LEGACY OF REDLINING

Evidence Of Lead Exposure In Drinking Water Samples From California Public Schools

University of California, Riverside

Photo Credit: Sam Ward/Reveal

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AGENDA

Presentation Overview

- INTRODUCTION
- BACKGROUND AND EVIDENCE
- METHODS AND OUTCOMES
- FINDINGS AND RECOMMENDATIONS
- CONCLUSION

INTRODUCTION

CURRENT POLICY

Assembly Bill 746
Effective Date 2017

Mandated Lead Testing of Potable Water System for Schools Built Prior to 2010.

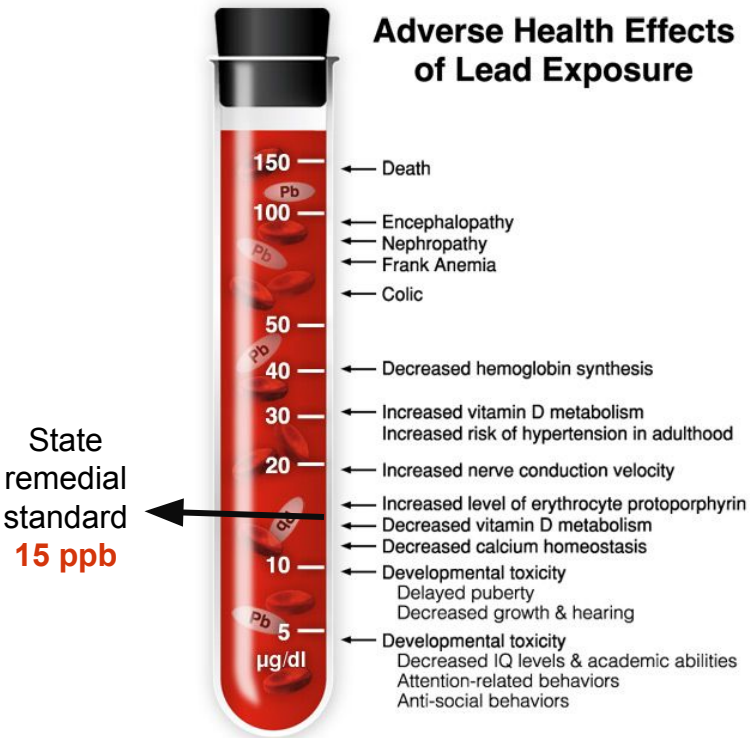
INTRODUCTION

The Issue

Lead is detectable throughout California's public school system.

Lead is a known **neurotoxin**.

Children absorb **4x** more lead and the harmful health effects of lead poisoning are **irreversible.**



Source: Bellinger, D. C., & Bellinger, A. M. (2006).

INTRODUCTION

Objective: Legacy of Redlining

Explore the association between the Home Owner's Loan Corporation (HOLC) 1930s discriminatory housing maps and the present day occurrence of lead exposure in California's public school system.

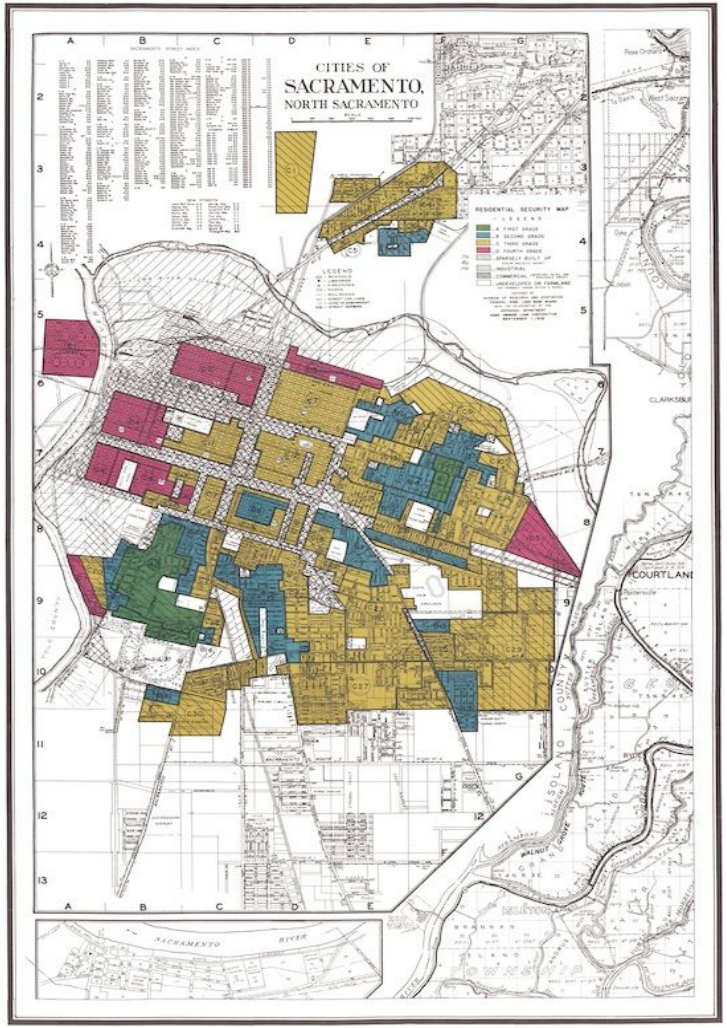
BACKGROUND

What is Redlining?

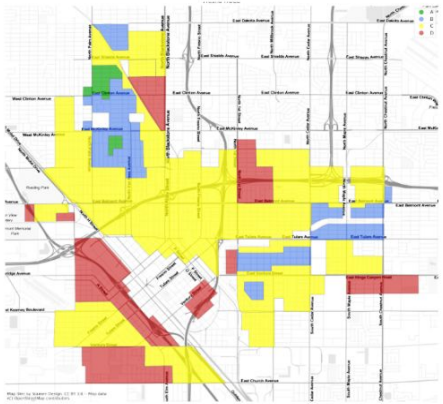
A discriminatory lending practice that denied loans to individuals based on the racial composition of the applicant's neighborhoods.

This practice primarily affected communities of color.

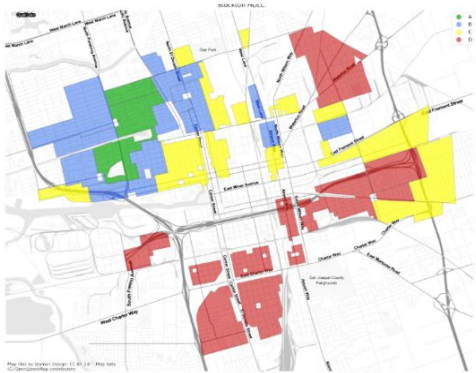
Lenders would "redline" the neighborhoods that were deemed hazardous to investment.



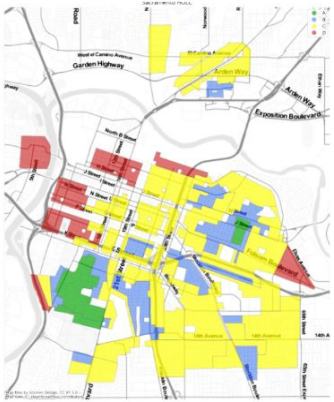
The original 1930s map of Sacramento showing 'Residential Security Grades.



