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Review article

A systematic review of historic neighborhood redlining and contemporary health outcomes

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A B S T R A C T

Objectives: Historic redlining grades that were assigned to US neighborhoods based largely on minority race or ethnicity by the Home Owners Loan Corporation (HOLC) during the 1930s have been linked with adverse health outcomes among neighborhood residents. This review aimed to summarize the quantitative evidence, so we could determine if any findings are replicated and otherwise identify research gaps.
Study design: Systematic review.
Methods: We conducted a systematic review by searching the PubMed® MEDLINE database for observational studies that reported on health outcomes among people who resided in neighborhoods that were assigned HOLC grades. We assessed quality by allocating points based on whether studies reported the sample size or count of people affected by outcomes (yes = 1 point, no = 2 points), and whether unadjusted magnitudes of association were reported alongside adjusted estimates (yes = 1 point, no = 2 points). The sum score was used to classify each study as high (2 points), average (3 points) or low quality (4 points).
Results: Among the 89 articles identified, 32 met inclusion criteria; 15 were deemed high-quality. The most frequently studied health conditions in order of descending frequency were: i) injury or violence (n = 8), ii) cancer (n = 7), iii) cardiometabolic (n = 6), iv) perinatal (n = 5), v) asthma (n = 2).
Conclusion: People who lived in areas with less desirable HOLC grades tended to suffer higher than expected rates of injury or violence, asthma, adverse pregnancy outcomes, and some cardiometabolic disorders; associations with cancer were mostly null. Methodological differences limited opportunities for direct comparison across studies, and there was significant heterogeneity among the few estimates that were generally comparable. While robust data are lacking, the limited existing evidence supports a possible association between historically redlined areas and heightened risk of adverse health outcomes. Why this association may exist remains unknown.

1. Introduction

During the 1930s the Home Owners Loan Corporation (HOLC) graded neighborhoods within large US cities according to the perceived lending risk associated with different community characteristics.[1] Neighborhoods with large numbers of racial and ethnic minority residents were given the least desirable grade 'D', a practice known as 'redlining' based on the color that HOLC used to map so-called hazardous areas. Decades later, after the discriminatory practices were outlawed, investigators began testing the hypothesis that contemporary health outcomes are worse in 'redlined' or otherwise downgraded areas compared to places that HOLC deemed low risk. The underlying premise is that areas designated high-lending risk based largely on the fraction of residents identified as racial or ethnic minorities might suffer economic disinvestment and/or a maldistribution of public resources that over time negatively influences health outcomes. Complexities arise, however, because the consequences of discriminatory lending practices are difficult to differentiate from the broader context of systemic racism and its proxies.[2]

The number of research studies probing the possibility that contemporary health outcomes are worse in historically redlined areas increased dramatically after the Mapping Inequality project made modern HOLC grade maps freely available online.[1] We were able to identify two previous literature reviews.[3,4] The first was a systematic review that included the twelve studies that were published through year 2021 with sufficient information to undergo meta-analysis.[3] The

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second was a scoping narrative review of an additional 21 studies published through March of 2022 that also offered a conceptual framework to explain how redlining might contribute to adverse health outcomes or environmental determinants.[4] Both reviews provided robust information about study quality indicators and potential sources of bias, but it remains unclear if any of the published magnitudes of association between historic neighborhood redlining and adverse health outcomes have been independently replicated. We therefore conducted an updated systematic review of articles published through year 2023, homing in on the subset that used multivariable regression modeling to investigate potentially adverse health outcomes associated with residence in areas that were deemed worsening or high lending risk by HOLC. In addition to adding another year of articles, our main focus was to visualize the reported magnitudes of associations grouped by the dependent variable, so we could more easily identify which findings are independently replicated and which modeling strategies might introduce variation.

2. Methods

2.1. Search strategy & quality assessment

Informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Reporting and other Guidelines,[5] we conducted a systematic search of articles in PubMed® through year 2023 using the following keywords: *redlining, redline, historical redline, historical redlining, and historical HOLC.* We excluded articles with study populations outside of the US given our focus on US mortgage lending practices. Eligible studies estimated the magnitude of association between residence in HOLC graded areas and adverse health outcomes (e.g., by calculating odds ratios, relative risk, or hazard ratios).

