The Historic Legacy of Redlining on Spatial Outcomes of Superfund Sites Within LA County

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ABSTRACT

In the 1930s, the Home Owners' Lending Corporation (HOLC) generated residential security maps using racist evaluations, known redlining, that contributed to discriminatory lending practices for decades. Today, redlining has been associated with patterns of home ownership in areas of increased risk of adverse health outcomes. Toxic waste sites, officially classified by the United States Environmental Protection Agency (US EPA) under the Superfund program, have also been associated with adverse health risks, particularly for historically marginalized communities. The objective of this study is to link the historic legacy of redlining maps with current Superfund site spatial distributions. Residential security maps were downloaded from the Mapping Inequality Project, 1940s census tract data through Individual Public Use Microdata Series National Historical Geographic Information Systems, and Superfund site data was collected through the Environmental Protection Agency. 1940s tract data was apportioned into HOLC neighborhoods to find distributions of relevant socio demographic variables. ArcGIS Pro near function was used to find median distances of closest Superfund Sites by HOLC neighborhood grading.

KEYWORDS

toxic waste, segregation, space, GIS, environmental justice

INTRODUCTION

A growing body of research has associated racist historic housing policies, known as redlining, to increased environmental health risks. The term redlining is derived from a series of residential security maps created in the 1930s by the Home Owners' Loan Corporation, a government sponsored corporation that graded predominantly minority and low-income neighborhoods as "high risk" for loans (and outlining them in red) while grading predominantly white neighborhoods as "low risk" for loans (Lynch, 2021). The cumulative impacts of these discriminatory housing policies promoted racial segregation, a cycle of disinvestment from redlined neighborhoods, and has driven an increase in exposure to environmental hazards for the existing communities (Nardone, 2021).

Historic disinvestment from communities generally leaves the potential for greater risk for exposure to environmental hazards. Namely, an increase in the proximity to Superfund sites, classified by the United States Environmental Protection Agency (US EPA, 2014) as toxic waste sites harmful to human health, has been associated with an increased risk of cancer and other chronic diseases (Amin, 2018). Additionally, living in close proximity to Superfund sites has been linked to decreased property values for existing neighborhoods (Nardone, 2021), while cleanups appear to increase the wealth, education, and shares in wealth for minorities (Gamper-Rabindran 2011).

Controversy surrounding the equitability of the US EPA's Superfund program, also known as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) has existed since its founding in 1980 (US EPA, 2014). In 1994, Clinton implemented Executive Order 12898 to address concerns about environmental injustices disproportionately burdening low-income minority communities. Specifically, to promote faster cleanup durations and more site approvals for the National Priority List (NPL) in communities impacted by the adverse health effects of living in close proximity to toxic waste (Gamper-Rabindran, 2011). Research studies show that the executive order has improved patterns of discrimination present prior to 1994, in addition to finding that involvement of community stakeholders improves the outcome of the Superfund site (Gamper-Rabindran, 2011). However, other research using spatial analysis still finds that low-income communities of color are disproportionately impacted by increased proximity and exposure to toxic waste sites (Burwell-Naney, 2013). The ongoing controversy reveals that more inquiry is required to assess root causes and state of environmental equitability with regards to toxic waste sites.

The objective of this research is to link the historic legacy of redlining maps to Superfund site distributions using Geographic Information Systems (GIS). The identification of the root causes involved in the inequity of the distribution of toxic waste can encourage greater collaboration between all stakeholders (community members, governmental, and non-governmental organizations), involved in addressing today's issues of environmental injustice(s).

The legacy of redlining in Los Angeles County

Redlining has shaped much of California's varying demographic landscape: the creation of segregated cities has left minority communities historically barred from access to wealth and resources (Levin, 2020). In 1939, the Home Owner's Lending Corporation generated a residential security map of the Los Angeles area, grading each neighborhood: A ("Best"), B ("Still Desirable"), C ("Declining"), or D ("Hazardous") (Nelson et al., 2018). Gradings were highly based on the racial makeup of neighborhoods: with "Declining" gradings given based "infiltration" of "Non-White" residents, while "Hazardous" ratings frequently given to predominantly neighborhoods with Black, "Non-White" and "Foreign White" residents (Nelson et al., 2018).