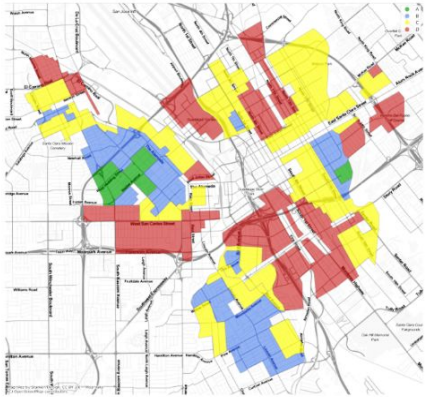
(a) Fresno



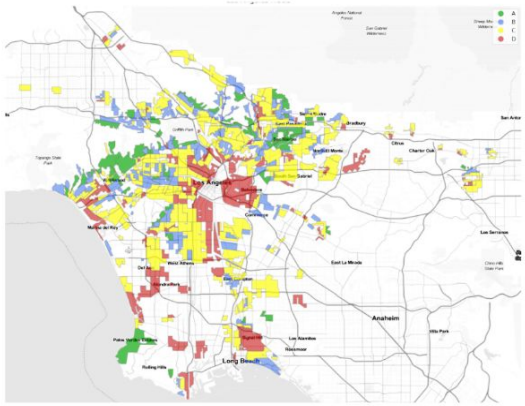
(b) Stockton



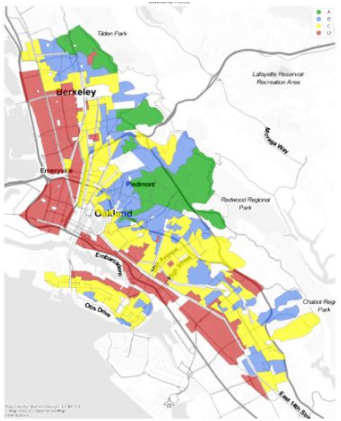
(c) Sacramento



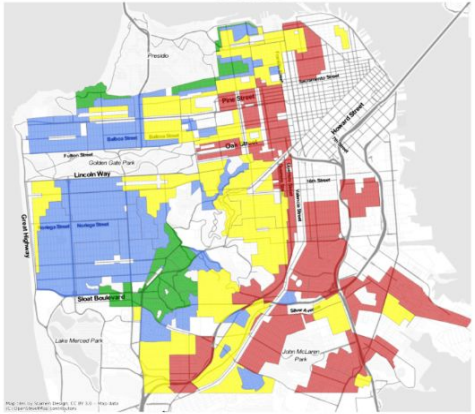
(d) San Jose



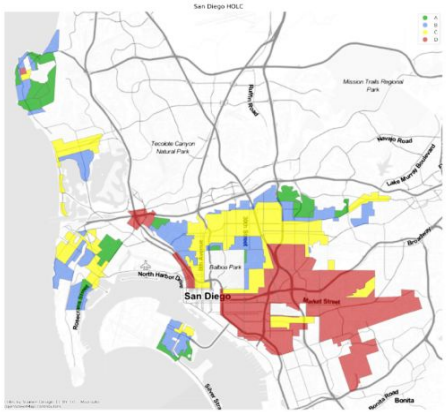
(e) Los Angeles



(f) Oakland



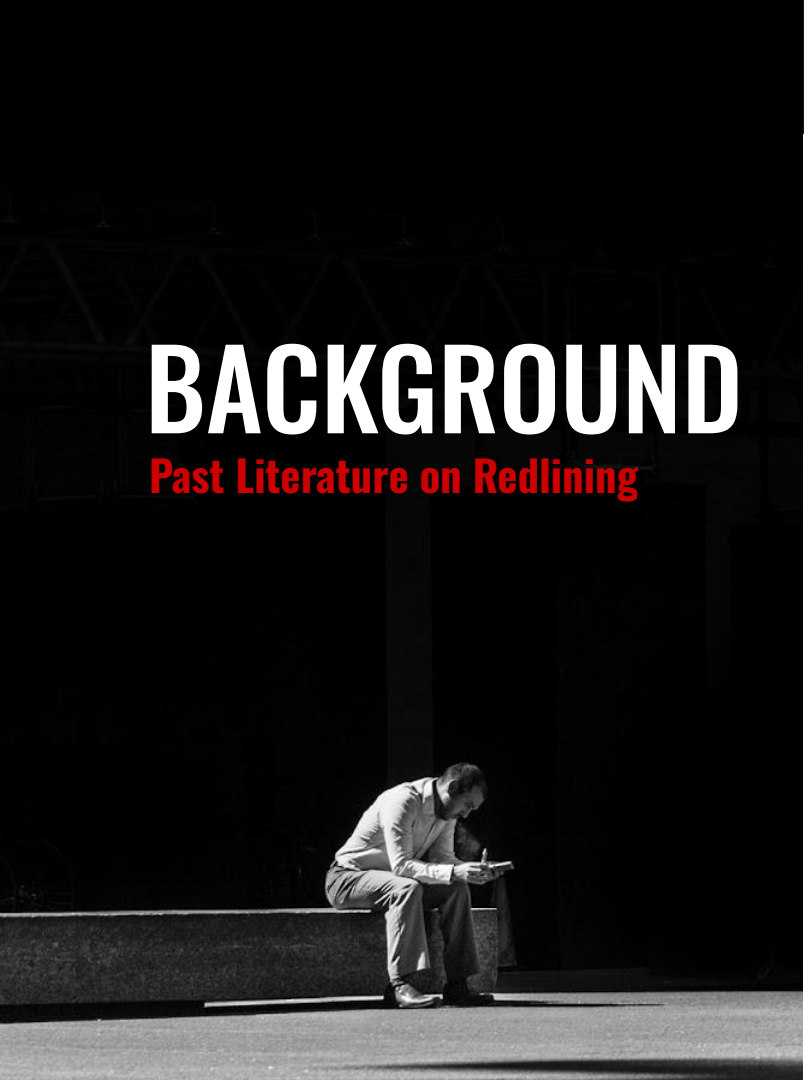
(g) San Francisco



(h) San Diego

Digitized Maps of 8 Historically Redlined Cities in California

A Grade
B Grade
C Grade
D Grade (Redlining)