Three co-authors performed primary searches, and three separate co-authors performed secondary searches to identify missed literature by scouring bibliographies and alternatively using the Web of Science platform for keyword searches instead of PubMed®. Information extracted from each article included the citation, study design, year(s) the data represented, sample size, primary/secondary outcomes, number of cases (of primary outcome), estimates of the magnitudes of association, model type, and study location. We also scoured the bibliographies of original research studies and reviews to determine whether any studies that met inclusion criteria were missed.

Quality was assessed by allocating points based on whether studies reported the total sample size and numbers of people that met criteria for each outcome investigated (yes = 1 point, no = 2 points), and also whether unadjusted magnitudes of association were reported alongside adjusted estimates (yes = 1 point, no = 2 points). Where unadjusted estimates were not reported, we derived odds ratios and 95 % confidence intervals when possible although this did not change the quality rating of the study. The sum score was used to classify each study as high (2 points), average (3 points) or low quality (4 points), based on whether there was sufficient information to enable replication. Additional quality/bias indicators and study characteristics are provided in the Supplement.

2.2. Primary exposure

Historically, HOLC neighborhood grades were based on not only racial and ethnic composition, but also on housing quality and sale or rental values.[1] Four color-coded categories were used to classify perceived lending risk: i) grade “A” or green areas were considered minimal investment risk, ii) grade “B” or blue areas had additional perceived risk but were ‘still desirable’, whereas iii) grade “C” or yellow areas were considered ‘definitely declining’, and iv) grade “D” or red areas were considered ‘hazardous’ for mortgage investment. Henceforward, we use the term ‘redlined’ to refer to ‘D’ graded areas, whereas the term ‘downgraded’ is used to describe grade ‘C’ areas relative to ‘A’ or ‘B’ graded areas.

2.3. Statistical analysis

Frequencies and percentages were calculated to describe study characteristics, and forest plots were used to display the estimated magnitudes of association between historical HOLC grades and contemporary health outcomes. We chose to not report summary estimates produced by meta-analysis because few studies were directly comparable given differences in case-definition, exposure classification and statistical approach.

3. Results

The annual number of articles retrieved by our keyword searches increased dramatically over time. From 1996-to-2019 just one-to-two per year were published, but in 2022 alone 33 papers were published. In total, 101 articles were identified, and information was extracted from the 32 that met inclusion criteria (Fig. 1). Included articles were published in 2018 through 2023. There were more cohort than ecological studies (i.e., n = 21 vs. n = 11); sample size ranged from approximately one thousand to more than ten million, and just 15 studies met ‘high quality’ criteria because most lacked information about sample sizes or failed to report unadjusted magnitudes of association. The **Supplement** provides additional study characteristics and quality indicators.

The forest plot in Fig. 2A and 2B depicts the estimated magnitude of association between residence in HOLC-graded areas and contemporary health outcomes extracted from each included study. In descending order, the most frequently investigated health outcomes were: i) injury or violence (n = 8), ii) cancer (n = 7), iii) cardiometabolic disorders (n = 6), iv) perinatal disorders (n = 5), v) asthma (n = 2), vi) other (n = 4). Studies that investigated associations between residence in HOLC-graded areas with other social or environmental determinants of health are described in the **Supplement** (e.g., characteristics of the built environment including the placement of firearms, alcohol, and tobacco products).

3.1. Injury or violence

There was consistent evidence that injuries and violence are significantly overrepresented among people living in areas graded ‘D’ or ‘C’. The six ecological studies[6–11] that focused mostly on combinations of violence or injury with mortality reported stronger magnitudes of association with historic redlining than were reported by the two cohort studies.[12,13]

3.2. Cancer

Evidence linking historic redlining with contemporary cancer risk was predominantly null. However, a single study of Medicare beneficiaries with invasive breast cancer reported elevated risk of all-cause or breast cancer-specific mortality,[14] while another similarly designed study did not.[15] Likewise, redlining was associated with excess risk of late-stage cancer diagnosis (i.e., III and IV for breast or colorectal cancers), though associations between redlining and cancer surgery (at stage 0-III) were null.[16] Findings with respect to preventive care were similarly mixed; a single study showed a reduced odds of mammograms and cervical or colorectal cancer screening,[17] while another reported no association between historic redlining and lung cancer screening.[18]

3.3. Cardiometabolic disorders

We were able to identify six studies that investigated the relationship between historic redlining and cardiometabolic disorders. Two studies reported significantly increased risk or hazard of heart failure among

