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Association of neighborhood gentrification and residential moves with hypertension and diabetes control in Los Angeles County, 2014–2019: A retrospective cohort study

Katherine L. Chen [a,b,*], Frederick J. Zimmerman [b,c], Paul M. Ong [c], Andrea Jones [d,e], Teryl K. Nuckols [f], Ninez A. Ponce [b,g], Kristen R. Choi [b,h,i], Xia X. Li [i], Ariadna Padilla [i], Claudia L. Nau [i]

[a] Division of General Internal Medicine & Health Services Research, David Geffen School of Medicine, University of California, Los Angeles (UCLA), 1100 Glendon Ave., Suite 900, Los Angeles, CA, 90024, USA
[b] Department of Health Policy and Management, UCLA Fielding School of Public Health, 650 Charles E. Young Drive South, Suite 31-269, Los Angeles, CA, 90095, USA
[c] Department of Urban Planning, UCLA Luskin School of Public Affairs, 337 Charles E. Young Drive East, Los Angeles, CA, 90095, USA
[d] Charles R. Drew University of Medicine & Science, 1731 E. 120th St., Los Angeles, CA, 90059, USA
[e] Healthy African American Families II, 4305 Degnan Blvd., Suite 105, Los Angeles, CA, 90008, USA
[f] Division of General Internal Medicine, Cedars-Sinai Medical Center, 8700 Beverly Blvd., Becker 118, Los Angeles, CA, 90048, USA
[g] UCLA Center for Health Policy Research, 10960 Wilshire Blvd., Suite 1550, Los Angeles, CA, 90024, USA
[h] UCLA School of Nursing, 700 Tiverton Dr., Los Angeles, CA, 90024, USA
[i] Department of Research & Evaluation, Kaiser Permanente Southern California, 100 S. Los Robles Ave., Pasadena, CA, 91101, USA

A B S T R A C T

Objective: To examine whether gentrification exposure is associated with future hypertension and diabetes control.
Methods: Linking records from an integrated health care system to census-tract characteristics, we identified adults with hypertension and/or diabetes residing in stably low-SES census tracts in 2014 (n = 69,524). We tested associations of census tract gentrification occurring between 2015 and 2019 with participants' disease control in 2019. Secondary analyses considered the role of residential moves (possible displacement), race and ethnicity, and age.
Results: Gentrification exposure was associated with improved odds of hypertension control (aOR: 1.08; 95% CI: 1.00, 1.17), especially among non-Hispanic Whites and adults >65 years. Gentrification was not associated with diabetes control overall, but control improved in the Hispanic subgroup. Disease control was similar regardless of residential moves in the overall sample, but disparate associations emerged in models stratified by race and ethnicity.
Conclusions: Residents of newly gentrifying neighborhoods may experience modestly improved odds of hypertension and/or diabetes control, but associations may differ across population subgroups.
Policy implications: Gentrification may support—or at least not harm—cardiometabolic health for some residents. City leaders and health systems could partner with impacted communities to ensure that neighborhood development meets the goals and health needs of all residents and does not exacerbate health disparities.

1. Introduction

In recent decades, many cities have seen accelerating rates of gentrification, a process in which under-resourced neighborhoods experience an influx of higher-income residents and capital (Ding et al., 2016; Freeman, 2006; Zuk et al., 2017). While health outcomes are consistently worse among residents of neighborhoods that remain persistently impoverished (Chyn and Katz, 2021; Diez Roux and Mair, 2010), the health effects of gentrification are uncertain (Schnake-Mahl et al., 2020; Smith et al., 2020a).

The Centers for Disease Control and Prevention has recognized that gentrification may produce both benefits and harms to community health (Centers for Disease Control and Prevention, 2017). Gentrification might improve health by ushering in health-promoting resources and economic opportunities alongside healthier and more diverse social networks (Byrne, 2003; Freeman, 2005). Conversely, gentrification might harm health and heighten stress by increasing costs of living, disrupting social connections, and widening economic polarization (Croff et al., 2021; Freeman, 2006; Gibbons, 2019). For those who feel excluded or cannot afford to stay, displacement from gentrifying

* Corresponding author. Division of General Internal Medicine & Health Services Research, David Geffen School of Medicine at the University of California, Los Angeles, 1100 Glendon Ave., Suite 850-833, Los Angeles, CA, 90024, USA.
E-mail address: KLChen@mednet.ucla.edu (K.L. Chen).

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neighborhoods to lower-resourced areas may amplify gentrification's health risks. If its benefits and harms are distributed unequally, gentrification could exacerbate health disparities.

Gentrification may particularly affect the self-management and control of common cardiometabolic diseases, especially hypertension and diabetes, as these conditions are responsive to acute and chronic stress (Hackett and Steptoe, 2017; Harburg et al., 1973; Liu et al., 2017; Spruill, 2010; Walker et al., 2016). In addition to its effect on stress, gentrification may influence cardiometabolic risk by altering environmental determinants of diet, exercise, safety, and social cohesion (Diez Roux et al., 2016). Although the American Heart Association has called for research on gentrification's influence on cardiovascular disease (Sims et al., 2020), only a few studies have examined hypertension- or diabetes-related outcomes in this context, with mixed findings (Bilal et al., 2019; Jacobson et al., 2020; Morenoff et al., 2007).

To address these gaps, this retrospective cohort study compared subsequent control of hypertension and diabetes between residents of low-socioeconomic status (SES) neighborhoods that began to gentrify relative to similar neighborhoods that did not. We also performed a series of analyses to understand the role of residential moves (and possible displacement) in these relationships. Finally, because gentrification may lead to heightened racial conflict and discrimination against minoritized groups (Freeman, 2006; Sullivan and Shaw, 2011), who are already at risk for other forms of structural oppression (Bailey et al., 2017), and because gentrification's financial and psychological toll could be exaggerated for older adults due to heightened place attachment (Binette, 2021; Gilleard et al., 2007) and reliance on fixed incomes and proximity-based social networks (Burns et al., 2011; Strohschein, 2012; Torres, 2020; Versey et al., 2019), we considered outcomes among subgroups stratified by race and ethnicity as well as by age group.

2. Methods

2.1. Setting and data sources

This study focused on residents of Los Angeles (L.A.) County, which has faced a decades-long housing affordability crisis (Ray et al., 2014) and an increasing pace of both gentrification (Chapple et al., 2018; Maciag, 2015; Richardson et al., 2020) and low-income displacement (Stancil, 2019). We examined neighborhood dynamics between 2010 and 2019 to capture housing market changes between the Great Recession and the COVID-19 pandemic. In our longitudinal follow-up of individual participants, we designated 2014 as the baseline year (to select a cohort of participants living in low-SES areas that subsequently did or did not gentrify) and 2019 as the follow-up year (to assess lagged disease control). During the study period, some renters in L.A. County were protected by rent stabilization laws, with rules varying among the county's 88 cities plus additional unincorporated areas. In the City of Los Angeles, the largest city in L.A. County, only apartments built before October 1, 1978 were subject to the city's Rent Stabilization Ordinance, which capped rent increases at 3–8% per year, depending on inflation (Chiland and Chandler, 2020).

We obtained geocoded electronic health record (EHR) data from Kaiser Permanente Southern California (KPSC), a large, nonprofit, integrated health care system covering approximately 20% of the residents of its catchment area (Davis et al., 2023). KPSC coverage options include employer-sponsored plans, Medicare plans for older adults, and self-paid individual or family plans. Medicaid plans are only available to existing KPSC members who become Medicaid-eligible (Kaiser Permanente, 2022), such as through loss of income. Prior research has demonstrated that the socioeconomic and ethnic diversity of KPSC's patients largely reflects that of its catchment area (Davis et al., 2023; Koebnick et al., 2012).

We merged KPSC data by census tract to American Community Survey data from 5-year files ending in 2010, 2014, 2015, and 2019 (U.S. Census Bureau, n.d.).