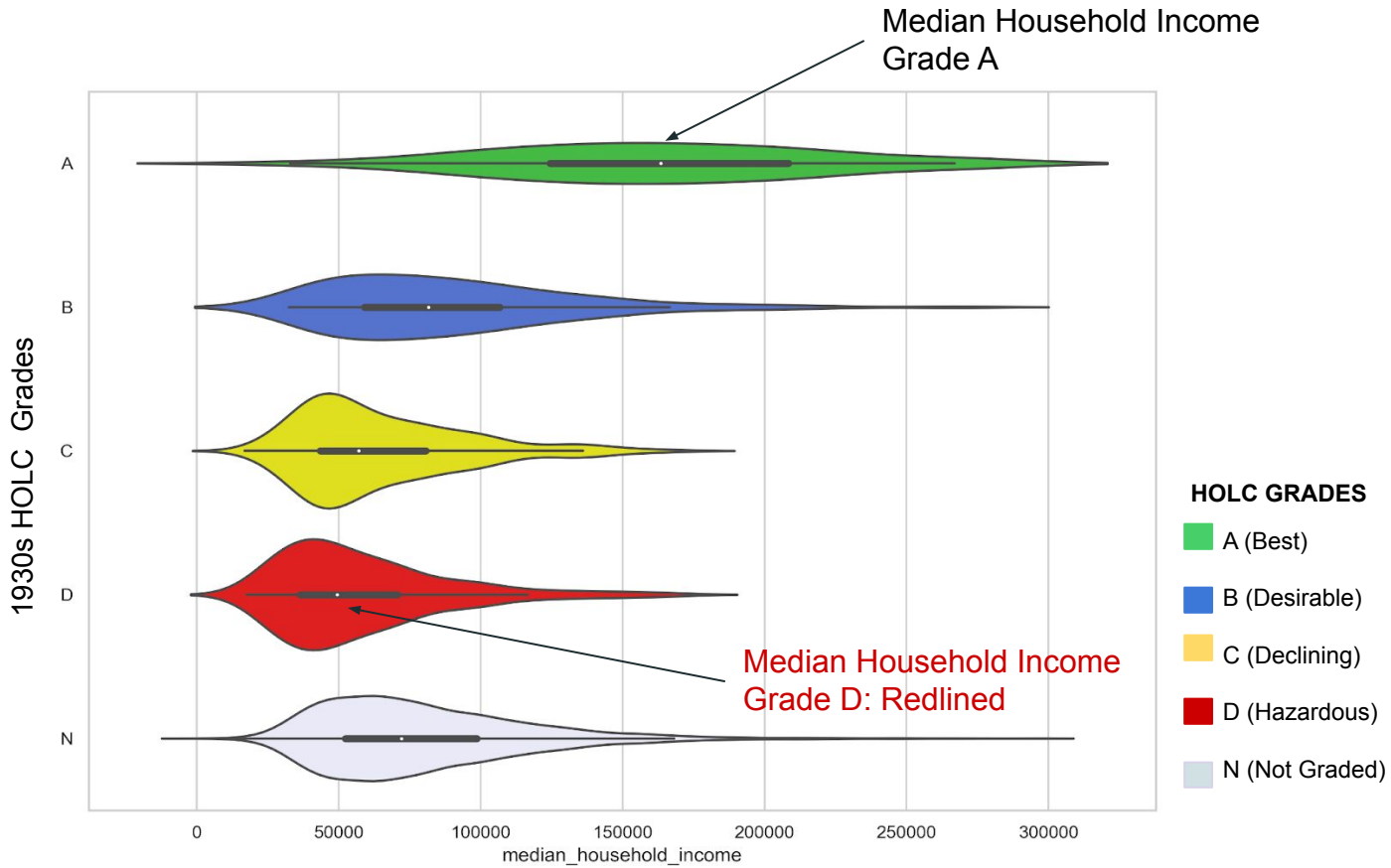
BACKGROUND

Past Literature on Redlining

- Redlining resulted in housing segregation
- Neighborhood disinvestment and a widening wealth gap were consequences of discriminatory lending practices
- Educational disparities observed across redlined areas
- Evidence of present day health disparities and environmental injustices

EVIDENCE

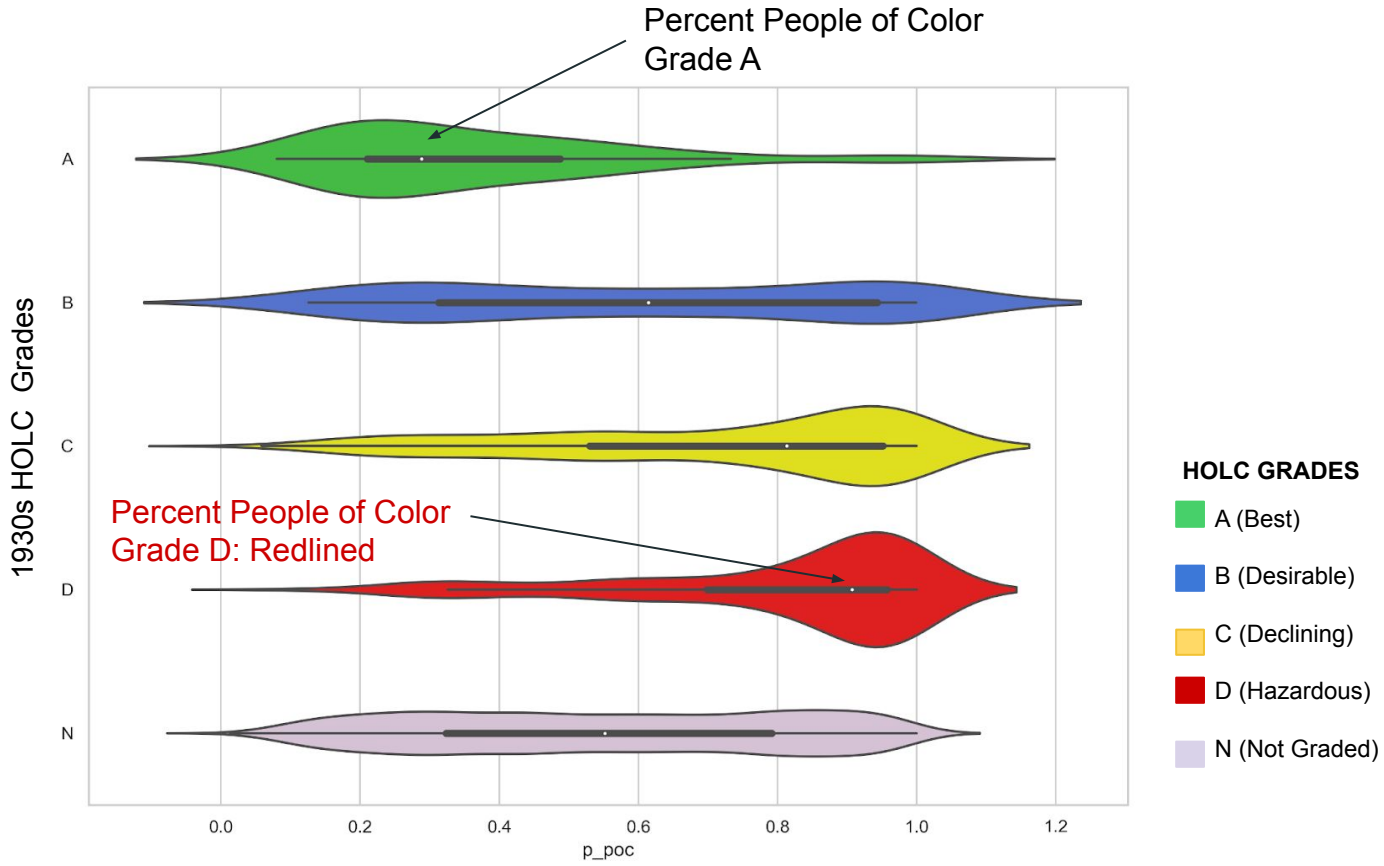
Income Disparities



Violin Plot A : Distribution of Median Household Income in 2010

EVIDENCE

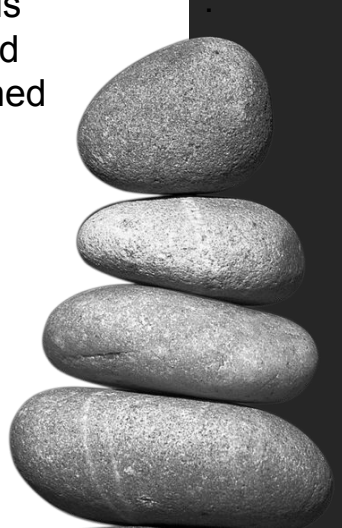
Racial Disparities



Violin Plot B: Distribution of Percent People of Color in 2010

Research Question 1

Are lead levels higher in schools belonging to historically redlined neighborhoods versus non-redlined neighborhoods?



Research Question 2

Are lead outcomes spatially clustered or randomly distributed throughout historically graded regions of redlined cities?

METHODS

Data Sources

State Water Resources Control Board

Lead Sample Results

7,555 Public Schools in California

Collected from 2017-2019

Mapping Inequality University of Richmond

1930's Digital HOLC Maps

8 Historically Redlined Cities in California

Census Bureau

2010 Census Tract Data for California

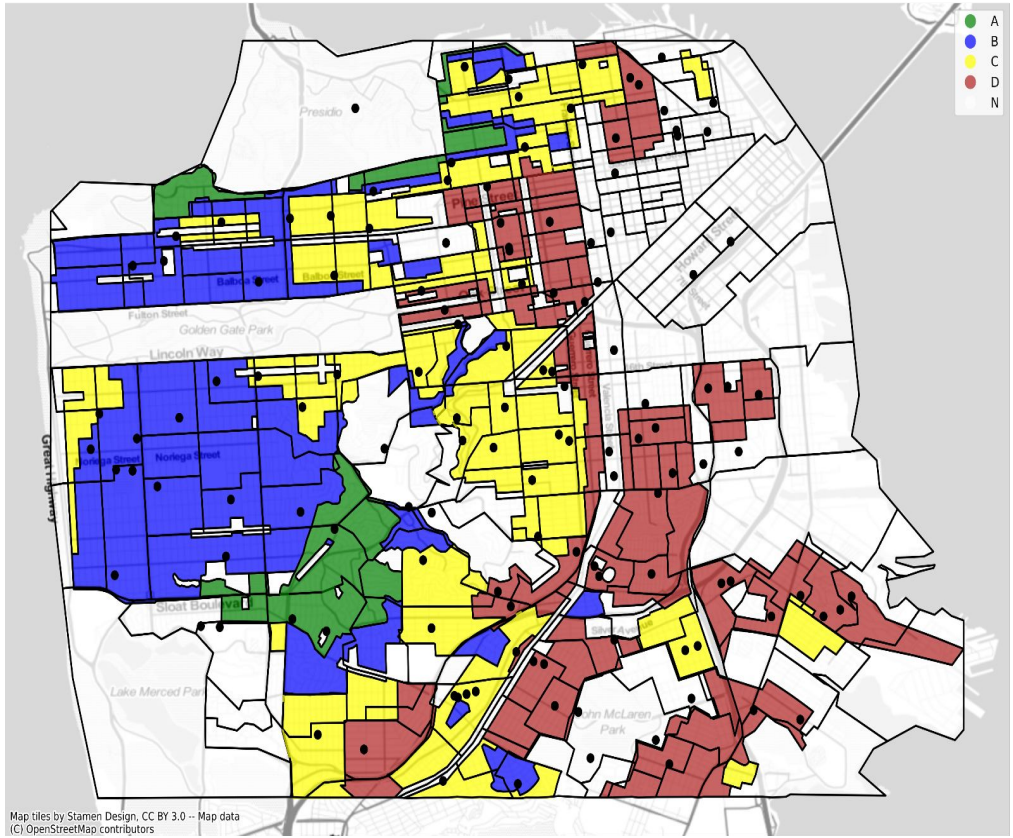
For Median Household Income and Racial Composition indicators

