-up to selection at baseline. To test this selection assumption, we fit a series of hierarchical bivariate linear regressions, regressing our gentrification index at each wave on predictors (age, race, gender, social support, welfare, education) from the previous wave. We report descriptive statistics for the full study population and tested for baseline imbalance in the covariates between the wave one follow-up neighborhood categories.

We also conducted additional robustness checks. We tested for sensitivity to a mean rather than median household income ratio, specification of the self-rated health models as ordered logistic regressions, and inclusion of an additional time-specific effect for the second

follow-up wave (2009). We tested if results were specific to living in New Orleans at follow-up by running models separately for those who moved back to New Orleans by 2006. Finally, we conducted a treatment on the treated effect, where we ran a simple longitudinal analysis controlling for gentrification at each stage of follow up, as well as potential confounders including baseline age, and race, and wave specific social support, welfare, employment, and number of children, clustering participants in their baseline census tracts, and observations within participants.

Analyses were conducted using Stata 15.0 (StataCorp 2017).

Results

Table 7 displays the baseline characteristics of all included participants, comparing the average or proportion of the population in each neighborhood category in the assigned neighborhoods. We did not include changes in outcomes between the baseline and the follow-up waves in the table but describe them here. The study population was young, with a mean age of 25 at baseline. The vast majority of the sample identified as non-Hispanic Black (nearly 85%), and 10.5% identified as Non-Hispanic White. At baseline, most (84%) had at least a 12^{th}-grade education. Respondents had on average 1.8 children and enjoyed high levels of social support (mean 3.18). Only one in ten respondents received welfare or cash assistance at baseline, though all lived under 200% of the poverty level, and just over 50% were employed. The average BMI at baseline was 28.36 kg/m^2 and increased by 1.34 points to 30.12 kg/m^2 by the second round of follow-up, and average self-rated health went from 4.1 to 3.3, indicating worsening general health.

We found high rates of housing instability and mobility in the population: participants moved an average of 3.7 times in the four years after Katrina and an average of 3.65 times just during the first year after Katrina. Only 36% of respondents were living in their assigned neighborhoods by 2009, and 23% were living back in their pre-Katrina neighborhoods in 2009.

In 2003, a quarter of census tracts and 28% of participants lived in neighborhoods designated as gentrified between 1990 and 2000. By 2006, 18% of census tracts and 17% of participants resided in neighborhoods that gentrified between 2000 and 2006-2009. Though a smaller percentage of census tracts where respondents lived gentrified at the first follow-up wave than at baseline, on average respondents' neighborhoods in 2006 had more than $10,000 higher median household income incomes. This likely in part reflects the very low household incomes in New Orleans county in comparison to counties where respondents were displaced to in 2006. We also found participants' baseline neighborhoods underwent substantial gentrification between 2000 and the final year of the study period, 2009: 61% of the census tracts had more than a five percentage point change between 2000 and 2009 (2008-2012 ACS).

Assigned neighborhoods were substantially more racially diverse than baseline neighborhoods, and assigned neighborhoods underwent substantial changes in racial composition between 2000 and 2006. In the baseline neighborhoods in 2000, 60% of respondents lived in majority Black neighborhood, and 28% lived in majority White neighborhoods. Whereas, in assigned neighborhoods in 2006, 44% of respondents lived in majority Black neighborhoods and 22% lived in majority White neighborhoods. Between 2000 and 2006 the percentage of participants living in majority Black neighborhoods decreased by four percentage points and the percent of respondents living in majority White neighborhoods increased by 17 percentage points.

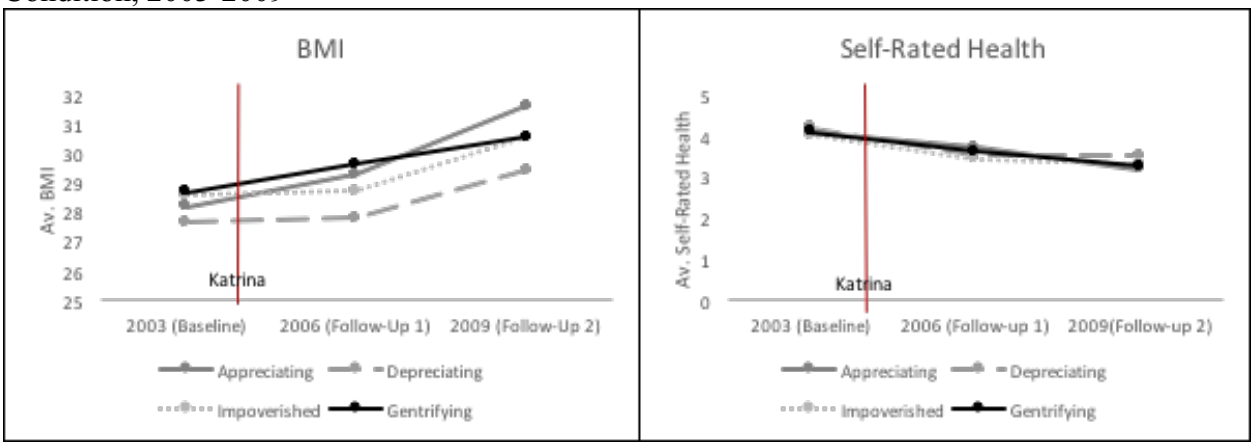
Table 7: Baseline Characteristics for participants, categorized by assigned (2006) neighborhood category

