Association of Covid-19 Rates and Mortality with Social Determinants of Health in Ontario

Paul James Geyer

June 18, 2021

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Introduction and Objectives

Background

Across the world, in Canada and in Ontario, people have been living with and dying from Covid-19. Data has been collected regarding a variety of metrics related to the pandemic, and a great deal of this data is publicly accessible and updated daily.

Objectives

The primary objectives of this study were to test the hypotheses social determinants associated with marginalized groups and/or poor socioeconomic status will be correlated with:

- Covid-19 case incidence per capita, and
- Covid-19 mortality per case.

Specifically, the null hypothesis is that social determinants of health are uncorrelated with rates of infection and rates of death given infection.

Additionally, in October 2020, Statistics Canada published a study showing that mortality per capita was higher in populations with a greater proportion of visible minorities (Subedi, Greenberg, & Turcotte, 2020), I also aim to evaluate whether this is due to those populations having a higher death rate per case, or rather a higher incidence of Covid in general.

Data Sources and Linkage

Using Public Health Unit level Covid-19 data collected over the past year, in conjunction with population descriptors I aim to define relationships between Covid-19 rates and outcomes and the social determinants of health.

1. **Confirmed Covid-19 case data** by Reporting Public Health Unit, patient age group and sex was obtained from the Ontario Data Catalogue. Key variables used from this dataset include case reported date, outcome, reporting PHU, gender, and age group: https://data.ontario.ca/dataset/confirmed-positive-cases-of-covid-19-in-ontario/

2. **Social Determinants of Health** by Public Health Unit were acquired from Public Health Ontario's estimates derived from Canada's 2016 census. https://www.publichealthontario.ca/en/data-and-analysis/health-equity/sdoh.

3. **Ontario Public Health Unit population estimates** by age, sex, and calendar year were obtained from the Ontario Ministry of Health IntelliHealth system.

Methodologies

Classifying Social Determinants of Interest

For this study, the social determinants I deemed indicative of marginalization or poor socioeconomic status are:

- % No High School Education
- % Low Income Households
- % Recent Immigrant Population
- % Visible Minority

Identification of first year of pandemic for Ontario and for PHUs

COVID-19 rates on the provincial and PHU level were calculated as cases per capita per year. To account for the difference in the date that each individual PHU had their first case of COVID-19, rates were calculated for each PHU using only cases that occurred within one year of that PHU's first reported case. The same logic was used for Ontario.

Populations for PHUs were interpolated using population estimates for 2020 and 2021, weighted by the proportion of the PHUs first year that was in each year.

Exploration of Age and Sex Association with Covid Rates and Mortality

It has been well documented that for many diseases, morbidity and outcomes are correlated to age and sex. For this reason, I deemed it appropriate to investigate the impact of age and sex in Covid.

Covid rates vary measurably among different age groups, as shown in figure 1. The medians and quartiles of Covid rates for males and females are similar, however, the medians and quartiles for different age groups have material variation. By contrast, mortality in Covid cases is dependant on both age and sex, as shown in figure 2.

As such, the analysis in this study standardizes PHU specific data as follows:

- PHU Covid confirmed cases per 1000 population are standardized to the age profile of Ontario population in 2021, and
- PHU Covid mortality per 100 confirmed covid cases is standardized to age and sex profile of the cohort of confirmed Covid cases.