METHODS

Data Analysis

Research Question 1
Regression Modeling

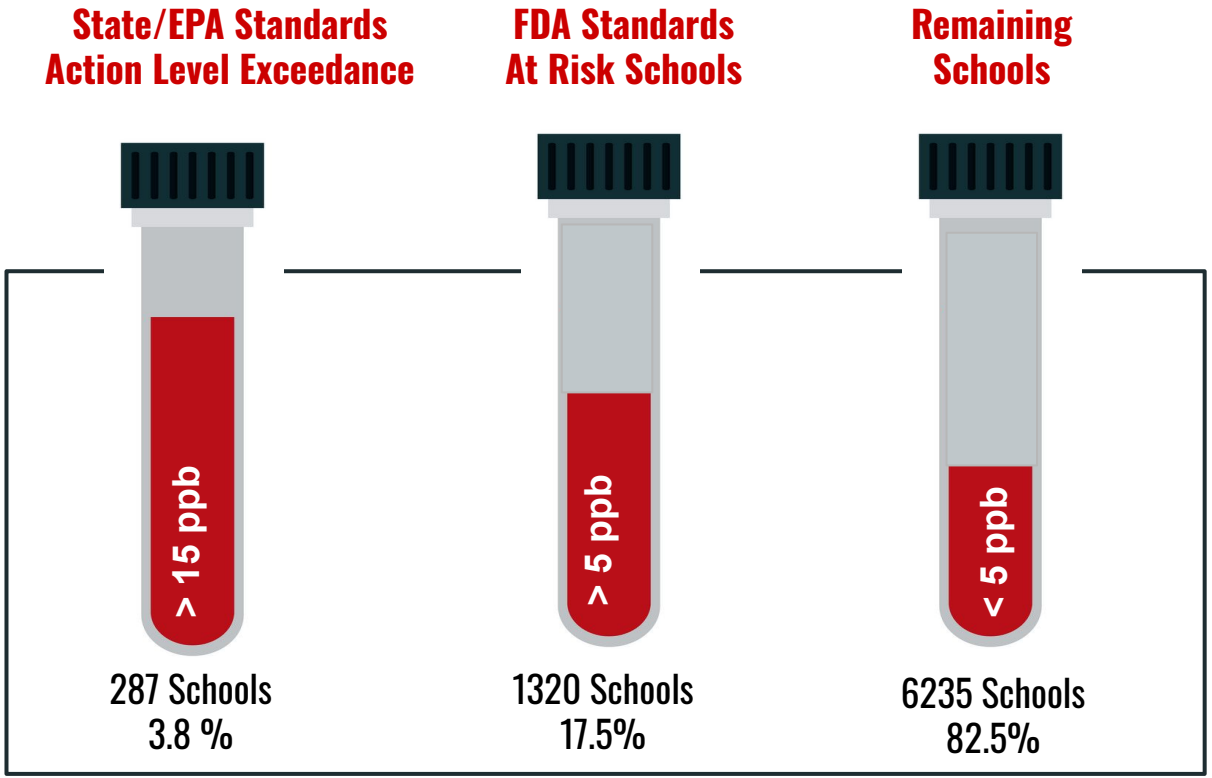
Research Question 2
Local and Global Measures of Spatial Autocorrelation



Schools Locations in San Francisco, California

STUDY OUTCOMES

Lead Exposure



Highest reported lead concentration in parts per billion (ppb) at a school site, sample size 7,555 public schools in California

FINDINGS

Regression Results

Outcome: Lead Concentration (ppb)

Sample Size (N) = 7,555

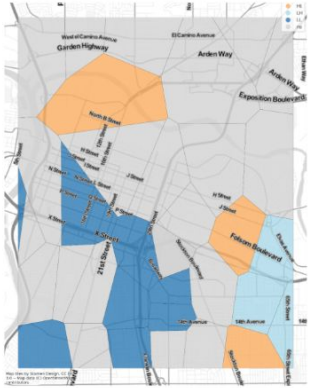
Subsample at Risk (N)= 1,320

No statistically significant relationship between redlined areas and lead concentrations in schools.

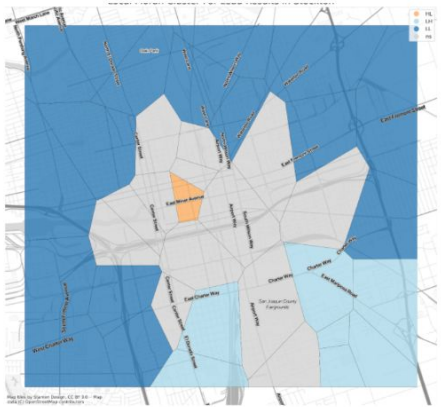
Ordinary Least Square Estimation

Outcome Variable: Lead Concentration				
	(1)	(2)	(3)	(4)
Observations	1,320	7,552	1,319	7,551
A	-2.018	0.783	-8.946	0.480
	(30.028)	(6.270)	(30.734)	(6.382)
B	-11.958	-1.566	-8.256	-0.846
	(17.483)	(3.732)	(17.791)	(3.778)
C	-2.005	0.022	4.462	1.016
	(11.634)	(2.173)	(12.155)	(2.264)
D	-7.324	-1.558	-0.229	-0.545
	(15.585)	(2.525)	(16.074)	(2.620)
HOLC City Status			-9.511	-1.595
			(5.870)	(1.024)
Median Household Income			0.000**	0.000
			(0.000)	(0.000)
People of Color			8.611	1.140
			(11.042)	(1.965)
Note:		*p<0.1; **p<0.05; ***p<0.01		