N=942	**Total Sample**						
	N	Mean (SD) or %	**Appreciating** Mean (SD) or %	**Depreciating** Mean (SD) or %	**Impoverished** Mean (SD) or %	**Gentrifying** Mean (SD) or %	P value/F -stat
Total Population	942		7.40%	25.40%	49.78%	17.42%	
BMI	899	28.36(7.02)	28.18 (6.2)	27.66(7.68)	28.57(7.04)	28.69(6.79)	0.501
Self-Rated Health	924	4.09(0.84)	4.08(0.79)	4.21(0.85)	4.02(0.82)	4.09(0.82)	0.101
Age at baseline	942	25.26(4.49)	25.26(3.82)	25.73(4.98)	24.79(4.3)	25.28(4.38)	0.136
Number of Children*	938	1.81(1.03)	1.71(0.94)	1.78(1.05)	1.84(1.10)	1.79(0.85)	0.821
Social Support (1=low 4=high)*	906	3.18(0.45)	3.15(0.51)	3.24(0.42)	3.16(0.47)	3.23(0.47)	0.190
Race/Ethnicity							
NH White	65	9.43%	23.08%	50.77%	15.38%	10.77%	
NH Black	597	86.65%	5.36%	22.45%	53.60%	18.59%	0.000
Hispanic/Other	27	3.92%	14.81%	29.63%	48.15%	7.41%	
Receipt of welfare or cash assistance	922	11.06%	5.66%	8.38%	15.80%	12.20%	0.036
Employed	940	51.49%	59.62	52.72%	49.68%	51.59%	0.602
Highest level of Education	929						
8^{th} grade	6	0.65%	0%	40.00%	20.00%	40.00%	
9^{th}grade	26	2.80%	10.53%	42.11%	42.11%	5.26%	
10^{th}	46	4.95%	5.71%	22.86%	54.29%	17.14%	0.528
11^{th}	67	7.21%	3.92%	33.33%	41.18%	21.57%	
12^{th}	784	84.39%	7.87%	24.79%	29.75%	17.59%	
Neighborhood Variables							
Racial Composition							
Majority White	308	38.5%	14.12%	37.79%	35.5%	12.6%	
Majority Black	351	43.88%	2.09%	19.7%	55.82%	22.39%	0.000
Majority Hispanic/ No majority	141	17.62%	7.5%	25.66%	49.23%	17.71%	

In Figure 3, we plot unadjusted time trends for average BMI and self-rated health at each of the data collection waves, and for each of the neighborhood categories. All data points use the 2006 "assigned" neighborhood categories. The black line represents gentrifying neighborhoods (the treatment), and the light grey dotted line represents continuously impoverished neighborhoods (the control).

Figure 3 shows that before Katrina, average BMI was slightly higher in gentrifying neighborhoods than the other neighborhood types, though this difference was not significant. There is a slight upward trend in BMI after Katrina, though this is noticeable across all neighborhood types. The figure for self-rated health shows that trends in self-rated health did not differ appreciably across the neighborhood types, though there is a clear downward trend for all groups after Katrina, indicating worsening general health.

Figure 3: Unadjusted Trends in Average BMI and Self-Rated Health by neighborhood Condition, 2003-2009



*red line represents Hurricane Katrina.

Table 8 displays results from our main difference-in-differences analysis. The estimates showed evidence of no statistically significant changes in BMI or self-rated health related to neighborhood assignment, in models with and without adjustment for covariates. The coefficient for the interaction between post and gentrifying neighborhoods for self-rated health was close to zero for the adjusted and unadjusted (β=-0.04 and β =-0.07) analysis, suggesting there is no effect of gentrification on self-rated health in our population. The magnitude of effect for BMI was also not significant in the unadjusted (β =-0.18 CI: -1.49,1.14) or adjusted (β =-1.12 CI:2.74,0.49) analysis. Results were consistent when we adjusted for age, race, welfare status, and

social support in fully adjusted multivariable models. In the adjusted analysis we find that for respondents pre-Katrina, BMI was significantly higher in gentrifying (β =1.85 p<.05) neighborhoods in comparison to consistently impoverished neighborhoods. Our results were substantively unchanged when we included a time-specific effect, with two separate post-Katrina periods.

