Examining the Lingering Effects of Redlining

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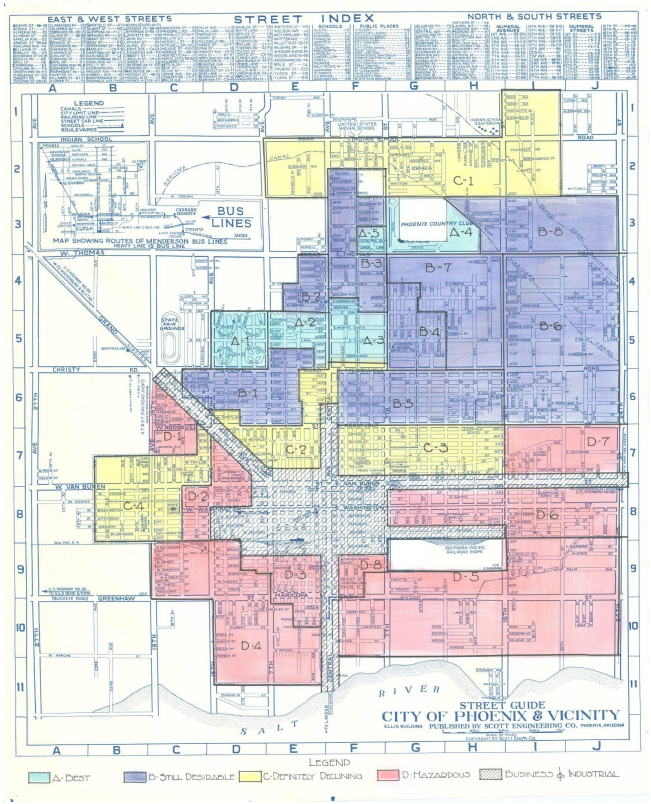
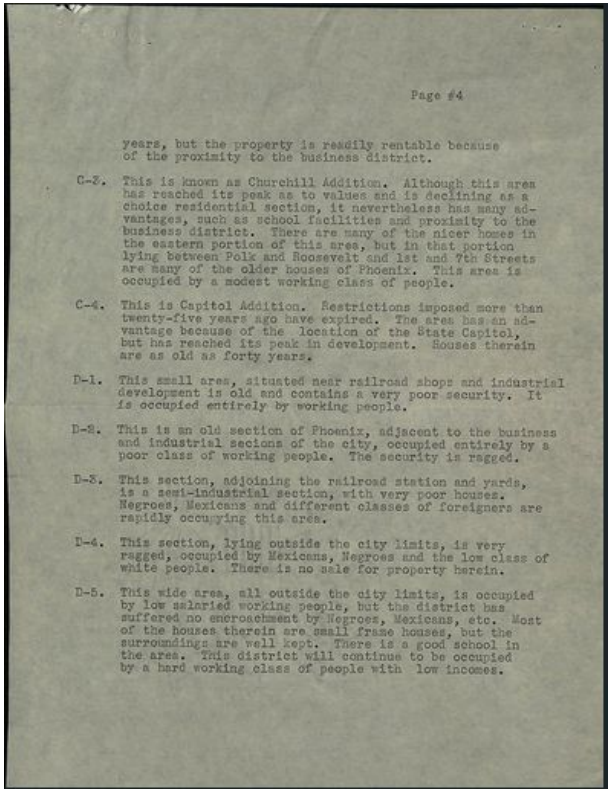
Background

- Between 1934 and 1940, the Home Owners Loan Corporation (HOLC) assessed mortgage investment and lending risks of neighborhoods across the United States and assigned areas grades based on their perceived risk.
- The grades were reflected on “Residential Security Maps” that assigned colors to areas based on their grades.
    - In the area descriptions produced by the HOLC, the writers took notes on the residents of those areas, including their race, ethnicity, and income.
        - Areas graded *D* and labeled Hazardous, were predominantly inhabited by black, immigrant, and poor residents.
- The practice of denying people access to loans and credit on the basis of class and race became known as redlining. This practice limited access to home ownership in areas with higher minority populations and reinforced racial segregation.

Example of Residential Security Map and Area Description





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years, but the property is readily rentable because of the proximity to the business district.

C-3. This is known as Churchill Addition. Although this area has reached its peak as to values and is declining as a choice residential section, it nevertheless has many advantages, such as school facilities and proximity to the business district. There are many of the nicer homes in the eastern portion of this area, but in that portion lying between Polk and Roosevelt and 1st and 7th Streets are many of the older houses of Phoenix. This area is occupied by a modest working class of people.

C-4. This is Capitol Addition. Restrictions imposed more than twenty-five years ago have expired. The area has an advantage because of the location of the State Capitol, but has reached its peak in development. Houses therein are as old as forty years.

D-1. This small area, situated near railroad shops and industrial development is old and contains a very poor security. It is occupied entirely by working people.

D-2. This is an old section of Phoenix, adjacent to the business and industrial sections of the city, occupied entirely by a poor class of working people. The security is ragged.