While the Fair Housing Act of 1968 officially outlawed discriminatory mortgage lending practices of enabled by redlining maps, the legacy of these practices continues today continue to exist today (Massey 2015). According to Article 34 in California's Constitution, local referendums are required before the building of low-income housing, leaving predominantly Black residents out of wealthier white neighborhoods for decades (Higgins, 2020). This leaves historically segregated low-income neighborhoods with a continued lack of access to infrastructure built by accumulated wealth, such as schools, from impacted communities.

With California's increasing population, the legacy of segregation and discrimination continues to build. This is further revealed in the racial wealth gap: a 2014 study of the Los Angeles Metropolitan area, showed that white households had a much higher median household net worth ($355,000) than Latinx households ($46,000) and Black households ($4,000) (Hutchful, 2018). Today, patterns of home ownership reveal that Black residents bear a disproportionate burden of the housing crisis: demonstrating a lower percentage of home-ownership, higher housing-cost burdens, and overrepresentation in the houseless population (Green, 2016). Patterns of wealth inequality, rooted in home ownership, possess consequences for entire neighborhoods leaving them less resources and at higher risk for environmental hazards.

History of superfund sites in Los Angeles County

California also possesses a history of toxic waste disproportionately burdening low-income marginalized communities. According to a study ranging from 1987-2007, California has the largest share of minorities living in close proximity to toxic waste (Bullard et al., 2008). Large investments are required to clean up toxic waste, and often business and industry entities have the largest means to complete the process, leaving communities without these resources behind. For example, the former Exide battery recycling plant in Vernon, California, home to a large Latinx population, released lead waste into the air for years. However, Exide declared bankruptcy before the completion of the cleanup process, leaving the community responsible for remaining costs of the toxic site cleanup (Nejman et al. 2022). Similarly, a collection of chemical companies, responsible for the pollution of Los Angeles groundwater in the 1940s-80s, has only recently reached a settlement through the EPA to pay for site remediation after the discovery of adverse health impacts for the local community (Water Technology 2021). Overall, the burden of Superfund site cleanups depend on the resources available for cleanup, as well as advocacy done by impacted communities, largely low-income communities of color (Bullard et al., 2008).

GIS research approach

Many similar studies have used GIS analysis to frame the study of redlining and proximity to both toxic wastes. These studies place an emphasis on the legacy of structural racism on the built environment and its influence on current environmental health. GIS provides tools to gather data on the built environment (landscape) and integrate analysis of risk. In one study analyzing the relationship between green space and redlining; vegetation data, census data, and residential security maps were analyzed in conjunction to reveal a lower percentage of green spaces in formerly redlined neighborhoods (Nardone et al. 2021). In another study researching the proximity of Superfund sites to minority communities in South Carolina, GIS distance analysis was used to assess census data and proximity to toxic waste sites. They found that census tracts with Black residents disproportionately host Superfund sites when compared to their white counterparts (Burwell-Naney et al. 2013). Both studies emphasize spatiality, thus GIS seems best suited as a method.

No study thus far has specifically studied redlined neighborhoods and their relation to toxic waste sites. By looking at specific, mapped areas of historic discrimination, it is more feasible to see if long-standing patterns of structural racism continue to influence the landscape. Specifically identifying spatial disparities can help to strengthen efforts to uplift communities experiencing disproportionate environmental hazards by drawing attention to organizations dedicated to the environmental justice movement.

METHODS

Study site

The study site, Los Angeles County, California, is the most populous county in the United States, covering an area of 12,310 km^2 **(**World Population Review). The total area mapped by the Home Owner's Lending Corporation (HOLC) is approximately 849.61 km^2 (Table 1). Los Angeles also possesses a history of historically high segregation, with residential segregation existing since its founding (Smith, 2021). HOLC mapped neighborhoods, or HOLC polygons, range in size with a median area of 1.34 km^2 within Los Angeles County.