Table 8: Associations between Post-Katrina Gentrification, and BMI and Self-Rated health

	BMI		**Self Rated Health**	
	Model 1 β (95% CI)	Model 2[a] β (95% CI)	Model 1 β (95% CI)	Model 2[a] β (95% CI)
Pre-Katrina Impoverished	-	-	-	-
Pre-Katrina Appreciating	0.38 (-1.50,2.25)	2.41* (-0.08,4.91)	0.07 (-0.22,0.35)	0.14 (-0.25,0.53)
Pre-Katrina Depreciating	-1.05* (-2.21,0.10)	0.73 (-0.94,2.41)	0.20** (0.03,0.37)	0.22* (-0.03,0.48)
Pre-Katrina Gentrifying	0.16 (-1.16,1.47)	1.85** (0.03,3.68)	0.08 (-0.11,0.28)	0.18 (-0.11,0.46)
Post-Katrina Impoverished	-	-	-	-
Post-Katrina Appreciating	0.44 (-1.28,2.16)	-0.90 (-3.02,1.21)	-0.05 (-0.40,0.30)	0.16 (-0.29,0.61)
Post-Katrina Depreciating	0.35 (-0.70,1.40)	-0.16 (-1.58,1.27)	-0.06 (-0.27,0.15)	-0.12 (-0.41,0.18)
Post-Katrina Gentrifying	-0.18 (-1.49,1.14)	-1.12 (-2.74,0.49)	-0.04 (-0.29,0.21)	-0.07 (-0.40,0.26)

* p<0.10, ** p<0.05, *** p<0.01
a. adjusted for age, race, welfare receipt and social support at baseline.

We then examined whether participants of different races were differentially affected by gentrification. Only Whites had a significant (β=-5.94 CI:-11.72,-0.15; p<.05) relationship between

gentrification and BMI, which should also be interpreted cautiously given the multiple subgroups and outcomes we tested. The significant relationship, for respondents in the "other" racial category, who were living in gentrifying neighborhoods pre-Katrina, compared to continuously low-income neighborhoods, and BMI should similarly be interpreted cautiously.

Table 9: Associations between gentrification, and BMI and self-rated health, adjusted models and stratified by individual race

	BMI[a]			**Self-Rated Health**[a]		
	White β (95% CI)	Black β (95% CI)	Other β (95% CI)	White β (95% CI)	Black	Other
Pre-Katrina Impoverished	-	-	-	-	-	-
Pre-Katrina Appreciating	-1.71 (-9.40,5.98)	3.03** (0.02,6.05)	-2.16 (-7.33,3.00)	-0.05 (-1.30,1.21)	0.12 (-0.36,0.60)	0.09 (-0.84,1.01)
Pre-Katrina Depreciating	-3.36 (-10.20,3.48)	0.98 (-0.84,2.81)	-2.95 (-10.53,4.62)	0.12 (-0.99,1.24)	0.17 (-0.11,0.45)	0.79 (-0.39,1.97)
Pre-Katrina Gentrifying	3.16 (-4.67,10.99)	1.64 (-0.31,3.58)	-12.31** (-23.53,-1.09)	-0.29 (-1.59,1.01)	0.18 (-0.12,0.48)	0.65 (-1.04,2.34)
Post-Katrina Impoverished	-	-	-	-	-	-
Post-Katrina Appreciating	-3.30 (-9.21,2.61)	-1.25 (-3.81,1.31)	2.55 (-1.94,7.04)	0.76 (-0.52,2.05)	0.09 (-0.46,0.64)	0.79 (-0.32,1.90)
Post-Katrina Depreciating	-4.22 (-9.34,0.89)	0.18 (-1.42,1.78)	0.75 (-3.21,4.71)	0.33 (-0.80,1.46)	-0.07 (-0.39,0.26)	0.04 (-1.41,1.49)
Post-Katrina Gentrifying	-5.94** (-11.72,-0.15)	-0.91 (-2.68,0.87)	2.33 (-2.71,7.36)	1.14* (-0.20,2.47)	-0.14 (-0.50,0.21)	0.29 (-1.66,2.24)

* p<0.10, ** p<0.05, *** p<0.01

a. all models adjusted for age, welfare receipt and social support at baseline.