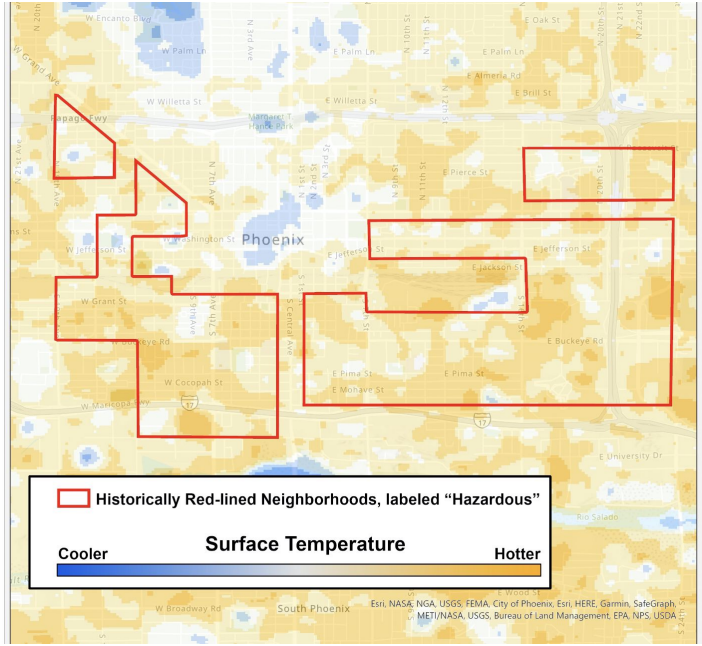
D-3. This section, adjoining the railroad station and yards, is a semi-industrial section, with very poor houses. Negroes, Mexicans and different classes of foreigners are rapidly occupying this area.

D-4. This section, lying outside the city limits, is very ragged, occupied by Mexicans, Negroes and the low class of white people. There is no sale for property herein.

D-5. This wide area, all outside the city limits, is occupied by low salaried working people, but the district has suffered no encroachment by Negroes, Mexicans, etc. Most of the houses therein are small frame houses, but the surroundings are well kept. There is a good school in the area. This district will continue to be occupied by a hard working class of people with low incomes.

Redlining in Phoenix

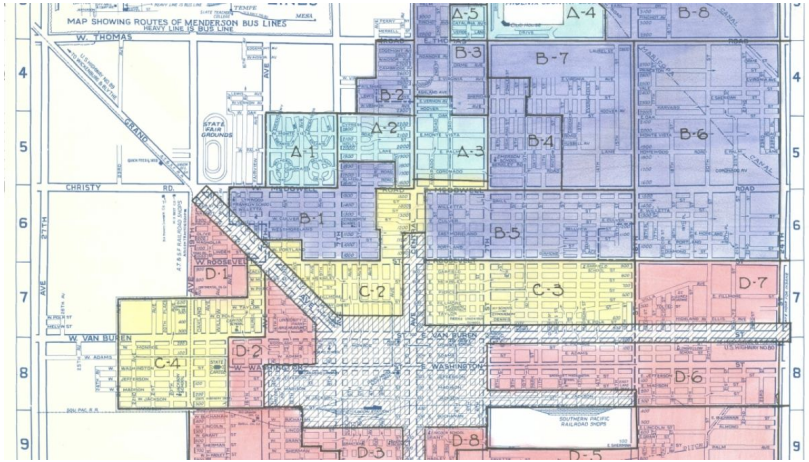
- In the 1950s, 75% of Phoenix's factories were located close to the railroad that divided North and South Phoenix, majority in South Phoenix
    - Bring hazardous waste that is process and stored in South and West Phoenix.
- Phoenix Sky Harbor airport built in redlined areas
- Air quality is poor in South Central Phoenix – levels of particulate matter regularly ranged from 62-87 above the health standard.
- Less heat resilience



Diane Sicotte. Dealing in toxins on the wrong side of the tracks: Lessons from a hazardous waste controversy in phoenix*.Social Science Quarterly, 89(5):1136–1152, 2008.

Redlining in Phoenix, Arizona

- HOLC actions heightened segregation, barring minorities from purchasing homes in certain areas, from 1913
- Redlining ensured POC residents were relegated to south side of Van Buren Avenue – filled with environmental and toxic hazards, superfund sites, factories, freeways.
- Revitalization and highway construction in redlined areas, displacing over 300,000 families
- Poor investment in communities



Arizona Town Hall. History of housing policy and discrimination in az. https://www.aztownhall.org/resources/Documents/114 Accessed: 2024-02-11.

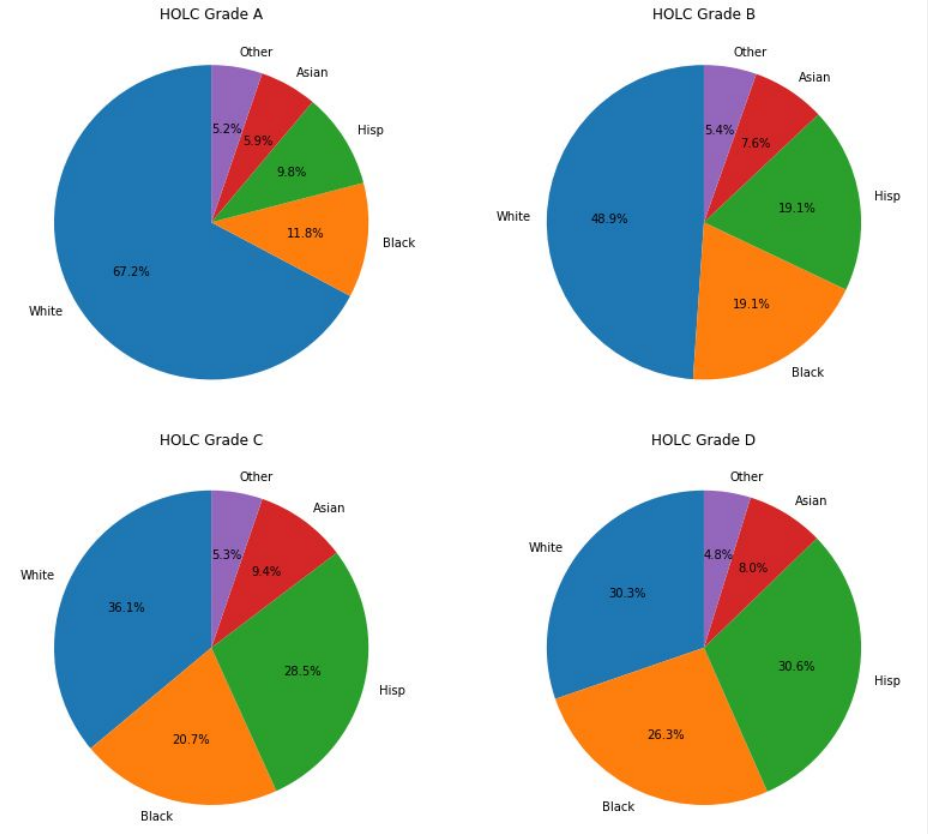
What is the lasting impact of redlining? How has redlining influenced diversity, education, health, and income?