Data collection and study design

I conducted a geospatial analysis of Los Angeles by combining multiple datasets through publicly available sources. I downloaded the residential security map shapefiles of Los Angeles available through the University of Richmond's Mapping Inequality Project as of 2021 (Nelson et al., 2018). I acquired 1940s census data through the Individual Public Use Microdata Series National Historical Geographic Information Systems (IPUMS NHGIS) (Manson et al., 2019). Lastly, I downloaded Superfund Site data for Los Angeles County through the EPA's Superfund Enterprise Management System database (US EPA, 2014).

Sociodemographic variables at the time of the HOLC security map creation influenced risk grades, I chose to use census data at the time of map creation. Additionally, the HOLC mapped Los Angeles in 1939 (Nelson et al., 2018), it was most appropriate to use census data from the 1940s census. A temporal gap exists between the time of HOLC redlining, in 1939 (Nelson et al., 2018), and the first Superfund Site cleanup in 1980 (US EPA, 2014). However, abandoned waste sites such as oil refineries, smelting facilities, mines, and other industrial areas (Ballotpedia) have existed since the 1930s and 1940s (Kiaghadi et al., 2021). Thus, the use of census data from the 1940s is also most appropriate to indicate the relationship between redlining and toxic waste placement.

1940 census data and areal apportionment of census tracts

I chose several to include several sociodemographic variables available through IPUMS NHGIS, and all categories are as those defined by the US Census Bureau. This included counts of the total population; the number of Non-White, foreign-born White, White, and Black residents; employed residents; number of residents with a high school diploma; total number of homes; number of homes needing major repairs; number of homes with radios; and median home value. Non-White was a grouping that included all racial groups not considered White, including Black residents (Hopkins and Austin 1940). The Home Owner's Lending Corporation's Neighborhood boundaries, or HOLC polygons, roughly coincided with 1940s census tract boundaries. HOLC polygons also roughly covered the same size and shape as 1940s census tracts. Using an areal apportionment method, I apportioned the census counts of sociodemographic variables into HOLC polygons, then converted counts into proportions.

Superfund site distribution and proximity analysis

In total, 1,073 Superfund sites fell within the boundaries of Los Angeles County, this includes all Superfund sites since the beginning of the program in 1980 (US EPA, 2014). Using ArcGIS Pro, I geocoded the location of each Superfund Site and intersected location point data with HOLC polygon boundaries to find the distribution of sites within each HOLC polygon.

I found the distance of the closest Superfund Site to each HOLC Polygon using ArcGIS Pro Near Feature (Esri Inc, 2021), which measures straight-line distance. I found the distribution of closest neighborhood distances by neighborhood grade. Once distances were aggregated by neighborhood grade, I conducted a Kruskal-Wallis with a significance level of 0.05 to test the significance in the difference of median nearest distances by HOLC neighborhood grade.

RESULTS

Sociodemographic Variables Distribution

Superfund Sites were most heavily distributed within D neighborhoods, followed by C, B, then A (Figure 1). Despite C neighborhoods possessing the largest shape area (Table 1), the number of Superfund sites per km^2 fell most largely within the boundaries of grade D neighborhoods.

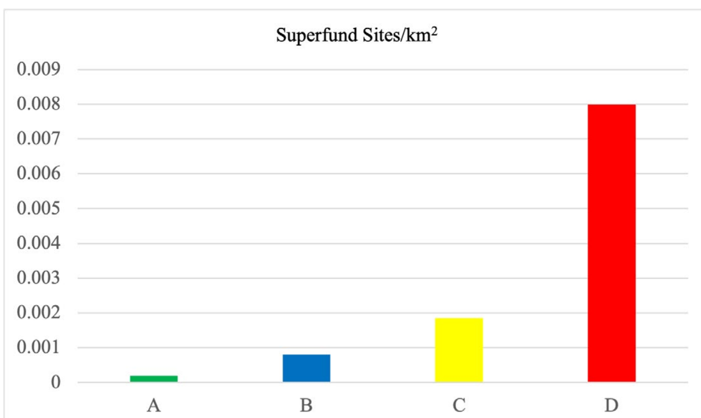

Figure 1. Distribution of Superfund Sites by HOLC grade. Superfund Site data was acquired from the Environmental Protection Agency's Superfund Enterprise Management System database.