1.Fresno



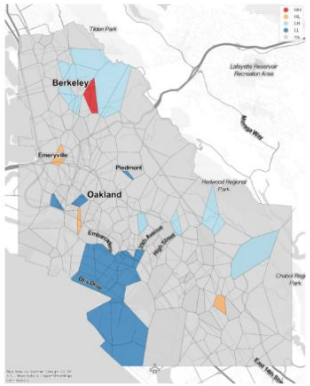
2. Stockton



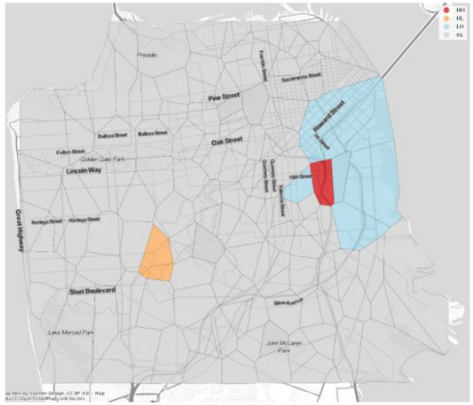
3. Sacramento

4. San Jose

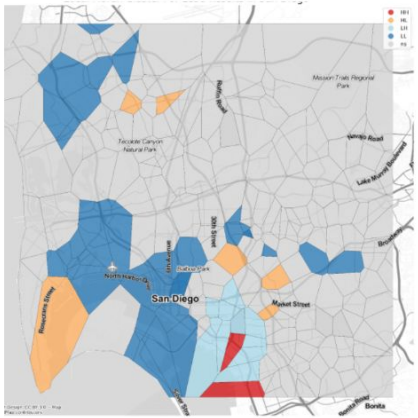
5. Los Angeles



6. Oakland



7. San Francisco



8. San Diego

Identifying Clustering of Schools Based on Lead Exposure

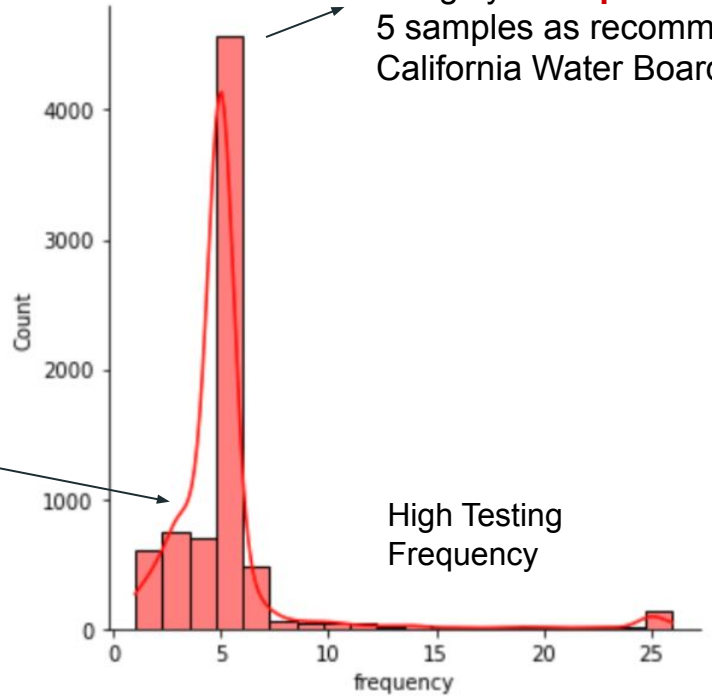
HH (Hotspot)
HL
LL(Coldspot)
LH

STUDY OUTCOMES

Frequency of Testing

Roughly **4000 public schools** collected 5 samples as recommended by California Water Boards

Low Testing Frequency



High Testing Frequency

Bar Graph: Testing Frequency Counts
From 7,555 Public Schools in California

FINDINGS

Regression Results

Outcome: Frequency of Testing

Sample Size (N) = 7,555

Subsample at Risk (N)= 1,320

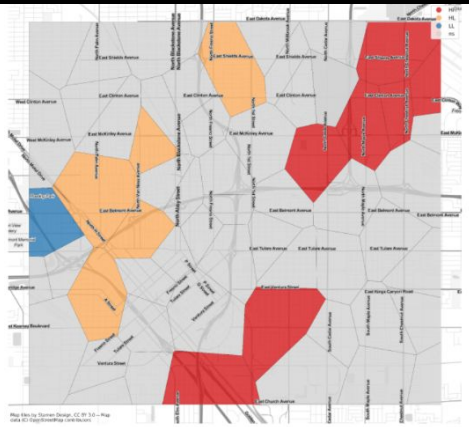
Testing frequency was **significantly associated** with all HOLC grades and median household income.

Negative Binomial Estimation

Outcome Variable: Frequency of Testing

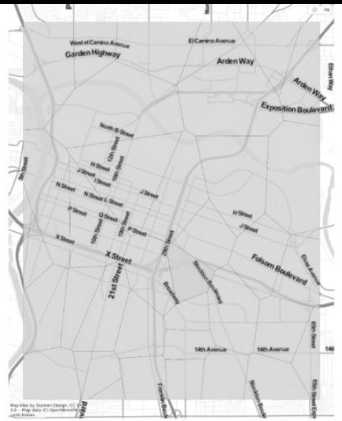
	(1)	(2)	(3)	(4)
Observations	1,320	7,552	1,319	7,551
A	0.667**	0.455***	0.421	0.325*
	(0.331)	(0.166)	(0.339)	(0.169)
B	0.408**	0.457***	0.309	0.424***
	(0.195)	(0.099)	(0.199)	(0.100)
C	0.570***	0.291***	0.538***	0.299***
	(0.129)	(0.058)	(0.135)	(0.061)
D	0.528***	0.295***	0.524***	0.312***
	(0.173)	(0.068)	(0.179)	(0.070)
HOLC City Status			0.101	0.011
			(0.067)	(0.028)
Median Household Income			0.000***	0.000***
			(0.000)	(0.000)
People of Color			0.075	0.073
			(0.126)	(0.054)

Note: *p<0.1; **p<0.05; ***p<0.01



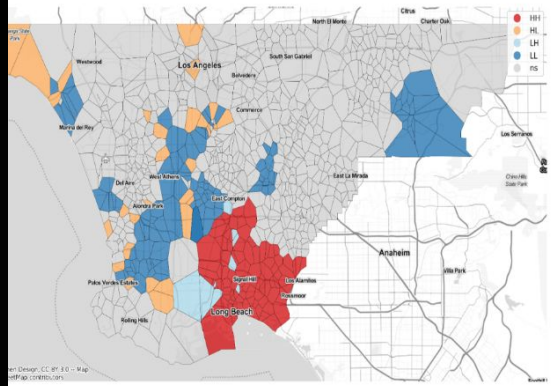
1.Fresno

2. Stockton

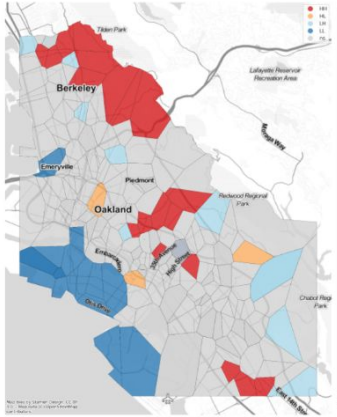


3. Sacramento

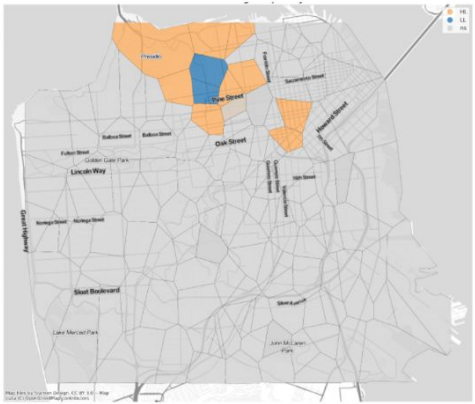
4. San Jose



5. Los Angeles



6. Oakland



7. San Francisco

8. San Diego

Identifying Clustering of Schools Based on Testing Frequency

HH (Hotspot)
HL
LL(Coldspot)
LH

FINDINGS

Major Takeaways

- Regression models produced **mixed results** for HOLC grades and lead outcomes.
- **Median household income is associated** with exposure (lead concentration) & testing frequency.
- We found at least **4 historically redlined cities** had **statistically significant hotspots/coldspots** for lead exposure and testing frequencies at neighboring schools locations.

RECOMMENDATIONS

Policy Alternatives

Revise remedial standards from 15 to 5 ppb

Estimated at-risk schools with action level exceedance **increase from 3% to 20%**

Point-of-use filtration units in schools

Ensure safe drinking water for **1300 at-risk schools**

Consistent sampling and reporting

Lead sample testing frequency **ranges from (1 to 26)** Standardize and increase the number of tests per site

3.8%

Current Policy Impacts: 287 Schools

17%

Policy Alternative Impacts: 1320 Schools

RECOMMENDATIONS

Effectiveness, Feasibility, and Efficiency

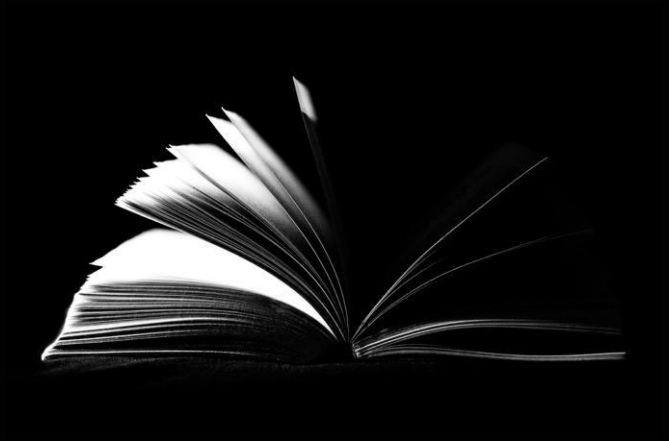
Benefits: Parents, Children and Society
Costs: School Districts and Water Service Providers

Funding Sources:
California SAFER program
Voter-approved bond measures
Infrastructure Investment and Jobs Act

LIMITATIONS

- **Scope:** Our spatial analysis was limited to HOLC graded regions within the redlined cities.
- **Unique Local Variables:** Our analysis excluded school and water service provider's characteristics.