Figure 1: Distribution of Covid Rates Per Capita In Ontario PHUs by Age and Sex

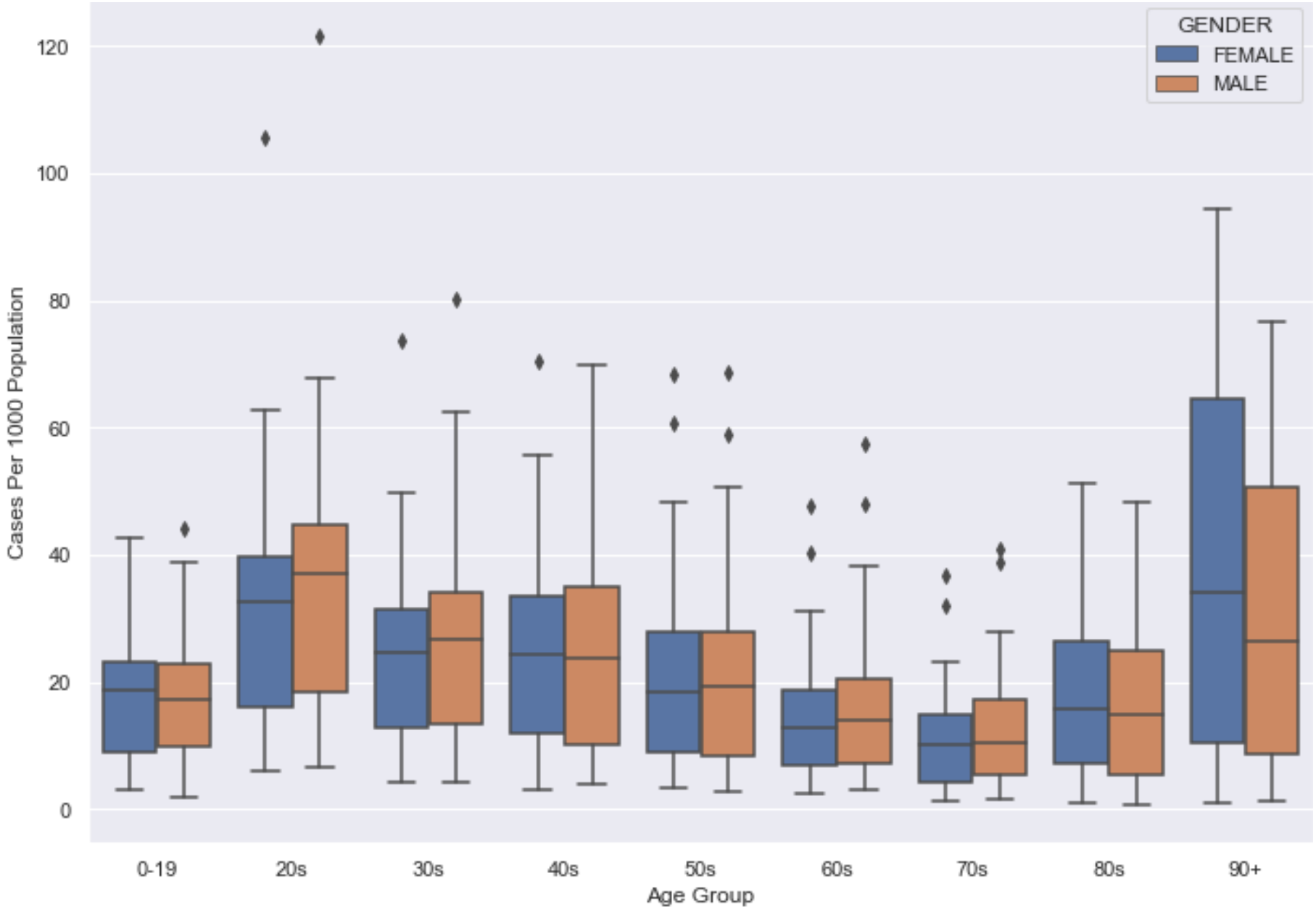
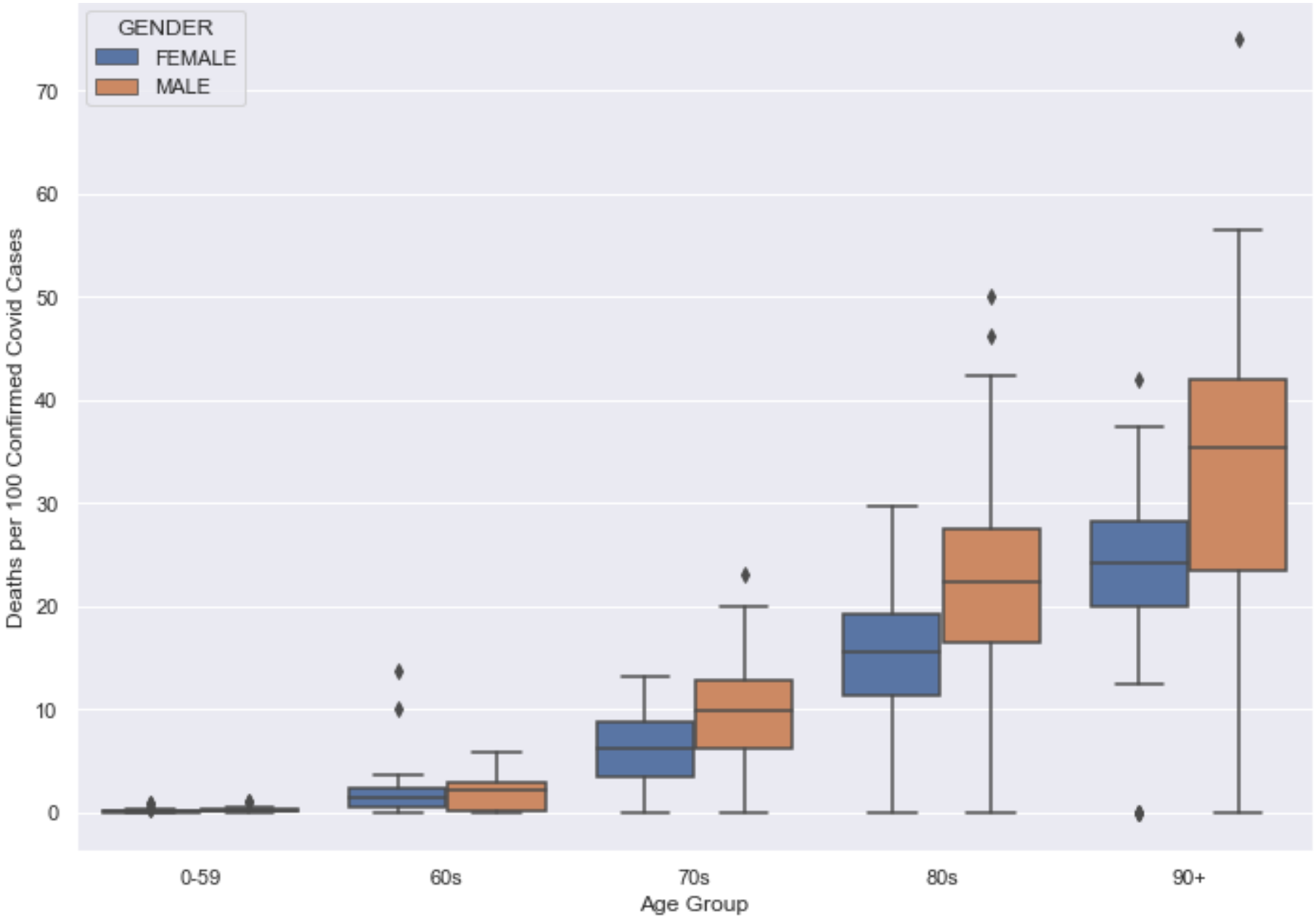