Racial Makeup Across HOLC Zones

Distributions of 2020 Population Estimates

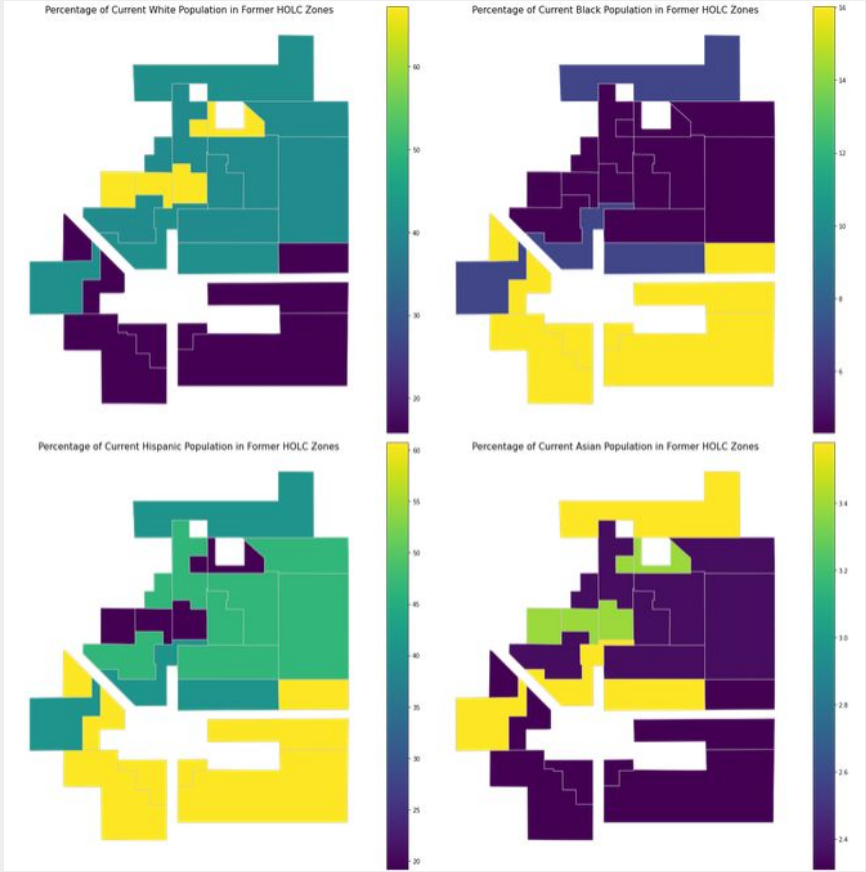
- 67.2% of the population in HOLC A areas were white.
- 59% of the population in HOLC D areas were black and hispanic.
- The white population decreased as the HOLC zone was rated more poorly and had the opposite effect for black and hispanic populations.

Source: 2020 U.S. Census



Spatial Visualization of Population Distribution in Arizona

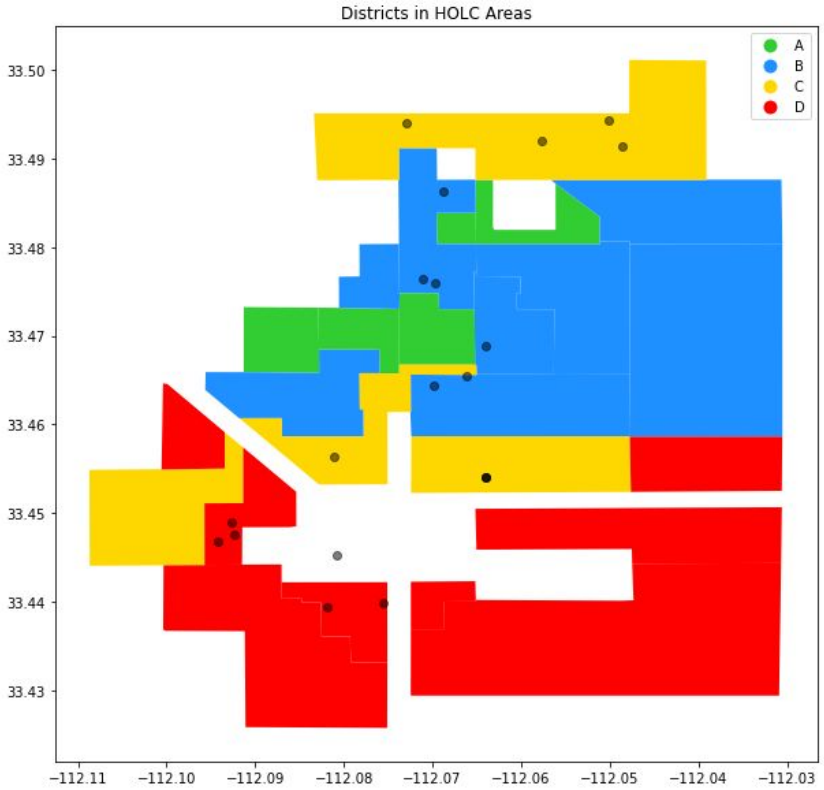
- 67.3% of the population in HOLC A areas were white.
- 60.7% of the population in HOLC D areas were hispanic.