CONCLUSION



- High levels of lead (**up to 2000 ppb**) were found in California public school system.
- Our research shows at least **13.7% additional schools** require preventive action to avert unhealthy exposure to lead.
- Despite absence of causal relation with lead concentration, **socioeconomic and racial disparities persist** within neighborhoods that were historically redlined.

THANK YOU

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Presentation slides, additional maps, and final report will be posted on Github

LEGACY OF REDLINING

QUESTIONS AND COMMENTS

REFERENCES

- AB 746 Public Health: potable water systems: lead testing: school sites (n.d.). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB746
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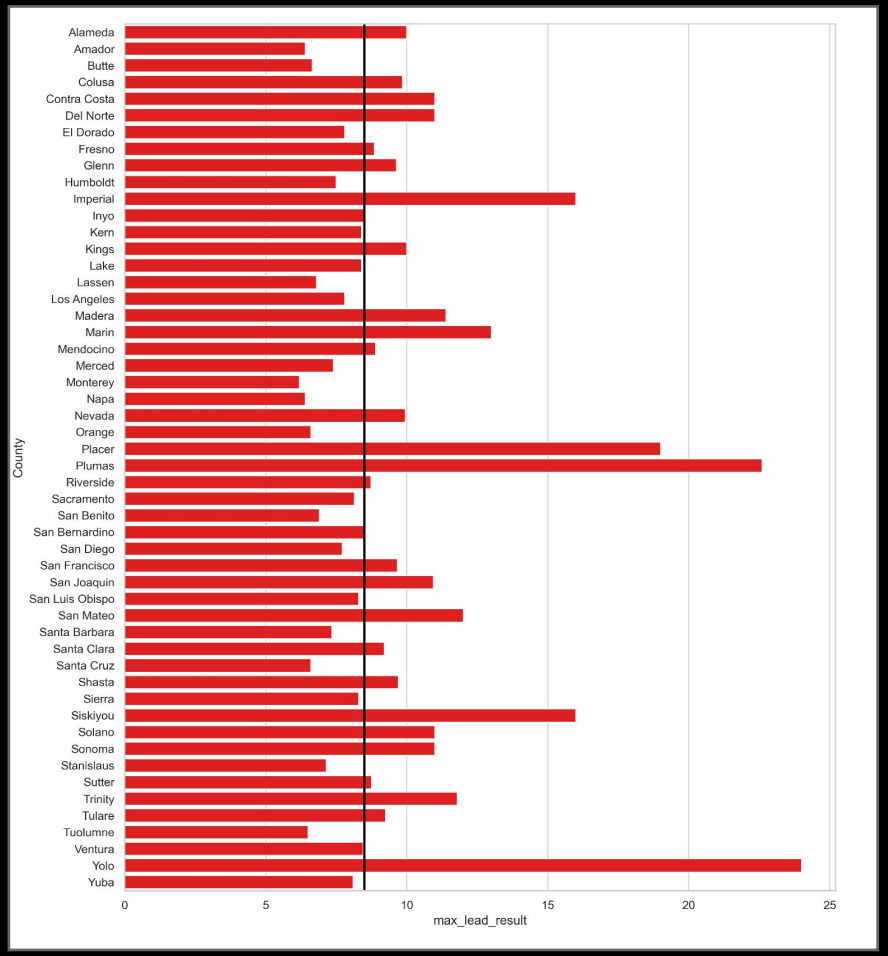


Fig 1: Median Lead Concentration in At Risk Schools by County

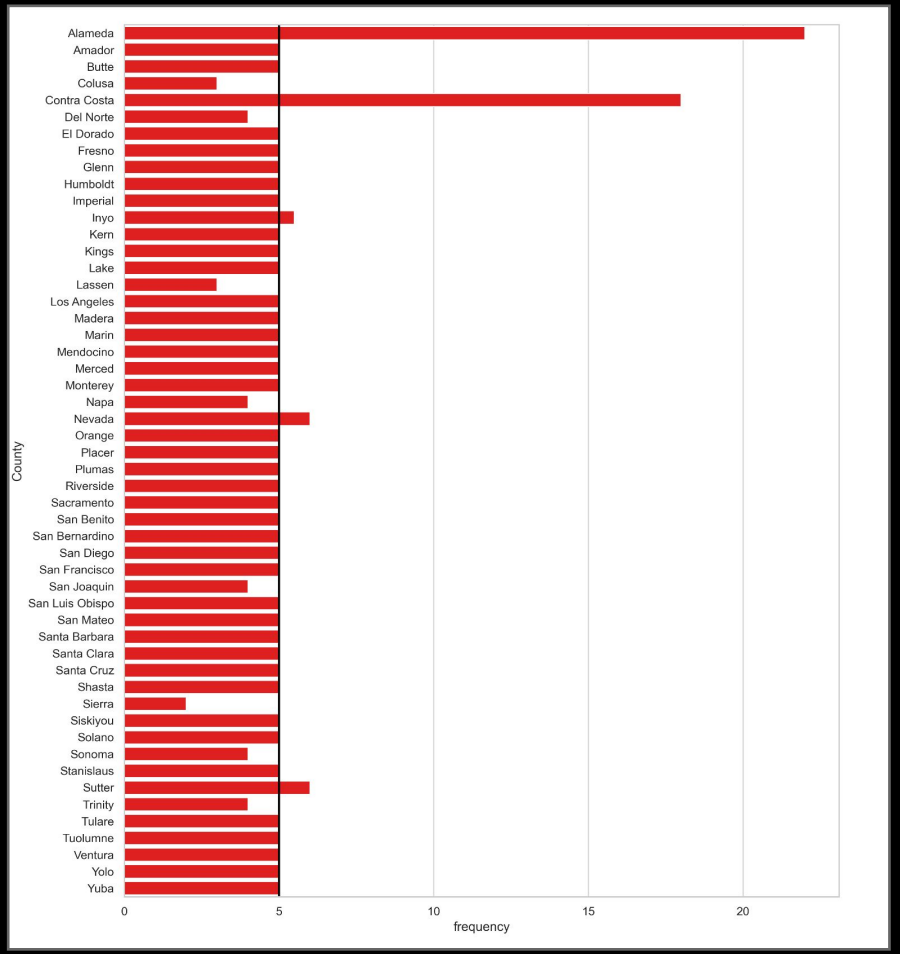
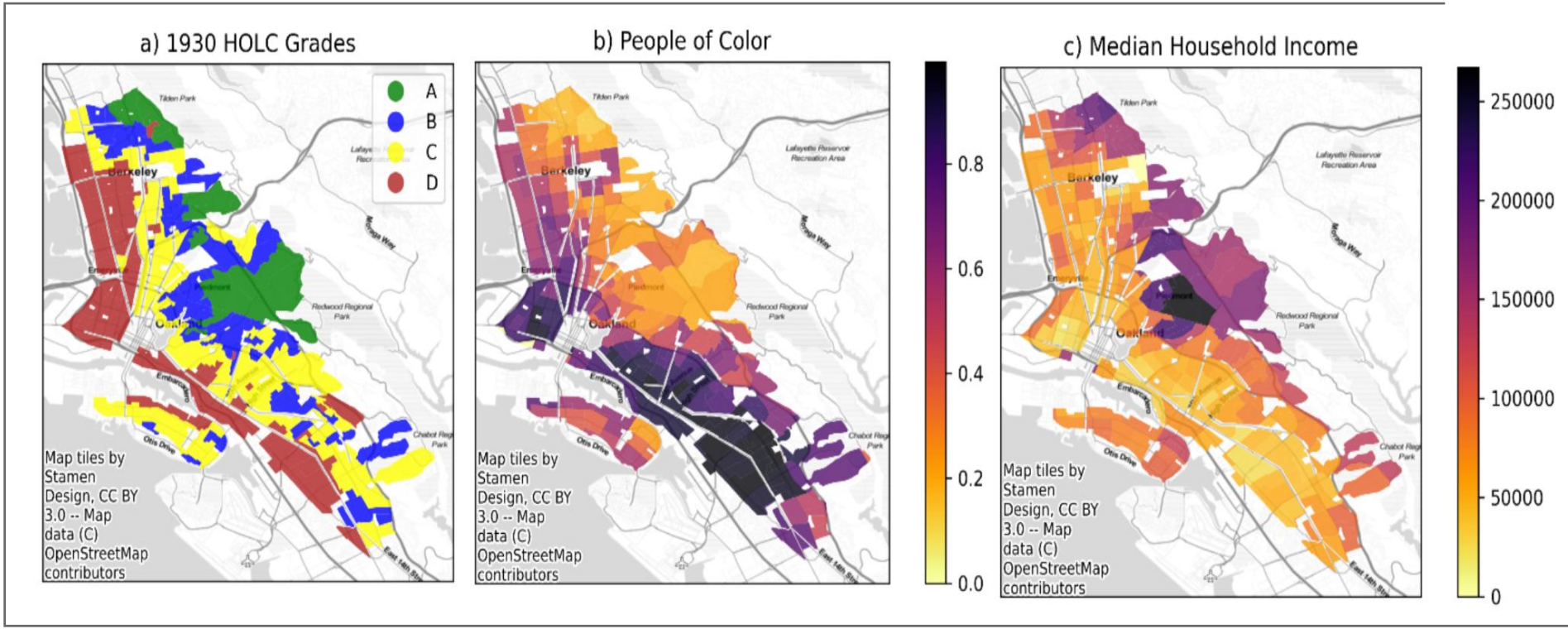