Finally, we examined whether neighborhood racial composition differentially affected individual outcomes. We find no differential effect post-Katrina of gentrification on either outcome, so fail to reject the null hypothesis that the effect of gentrification was the same for neighborhoods with majority White, majority Black, or majority Hispanic/no majority. We do however find that for respondents living in majority White neighborhoods pre-Katrina, BMI was significantly higher in gentrifying (β =3.01 CI: 0.13,5.89 p<0.05) and appreciating (β =2.96 CI: 0.13, 5.89 p<0.05) neighborhoods in comparison to consistently impoverished neighborhoods.

Table 10: Associations between post-Katrina gentrification, and BMI and self-rated health, adjusted models and stratified neighborhood racial composition

	BMI[a]			**Self-Rated Health**[a]		
	Majority White β (95% CI)	Majority Black β (95% CI)	Other[b] β(95%CI)	Majority White β(95%CI)	Majority Black β(95%CI)	Other[b] β(95% CI)
Pre-Katrina Impoverished	-	-	-	-	-	-
Pre-Katrina Appreciating	2.96** (0.13,5.80)	1.56 (-4.95,8.07)	0.69 (-6.88,8.26)	0.23 (-0.28,0.75)	0.07 (-0.86,1.00)	0.72 (-0.40,1.85)
Pre-Katrina Depreciating	0.26 (-2.04,2.56)	0.41 (-2.56,3.38)	1.94 (-2.09,5.98)	0.22 (-0.20,0.63)	0.38* (-0.03,0.78)	-0.10 (-0.69,0.50)
Pre-Katrina Gentrifying	3.01** (0.13,5.89)	1.16 (-1.79,4.12)	1.47 (-2.20,5.13)	0.14 (-0.37,0.65)	0.22 (-0.19,0.63)	0.13 (-0.42,0.67)
Post-Katrina Impoverished	-	-	-	-	-	-
Post-Katrina Appreciating	-0.75 (-3.59,2.10)	-0.60 (-5.93,4.73)	-1.48 (-6.17,3.21)	0.23 (-0.36,0.82)	0.15 (-0.96,1.25)	0.10 (-0.95,1.15)
Post-Katrina Depreciating	-0.16 (-2.46,2.15)	-0.15 (-2.36,2.05)	0.26 (-2.95,3.47)	-0.06 (-0.53,0.41)	-0.27 (-0.75,0.21)	0.27 (-0.37,0.91)
Post-Katrina Gentrifying	-1.68 (-4.74,1.38)	-0.55 (-2.69,1.59)	-1.57 (-4.21,1.07)	0.11 (-0.50,0.72)	-0.27 (-0.75,0.21)	0.19 (-0.38,0.76)

* p<0.10, ** p<0.05, *** p<0.01
a. adjusted for age, race, welfare receipt and social support at baseline.
b. Neighborhoods categorized as "Other" have majority Hispanic, or no majority population

ROBUSTNESS CHECKS

Appendix 4 Table 1 shows our analysis using 10% as the cutoff. Our results did not change substantively from using a five percentage point change as the cut off, with the exception that neighborhoods that had no majority or majority Hispanic racial/ethnic composition were associated with -2.43 ($p<.05$, CI: -4.29,-0.56) units lower BMI than neighborhoods with majority White or majority Black neighborhoods. Our results remained substantively unchanged when we categorized neighborhoods that experienced an increase in their relative income ratio as having gentrified, though a much larger percentage of neighborhoods (24.83% vs 17.71%) were categorized as gentrifying using the more lenient definition compared to the five percentage point definition.

We tested for selective attrition and non-response bias at the two follow-up waves, and found that gender was the only source of substantial selective attrition or non-response bias, so we replicate previous analysis using the RISK dataset (Lowe, Rhodes, and Waters 2015), and drop all men from the analysis (N=77; 7.56% of the sample). Our final sample size includes 942 participants. Respondents lived in 256 census tracts across one state at baseline, at the first follow-up wave they lived in 26 states and 447 census tracts.

Neighborhood selection with respect to measured confounders and gentrification appears to be random. We find no evidence of significant selection associated with gentrification at follow-up. No measured variables were significantly associated with the gentrification index, though there was a marginally significant relationship (B=-0.12 p=0.057) between being non-Hispanic Black compared to non-Hispanic White, and living in a neighborhood that between 2000 and 2006 experienced a decrease in the census tract to county ratio of median household income. In Table 7, we showed the distribution of the participant characteristics between the four

neighborhood types, and show that for most variables, there was participant balance at baseline between the neighborhood types. We found evidence of imbalance on race and receipt of welfare at baseline and therefore included these variables in our main regression analysis. There was no evidence of significant imbalance in social support using the five percentage point cutoff ($p=0.190$), but there was evidence of imbalance when using the ten percentage point cut off, suggesting there might be potential imbalance along this variable, and we therefore also included social support in the adjusted models.