Figure 2: Distribution of Covid Mortality Rates In Ontario PHUs by Age and Sex



The standardized rates are computed as follows:

$$\left(\begin{array}{c} Standardized \\ Case\ Rate\ Per\ 1000 \\ Population \end{array}\right)_{PHU} = \sum_{Age} 1000 \times \frac{Ontario\ Population_{Age}}{Ontario\ Population} \times \frac{PHU\ Cases_{Age}}{PHU\ Population_{Age}}$$

$$\left(\begin{array}{c} Standardized \\ Mortality\ Rate\ Per\ 100 \\ Cases \end{array}\right)_{PHU} = \sum_{Age\ \&\ Sex} 1000 \times \frac{Ontario\ Covid\ Cases_{\ Age\ \&\ Sex}}{Ontario\ Covid\ Cases} \times \frac{PHU\ Deaths_{Age\ \&\ Sex}}{PHU\ Cases_{\ Age\ \&\ Sex}}$$

For standardized rates, 10 year age groups are used with the exception of 0-19, and 90+, otherwise, 10 year age groups are used.

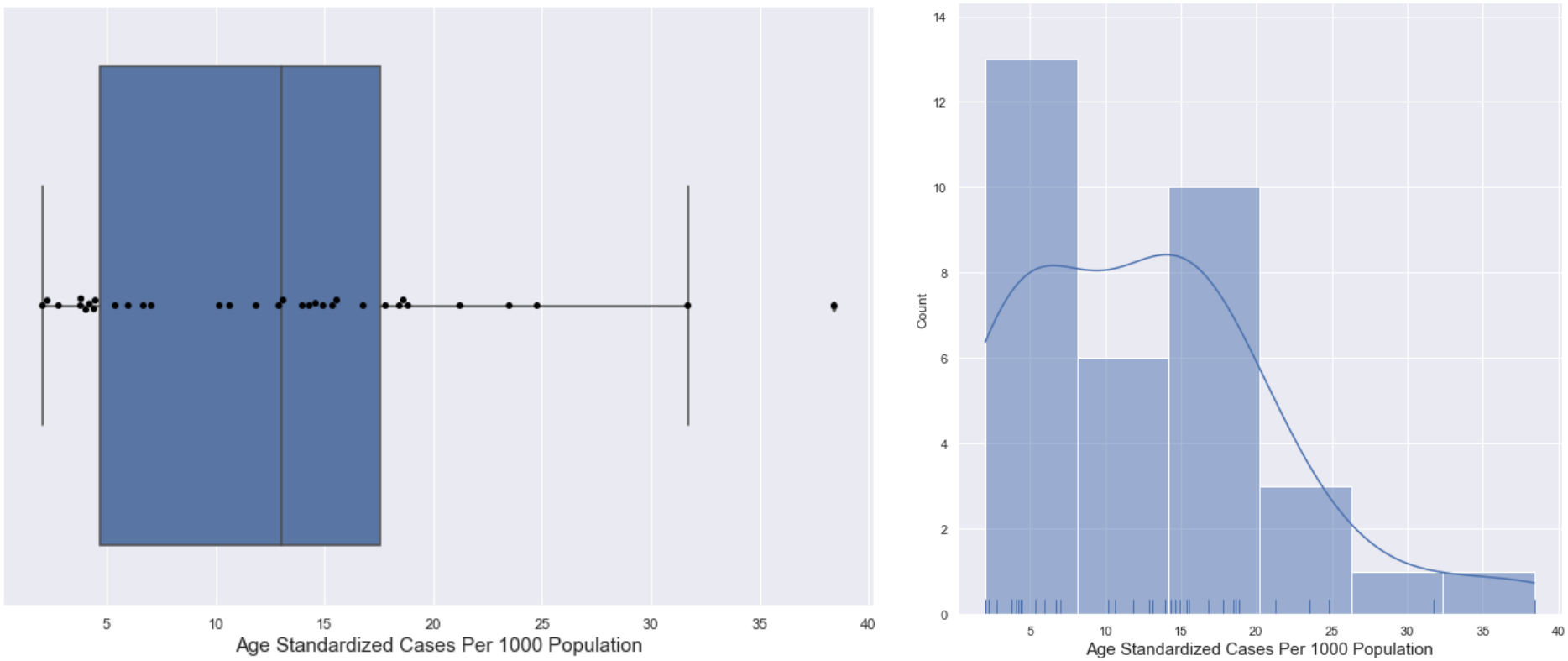
The rate of mortality in age groups less than 60 is nearly zero, so they are combined, otherwise, the same age groups are used.

PHU Covid-19 Standardized Rates per 1000 Population

In my analysis, it was found the distribution of standardized rates is skewed, as shown in figure 3. The mean value for the standardized rate was 12.783 cases per 1000 population, which falls bellow the threshold for the 50th percentile, 13.006.