Fig 2: Median Testing Frequency in At Risk Schools by County

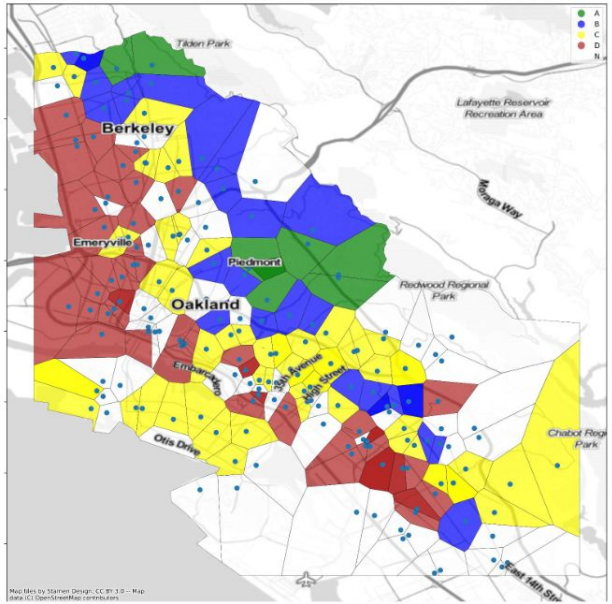


Map of Oakland, California

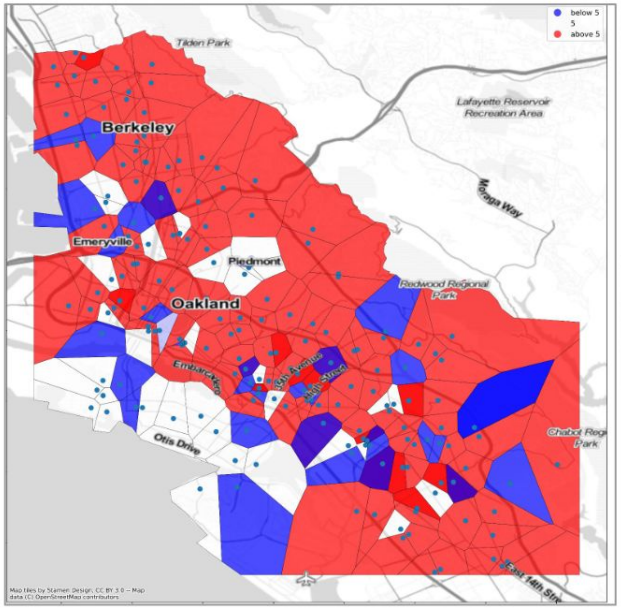
Map (a) shows the reconciled 1930's HOLC grades with modern 2010 census tracts. Census tracts belonging to 1930s HOLC grade A are shaded in green whereas grade D are colored red. Maps (b) show the percent of people of color and map (c) represent median household income in 2010. On the choropleth maps (b) and (c) the highest values of the people of color and median household income are represented in deep purple whereas the lowest values are shown in yellow.