In our test of differential effects for those living back in New Orleans by 2006, we found no significant differences in effect size or significance between the population that returned to New Orleans by 2006, and those who remained elsewhere. We also tested modeling self-rated health as continuous and ordered logistic (Arcaya et al. 2018). Though ordered logistic models were a better fit to the data, for ease of interpretation we presented the linear regressions, as results did not differ based on the model specification.

Discussion

Among a population of Hurricane Katrina survivors with high rates of housing mobility after the storm, gentrification was not associated with differential changes in self-rated health or BMI, with non-significant point estimates close to zero. We did find high levels of gentrification in our study sample. Only a quarter of residents were living in their Pre Katrina neighborhoods in 2009, while 61% of respondents' baseline neighborhoods gentrified between 2000 and 2009.

Using an intent-to-treat study design and differences-in-differences analysis we found no significant differences in health between participants living in gentrified neighborhoods compared with continuously impoverished neighborhoods. Across models, there was a negative,

but non-significant, relationship between BMI and gentrification post-Katrina in comparison to continually impoverished neighborhoods, suggesting that if anything living in a gentrifying compared to a consistently impoverished neighborhood is associated with lower BMI, but that there is not evidence that this relationship is significant. In our adjusted model we found a significant positive relationship between gentrification and BMI pre-Katrina, but importantly pre Katrina neighborhood assignment was not random, so there may have been systematic differences between neighborhood residents that account for the significant association between gentrification and BMI.

There are several possible explanations for our results showing no significant effects of gentrification on health. First, it is possible that we are underpowered to detect a real effect, as we have a relatively small sample size. However, our effect sizes, especially for self-rated health, were close to zero across models, and power was sufficient to show statistically significant associations between county sprawl and BMI, after adjustment for individual characteristics, in another study using the RISK dataset, which used an even smaller sample size (n=280) (M. Arcaya et al., 2014).

Second, gentrification, as measured by change in the census tract to county median household income between 2000 and 2006, may not cause self-reported BMI or general health to change. Gentrification may also positively and negatively affect health, and the different directional effects may cancel out any net effect. Third, it is possible that these findings are unique to BMI and self-rated health. For other outcomes, there may be a unidirectional impact that our measures of health fail to capture.

Other studies on gentrification and health have found disparate effects of gentrification on health, and a systematic review of quantitative studies on gentrification and health found that

estimated effects varied by outcome, period studied, and operationalization of gentrification (Schnake-Mahl et al. 2018), and generally quantitative studies less substantial consequences of gentrification than qualitative studies (Brown-Saracino, 2017). However, these significant findings may be due to selection effects, as only one of the previous studies on the empirical relationship between gentrification and health used a study design that can remove potential selection bias (Lee 2010). Using an earthquake as an instrumental variable, Lee, 2010 found no significant effect of gentrification on crime or violent crime in low-income tracts but found that in the short term gentrification increased the number of assaults in moderate-income neighborhoods (Lee 2010). Given the contentious debates about the causal relationship between neighborhoods and health (Ellen, Mijanovich, and Dillman 2001, Diez Roux and Mair 2010, Arcaya et al. 2016), and susceptibility of estimates to confounding by neighborhood selection, quasi-experimental designs represent a major methodological improvement to previous work.

One potential limitation of our analysis is that the context of Hurricane Katrina may be unique and limit generalizability. The overall shock and disruption of Hurricane Katrina, and forced displacement after the storm may have overwhelmed the effects of neighborhood socioeconomic and cultural transformation. African-American women, who made up the majority of our study population, experienced the most difficulty returning to their post-Katrina homes: a study found that only 42% of African-American women returned in the year after Katrina, compared to 70% of all Whites (Henderson, Davis, and Climek 2015). In our study population, only 27% of respondents indicated that from 2009 to 2010 they lived in their Pre-Katrina home. Participants moved numerous times, on average four times in the five years after Katrina, and only 40% of participants stayed in their assigned neighborhoods. The high levels of mobility may have reduced any neighborhood effects, as research suggests that neighborhood

exposures may need to accumulate over time to impact health (Roux 2007). Another possible explanation for our null findings is that long-term neighborhood residents may be most susceptible to impacts of gentrification, as they are more deeply embedded in their community, and our study participants were largely new to the communities where they were displaced to after the storm.

These explanations indicate that while displacement after Hurricane Katrina serves as a useful tool to assess internal validity by creating a natural experiment and opportunity for a quasi-experimental study, the external validity of our findings is limited and should be cautiously extrapolated to gentrification that low-income populations are exposed to when natural disasters do not occur.