2.2. Participants

As summarized in Supplemental Figure A, we included KPSC members with L.A. County addresses on file in 2014 and 2019 who were aged 18–85 years throughout the study. KPSC members who moved out of L.A. County during the study were excluded. We also required twelve consecutive months of KPSC membership including the year 2014, allowing up to a 90-day enrollment gap, to assess baseline demographic and clinical characteristics. We defined overlapping subpopulations with hypertension and diabetes using EHR-based criteria (Supplemental Table A) employed in prior research (Nichols et al., 2012; Shaw et al., 2014; Sim et al., 2014). A small number of observations were omitted due to incomplete covariate data (n = 5) or inconsistent census tract and block identifiers (n = 47).

2.3. Outcome variables

We assessed participants' health outcomes at follow-up using 2019 data. For the hypertension subpopulation, the primary outcome was whether hypertension was controlled. This was defined following National Committee for Quality Assurance (NCQA) criteria as whether the lowest systolic and diastolic blood pressure (SBP and DBP) readings for the year were below 140 and 90, respectively (National Committee for Quality Assurance, 2019). We excluded values deemed biologically implausible in the outpatient setting (SBP <70 or >300; DBP <30 or >160) (Garies et al., 2021; Horth et al., 2019).

For the diabetes subpopulation, we analyzed two NCQA-based outcomes: whether diabetes was controlled (lowest hemoglobin A1c [HbA1c] <8%) and whether diabetes was not poorly controlled (highest HbA1c <9%) (National Committee for Quality Assurance, 2019). We excluded HbA1c <1% or >50% as implausible (Horth et al., 2019).

Following NCQA procedures, missing outcomes were regarded as uncontrolled disease.

2.4. Gentrification exposure variables

First, we classified the gentrification trajectory of Los Angeles census tracts during sequential time periods in order to identify tracts that were stably low-SES during an initial period and then subsequently did or did not gentrify during a second period. We then assessed study participants' individual-level exposures based on gentrification trajectories of their census tracts of residence in 2014 and 2019, as described below and summarized in Fig. 1.

2.4.1. Gentrification trajectories (census-tract level)

Using census tracts as proxy for neighborhoods, we separately assessed gentrification for each tract in L.A. County during two five-year periods, 2010–2014 and 2015–2019. In brief, for each period, we classified tracts as stably low SES, gentrifying, or higher SES. We then examined changes in this gentrification classification between the two periods.

We defined gentrification by adapting Chapple et al.'s approach, which was designed to reflect conditions of the L.A. housing market (Chapple et al., 2017; Loukaitou-Sideris et al., 2017). Unlike other gentrification measures (Ding et al., 2016; Freeman, 2005; Landis, 2016), this method considers changing racial composition, which may be an important proxy for structural racism's role in shaping which neighborhoods experience disinvestment and re-development (Rucks-Ahidiana, 2021).

Assessing gentrification for each period involved three steps. First, we identified a tract as vulnerable to gentrification at the start of each period (i.e., in 2010 or 2015) if it had a population ≥500 and met at least three of four additional criteria: percentage of households earning <80% of the county median income was above the county median; percentage of adults residents who were college-educated was below the county median; percentage of households that were renters was above

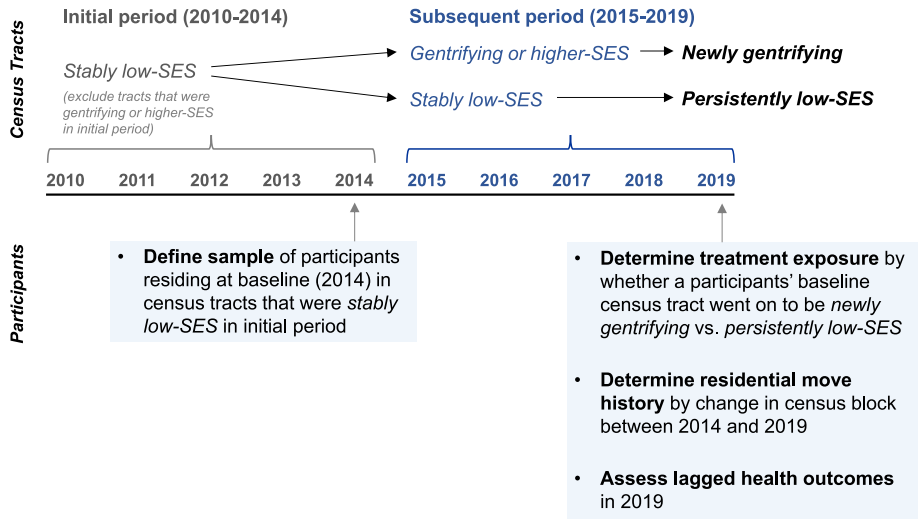

Fig. 1. Overview of Study Design
SES = socioeconomic status.

the county median; and percentage of residents identifying as non-Hispanic White was below the county median (Supplemental Table B). Tracts not meeting criteria as vulnerable at the start of each period were deemed higher-SES, regardless of any subsequent demographic change.

Second, among vulnerable tracts, we labeled tracts as having gentrified if, at the end of the five-year period (i.e., by 2014 or 2019), tract-level changes exceeded county-level increases in each of the following measures: percentage of adults who were college-educated, percentage of the population identifying as non-Hispanic White, median household income, and median gross rent. Vulnerable tracts not meeting these criteria were considered stably low-SES (Supplemental Table B).

Third, to summarize each tract's *gentrification trajectory* across the two time periods, we designated tracts that were stably low-SES in 2010–2014 and subsequently gentrifying or higher-SES in 2015–2019 as *newly gentrifying*. Tracts that were stably low-SES in both periods were considered *persistently low-SES* (see map in Fig. 2). Other gentrification trajectories (i.e., gentrifying and then higher-SES) were excluded from analyses.

2.4.2. Gentrification exposure (participant-level)

Our primary exposure variable was whether a participant was exposed to gentrification. This was a binary indicator of whether the census tract where the participant lived at baseline (2014) met criteria as newly gentrifying or persistently low-SES. Because we wished to assess the net health associations of gentrification exposure, including the potential effects of both staying in and being displaced from a newly gentrifying neighborhood, participants were included regardless of whether they stayed in or moved from their baseline census tract between 2014 and 2019. Because our research question focused on understanding health outcomes associated with a low-SES neighborhood's transition into gentrification versus a counterfactual condition in which that neighborhood did not gentrify, residents of tracts with trajectories other than "newly gentrifying" or "persistently low-SES" were excluded from analyses.

2.4.3. Residential move history (participant-level)

Our secondary exposure variable considered whether participants moved between 2014 and 2019, defined by a change in census block (a geographic unit within tracts). We generated a 4-level categorical variable for residential move history to describe whether participants were exposed to gentrification (G) and/or moving (M):

(1) G+/M-: stayed in newly gentrifying tract
(2) G+/M+: moved from newly gentrifying tract to persistently low-SES tract (i.e. possibly displaced by gentrification)
(3) G-/M-: stayed in persistently low-SES tract
(4) G-/M+: moved between persistently low-SES tracts (including moves between blocks within the same tract)

Because we excluded other combinations of gentrification exposure and moves (e.g., having moved from a newly gentrifying tract to a higher-SES tract or to another gentrifying tract), the sample size for analyses of residential move history was smaller than that for analyses of gentrification exposure. Except where noted, we excluded moves between blocks within the same tract.

2.5. Controls

Covariates assessed in 2014 included variables that were measurable in the EHR and hypothesized to be correlated with both cardiometabolic disease control and selection into a given neighborhood context. These control variables included measures of baseline disease control (measured analogously to disease control at follow-up), socioeconomic position (age, gender, health insurance type [commercial, Medicare alone, any Medicaid, or self-pay]) (Phelan et al., 2010), exposure to structural racism in health and housing (proxied via race and ethnicity [Hispanic or non-Hispanic Asian American/Pacific Islander [AAPI]; Black; White; or Native American/Alaska Native, Multiple, Other, or Unknown]) (Bailey et al., 2017), and acculturation (English as preferred language) (Abraído-Lanza et al., 2016).