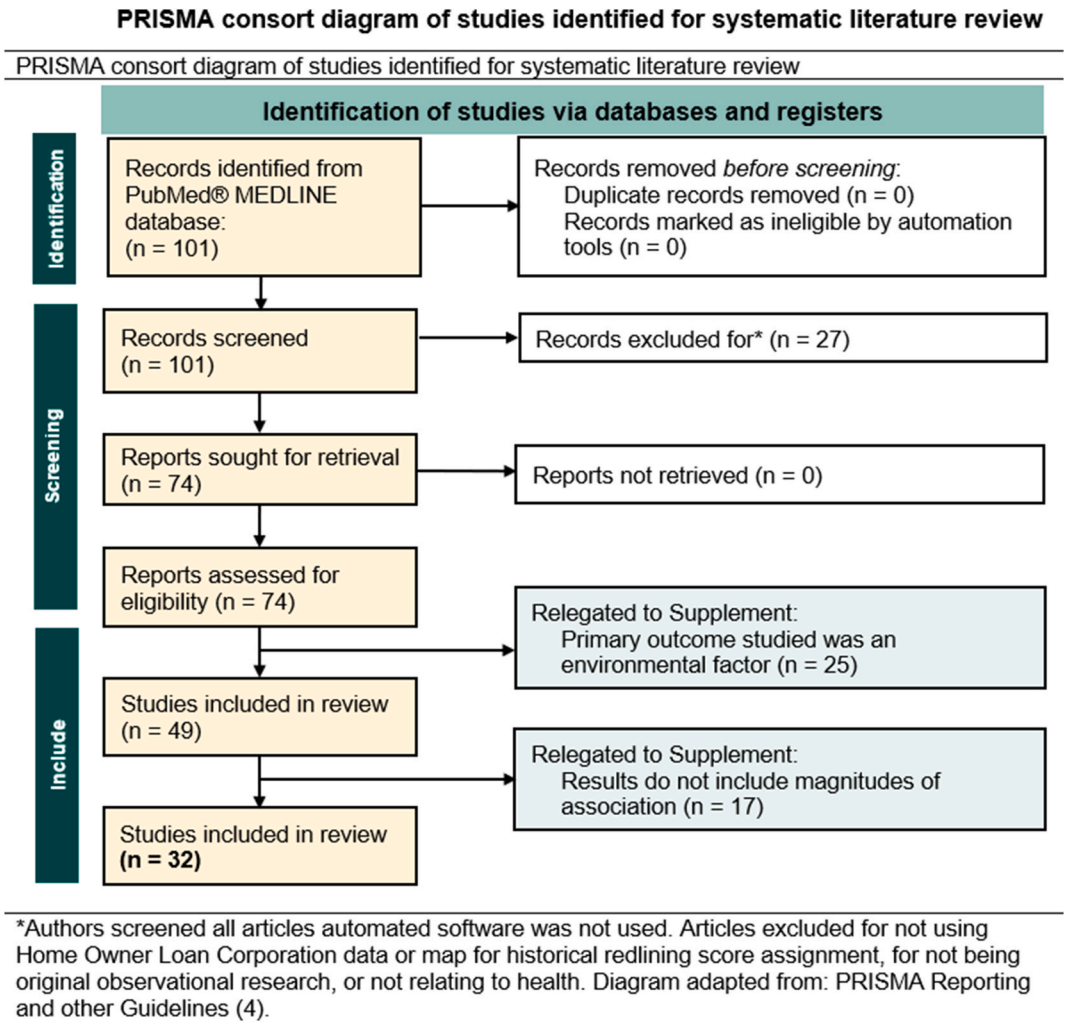


Fig. 1. PRISMA consort diagram of studies identified for systematic literature review.

people who lived in HOLC grade 'D' versus 'A' areas.[19,20] Individual studies also reported associations between residence in a redlined area and increased risks of myocardial infarction or revascularization, any cardiovascular event, and cardiometabolic-disorder associated mortality.[19,21] One additional study reported reduced prevalence rates of healthy body mass index and healthy blood pressure in redlined areas.[22]