Tragically, natural disasters such as Katrina are increasing in frequency (Smith and Katz 2013), and have in some cases also catalyzed neighborhood change, pushing out some residents and attracting others (Lee 2010, Lee 2017). Areas with more severe physical property damage are more likely to undergo change (Kamel 2012, Landry et al. 2007) and because of preexisting social and economic inequalities, low-income areas are often disproportionately impacted by natural disasters (Cutter et al. 2008), and have worse baseline health indicators (Davis et al. 2010). Low-income groups are also slowest to return after catastrophes, and often have the most difficulty rebuilding because of lower rates of investment in hazard mitigation such as natural hazard insurance (Peacock and Girard 1997), as well as more limited access to recovery resources and health care access (Quarantelli 2003, Davis et al. 2010). Studies after Katrina showed that low-income households were more likely to leave after the storm (Frey and Singer 2006), and renters and Blacks were less likely to return to their Pre Katrina homes (Elliott and Pais 2006, Mueller et al. 2011).

Exogenous shocks such as storms can exacerbate existing spatial inequality, as natural hazards differentially impact neighborhood change processes according to prior neighborhood characteristics (Pais and Elliott 2008). While building resiliency to future storms is integral to the rebuilding process, respecting residents' right to remain and incorporating broad voices in the recovery planning should also be prioritized (NOLA 2015, Orleans 2017, Henderson, Davis, and Climek 2015), as should minimizing rapid gentrification induced by a hazard. Broadly, proactive policies to build and rebuild affordable housing, and investing in community organizing social connections and anchor institutions can help residents remain in their neighborhoods and build resiliency and reduce vulnerability to future disasters. Further, to minimize recovery disparities after natural disasters, governments and emergency management professionals can more equitably distribute rehabilitation resources and bring low-income and working-class voices into the recovery planning and process, to minimize recovery disparities.

LIMITATIONS

The near randomization in our sample improves our ability to make causal inference, and allows us to explore the effect of gentrification, net of selection into those neighborhoods. While our study represents a major methodological improvement on previous studies on gentrification and health, we mention several additional limitations. We control for individual-level covariates imbalanced at baseline, but it is possible that imbalance remained on unmeasured variables. Our differences-in-differences model also assumes that we can remove any unobserved time and neighborhood-specific effects, (parallel trends assumption), but the time-varying confounders may remain despite the robust study design.

Additionally, our measure of gentrification may be imprecise and may not be able to distinguish gentrification from other forms of neighborhood transition, as our measure relies on census data that only captures the socioeconomic characteristics of gentrification. Recognizing the limitation of census data, we nonetheless chose to use the census tract to median household income because it allowed us to compare geographies across the U.S., which was necessary given that our study participants were displaced to nearly 100 different counties across the country after Katrina. Furthermore, our use of census tract to median county income is a commonly used measure that correlated well with other indicators of gentrification (Bostic & Martin, 2003; Ding et al., 2015). Our measure of gentrification may also understate upgrading in neighborhoods where the whole metropolitan area is growing economically. However, given the period of study, which is at and immediately following the peak of the financial crash, this is unlikely to have commonly occurred, and reports show that median household income did not grow in New Orleans between 2000 and 2010. Additionally, we tested several alternative specifications of our gentrification measure, and results were not sensitive to changes in the measure.

Our outcomes are self-reported, which can potentially result in a social desirability bias or recall bias. However, it is unlikely this bias would occur differentially among participants based on the neighborhood of assignment and therefore should not impact the estimates. Finally, as mentioned earlier, our results also may not be generalizable, as the study cohort was drawn from a single geographic area, comprises mostly young, African-American, low-income mothers and all participants were exposed to a devastating hurricane.

CONCLUSION

This article is, to our knowledge, only the second paper using a natural experiment to examine the relationship between a neighborhood exposure and individual health (Arcaya et al. 2014). In this longitudinal quasi-experimental analysis using a unique dataset, we find that essentially random assignment post-Katrina to neighborhoods with varying levels of gentrification produced no detectable effects on health. While gentrification likely has numerous important social and economic effects, we do not find quantitative evidence for health impacts in this population of survivors of Hurricane Katrina.

Appendix 4

Appendix 4 Table 1: Effect of Gentrification on BMI and Self-Rated Health, using 10% gentrification cut off