Redlining Effects on Education

Financial Disparities Among Districts in Different HOLC Areas

- The National Center for Education Statistics (NCES) provides the geometries and financial data of every school district in the United States.
  - The financial data is collected from the annual F-33 survey in which schools report the money they receive and spend.
- By spatially joining the data provided by the NCES and the HOLC maps, we can see which districts lie in HOLC- rated areas.
  - 52 districts in HOLC A Zones
  - 255 districts in HOLC B Zones
  - 713 districts in HOLC C Zones
  - 594 districts in HOLC D Zones



Comparing School-Level Finance Data

- Districts in HOLC A areas had the highest average expenditures, revenues, and local revenues amongst districts in HOLC B, C, and D areas.
- Districts in HOLC D had the lowest averages in all categories.

```
Average Expenditures for HOLC A: 65217288.461538464
Average Expenditures for HOLC B: 59000666.55686274
Average Expenditures for HOLC C: 55647182.22720898
Average Expenditures for HOLC D: 35817259.15993266
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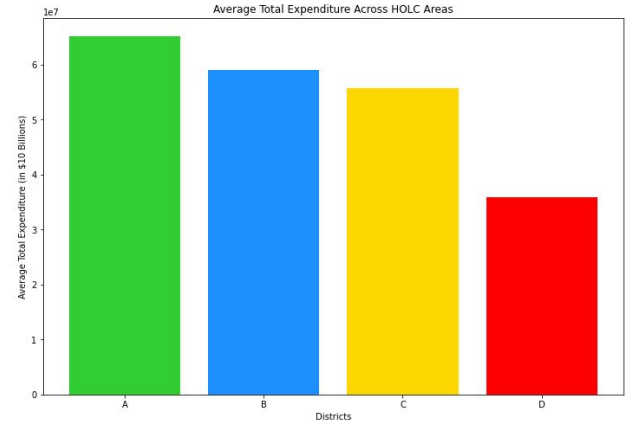


```
Average Revenues for HOLC A: 64737826.92307692
Average Revenues for HOLC B: 58292176.360784315
Average Revenues for HOLC C: 58071098.07573633
Average Revenues for HOLC D: 33350203.604377106
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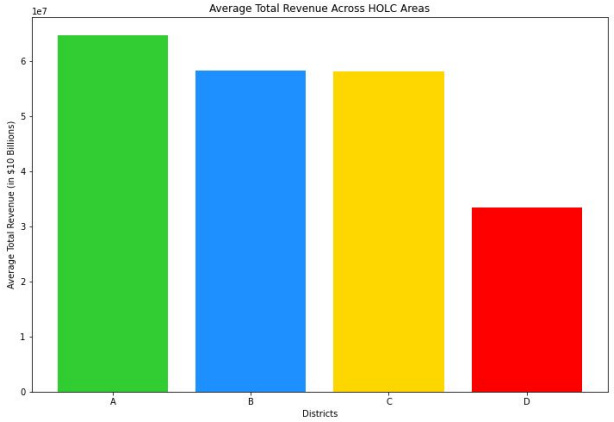


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Average Local Revenue for HOLC A: 33779596.15384615
Average Local Revenue for HOLC B: 28078019.498039216
Average Local Revenue for HOLC C: 23146291.62412342
Average Local Revenue for HOLC D: 13203388.789562289
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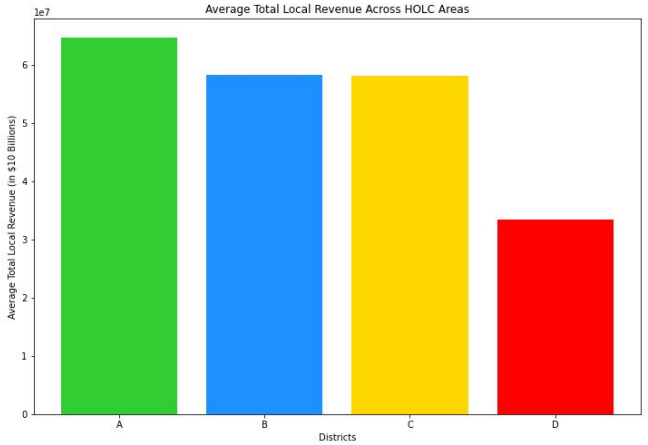
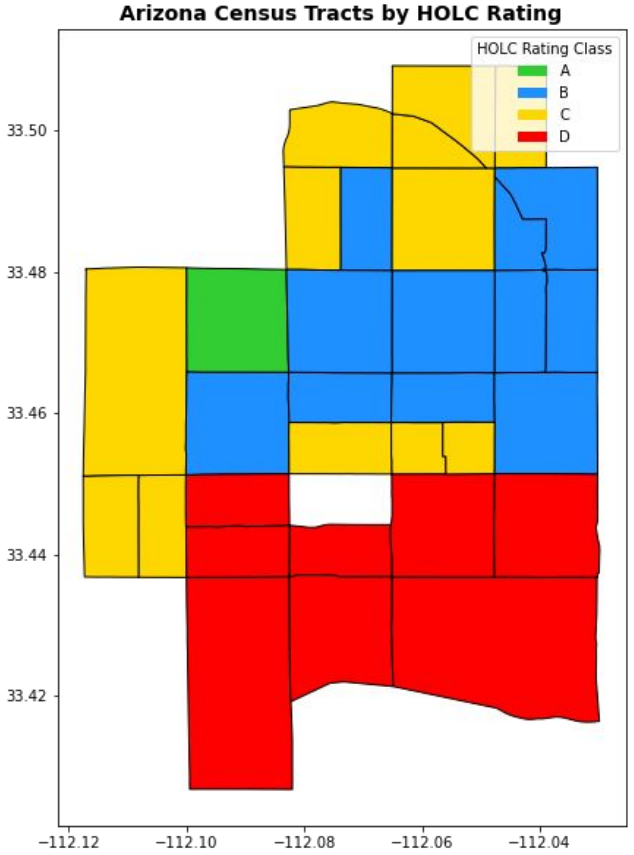