The 4th quartile composed predominantly of PHUs with extremely high COVID incidence, such as Windsor-Essex, Toronto, York Region, and Lambton Public Health. Peel Region's cases per 1000 population is an outlier at ~38 cases per 1000 population.

Figure 3: The distribution of age standardized Covid rates in Ontario PHUs



Note: an outlier is defined here as any datapoint that falls beyond $Q3 + 1.5(Q3 - Q1)$.

Association of Covid-19 Standardized Rates with Social Determinants of Health

Analysis of the association between covid rates and social determinants of health includes:

- Correlation
- Linear regression and
- Visualization of the correlation and regression.

The correlation is based on Pearson's r, and the test of the hypothesis of no association is based on the t test from the regression for 32 degrees of freedom. The threshold for statistical significance is a P value of 0.05.

Points of Interest:

- Covid rate has a positive correlation with every selected indicator except education, which is negatively correlated with rate, as well as each other indicator, as shown in Figure 4.
- All four indicators tested have a statistically significant linear relationship with Covid rates, however:
- High school education explains a very minimal amount of variance in the dataset (Figure 7), it is also the only one that has a negative coefficient.
- The same is true for low income households (Figure 8)

Figure 4: Correlation of Indicators with Standardized Rate of COVID

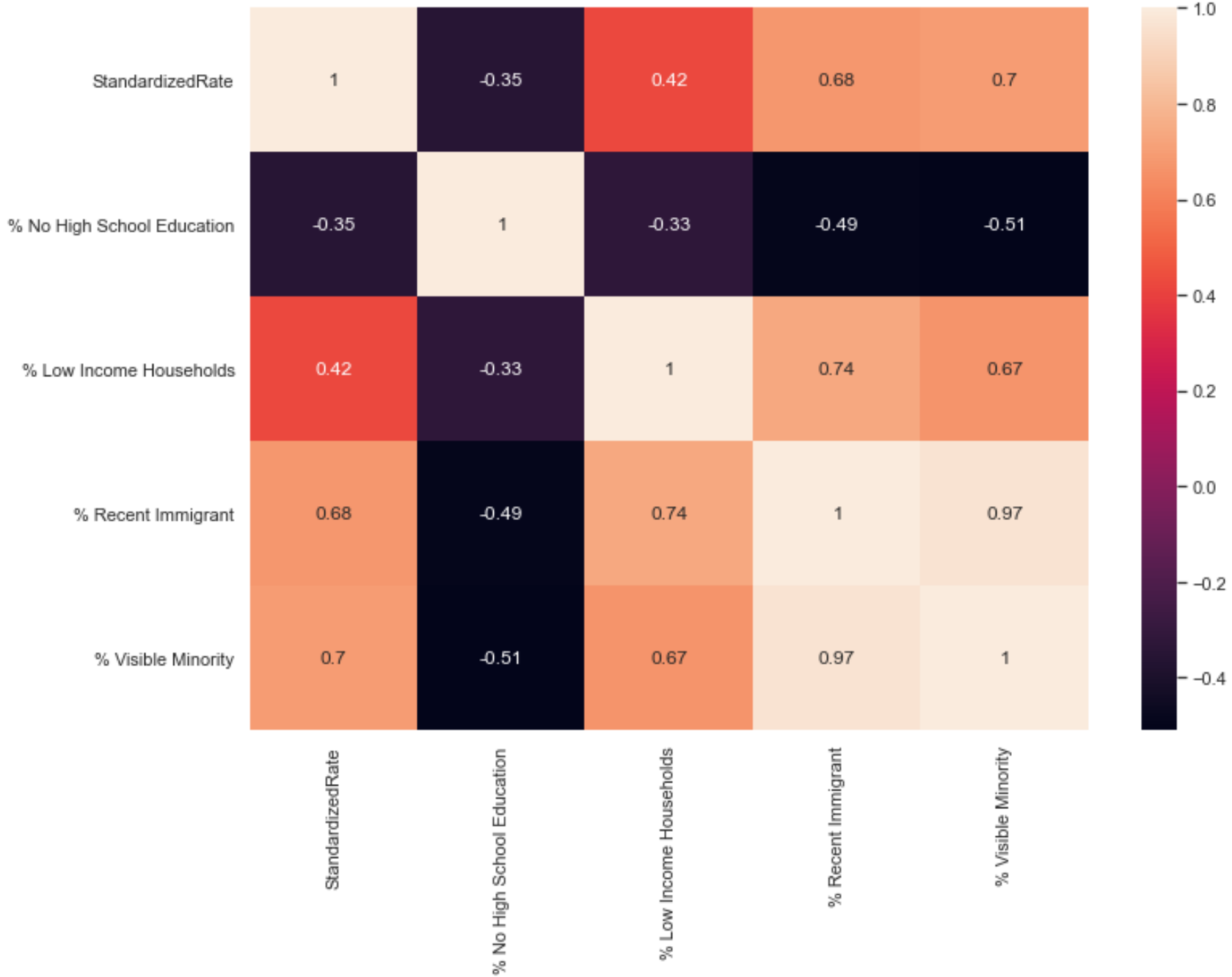
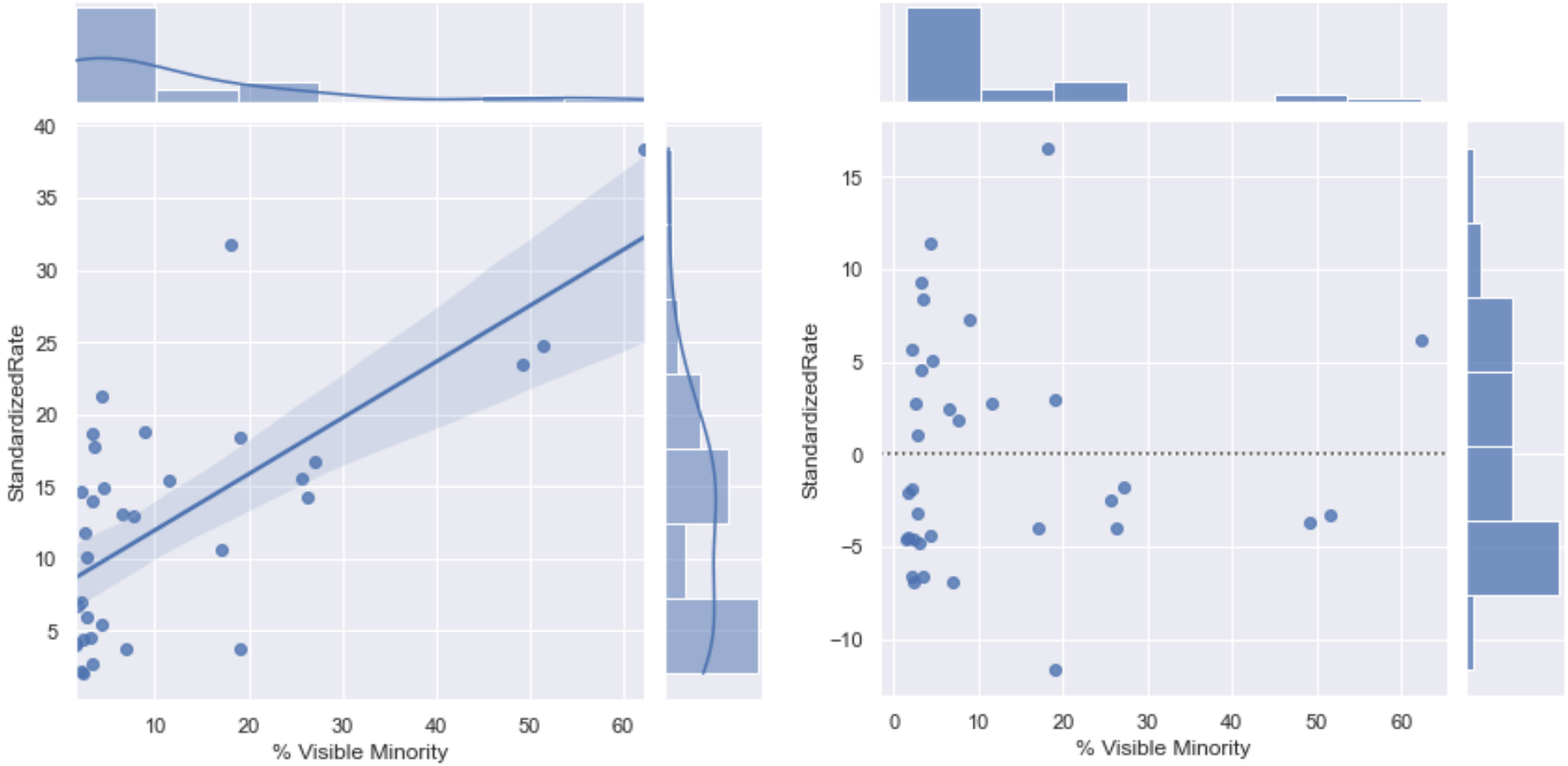
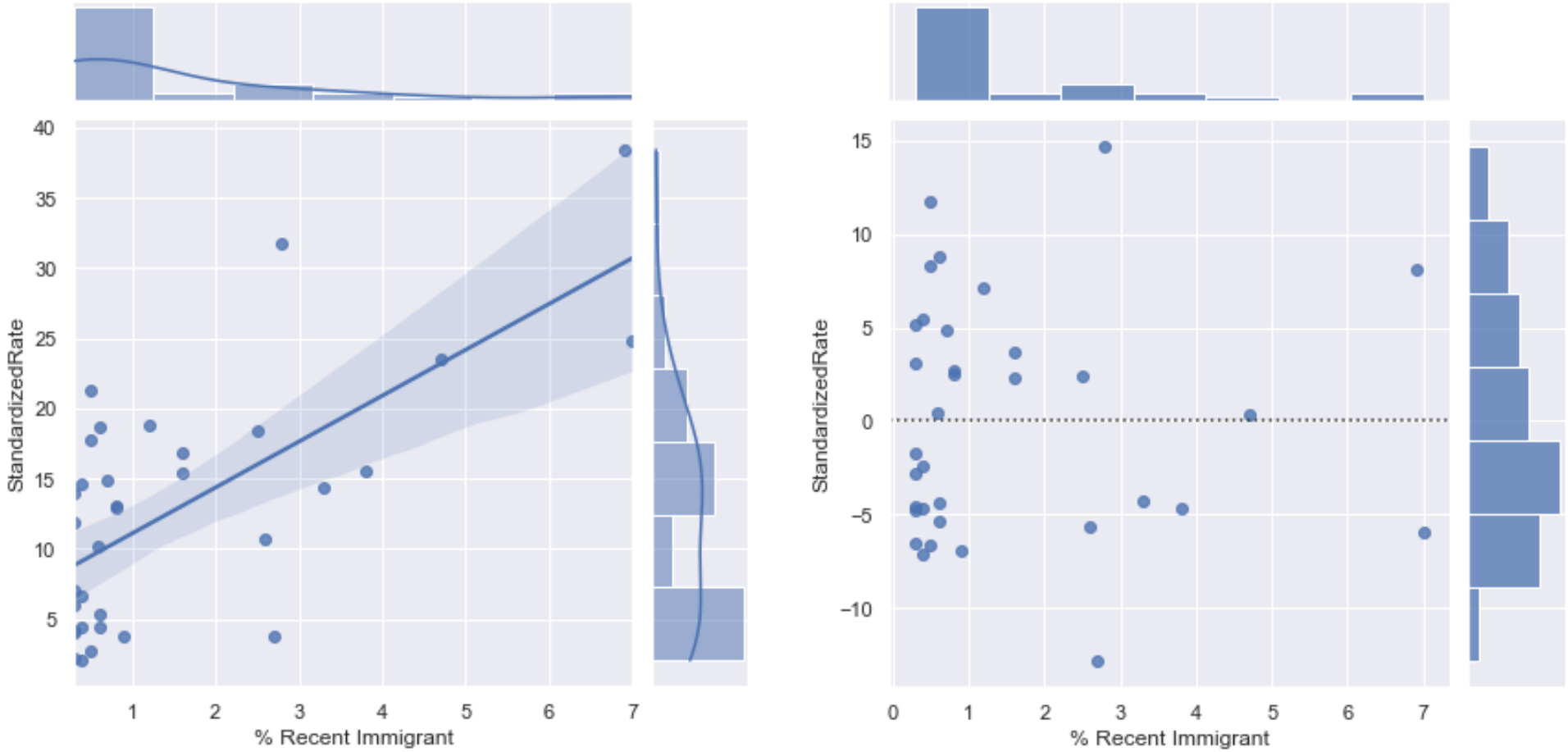