Additional baseline covariates considered in sensitivity analyses included 2014 values for frequency of health care contact (log of the number of office visits attended) and multimorbidity (Elixhauser Comorbidity Index) (Quan et al., 2005).

2.6. Statistical analyses

All statistical models used multivariable binary logistic regression with individual-level data, controlling for covariates noted above. Because gentrification exposure status was assigned by census tract, we considered models that allowed for intragroup correlation via either 1) cluster-robust (sandwich) estimation of standard errors by baseline census tract (i.e. single-level models with clustered standard errors) or 2) random errors for baseline census tract (i.e. multi-level models) (Abadie et al., 2022; Cameron and Miller, 2015). As results were nearly

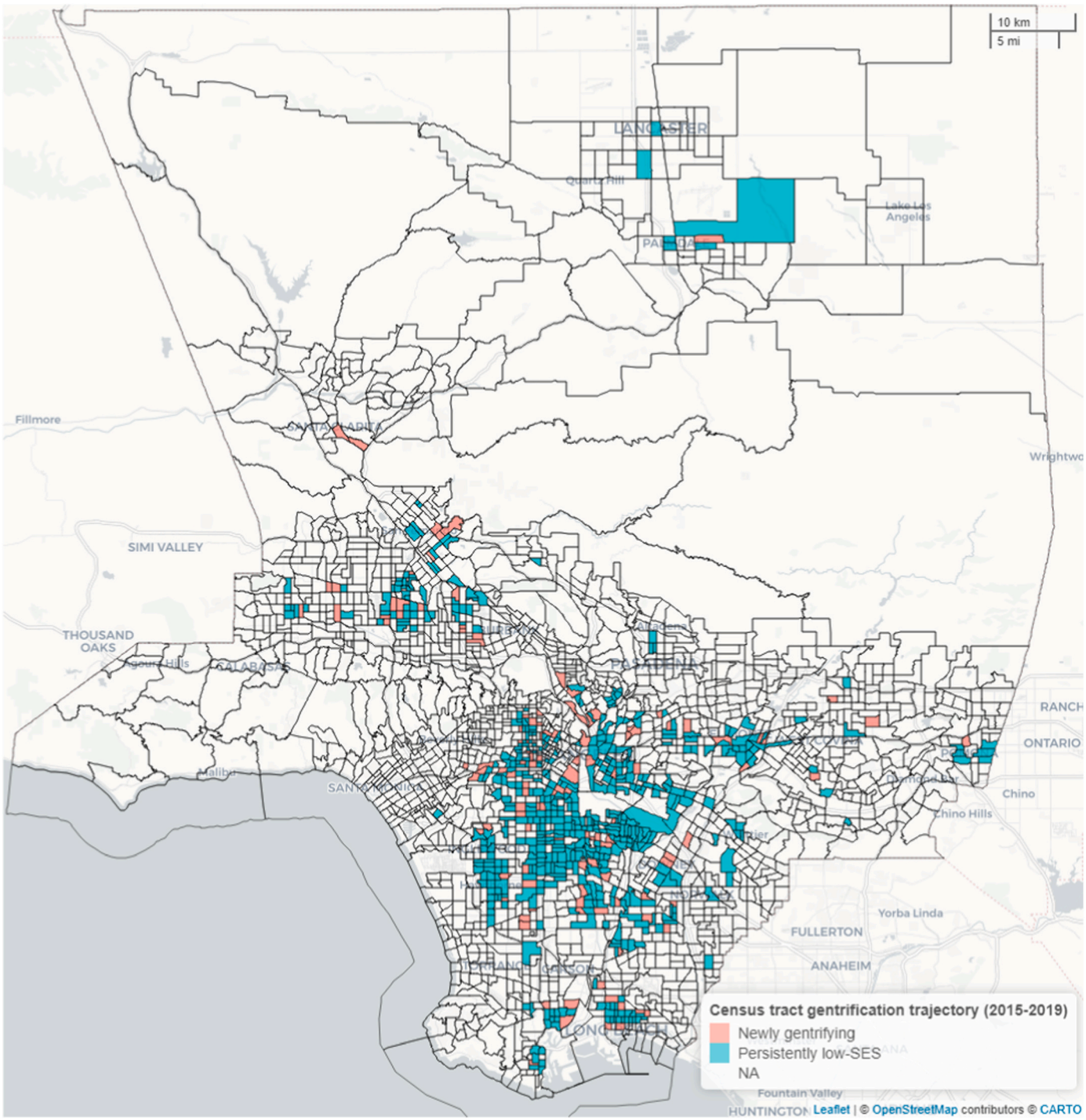

Fig. 2. Gentrification Trajectory of Los Angeles County Census Tracts, 2015–2019.
Note: SES = socioeconomic status. NA = not applicable (describes census tracts that were higher-SES [not classified as vulnerable to gentrification] in 2010–2014).

identical between the two approaches (Supplement, Tables D and E), we proceeded with the former to avoid assumptions in the latter about the structure of within-cluster error correlation (Cameron and Miller, 2015).

First, to understand the overall relationship between gentrification and odds of hypertension and diabetes control, we regressed participants' *gentrification exposure* on their disease control outcomes. We calculated adjusted probabilities for significant associations.

Second, to test the role of residential moves in the context of gentrification, we regressed participants' *residential move history* on hypertension and diabetes outcomes, focusing on four comparisons:

(1) G+/M- vs. G-/M-
(2) G+/M+ vs. G-/M-
(3) G+/M+ vs. G+/M-
(4) G+/M+ vs. G-/M+

Comparisons (1) and (2) relate experiences of staying in and moving from a low-SES tract that begins to gentrify to a counterfactual in which the low-SES tract does not gentrify and the participant does not move. Comparison (3) considers differences between moving from versus staying in a census tracts as it begins to gentrify, while comparison (4) distinguishes the effect of moving in the context of gentrification from

that of moving in general.

2.6.1. Stratified analyses

To understand associations within subgroups, we performed analyses stratified by race and ethnicity (focusing on non-Hispanic Black, Hispanic, and non-Hispanic White subgroups) and age group (<65 or ≥65 years).

2.6.2. Sensitivity analyses

We tested the robustness of our results to several alternate analytic approaches. First, as noted above, we assessed a set of models incorporating random effects for baseline census tract instead of clustered standard errors.

We initially excluded frequency of health care contact and multimorbidity from our main models as potential mediators, since gentrification might influence disease control by shaping access to or need for health care. However, these factors could also act as confounders if participants with frequent and complex health care needs have more opportunities for evaluation and treatment to facilitate— or hinder— their disease control and if poor health also contributes to economic disadvantage that influences the gentrification propensity of their neighborhood of residence. To address this, we conducted sensitivity analyses controlling for (1) the log of the number of office visits attended and (2) Elixhauser Comorbidity Index at baseline.

Next, to account for potential bias introduced by the assumption that missing outcomes represent uncontrolled disease, we ran models substituting 2018 outcomes for missing 2019 outcomes.

Finally, because census tract boundaries might not align with how participants experience gentrification, we ran analyses using a version of the exposure variables that classified participants as gentrification-exposed if their census tract was adjacent to a newly gentrifying tract.

3. Results

3.1. Sample characteristics

From 273,990 potentially eligible KPSC patients in Los Angeles County with hypertension and/or diabetes, we identified 69,524 participants who met criteria for inclusion in gentrification exposure analyses because their baseline census tract was stably low-SES in 2010–2014 and either newly gentrifying or persistently low-SES in 2015–2019 (Table 1). Residents of newly gentrifying tracts were more likely to be non-Hispanic White or AAPI, to speak English as their preferred language, and to have insurance other than Medicaid. Characteristics of KPSC patients excluded because of residence in ineligible census tracts are given in Supplemental Table C.

Secondary analyses of residential move history included 61,351 patients exposed to any of the included combinations of gentrification and moving experiences (G+/M-, G+/M+, G-/M-, or G-/M+) (Table 2). Participants who stayed in newly gentrifying tracts were most likely to be non-Hispanic White or AAPI, to speak English as their preferred language, and to have Medicare. Compared to those who did not move, participants who moved were more likely to be younger and covered by non-Medicare insurance.