	BMI		**Self Rated Health**	
	Model 1 β (95% CI)	Model 2[a] β (95% CI)	Model 1 β (95% CI)	Model 2[a] β (95% CI)
Pre-Katrina Impoverished	-	-	-	-
Pre-Katrina Appreciating	0.41 (-1.59,2.40)	2.68** (0.02,5.34)	0.15 (-0.15,0.45)	0.22 (-0.19,0.64)
Pre-Katrina Depreciating	-0.98* (-2.11,0.14)	0.59 (-1.03,2.21)	0.16* (-0.01,0.33)	0.19 (-0.06,0.43)
Pre-Katrina Gentrifying	0.31 (-1.17,1.78)	1.93* (-0.14,4.01)	0.06 (-0.16,0.28)	0.20 (-0.12,0.52)
Post-Katrina Impoverished	-	-	-	-
Post-Katrina Appreciating	0.66 (-1.16,2.49)	-0.69 (-2.99,1.61)	-0.04 (-0.41,0.33)	0.16 (-0.32,0.64)
Post-Katrina Depreciating	0.37 (-0.65,1.39)	-0.03 (-1.40,1.34)	-0.06 (-0.27,0.15)	-0.11 (-0.40,0.17)
Post-Katrina Gentrifying	0.06 (-1.45,1.56)	-0.60 (-2.48,1.28)	-0.04 (-0.33,0.24)	-0.11 (-0.48,0.27)

Appendix 4 **Table 2:** Associations between post-Katrina gentrification, and BMI and self-rated health, adjusted models and stratified by individual race/ethnicity, using 10% gentrification cut off

	BMI[a]			**Self Rated Health**[a]		
	White β (95% CI)	Black β (95% CI)	Other β (95% CI)	White β(95% CI)	Black β(95% CI)	Other β(95% CI)
Pre-Katrina Impoverished	-	-	-	-	-	-
Pre-Katrina Appreciating	-0.36 (-4.18,3.46)	0.81* (-0.01,1.63)	-0.54 (-2.99,1.90)	0.40 (-0.70,1.51)	0.17 (-0.36,0.69)	0.39 (-0.63,1.41)
Pre-Katrina Depreciating	-4.26 (-11.37,2.85)	3.66** (0.37,6.95)	-2.63 (-8.29,3.02)	0.58 (-0.39,1.54)	0.14 (-0.13,0.41)	0.30 (-0.70,1.30)
Pre-Katrina Gentrifying	-5.86* (-12.13,0.4)	0.90 (-0.86,2.67)	-1.59 (-7.49,4.31)	0.52 (-0.74,1.78)	0.18 (-0.15,0.52)	0.56 (-1.12,2.24)
Post-Katrina Impoverished	-	-	-	-	-	-
Post-Katrina Appreciating	0.59 (-5.02,6.20)	-1.24 (-4.17,1.69)	2.58 (-2.05,7.20)	0.40 (-0.78,1.58)	0.11 (-0.49,0.72)	0.79 (-0.44,2.01)
Post-Katrina Depreciating	-0.43 (-5.11,4.25)	0.14 (-1.39,1.67)	0.83 (-3.07,4.72)	-0.03 (-1.04,0.98)	-0.06 (-0.38,0.25)	0.29 (-0.94,1.51)
Post-Katrina Gentrifying	0.98 (-5.25,7.21)	-1.02 (-3.12,1.07)	2.34 (-2.70,7.37)	0.67 (-0.71,2.05)	-0.18 (-0.58,0.22)	0.29 (-1.65,2.22)

* p<0.10, ** p<0.05, *** p<0.01

Appendix 4 Table 3: Associations between post-Katrina gentrification, and BMI and self-rated health, adjusted models and stratified neighborhood racial/ethnic composition, using 10% gentrification cut off

	BMI[a]			**Self-Rated Health[a]**		
	Majority White β (95% CI)	Majority Black β (95% CI)	Majority Hispanic or no majority β (95% CI)	Majority White β (95% CI)	Majority Black β (95% CI)	Majority Hispanic or no majority β (95% CI)
Pre-Katrina Impoverished	-	-	-	-	-	-
Pre-Katrina Appreciating	0.59 (-5.02,6.20)	-1.24 (-4.17,1.69)	2.58 (-2.05,7.20)	0.24 (-0.30,0.77)	0.07 (-0.85,1.00)	1.06 (-0.81,2.93)
Pre-Katrina Depreciating	-0.43 (-5.11,4.25)	0.14 (-1.39,1.67)	0.83 (-3.07,4.72)	0.19 (-0.21,0.59)	0.38* (-0.02,0.79)	-0.10 (-0.65,0.45)
Pre-Katrina Gentrifying	0.98 (-5.25,7.21)	-1.02 (-3.12,1.07)	2.34 (-2.70,7.37)	0.08 (-0.46,0.62)	0.33 (-0.13,0.79)	0.12 (-0.57,0.81)
Post-Katrina Impoverished	-	-	-	-	-	-
Post-Katrina Appreciating	-0.39 (-3.34,2.56)	-0.49 (-5.82,4.84)	3.32 (-14.72,21.35)	0.23 (-0.38,0.84)	0.16 (-0.94,1.27)	0.60 (-1.68,2.87)
Post-Katrina Depreciating	0.28 (-1.96,2.51)	-0.05 (-2.23,2.13)	-0.57 (-3.21,2.07)	-0.07 (-0.53,0.39)	-0.26 (-0.73,0.22)	0.19 (-0.39,0.77)
Post-Katrina Gentrifying	-0.21 (-3.48,3.07)	-0.08 (-2.80,2.64)	-3.09** (-5.82,-0.37)	0.04 (-0.60,0.69)	-0.28 (-0.84,0.27)	0.14 (-0.54,0.82)

* p<0.10, ** p<0.05, *** p<0.01

a. adjusted for age, race, welfare receipt and social support at baseline.