Figure 5: Regression of Standardized Rate and % Visible Minority



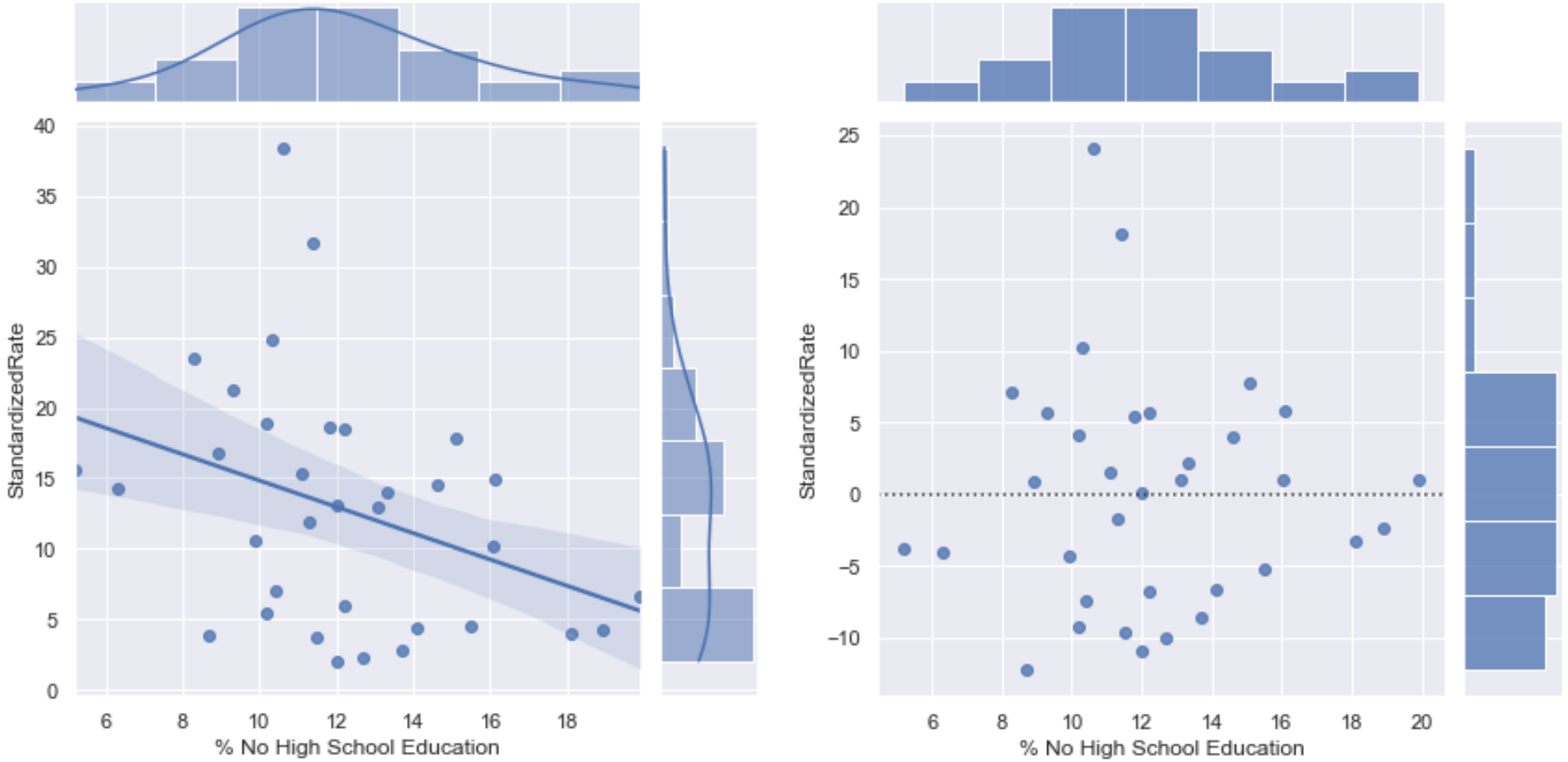
	Coefficient	Std Err	t	P>|t|	95% Confidence Interval	R^2 = 0.484
Intercept	8.0985	*1.380*	5.869	0.000	5.288 – 10.909	
Visible Minority	0.3880	*0.071*	5.480	0.000	0.244 – 0.532	