3.2. Health associations of gentrification exposure

Exposure to a newly gentrifying tract, versus a persistently low-SES tract, was associated with 8% higher odds of controlled hypertension (95% CI: 0–17%) (Fig. 3), equivalent to an increase in adjusted probability of hypertension control from 88% to 89%. Gentrification exposure was not significantly associated with diabetes outcomes (Fig. 3).

3.2.1. Stratified analyses, gentrification exposure

In stratified analyses, the protective association of gentrification with hypertension control was significant only among non-Hispanic Whites and older adults (Fig. 4). In the Hispanic subgroup only, gentrification was associated with significantly improved diabetes outcomes.

3.3. Health associations of residential move history

There were no significant associations between any of the four residential move history comparisons and disease outcomes in the full sample (Fig. 5).

3.3.1. Stratified analyses, residential move history

In stratified analyses, among people who did not move, gentrification was associated with better hypertension control for older adults and with better diabetes outcomes for Hispanics (Fig. 6). Moving from a newly gentrifying tract, compared to staying in a persistently low-SES tract, was associated with improved hypertension control among Hispanics. Among gentrification-exposed participants, moving, relative to staying, was associated with better hypertension control among Hispanics and with worse hypertension control among non-Hispanic Black participants. Finally, moving from a newly gentrifying tract to a persistently low-SES tract, versus moving between persistently low-SES tracts, was associated with improved hypertension control among Hispanics and with better odds of not having poorly controlled diabetes among non-Hispanic Blacks.

3.4. Sensitivity analyses

Results were nearly identical after modeling random effects for baseline census tract as well as after adjustment for frequency of health care contact and multimorbidity (Supplemental Tables D & E). Of note, low intraclass correlations (<0.01) in the random effects models should not be interpreted as evidence that census tract characteristics are irrelevant to study outcomes. Prior research indicates that despite often being underpowered to detect between-neighborhood variance, models of neighborhood effects can have sufficient power to detect the fixed effect of a relevant neighborhood attribute, such as gentrification exposure in our study (Diez Roux, 2004; Duncan and Raudenbush, 1999).

Imputing missing outcomes from prior-year data produced overall-consistent results; notably, the association between gentrification and not having poorly controlled diabetes gained significance, especially among stayers. Models accounting for adjacent-tract gentrification were likewise consistent with our main results, although some associations gained or lost significance.

4. Discussion

In this retrospective cohort study, adults with hypertension who lived in low-SES census tracts that gentrified were slightly more likely to go on to have well-controlled hypertension compared to residents of tracts that remained persistently low-SES. Gentrification was associated with improved diabetes control among Hispanics only. Outcomes in the overall sample were similar regardless of whether participants stayed in or moved from newly gentrifying tracts relative to people who stayed in or moved between persistently low-SES tracts, but in subgroup analyses we observed contrasting results by race and ethnicity. Relative to staying in a gentrifying tract, moving (possible displacement) from such a tract was negatively associated with hypertension control among non-Hispanic Black participants and positively associated with hypertension control among Hispanics.

Overall, our results do not support the conclusion that gentrification is associated with major harm to cardiometabolic health, at least in this patient population. One possibility is that the KSPC system, which has facilities throughout L.A. County and emphasizes value, coordinated care, and population health management (Kaiser Permanente Institute for Health Policy, 2021), shelters its members from gentrification's

Table 1
Characteristics of Participants with Hypertension and/or Diabetes Residing in Los Angeles County Census Tracts That Were Stably Low-SES in 2010–2014, by Subsequent Gentrification Exposure[a] in 2015–2019.

	Participant's Gentrification Exposure Status (2015–2019)[a]			
	Exposed to newly gentrifying census tract	Exposed to persistently low-SES census tract	Total	p-value
	Combined N[b] = 13,369	Combined N[b] = 56,155	Combined N[b] = 69,524	
	(HTN subsample: N = 10,685 DM subsample: N = 7192)	*(HTN subsample: N = 44,557 DM subsample: N = 30,778)*	*(HTN subsample: N = 55,242 DM subsample: N = 37,970)*	
Demographic Characteristics				
Age in 2014, mean (SD)	58.9 (12.2)	58.4 (12.3)	58.5 (12.3)	<0.001
Female, %	56.0%	56.4%	56.4%	0.41
Race and ethnicity, %				<0.001
Hispanic	49.9%	55.8%	54.7%	
AAPI, NH	14.0%	8.7%	9.7%	
Black, NH	23.5%	26.2%	25.7%	
NAAN/Multiple/Other NH or Unknown	1.3%	1.1%	1.2%	
White, NH	11.3%	8.2%	8.8%	
Preferred language is English, %	86.1%	83.0%	83.6%	<0.001
Insurance in 2014, %				<0.001
Commercial only	60.7%	61.1%	61.0%	
Medicare, no Medicaid	32.9%	31.8%	32.0%	
Any Medicaid	4.8%	5.8%	5.6%	
Self-Pay	1.6%	1.3%	1.4%	
Elixhauser Comorbidity Index in 2014, mean (SD)	2.8 (1.8)	2.8 (1.8)	2.8 (1.8)	0.55
Number of office visits in 2014, %				0.49
0	3.5%	3.7%	3.7%	
1-3	24.8%	24.3%	24.4%	
4-6	24.4%	24.2%	24.2%	
7-12	25.6%	25.6%	25.6%	
13+	21.7%	22.1%	22.0%	
Hypertension Subsample Characteristics				
HTN controlled at baseline (lowest BP < 140/90)[c], %	92.6%	92.6%	92.6%	0.98
HTN controlled at follow-up (lowest BP < 140/90)[c], %	88.6%	88.0%	88.1%	0.06
Missing BP at follow-up, %	8.0%	8.3%	8.2%	0.32
Diabetes Subsample Characteristics				
DM controlled at baseline (lowest HbA1c <8%)[c], %	68.1%	67.7%	67.7%	0.45
DM controlled at follow-up (lowest HbA1c <8%)[c], %	65.5%	64.5%	64.7%	0.12
DM not poorly controlled at baseline (highest HbA1c <9%)[c], %	66.4%	66.1%	66.1%	0.53
DM not poorly controlled at follow-up (highest HbA1c <9%)[c], %	65.0%	63.1%	63.5%	0.003
Missing HbA1c at follow-up, %	13.2%	13.3%	13.3%	0.75

SES = low-socioeconomic status. SD = standard deviation. HTN = hypertension. DM = diabetes mellitus. NH = non-Hispanic. AAPI = Asian American or Pacific Islander. NAAN = Native American or Alaska Native. BP = Blood pressure. SBP = systolic blood pressure. DBP = diastolic blood pressure. HbA1c = hemoglobin A1c. P-values were estimated using analysis of variance (ANOVA) for continuous outcomes and Pearson's chi-squared test for categorical variables.

[a] Participants' gentrification exposure was determined based on the 2015–2019 trajectory of the census tract were a participant resided in 2014. All included participants lived in 2014 in census tracts that were considered stably low-socioeconomic status (not gentrifying) from 2010 to 2014.

[b] Combined N refers to the combined hypertension and diabetes subsamples, which overlap. Statistics in the table are reported for the combined hypertension and diabetes subsamples.

[c] Following National Committee for Quality Assurance procedures, observations missing follow-up blood pressure and hemoglobin A1c readings were coded in main analyses as having uncontrolled disease. (National Committee for Quality Assurance, 2019)

potential harms by helping ensure continuous access to health care and other supportive services. Relative to neighbors in their census tracts, socioeconomic advantage in our study population – evident in the low proportion with Medicaid – might offer additional protection from the stresses of gentrification.

The positive association between gentrification and hypertension control has several potential explanations. First, gentrification-related neighborhood investment might lead to upgraded amenities (e.g. new grocery stores) and increased funding for local institutions, like community centers, libraries, and parks (Formoso et al., 2010; Freeman,

Table 2
Characteristics of Participants with Hypertension and/or Diabetes Exposed to Newly Gentrifying or Persistently Low-Socioeconomic Status Census Tracts in Los Angeles County, by Participants' 2015–2019 Residential Move History.[a].