HOLC Districts and Health Relating to the Environment

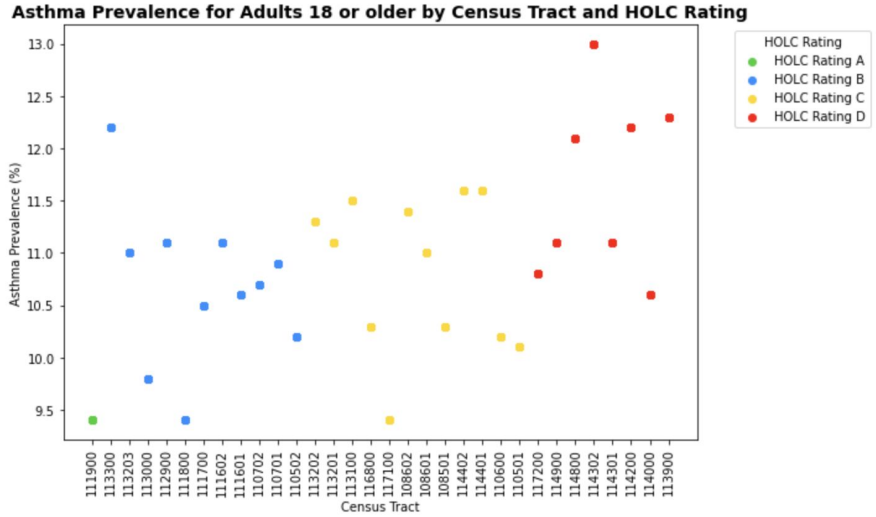
Visualizing HOLC neighborhoods and census tracts

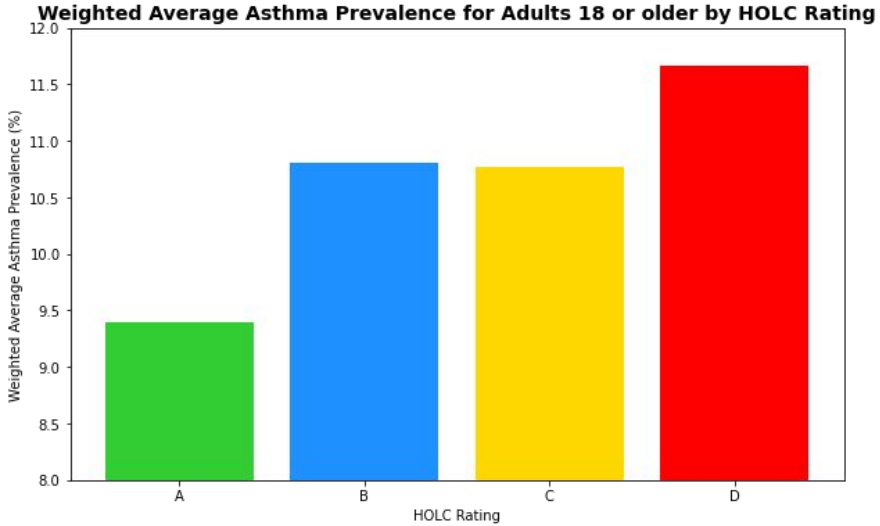
- Diversity Data Kids –organization that uses research and data to enhance racial and justice equity.
  - Dataset that maps neighborhood grades by THe HOLC mapped to the 2010 US Census Tracts
  - Indicates the HOLC grade that covers the largest portion of of the census tract area.
- Merged with a shapefile from the US Census Bureau to show a visual representation of the census tract HOLC neighborhoods.



Asthma Prevalence

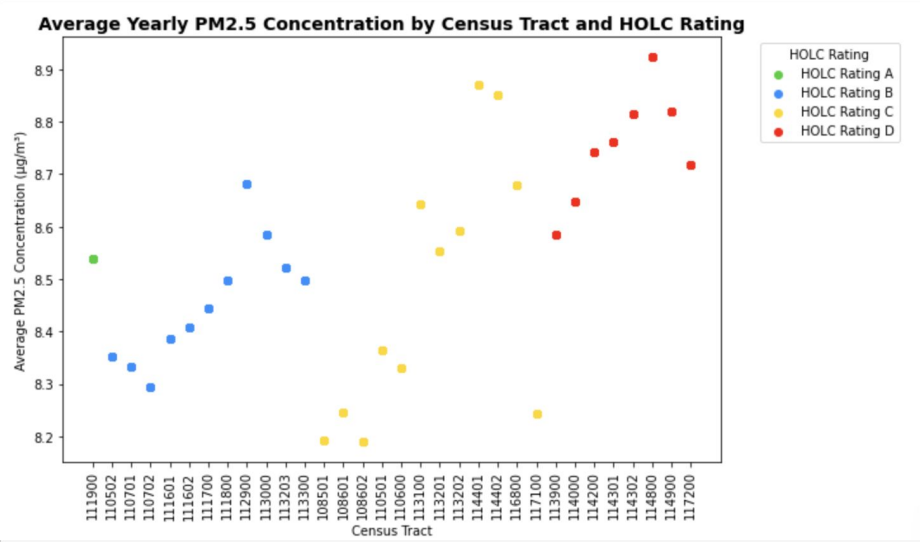
- Use census tract data from the centers for disease control (CDC) taken in 2017 (based on 2010 census tracts) to determine asthma prevalence by HOLC grade
- According to CDC, environmental triggers can cause or exacerbate asthma.
- Weighted average shows higher rates of asthma on D rated neighborhoods and lower rates of asthma in A neighborhoods.