Figure 6: Regression of Standardized Rate and % Recent Immigrant



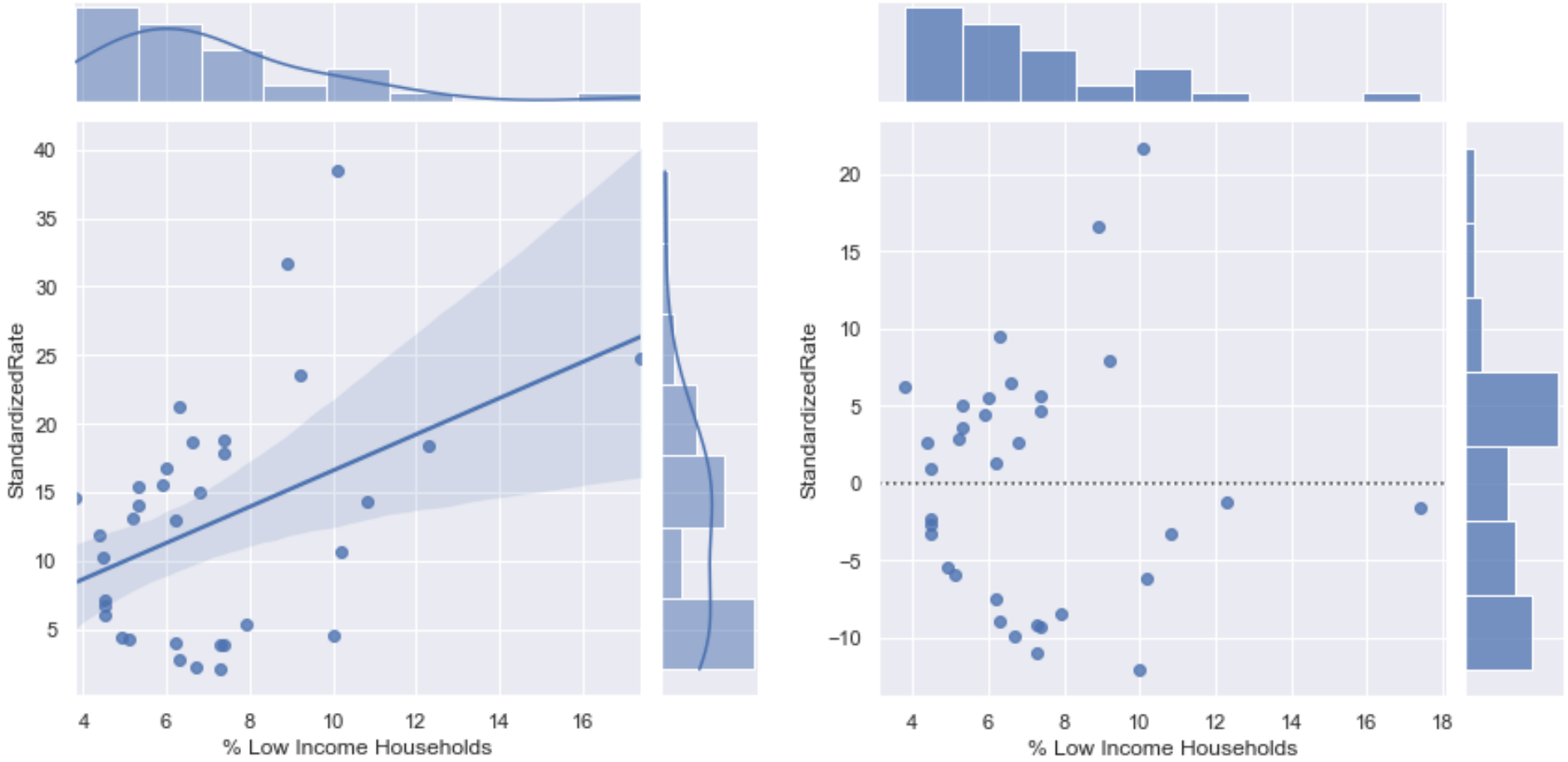
	Coefficient	Std Err	t	P>|t|	95% Confidence Interval	R^2 = 0.460
Intercept	7.8374	*1.457*	5.378	0.000	4.869 – 10.806	
Recent Immigrant	3.2655	*0.625*	5.223	0.000	1.992 – 4.539	