	Residential Move History (2015–2019)[a]				
	Stayed in newly gentrifying tract (G+/M-)	Moved from newly gentrifying to persistently low-SES tract (G+/M+: possibly displaced)	Moved between persistently low-SES tracts (G-/M+)	Stayed in persistently low-SES tract (G-/M-)	p-value
	Combined N[b] = 10,734	Combined N[b] = 742	Combined N[b] = 5164	Combined N[b] = 44,711	
	(HTN subsample: N = 8641 DM subsample: N = 5784)	*(HTN subsample: N = 542 DM subsample: N = 413)*	*(HTN subsample: N = 3954 DM subsample: N = 2813)*	*(HTN subsample: N = 35,720 DM subsample: N = 24,659)*	
Demographic Characteristics					
Age in 2014, mean (SD)	59.9 (11.9)	53.8 (12.4)	54.4 (12.7)	59.5 (12.0)	<0.001
Female, %	56.0%	56.5%	55.9%	56.6%	0.58
Race and ethnicity, %					<0.001
Hispanic	50.6%	50.4%	54.5%	57.1%	
Black, NH	22.8%	31.9%	32.9%	25.0%	
AAPI, NH	13.6%	10.8%	6.6%	8.5%	
White, NH	11.7%	5.5%	4.9%	8.3%	
NAAN/Multiple/Other NH or Unknown	1.3%	1.3%	1.1%	1.2%	
Preferred language is English, %	85.7%	82.7%	80.9%	82.5%	<0.001
Insurance in 2014, %					<0.001
Commercial only	58.3%	72.8%	70.7%	58.9%	
Medicare, no Medicaid	35.4%	19.1%	21.1%	34.3%	
Any Medicaid	4.6%	6.5%	7.5%	5.4%	
Self-pay	1.6%	1.6%	0.7%	1.4%	
Elixhauser Comorbidity Index in 2014, mean (SD)	2.8 (1.8)	2.7 (1.8)	2.8 (1.9)	2.8 (1.8)	0.36
Number of office visits in 2014, %					<0.001
0	3.4%	5.8%	4.4%	3.6%	
1-3	24.3%	26.7%	25.8%	24.1%	
4-6	24.5%	23.5%	23.3%	24.5%	
7-12	26.2%	22.6%	25.0%	25.7%	
13+	21.6%	21.4%	21.5%	22.1%	
HTN Subsample Characteristics					
HTN controlled at baseline (lowest BP < 140/90)[c], %	92.9%	90.0%	91.4%	93.0%	<0.001
HTN controlled at follow-up (lowest BP < 140/90)[c], %	88.8%	87.5%	86.9%	88.4%	0.012
Missing BP at follow-up, %	7.8%	7.9%	8.4%	8.1%	0.74
DM Subsample Characteristics					
DM controlled at baseline (lowest HbA1c <8%)[c], %	69.2%	58.8%	60.7%	69.0%	<0.001
DM controlled at follow-up (lowest HbA1c <8%)[c], %	66.8%	54.0%	57.1%	65.9%	<0.001
DM not poorly controlled at baseline (highest HbA1c <9%)[c], %	67.7%	54.5%	59.2%	67.5%	<0.001
DM not poorly controlled at follow-up (highest HbA1c <9%)[c], %	66.3%	53.8%	54.5%	64.7%	<0.001
Missing HbA1c at follow-up, %	12.8%	16.7%	15.6%	12.9%	<0.001

SES = socioeconomic status. G+ = exposure to newly gentrifying socioeconomic status census tract, as opposed to a persistently low-socioeconomic status tract (G-). M+ = moving to a persistently low-socioeconomic status census tract, as opposed to staying in baseline residence (M-). HTN = hypertension. DM = diabetes mellitus. NH = non-Hispanic. AAPI = Asian American or Pacific Islander. NAAN = Native American or Alaska Native. BP = Blood pressure. SBP = systolic blood pressure. DBP = diastolic blood pressure. HbA1c = hemoglobin A1c. P-values were estimated using analysis of variance (ANOVA) for continuous outcomes and Pearson's chi-squared test for categorical variables.

[a] Participants were included in analyses of residential move history only if they fell into one of the four residential move history categories shown in the table (for example, those who moved into newly gentrifying census tracts were excluded).

[b] Combined N refers to the combined hypertension and diabetes subsamples, which overlap. Statistics in the table are reported for the combined hypertension and diabetes subsamples.

[c] Following National Committee for Quality Assurance procedures, observations missing follow-up blood pressure and hemoglobin A1c readings were coded in main analyses as having uncontrolled disease. (National Committee for Quality Assurance, 2019)

2006; Tulier et al., 2019). Gentrification might also foster increased employment opportunities, which have been linked to better health (Pratap et al., 2021; Virtanen et al., 2005); however, this is complicated by evidence that gentrification may drive local job losses for incumbent residents even when total jobs increase (Meltzer and Ghorbani, 2017). Alternatively, this positive result could reflect how people sort into neighborhoods and how neighborhoods evolve over time. Although we restricted our sample to residents of tracts that were similarly low-SES at baseline, gentrification is not a random event, but the result of policy decisions, consumer preferences, and market opportunities that often

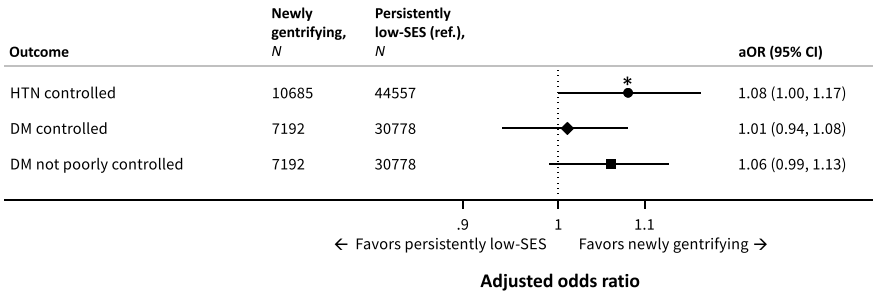

Fig. 3. Association of Gentrification Exposure[a] with Hypertension and Diabetes Outcomes in 2019
***p < 0.001, **p < 0.01, *p < 0.05.
SES = socioeconomic status. aOR = adjusted odds ratio. CI = confidence interval. HTN = hypertension. DM = diabetes mellitus.
[a]Gentrification exposure was determined based on 2015–2019 demographic changes in the census tract where a participant resided in 2014, regardless of whether participants stayed in or moved from their 2014 census tracts.
Notes: Figure depicts the adjusted odds ratio of each outcome for participants whose baseline census tract went on to be newly gentrifying versus those whose baseline census tract remained persistently low-socioeconomic status. Hypertension was defined as controlled if the lowest systolic blood pressure was <140 mm Hg and lowest diastolic blood pressure was <90 mm Hg for the measurement year. Diabetes was defined as controlled if the lowest hemoglobin A1c was <8% for the measurement year. Diabetes was defined as not poorly controlled if the highest hemoglobin A1c ≥ 9% for the measurement year. All estimates were adjusted for baseline disease control, age, gender, race and ethnicity, English as preferred language, and insurance type and included standard errors adjusted for clustering by baseline census tract.