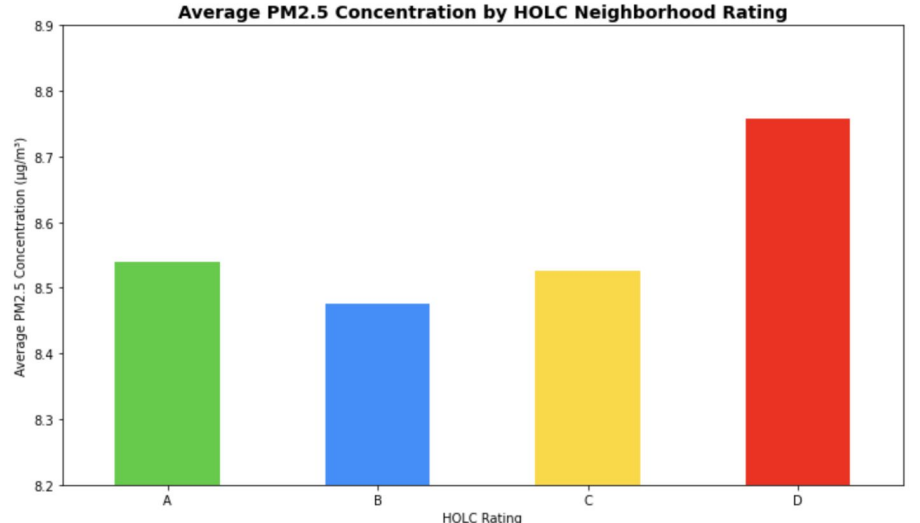




Air Quality - PM2.5 concentrat

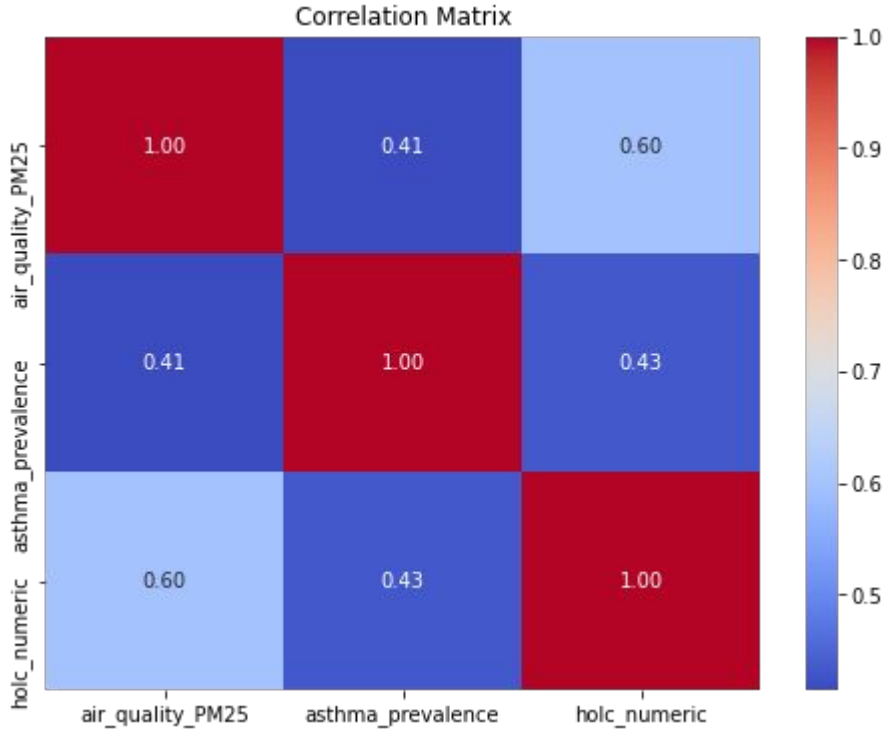
- According to the California Air Resources Board, PM2.5 is particulate matter that derives from combustion of gasoline, oil, diesel fuel or wood produce. PM2.5 is associated with the greatest proportion of adverse health effects related to air pollution.
- Using cdc dataset, contains modeled predictions of PM2.5 levels from the EPA's Downscaler mode in 2017
- D neighbhorhoods have the highest PM2.5 concentration, B neighborhoods have the least.





Discussion: Environmental Health & Correlations with HOLC Grades

- Air Quality and Asthma Prevalence:
  - 0.41
  - moderate positive correlation.
  - As air quality worsens (higher PM2.5 levels), the prevalence of asthma also increases.
- Air Quality and HOLC Rating:
  - 0.60,
  - relatively strong positive correlation.
  - Areas with worse HOLC ratings (higher numeric values, meaning lower desirability) have poorer air quality.
- Asthma Prevalence and HOLC Rating:
  - 0.43
  - moderate positive correlation
  - Areas with worse HOLC ratings might see a higher prevalence of asthma.
- lower-graded HOLC areas have a higher association with poor air quality and higher asthma prevalence.