VORONOI MAPS FOR OAKLAND, CALIFORNIA

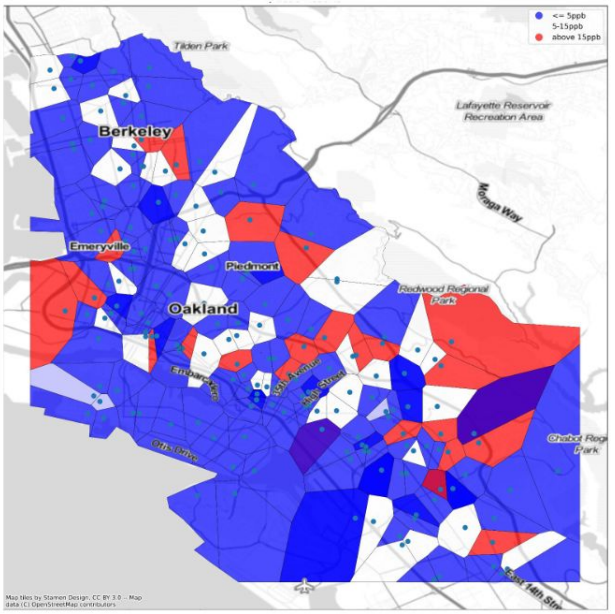
d) HOLC Grades



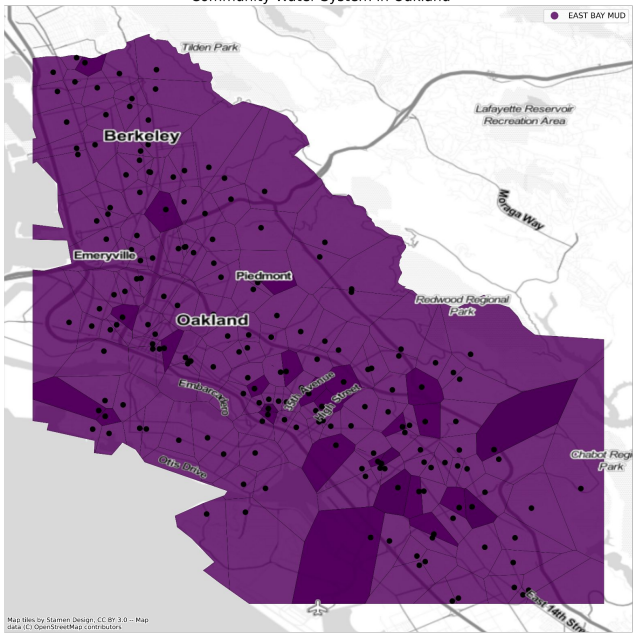
e) Testing Frequency



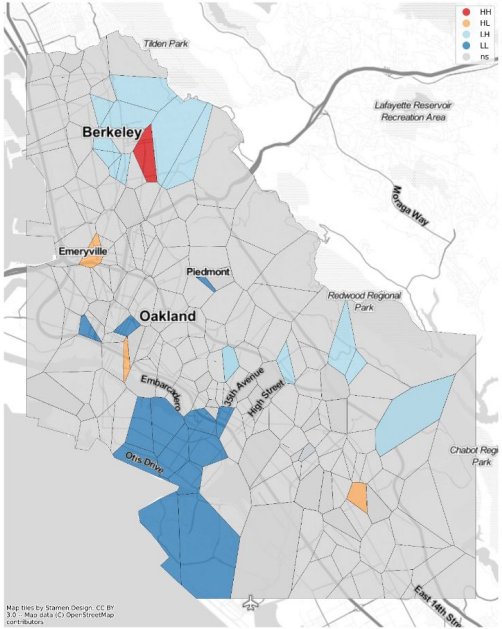
f) Lead Results



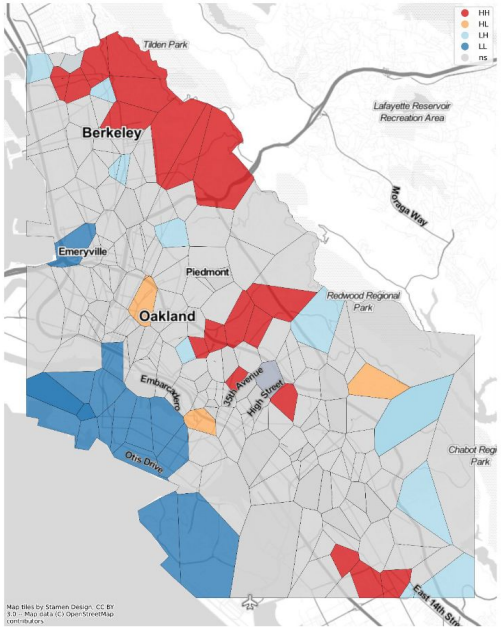
Community Water System in Oakland



LISA FOR OAKLAND, CALIFORNIA



Map A Local Moran Cluster for Lead Results



Map B Local Moran Cluster for Testing Frequency

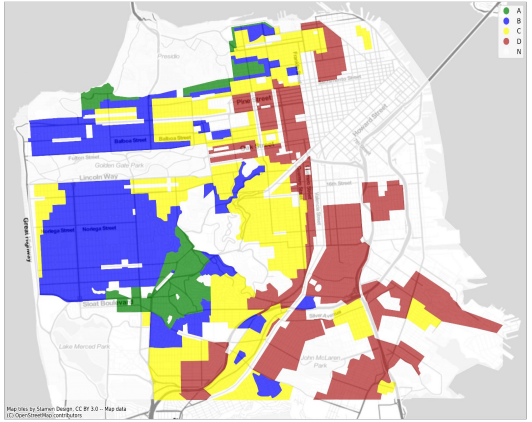
STEPS

Data Wrangling

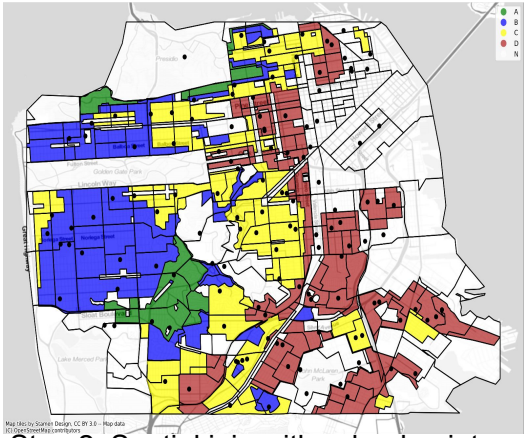
Reconcile 1930's map to modern census tracts data

Spatial join of school outcomes with new boundaries

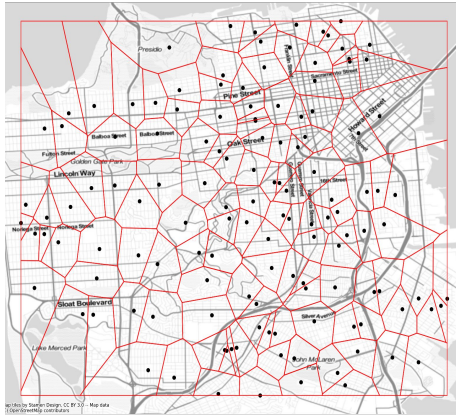
Voronoi polygons for schools points



Step 1: Reconcile HOLC maps



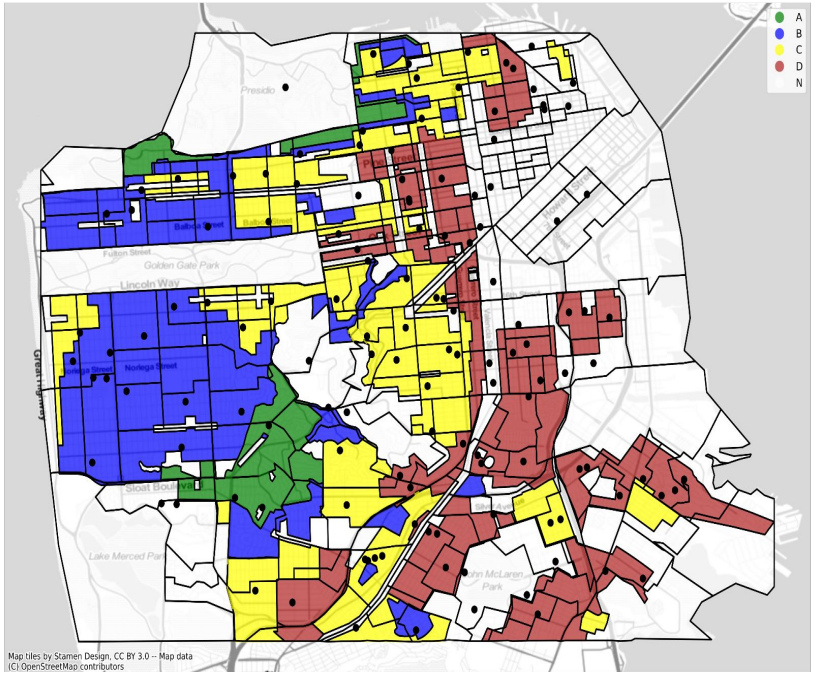
Step 2: Spatial join with school points

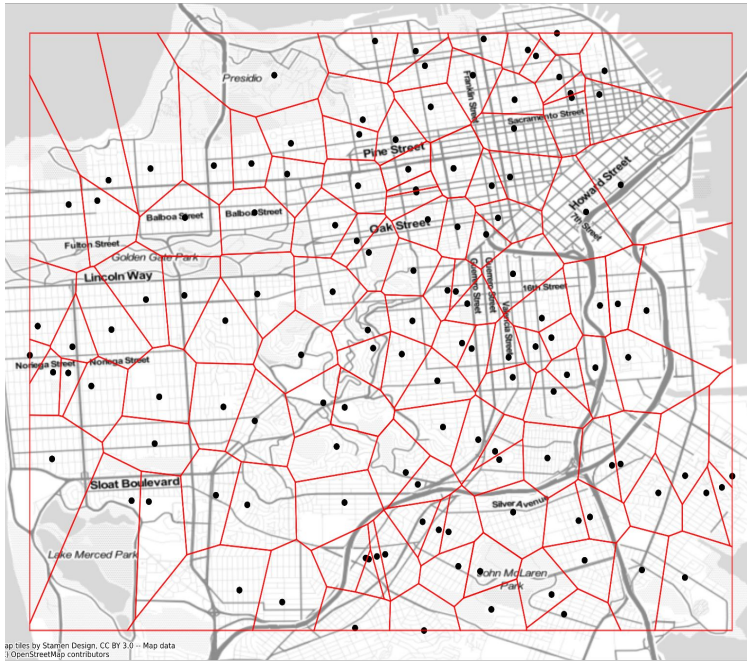


Step 3: Voronoi polygons from school point

Map of San Francisco, California

Map of San Francisco, California





WHAT IS VORONOI DIAGRAM

On the Voronoi diagram, each polygon contains exactly one initiation point (in this case the school) and every point in a given Voronoi polygon is closer to its generating points than others (Burrough et al. 2015). In most geospatial analyses, this technique is used to illustrate distance within a polygon to its centroid and accessibility to school locations