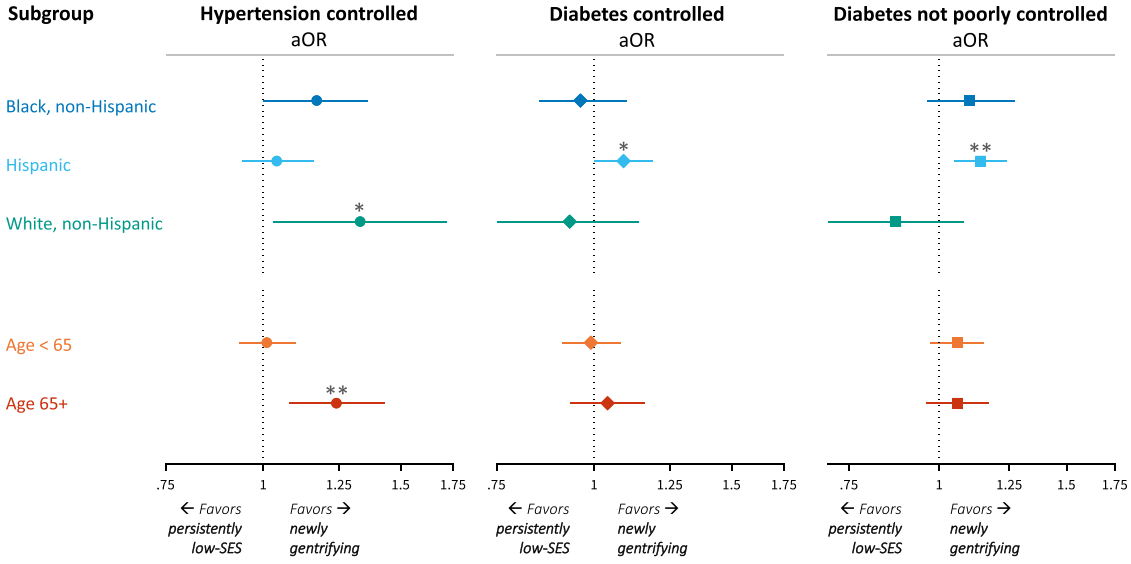

Fig. 4. Association of Gentrification Exposure[a] with Hypertension and Diabetes Outcomes in 2019, Stratified by Race and Ethnicity and Age Group
***p < 0.001, **p < 0.01, *p < 0.05. SES = socioeconomic status. aOR = adjusted odds ratio. CI = confidence interval. HTN = hypertension. DM = diabetes mellitus.
[a]Gentrification exposure was determined based on 2015–2019 demographic changes in the census tract where a participant resided in 2014, regardless of whether participants stayed in or moved from their 2014 census tracts.
Notes: Figure depicts the adjusted odds ratio of each outcome within each subgroup for participants whose baseline census tract went on to be newly gentrifying versus those whose baseline census tract remained persistently low-socioeconomic status. Hypertension was defined as controlled if the lowest systolic blood pressure was <140 mm Hg and lowest diastolic blood pressure was <90 mm Hg for the measurement year. Diabetes was defined as controlled if the lowest hemoglobin A1c was <8% for the measurement year. Diabetes was defined as not poorly controlled if the highest hemoglobin A1c ≥ 9% for the measurement year. All estimates were adjusted for baseline disease control, age, gender, race and ethnicity, English as preferred language, and insurance type and included standard errors adjusted for clustering by baseline census tract.

favor areas with certain existing advantages (Rucks-Ahidiana, 2021; Zuk et al., 2017). If relative socioeconomic privilege confers both health advantages and propensity to live in neighborhoods on the verge of gentrifying, our results would be biased toward positive health associations.

Only a few prior studies have examined hypertension or diabetes outcomes in the context of gentrification, finding either no effect or protective associations between gentrification and disease prevalence or incidence (Bilal et al., 2019; Jacobson et al., 2020; Morenoff et al., 2007). Regarding disease control, Morenoff et al. found no association between gentrification and hypertension control, albeit with a smaller, potentially underpowered sample (Morenoff et al., 2007). However, while the authors controlled for more individual socioeconomic traits than our data permitted, their cross-sectional approach might not capture the change that is central to the experience of gentrification and might be more vulnerable to neighborhood selection bias.

Our analyses of residential move history showed no significant associations between moving— or possible displacement— from a gentrifying tract and hypertension and diabetes control, consistent with results of a prior study focused on disease incidence (Jacobson et al., 2020). This finding should not signal that displacement is benign relative to living in more affluent neighborhoods or moving into gentrifying neighborhoods. Our study population included only residents of tracts that were low-SES at baseline, who are at risk for many health hazards already (Chyn and Katz, 2021; Diez Roux and Mair, 2010). Moving in response to gentrification may be just another of many stressors that residents of low-SES areas endure, with no large impact on chronic disease control. Making compromises in order to resist displacement and

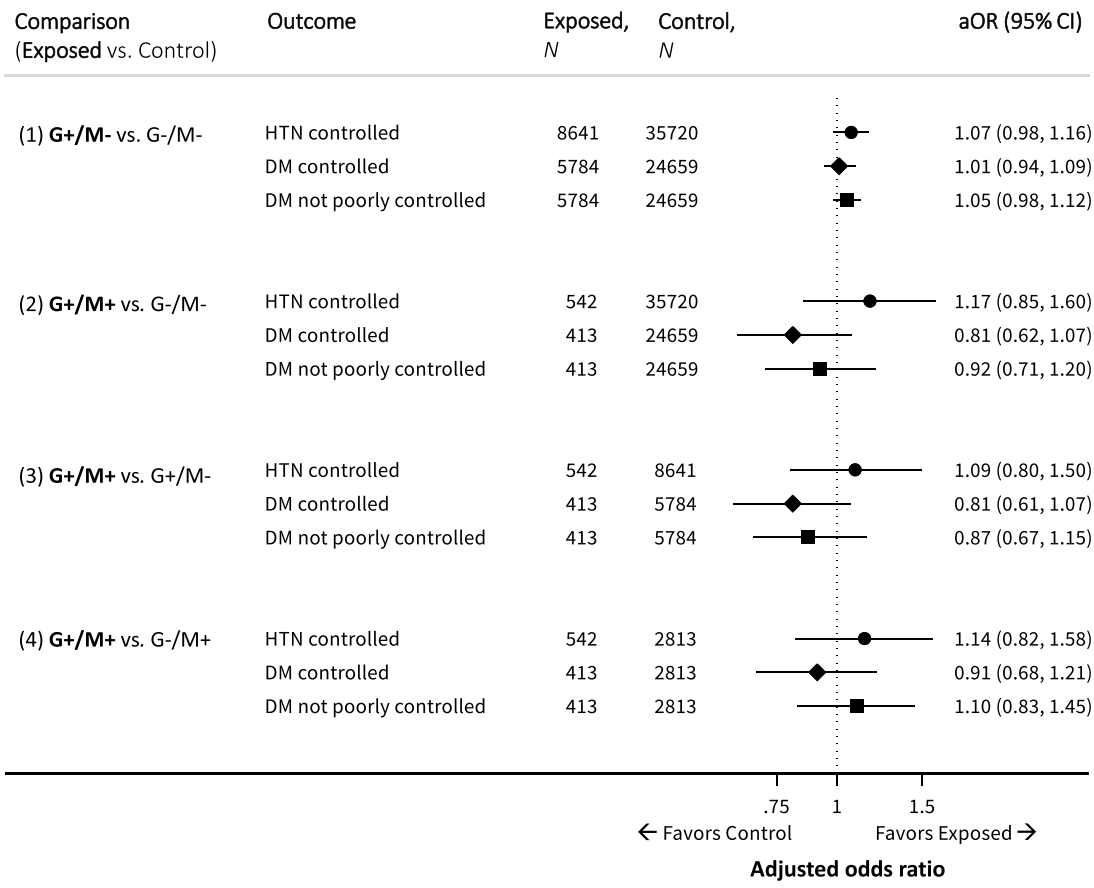

Fig. 5. Association of Residential Move History in the Context of Gentrification Exposure with Hypertension and Diabetes Outcomes in 2019
***p < 0.001, **p < 0.01, *p < 0.05. aOR = adjusted odds ratio. CI = confidence interval. G+ = exposure to newly gentrifying census tract, as opposed to a persistently low-socioeconomic status tract (G-). M+ = moving to a persistently low-socioeconomic status census tract, as opposed to staying in baseline residence (M-). HTN = hypertension. DM = diabetes mellitus. Notes: Figure depicts the adjusted odds ratio of each outcome for each of four comparisons by residential move history and gentrification exposure. Comparisons (1) and (2) relate experiences of staying in and moving from a low-SES tract that begins to gentrify to a counterfactual in which the low-SES tract does not gentrify and the participant does not move. (3) considers differences between moving from or staying in a census tracts as it begins to gentrify, while (4) distinguishes the effect of moving in the context of gentrification from that of moving in general. Hypertension was defined as controlled if the lowest systolic blood pressure was <140 mm Hg and lowest diastolic blood pressure was <90 mm Hg for the measurement year. Diabetes was defined as controlled if the lowest hemoglobin A1c was <8% for the measurement year. Diabetes was defined as not poorly controlled if the highest hemoglobin A1c ≥ 9% for the measurement year. All estimates were adjusted for baseline disease control, age, gender, race and ethnicity, English as preferred language, and insurance type and included standard errors adjusted for clustering by baseline census tract.