Findings with respect to stroke were mixed; of the three studies we identified, only the one that transformed HOLC grades into scores (i.e., 1 through 4) and examined the magnitude of association per unit change reported a significant association.[19,23,24] By contrast, at least two studies each provided evidence that peripheral artery disease and atrial fabulation were no different among people living in areas graded 'D' vs areas graded 'A'.[19]

3.4. Perinatal disorders

Despite differences in case-definitions and HOLC grade comparisons across studies, there was a consistent pattern of association between residence in redlined (or grade 'C') areas and an approximately 1.5-to-3-fold heightened risk (or odds) of gestational hypertension, preterm delivery, low Apgar scores, and neonatal intensive care unit admission compared to people who lived in grade 'A' (or 'A'+ 'B') areas. Stronger magnitudes of association with maternal depression and maternal substance use were also reported.[25] By contrast, the only study that provided evidence of a significantly *decreased* odds of preterm birth among people living in HOLC grade 'D' areas used people living in grade 'C' areas as the reference group.[26]

3.5. Asthma

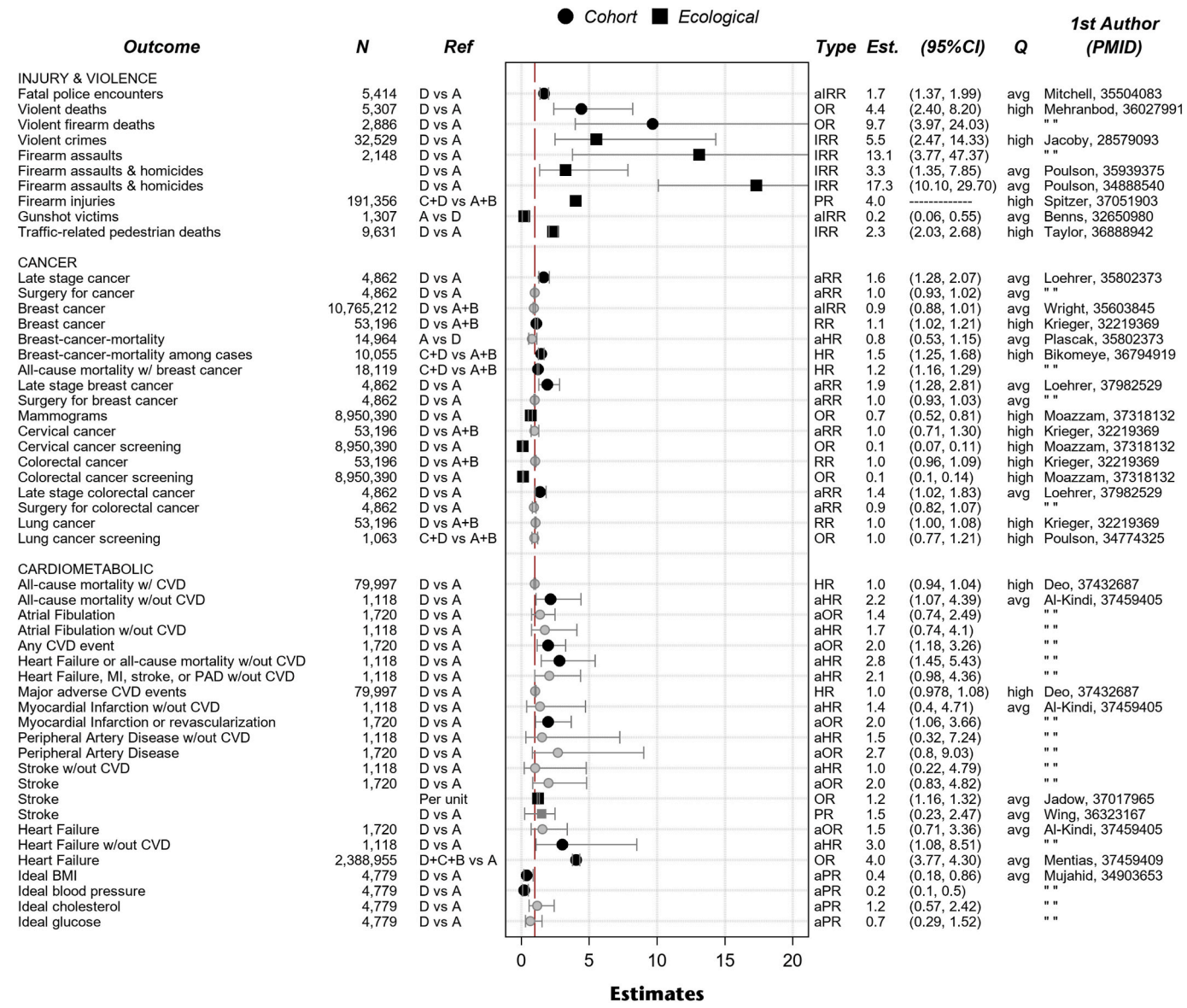
The two asthma studies we identified, one of Missouri participants and the other California, provided consistent evidence of 1.2-to-1.5-fold increased risk in historically redlined areas.[27,28]