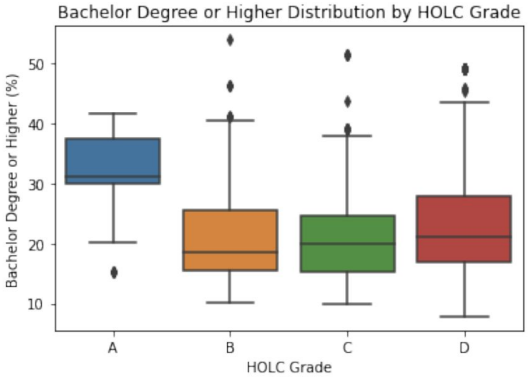


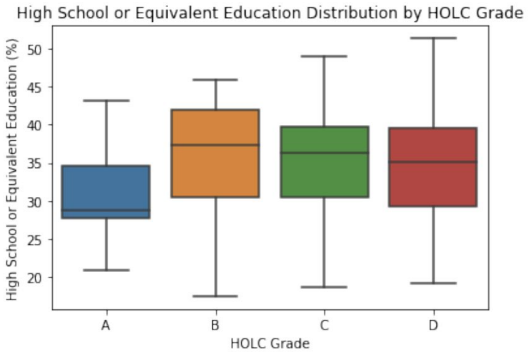
Redlining on Socioeconomic Outcomes

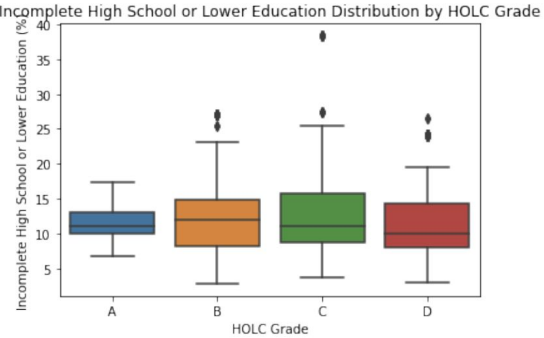
Education attained

Analysis of educational attainment within HOLC-graded areas.

Based on HOLC grade, group individuals based on education completed



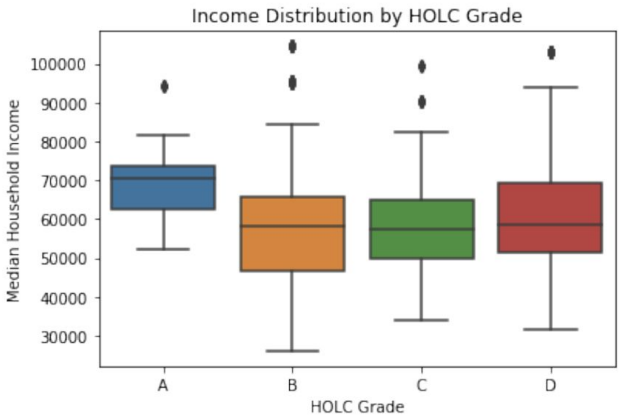


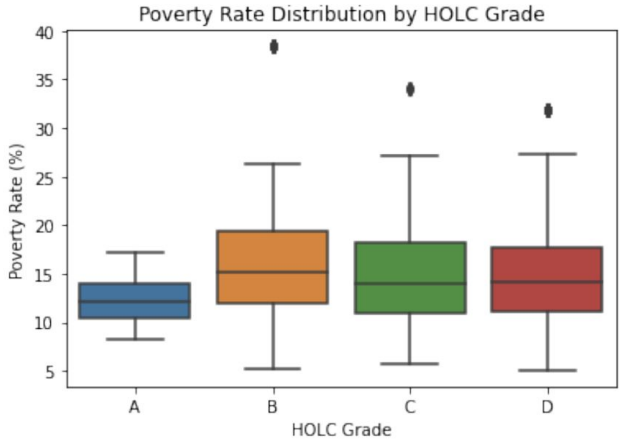


Income and Poverty Distribution

Median household incomes across different HOLC-graded districts

Poverty rates within the HOLC grading framework.How poverty rates vary across areas with different designations





Regression Analysis

- Regression analysis to predict poverty rates
- Model included predictors such as median income, employment variables, education levels, and HOLC grades. Indicating high accuracy
- Performance declined when excluding income

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Regression RMSE: 1.0034829436393615
Regression R^2: 0.9698588710239728
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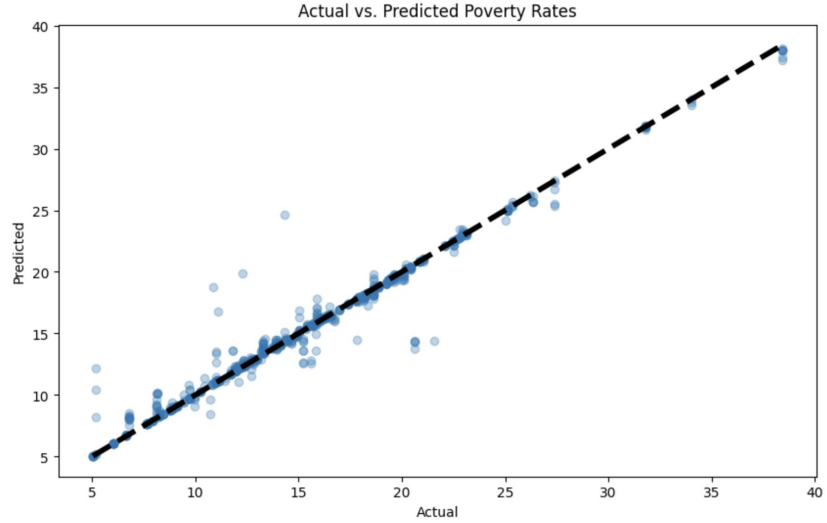


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Regression RMSE: 5.993615211915679
Regression R^2: -0.07526928657724619
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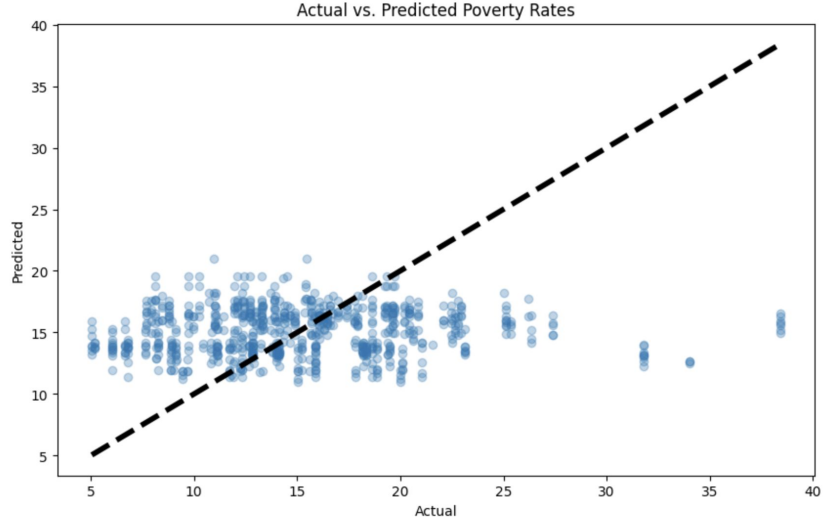


Analysis of variance and Comparative Analysis

- Results reveal statistically significant differences across HOLC grades in median income, poverty rates, educational attainment, and income inequality
- Differences between the Gini Index of HOLC grades indicating more substantial income inequality in lower-rated areas.
- Differences between the income of grade A and all other grades, with grade A having higher income levels.