stay in a gentrifying area, such as by paying more for rent, living in overcrowded or poor-quality housing, or losing community networks as friends and family leave, may also carry health risks that offset the observed harms of displacement when we compare staying in versus moving from gentrifying areas (Newman and Wyly, 2006). Alternatively, our gentrification measures might miss nuances in the displacement experience documented in qualitative research (Marcuse, 1985; Slater, 2009; Versey et al., 2019), or health changes accompanying gentrification-related displacement may unfold on a longer time frame than measured in our study. If so, we might not fully detect adverse effects related to displacement. However, there is some speculation that displacement risk may peak relatively early in the course of gentrification (Easton et al., 2020; Newman and Wyly, 2006). Lastly, given the small sample size of participants moving from a newly gentrifying tract to a persistently low-SES tract, our study may have been underpowered to detect subtle health associations with this exposure. Given ardent debates elsewhere in the literature around the true prevalence of gentrification-induced displacement (Easton et al., 2020; Slater, 2009; Zuk et al., 2017), it is unclear to what extent the small G+/M+ group sample size reflects low population prevalence versus a biased sample of residents who were less likely to be displaced when their neighborhoods gentrified.

While we had expected that pathways between gentrification and disease control would be similar for hypertension and diabetes, gentrification was associated with improved outcomes for hypertension but not for diabetes in the total sample. Given that assessing HbA1c requires more steps— a clinician's order plus a blood draw— compared to blood pressure evaluation, differential measurement barriers might partially explain the less-favorable diabetes outcomes. Indeed, in sensitivity analyses that replaced missing values with prior-year observations, there was a significant association between gentrification and odds that participants' diabetes was not poorly controlled.

Our stratified analyses demonstrated several notable patterns. That the association between gentrification exposure and hypertension control was most pronounced in non-Hispanic White and older adults raises the concern that gentrification is most beneficial to already-privileged groups. For example, homeowners— who are disproportionately White and older (Joint Center for Housing Studies, 2021)— might be protected from gentrification's effect on rents and better positioned to enjoy its health benefits. When we considered residential moves, the association between gentrification and hypertension control among older adults remained significant only among stayers, suggesting that

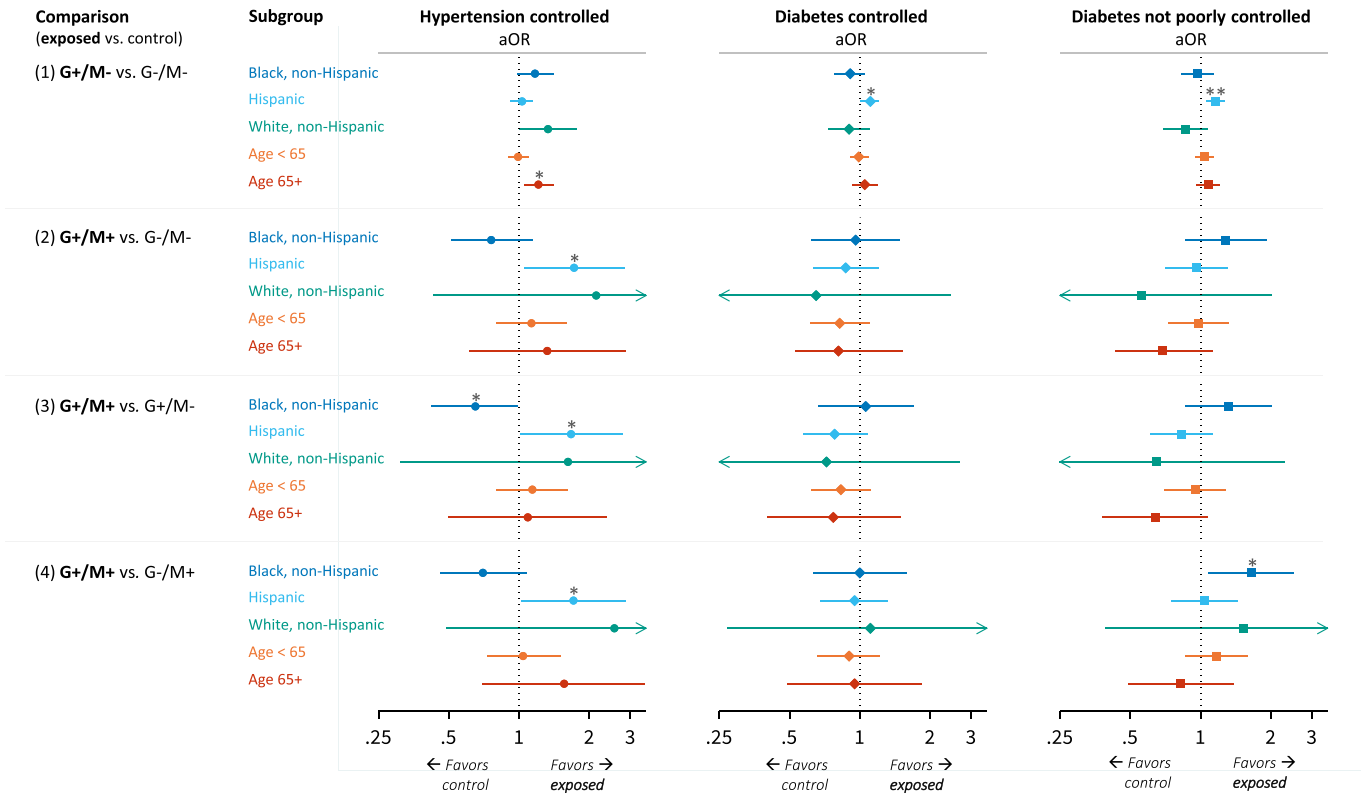

Fig. 6. Association of Residential Move History in the Context of Gentrification Exposure with Hypertension and Diabetes Outcomes in 2019, Stratified by Race and Ethnicity and Age Group

***p < 0.001, **p < 0.01, *p < 0.05. aOR = adjusted odds ratio. CI = confidence interval. G+ = exposure to newly gentrifying tract, as opposed to a persistently low-socioeconomic status census tract (G-). M+ = moving to a persistently low-socioeconomic status census tract, as opposed to staying in baseline residence (M-). HTN = hypertension. DM = diabetes mellitus. Notes: Figure depicts the adjusted odds ratio of each outcome, within each subgroup, for each of four comparisons by residential move history and gentrification exposure. Comparisons (1) and (2) relate experiences of staying in and moving from a low-SES tract that begins to gentrify to a counterfactual in which the low-SES tract does not gentrify and the participant does not move. (3) considers differences between moving from or staying in a census tracts as it begins to gentrify, while (4) distinguishes the effect of moving in the context of gentrification from that of moving in general. Hypertension was defined as controlled if the lowest systolic blood pressure was <140 mm Hg and lowest diastolic blood pressure was <90 mm Hg for the measurement year. Diabetes was defined as controlled if the lowest hemoglobin A1c was <8% for the measurement year. Diabetes was defined as not poorly controlled if the highest hemoglobin A1c ≥ 9% for the measurement year. All estimates were adjusted for baseline disease control, age, gender, race and ethnicity, English as preferred language, and insurance type and included standard errors adjusted for clustering by baseline census tract.

any health advantage was concentrated among people with the resources and support to stay in their changing communities. This finding aligns with prior work on the importance of aging in place and adds to the mixed literature on how gentrification affects health and quality of life in aging (Burns et al., 2011; Croff et al., 2021; Smith et al., 2018; Torres, 2020; Versey, 2018).