Conclusion

This dissertation applies social epidemiologic theory, specifically Ecosocial theory, and methods to questions typically examined by sociology, demography, and urban planning. Ecosocial theory helps us to concretize potential pathways connecting these geographic patterns to health, and guide analysis of these phenomena. It further relies on the emergent positive health science literature to assess the relationships between community-level contextual effects, and health, happiness, and well-being, in changing neighborhoods and communities. This dissertation also contributes to our understanding of how current and new social and geographic contexts are embodied and impact health, and how they affect social inequities in health.

Motivated by reports of increasing poverty in American suburbs (Allard 2017, Kneebone and Berube 2013), the first chapter compared national patterns of insurance coverage and health care access in suburban, urban, and rural areas both before and after the ACA. We found that 40% of the uninsured population lived in the suburbs, and one in seven low-income suburbanites lacked insurance. Though crude rates of access were better in suburban areas, this advantage was greatly attenuated after adjustment for income and other demographics. Suburban areas of the U.S. have substantial populations lacking health insurance and experiencing challenges accessing care. Increased attention to these issues will be critical to identifying the unique features of the suburbs that may present challenges to the health care safety-net in serving vulnerable populations.

The second chapter provides a systematic review of empirical articles assessing the relationship between gentrification and neighborhood change processes, and health. We identified twenty-two articles that suggest that the impacts of gentrification vary by health outcome, and exposure definition and operationalization. Our article helps to inform the debate

on the effects of gentrification and urban development for health. Given the influence of place on health and trend of increasing gentrification and urban development in many American cities, the health field can approach understanding and researching the impacts of these processes on health.

The final chapter contributes to the urban health literature by assessing the effect of neighborhood gentrification on self-rated health and BMI. It is among the first studies to examine gentrification and health using a quasi-experimental design. While we do not find a significant relationship between gentrification and health, our study represents additional methodological improvements to other studies of gentrification and health. Namely, it includes a study population that is relatively homogenous with regards to race and income, thereby eliminating potential unmeasured confounders, and also focuses on a low-income population who are the most exposed and vulnerable to negative effects of gentrification. This work adds evidence and theory to discussion about how to maintain cities inclusive of residents across the economic spectrum after natural disasters, and understanding causal effects of gentrification on health.

These new geographic patterns in suburbs and cities can strain or breakdown positive neighborhood factors- the social and coping assets communities have developed over decades of disinvestment- and create new challenges for low-income populations as they are forced to adjust to lives in new neighborhoods or to live in neighborhoods undergoing substantial change. The importance of geographic setting for health (Sally Macintyre & Ellaway, 2000), substantive role of place in understanding area variations in health (M. Arcaya, Brewster, Zigler, & Subramanian, 2012), and consistent association between socioeconomic status and health (Adler et al., 1994; Glymour, Avedano, & Kawachi, 2014), indicate that changes in where low-income populations

live likely affect both individual and area-level health metrics. When using area-based measures to track changes in population health disparities over time, widening or shrinking inequities may not reflect true changes in a population's health but rather changes in the composition (in and out-migration) of a population. Recognizing geographic population patterns will help to identify when observed changes are due to compositional or contextual changes and allow meaningful substantive and statistical inferences. Failure to examine these types of population movements may result in miss estimation of health outcomes, leading to inappropriate targeting of policies and interventions to address health inequities. This underscores the importance of monitoring and evaluating variation and change in the spatial sorting of populations across the social and economic spectrum, changes in features of local social and physical environments, and changes in population health.

In summary, findings from this dissertation will have important implications for urban and metropolitan area policy and priority setting, the distribution of safety-net resources, and for research on social and economic inequities in health outcomes and access to care. Changing spatial patterns in U.S. metro areas may result in wider disparities and negatively impact well-being, particularly for low-income populations and communities of color, but without further analysis, the full effects will remain obscure. Additionally, we cannot make inferences about the causal processes involved in producing these inequities until we fully account for and identify changes in the composition of places. We suggest that geographic patterns of social disparities are fundamentally shifting in many American metropolitan areas, and that recognizing these changes is integral to addressing and reducing health inequity.

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