3.6. Other

One study associated historic redlining with increased risks of postoperative 30-day and all-cause mortality.[29] While increased risk of patients bypassing their nearest capable hospital (for a further capable hospital) was associated with those living in redlined areas compared to non-redlined areas.[30] Likewise, redlined areas were further associated with increased risk of mental-disorder-related emergency department visits[31] compared to non-redlined areas, whereas vision impairment or blindness[32] rates increased with increasing HOLC grade ranks from one (i.e., 'A') to four (i.e., 'D'). Additional study details and information about the distributions of environmental exposures are provided in the online **Supplement**.

4. Discussion

Despite methodological differences that limited the number of direct comparisons between studies, there is compelling evidence that people



NOTE: dark filled symbols indicate statistical significance; abbreviations: adjusted (a), cardiovascular disease (CVD), chronic kidney disease (CKD), heart failure (HF), hypertension (HTN), estimate (Est),PubMed ID (PMID), sample size or number of cases (N), Quality score (Q); estimate types: Hazard Ratio (HR), Incidence Rate Ratio (IRR), odds ratio (OR), prevalence rate (PR), Relative Risk (RR), Confidence Intervals |-----|(95%CI).

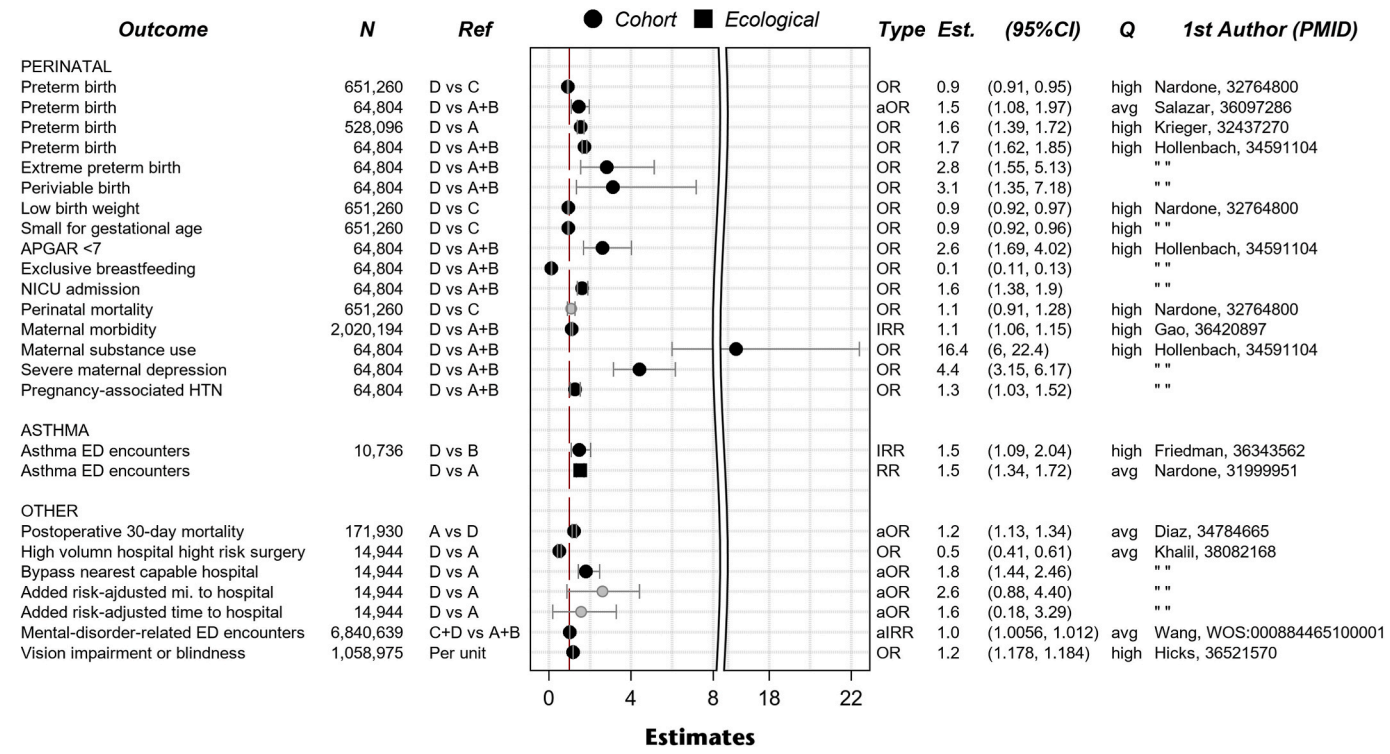
Fig. 2A. Forest plot of estimated magnitudes of association between historic redlining and contemporary adverse health outcomes.