Overall, median values for population density rose as neighborhood grade worsened (Table 1). As neighborhood gradings worsened, median values for Population Density, Homes No Radio, and Homes Needing Major Repair increased. Conversely, there were decreases in median values as neighborhood grade worsened for Employment and Completed High School. Given that gradings were based partially based on the perceived wealth monetary value of the neighborhood (Nelson et al., 2018) these findings were expected.

Table 1. Summary of Sociodemographic Variables by HOLC grade. Data was downloaded from Individual Public Use Microdata Series's National Historical Geographic Information Systems.

Polygon Characteristic		**HOLC Grade**			
Grade	Total	A	B	C	D
Polygon *count*	416	57	121	167	71
Shape Area km^2 [Median(IQR)]	1.34(1.67)	1.21(1.32)	1.09(1.06)	1.58(1.88)	1.25(2.74)
Total Area km^2	849.61				
		Census Characteristic [Median(IQR)]			
Population Density: *Thousand Persons/*km^2	1.36(2.17)	0.81(0.81)	1.43(1.95)	1.45(2.78)	1.59(2.74)
White(%)	99.00(1.63)	98.41(1.91)	99.20(1.28)	99.19(1.47)	98.20(3.85)
Black(%)	0.19(0.75)	0.76(1.55)	0.18(0.74)	0.149(0.38)	0.16(0.94)
Foreign White(%)	10.22(4.38)	9.50(3.93)	9.80(4.11)	10.33(4.63)	10.80(3.72)
Non White(%)	1.00(1.72)	1.56(2.05)	0.78(1.36)	0.81(1.44)	1.85(3.90)
Completed High School(%)	31.72(17.38)	44.30(11.10)	36.62(16.38)	29.38(13.93)	22.67(10.66)
Employed(%)	37.91(6.24)	39.91(5.12)	38.61(5.12)	37.82(6.29)	34.64(6.41)
Homes Needing Major Repairs(%)	1.96(3.10)	0.79(1.37)	1.65(2.06)	2.03(2.89)	4.05(5.40)
Homes No Radio(%)	2.02(2.07)	1.03(1.18)	1.57(1.35)	2.23(1.74)	3.77(2.67)
Median Value Home [$1000 (1940s US$)]	1.46(3.24)	1.343(1.86)	1.38(2.60)	1.86(4.29)	1.05(4.34)

Population characteristics indicating racial categories (percent White, Black, Foreign White, Non White) failed to vary with the same consistency, Given that neighborhood gradings were highly discriminatory, with neighborhoods with high percentages of Black residents given grades "C" and "D" (Nelson et al., 2018), it was expected that median values of racial categories of than "White" would increase with worsened neighborhood gradings. While the median percentages of Foreign White increased with declining neighborhood grade (Table 1), the values for White, Non-White, and Black residents varied inconsistently. Further inquiry is necessary to determine the causes of the variation.

Superfund Site Distribution & Proximity Analysis

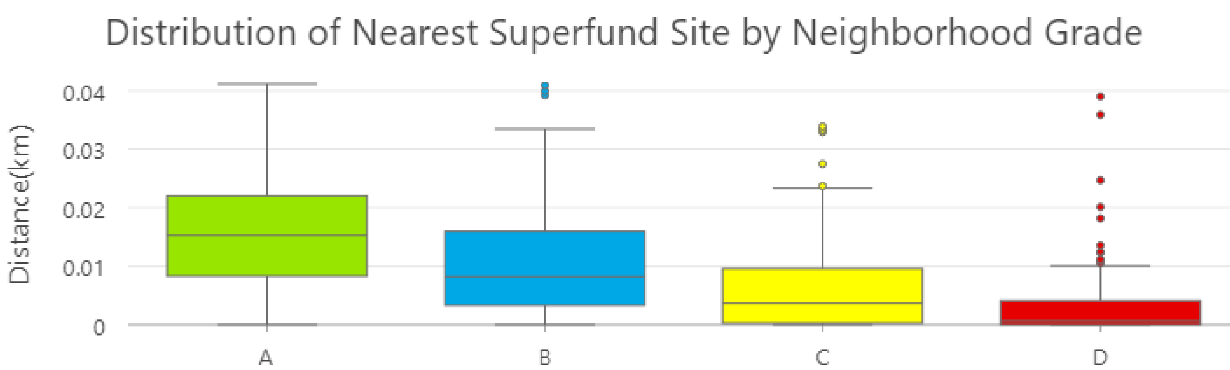

Figure 2. Proximity of Nearest Superfund Sites to Neighborhood by HOLC grade. ArcGIS Pro's Near Function was utilized to find distances. Superfund Site data was acquired from the Environmental Protection Agency's Superfund Enterprise Management System database.