Variable	F-value	p-value
Median Income	14.773	1.557×10^{-9}
Poverty Rate	7.071	9.908×10^{-5}
Bachelor or Higher Education	32.126	2.285×10^{-20}
Gini Index	6.721	1.63×10^{-4}

Multiple Comparison of Means - Tukey HSD for Gini Index

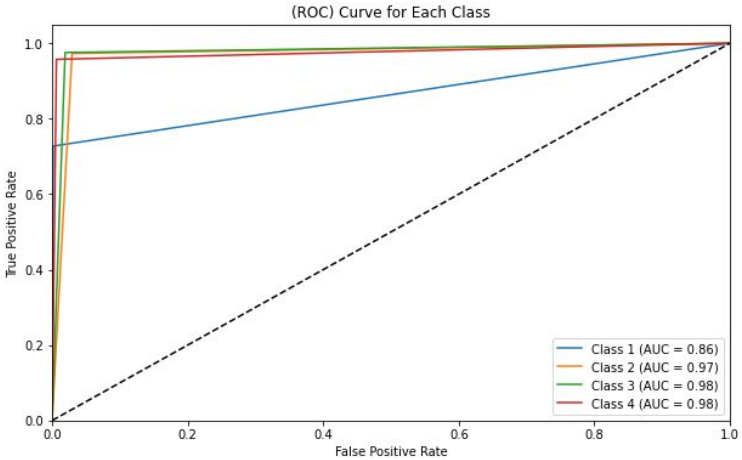
Group1	Group2	Mean Diff	p-adj	Lower	Upper	Reject
A	B	0.0086	0.0029	0.0022	0.015	True
A	C	0.0088	0.0025	0.0024	0.0153	True
A	D	0.0067	0.0353	0.0003	0.013	True
B	C	0.0002	0.9909	-0.0019	0.0024	False
B	D	-0.0019	0.0374	-0.0037	-0.0001	True
C	D	-0.0022	0.0485	-0.0043	0.0000	True

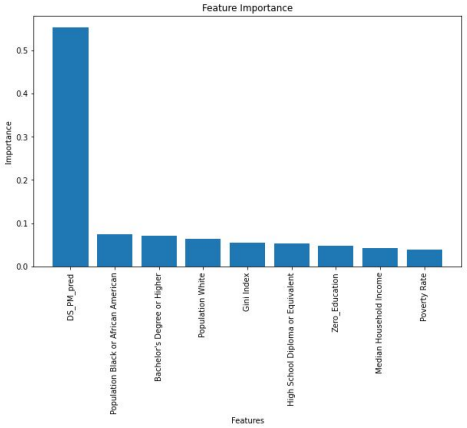
Multiple Comparison of Means - Tukey HSD for Median Income

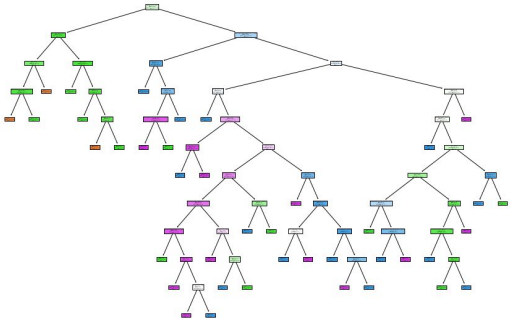
Group1	Group2	Mean Diff	p-adj	Lower	Upper	Reject
A	B	-11090.6022	0.0	-16842.2286	-5338.9758	True
A	C	-12760.1516	0.0	-18599.9138	-6920.3894	True
A	D	-9402.1915	0.0002	-15159.3799	-3645.0032	True
B	C	-1669.5494	0.1159	-3595.7059	256.607	False
B	D	1688.4107	0.0443	29.3526	3347.4688	True
C	D	3357.9601	0.0001	1415.2585	5300.6617	True

Predicting an Area's HOLC Grade Based on Population, PM2.5 Levels, College Attainment, and Income Levels

- A random forest model was trained to forecast HOLC grades of an area based on factors such as population, air quality, college attainment, and income levels.
- The model had an accuracy of 0.9657027572293208.







Accuracy: 0.9657027572293208

	precision	recall	f1-score	support
1	0.92	0.73	0.81	33
2	0.97	0.97	0.97	774
3	0.96	0.98	0.97	446
4	0.97	0.96	0.96	234
accuracy			0.97	1487
macro avg	0.95	0.91	0.93	1487
weighted avg	0.97	0.97	0.97	1487

Challenges

- Since the creation of the HOLC Residential Security Maps, the graded areas have grown significantly, allowing us to only examine a small portion of the United States.
- We had to omit district finance data and asthma prevalence data from our random forest since there was no effective way of merging that data with the rest of data, which possibly affected the utility of our model.
- It is dangerous to make generalizations based on our findings since they just suggest that redlining has amplified existing segregation patterns.

Conclusion

- Given the disparities revealed through our analysis and the utility of our machine learning models, we hope that we are able to provide insights into the lasting impact of redlining in the United States.
- These findings can help areas that have been subject to disinvestment and help inform strategies for equitable urban development.