who live in historically redlined or downgraded areas suffer disproportionately higher rates of pregnancy complications, asthma, injuries and violence, and both condition-specific and all-cause mortality. Mixed evidence also linked historic redlining with some, but not other, cardiometabolic disorders; however, small sample sizes prompt concern about an increased risk of type II errors (i.e., false negative findings) due to inadequate statistical power. By contrast, historic HOLC redlining was not significantly associated with cancers in the few large studies examining these possibilities, whereas positive associations were reported by two studies with much smaller sample sizes. Importantly, outside of pregnancy and injury, none of the associations with historic redlining have been independently replicated.

4.1. *Evidence gaps and future research implications*

While the number of historic redlining articles has increased dramatically in recent months, the number of opportunities for direct comparisons among similarly designed studies has not. More than ten different approaches were used to compare health outcomes among people living in HOLC-graded-areas (e.g., propensity score methods, structural equation models, bivariate correlations), and no less than 18 different regression models were used. Models used more than once, in order of descending frequency, were: i) logistic regression (n = 5), ii) Cox proportional hazards (n = 4), iii) negative binomial (n = 3), iv) mixed effects logistic regression (n = 2), v) Poisson regression (n = 2), and vi) zero-inflated negative binomial (n = 2)).

The heterogeneity across studies prompts us to echo our colleagues' call for greater clarity about the underlying conceptual framework and justification for the study design and statistical choices that are made when investigating the role historic redlining might play in adverse health outcomes.[4] An emphasis on the descriptive epidemiology of underlying frequency distributions of competing exposures and potentially related outcomes combined with robust sensitivity analyses is probably necessary to establish an optimal study design and regression modeling strategy. In turn, future studies should carefully describe the frequency distributions of primary and secondary outcomes and exposures, and



NOTE: dark filled symbols indicate statistical significance; abbreviations: adjusted (a), cardiovascular disease (CVD), chronic kidney disease (CKD), heart failure (HF), hypertension (HTN), estimate (Est),PubMed ID (PMID), sample size or number of cases (N), Quality score (Q); estimate types: Hazard Ratio (HR), Incidence Rate Ratio (IRR), odds ratio (OR), prevalence rate (PR), Relative Risk (RR), Confidence Intervals |-----|(95%CI).

Fig. 2B. Forest plot of estimated magnitudes of association between historic redlining and contemporary adverse health outcomes.

both crude magnitudes of association and adjusted estimates should be reported after describing a rationale for the candidate covariables and model selection strategy in the methods section.

4.2. Systemic racism and human health

The social and structural processes linking 1930s HOLC grades to contemporary health outcomes are complex (see Ref. [33] for a discussion of the distinction between the two). On one hand the HOLC offered people of color new opportunities to own homes, but on the other it opened the door for unfair lending practices. Indeed, by designating areas 'hazardous' lending risk based largely on the fraction of residents who identified by minority race or ethnicity, a precedent was set for ongoing systematic disinvestment along such lines.