Superfund site distances fell overwhelmingly in closer proximity as neighborhood grades worsened (Figure 2). Median values of distances to Superfund sites decreased from A to D. A non-parametric Kruskal Wallis test showed a significant p-value of 3.14E-09 (Table 3).

Table 3. Kruskal Wallis test for Nearest Superfund Site Distances. A non-parametric Kruskal Wallis test with a significance level of 0.05 was used.

df	K	P-value	K crit
3	51.73	3.41E-11	7.81

DISCUSSION

Historical redlining continues to play an important role in disproportionate proximity of marginalized communities to adverse health risks within the United States. Cyclical neighborhood disinvestment, driven by redlining and other discriminatory housing practices, such as blockbusting, exclusionary zoning, and restrictive deed covenants (Massey, 2015) increases the risk of exposure for historically marginalized communities to environmental health risks. Within this study, I found evidence of an association between increasing proximity to toxic waste sites and poor neighborhood gradings by the HOLC.

Superfund site health outcomes

Superfund sites possess a history of closer proximity to low-income, historically marginalized communities. Closer proximity to superfund sites has been associated with increased risks for adverse birth outcomes (Currie et al., 2011), prevalence of asthma and bronchitis (Meltzer et al. 2020), and lower life expectancies **(**Kiaghadi et al., 2021). While risks vary by site and exposure type, more inquiry is required to how to mitigate risk adverse health outcomes for predominantly historically marginalized communities.

Lasting legacy of redlining

This research follows a growing body of literature that studies the legacy of historical redlining maps on current health inequities. These risks come from redlining influence on the built environment. Historically redlined neighborhoods have been linked with higher urban temperatures (Hoffman, 2020), as well as an increased risk for emergency asthma visits (Nardone et al. 2020). In a more recent study, neighborhoods that were formerly redlined faced an increased risk for COVID-19 deaths (Li and Yuan, 2021)**.** The lasting health inequities predominantly impact low-income people of color living within these areas (Nardone et al., 2021).

Limitations and Future Directions

There are limitations within the study. Patterns of racialization and neighborhood grading did not show as clearly as expected within the study. This may be because of possible discrepancies between HOLC surveyors and census data. Additionally, the relationship between proximity of neighborhoods to superfund sites and sociodemographic variables were not linked, which could reveal a stronger relation between proximity and neighborhood grade. This remains a potential area for future direction of research.

Future directions for this study also include expansion of the study area to all formerly Home Owners' Lending Corporation mapped cities within the United States. Additionally, an exploration of the current health risks associated with closer Superfund Site proximity. Given that Superfund site cleanup duration and National Priority listings are potential indicators of equity in the Superfund program (O'Neil, 2007), a determination of neighborhood grading these determinants is also a possibility.

Conclusion

Redlining plays an active role in the current landscape of risk for historically marginalized communities. In order to rectify environmental injustices, a concerted effort to include by all stakeholders; government agencies, private and public agencies, and community members, is required in order to challenge the outcomes of historic discrimination.

ACKNOWLEDGEMENTS

I would like to thank the ESPM175 teaching team including Patina Mendez; who constantly supported and encouraged me to see myself as a scientific researcher; Sangcheol Moon and Chelsea Andreozzi, my GSIs who provided thoughtful and motivating feedback with both intention and patience. My mentor Maggi Kelly also was an incredible guide and source of encouragement, who constantly pushed me to see the potential for further research and inquiry. My ESPM175 peers and fellow researchers Brianna Betts, Zoe Chan, Ally Zhu, and Catherine Jennifer also provided an incredible network throughout the process. Lastly, I simply could not have completed this project without the support of my family, my constant source of inspiration, guidance, and grounding.

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