Finally, among people exposed to gentrification, moving (i.e. possible displacement) was associated with worse hypertension control among non-Hispanic Black participants only. Meanwhile, several beneficial health associations emerged in the Hispanic subgroup where there were none in the main sample. In particular, Hispanic participants who moved from a newly gentrifying tract had better odds of hypertension control than those who stayed, in direct contrast to the adverse association seen among non-Hispanic Black participants. While further investigation is needed to fully understand these findings, trends in L.A.'s ethnoracial spatial structure might help to explain these disparate subgroup observations. From 1970 to 2014, the proportion of Hispanic-majority census tracts in L.A. County grew from 5% to 36%, spurred first by policy change that facilitated immigration from Latin America and then by growth in the native-born Hispanic population (Ong et al., 2016; Ong and González, 2019). Meanwhile, during the same time period, the proportion of Black-majority census declined from 11% to 4% as Black Angelenos began to leave Black inner-city enclaves (long subject to systemic disinvestment and neglect) for outer-ring suburbs and exurbs (Ong et al., 2016; Tareen, 2022), seeking to escape affordable housing shortages, urban crime, and, for some, concerns that the growing Hispanic population was encroaching on historically Black neighborhoods (Pfeiffer, 2012; Tareen, 2022). However, the L.A. County suburbs and exurbs receiving these Black movers have not always been welcoming, and some Black residents have documented heightened exposure to White hostility and hate crimes in their new neighborhoods (Hepler, 2020; Ho, 2020; Masunaga et al., 2022; Sonksen, 2017; Stringfellow, 2017). Together, the decline in Black neighborhoods and the threat of increased racism elsewhere could help to explain why gentrification-related displacement may be particularly traumatic to Black residents. In contrast, although they have not been immune from racism and nativism, Hispanic residents facing displacement from L.A.'s gentrifying neighborhoods may have had easier access to cultural enclaves elsewhere that might protect against racial conflict and the stresses of displacement and neighborhood poverty (Bécares et al., 2012; Eschbach et al., 2004). Consistent with prior research showing heightened health harms in Black adults exposed to gentrification (Gibbons and Barton, 2016; Huynh and Maroko, 2014; Izenberg et al., 2018a; Schnake-Mahl et al., 2019; Smith et al., 2020b), our findings fuel further concern that gentrification may reinforce health disparities.

This study has several limitations. First, we lack information about

why participants moved, whether they rented or owned their homes, and whether local restrictions on rent increases applied to participating renters' buildings, which might have influenced the intensity of displacement pressure experienced by participants exposed to gentrification. Next, findings may not be generalizable outside of the integrated health system setting or L.A. County. Our EHR data source also lacked important individual-level socioeconomic indicators, such as income, education, and occupation. Uncontrolled confounding by these factors might have biased our results. For example, people employed in higher-earning jobs or in sectors that tend to benefit from gentrification (i.e. restaurant and service industries, as opposed to manufacturing and wholesale (Lester and Hartley, 2014)) might have been better positioned to stay in their neighborhoods; observed associations between gentrification and health could be favorably biased if similar employment- and income-related factors also support better access to health-promoting opportunities. At the same time, our results may also be biased toward the null due to the fact that our data source included few Medicaid enrollees and no uninsured patients, who may be most vulnerable to harm from gentrification and displacement. However, although our use of KPSC data may have introduced bias related to omitted variables and selection, focusing on patients within the KPSC system helped us reduce confounding by health-system factors.

We also excluded patients who disenrolled from KPSC or moved out of Los Angeles, and analyzing participants' addresses longitudinally likely introduced retention bias. To prevent additional retention bias, we did not evaluate participants' length of residence in their neighborhoods prior to baseline, which might moderate gentrification's health effects (Izenberg et al., 2018b; Tran et al., 2020). Additionally, there is no gold standard for measuring gentrification, and results may be biased if participants experience gentrification at geographic and temporal scales that differ from census tracts and our chosen time periods (Bhavsar et al., 2020; Firth et al., 2020; Mujahid et al., 2019). By classifying gentrification based on demographic change over a fixed interval, we may have missed more sporadic and unsustained periods of gentrification as well as nuance related to different stages of gentrification and displacement, the timing and intensity of which may vary with economic cycles and other contextual factors (Finio, 2022; Newman and Wyly, 2006; Phillips et al., 2021). We also did not assess whether low-SES tracts became even more impoverished over time. Finally, results from stratified analyses should be interpreted as exploratory given small sample sizes and multiple comparisons.

Nonetheless, our study has several strengths. Most importantly, longitudinal address and health data permitted us to control for baseline characteristics and explore the role of residential moves in the relationship between gentrification and health. Next, measuring gentrification over two time periods allowed us to partially standardize the stage and duration of participants' gentrification exposure (Finio, 2022; Firth et al., 2020; Newman and Wyly, 2006; Phillips et al., 2021). Additionally, our chosen health outcomes, which are measured in a clinical setting and can fluctuate on a relatively short time scale, may have been more sensitive to acute detect health associations than the self-reported health status and mental health outcomes often used in this research area (Firth et al., 2020). Finally, sensitivity analyses considering gentrification in adjacent census tracts help reassure us, at least in part, against issues of spatial dependency or spillover (Tulier et al., 2019).

5. Public health implications

Overall, our results indicate that there are some positive associations between gentrification and chronic disease control, but this benefit is modest at best and inconsistent across disease states and demographic subgroups. Although exploratory in nature, our stratified analyses suggest that by primarily benefitting more socioeconomically privileged groups, gentrification could compound health disparities. Future research should clarify causal mechanisms, pinpoint which aspects of gentrification may be most beneficial for health, evaluate results in a sample with larger Medicaid or uninsured populations, consider differences by other individual characteristics that may moderate neighborhood effects (e.g. gender, family structure, or occupation), and elucidate whether features of the KPSC context explicitly protect against gentrification's potential harms. Emergence of a validated tool for measuring perceived gentrification (Hirsch et al., 2021) holds promise for improving upon existing gentrification indices.

To the extent that changes in the lived environment can support improved cardiometabolic health (Diez Roux et al., 2016), urban planners and city officials could partner with marginalized communities to ensure that neighborhood development emphasizes resources and amenities that address the health needs of all residents, not just the most privileged (Carrión et al., 2022). To ensure equitable access to new and existing opportunities in gentrifying neighborhoods, policymakers could focus on pairing economic development incentives with strategies to keep disadvantaged residents stably housed and connected to their communities. A multi-faceted strategy might include income supports, rent stabilization, eviction protections, affordable housing construction and preservation, community land trusts, job training programs, local-hiring incentives, and investment in community centers and local businesses (Zuk, 2019). Health care systems, like KPSC, that act as community anchor institutions may also have a role to play in centering the voices and priorities of local communities to promote equitable investment in health-promoting services and amenities (Koh et al., 2020).

6. Conclusion

We analyzed longitudinal electronic health record data from an integrated health care system in Los Angeles County to explore whether gentrification exposure was associated with future hypertension and diabetes control. We found that residents of newly gentrifying census tracts may experience modestly improved odds of hypertension and/or diabetes control relative to residents of persistently low-SES tracts that do not gentrify. We did not identify significant health associations with moving from a newly gentrifying tract to a persistently low-SES tract (i.e. possible displacement) in the overall sample. Differences in these associations across population subgroups and clinical outcomes should motivate further inquiry into causal pathways and generalizability to other populations and settings. City leaders and health systems may wish to partner with impacted communities to ensure that neighborhood development meets the goals and health needs of all residents and does not exacerbate health disparities.

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Data availability

The data that has been used is confidential.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2023.103109.

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