Overt policies surrounding HOLC lending practices changed in subsequent decades with the passage of three separate acts: the Fair Housing Act in 1968, the Equal Credit Opportunity Act in 1974, and the Community Reinvestment Act in 1977.[34] However, the bias against formerly redlined or downgraded areas likely remained. This premise is what prompted investigators to test the generalized null hypothesis that there are no differences in contemporary health outcomes among people who live in areas that received different HOLC grades in the 1930s. That is, if there was no enduring systemic racism, then there should be no differences in contemporary health outcomes across HOLC-graded areas after accounting for population differences (e.g., age). Of course, this is easier said than done, because much has changed since the 1930s, including the sociodemographic characteristics of formerly redlined or downgraded areas (e.g., due to gentrification in downtown urban areas). Indeed, historical neighborhood sociodemographic characteristics are included as potential confounders in some studies, which may offer additional insights.[14, 71]. Alternatively, because of the multicollinearity with exposure to systemic racism, measured race might lie on a causal pathway linking historic redlining to contemporary health outcomes; if so, race-adjustment could introduce collider stratification bias or otherwise negatively influence reproducibility. For example, the impact of mortgage lending may be imperceptible in models that attempt to decompensate the total association into direct and indirect 'effects' for reasons that resemble confounding by indication; i.e., no statistical technique fully resolves that conundrum in observational studies.

We do not know why some health problems appear to be over-represented in formerly redlined areas. Evidence from preclinical and human observational studies supports the possibility that developmental programming specifically involving hypertension and chronic inflammation-related phenomena (e.g., obesity) induces heightened susceptibility to racially patterned exposures throughout the lifespan and even across generations.[35] Thus, the same mechanism or related exposures (e.g., air pollution[36]) might explain why pregnancy disorders, asthma diagnosed in childhood, and some adult cardiometabolic disorders appear to be over-represented in areas that were redlined or downgraded by the HOLC so long ago. In short, suboptimal gestational environments might be overrepresented in redlined areas, which could induce exaggerated offspring responses to subsequent environmental and social vulnerability factors that are also overrepresented in the same areas, in-turn creating a deleterious feedback loop that might operate across generations. If so, then early intervention will be key to mitigating the impact of racial disparities related to redlining.[37]

Our review focused on historic redlining by the HOLC during the 1930s, but it is important to recognize that the practice has unfortunately persisted into the modern era. For example, the Associated Press reported that the Department of Justice and Consumer Financial Protection Bureau settled a case against Trident Mortgage Co. in 2022 for deliberately avoiding writing mortgages in minority-majority neighborhoods.[38] While the settlement does not require Trident Mortgage Co. to admit fault, it nevertheless forces the company to set aside $20 million for loans in underserved neighborhoods. Ongoing research is needed to determine whether that is enough to avoid what appear to be

harms rooted in historic redlining practices.

4.3. Strengths & limitations

The major strength of this study is that we performed a systematic literature review of multiple health outcomes to cast the 'widest net' possible in our effort to describe what is known specifically about the magnitude of association between historic redlining and population health. In addition to including an additional 12 articles beyond what was previously reported,[4] we uniquely visualized the information in a forest plot designed that helps illustrate reproducibility or a lack thereof across all modeled health outcomes. Nevertheless, it is possible that we failed to identify all pertinent literature; to lessen this possibility, we scoured the bibliographies of original research studies and reviews to find previously unidentified work. Our review also focused on just one type of redlining; we do not know if the findings from HOLC redlining studies apply to all redlining practices. For example, maps that were created by the Federal Housing Administration (FHA) may have impacted mortgage lending practices in similar ways.[39] Another limitation is that there was insufficient data from comparable studies for quantitative meta-analytics.

4.4. Conclusion

People who live in historically redlined or downgraded areas appear to develop multiple adverse health outcomes more often than their peers who do not live in redlined areas, but we do not know why or more importantly how to mitigate the potential risks.

Author statements

Ethical approval

None required.

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Competing interests

None declared.

Contributors statement

Study Conception: SJK, Data Curation: SJB, RSE, AHH, MH, BRS Formal (Statistical) Analysis: SJB Funding Acquisition: PDL, SJK Investigation/ Critical Revision for important intellectual content: SJB, BRS, RE, INO, HW, RSE, AHH, MH, PDL, SJK Methodology: SJK Project Administration: PDL, SJK Resources: PDL, SJK, Software: SJB Supervision: SJK Visualization: SJK, SJB Writing – Original Draft Preparation: SJK, SJB, BRS Writing – Review & Editing: SJB, BRS, RE, INO, HW, RSE, AHH, MH, PDL, SJK

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2024.10.022.

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