Figure 7: Regression of Standardized Rate and % No High School Education



	Coefficient	Std Err	t	P>|t|	95% Confidence Interval	$R^2 = 0.178$
Intercept	24.1535	*5.481*	4.407	0.000	12.990 – 35.317	
No High School Education	-0.9317	*0.434*	-2.147	0.039	-1.816 – -0.048	

Figure 8: Regression of Standardized Rate and % Low Income Households



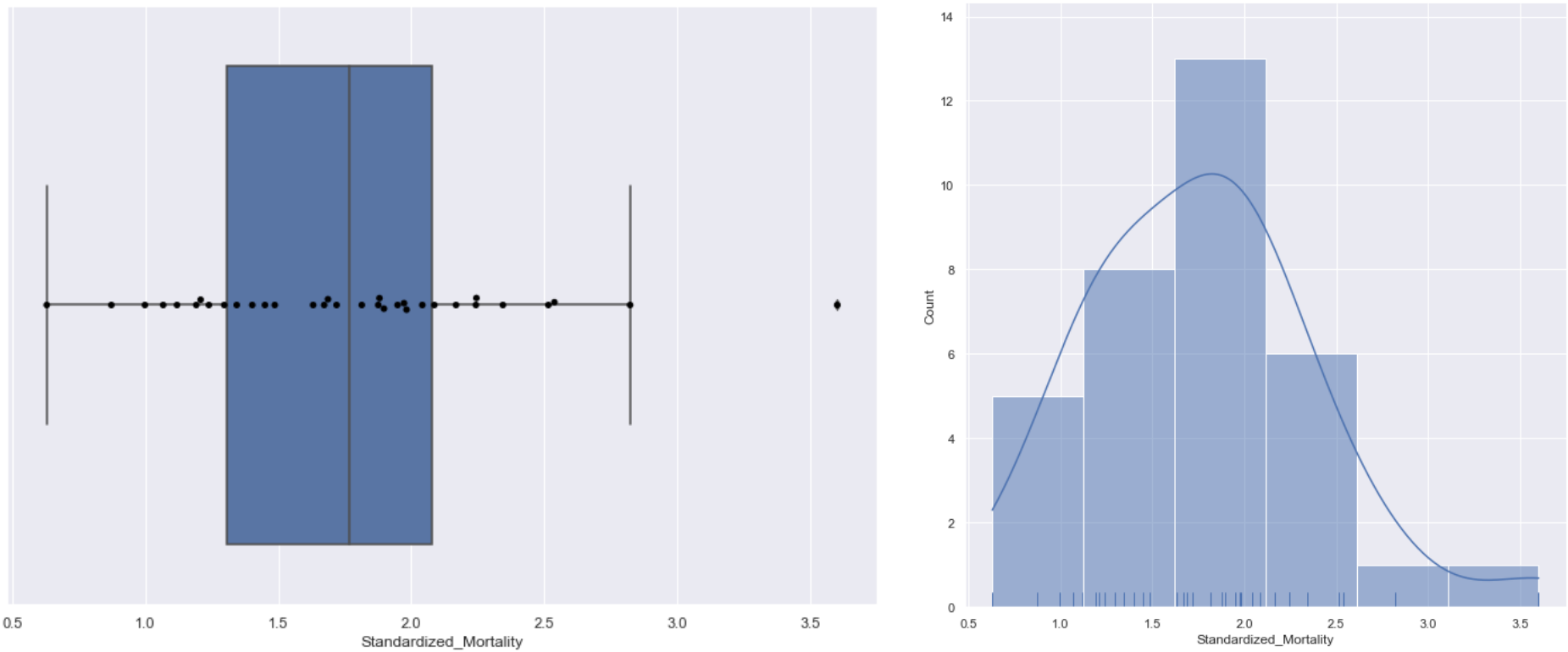
	Coefficient	Std Err	t	P>|t|	95% Confidence Interval	R^2 = 0.126
Intercept	3.3595	*3.829*	0.877	0.387	-4.440 – 11.159	
Low Income Households	1.3209	*0.501*	2.635	0.013	0.3 – 2.342	

PHU Standardized Mortality Rates per 100 Cases

In my analysis of mortality, after standardizing for age and sex the distribution was very tight. The mean and median mortality rate is approximately 1.767%. There is one outlier with a mortality rate of 4.851%, Porcupine Health Unit, a small PHU in Northeastern Ontario.

The 2nd to 3rd quartile comprises PHUs with a mortality between 1.309% and 2.076%, and the observations in the 1st and 4th quartile is approximately equal. Interestingly, this is below the crude global mortality rate, which is approximately 2.16%. (World Health Organization, 2021)

Figure 9: The distribution of age and sex standardized mortality rates in Ontario PHUs



Note: an outlier is defined here as any datapoint that falls beyond $Q3 + 1.5(Q3 - Q1)$.

Association of PHU Standardized Mortality Rates with Social Determinants of Health

Analysis of the association between covid mortality and social determinants of health includes:

- Correlation
- Linear regression and
- Visualization of the correlation and regression.

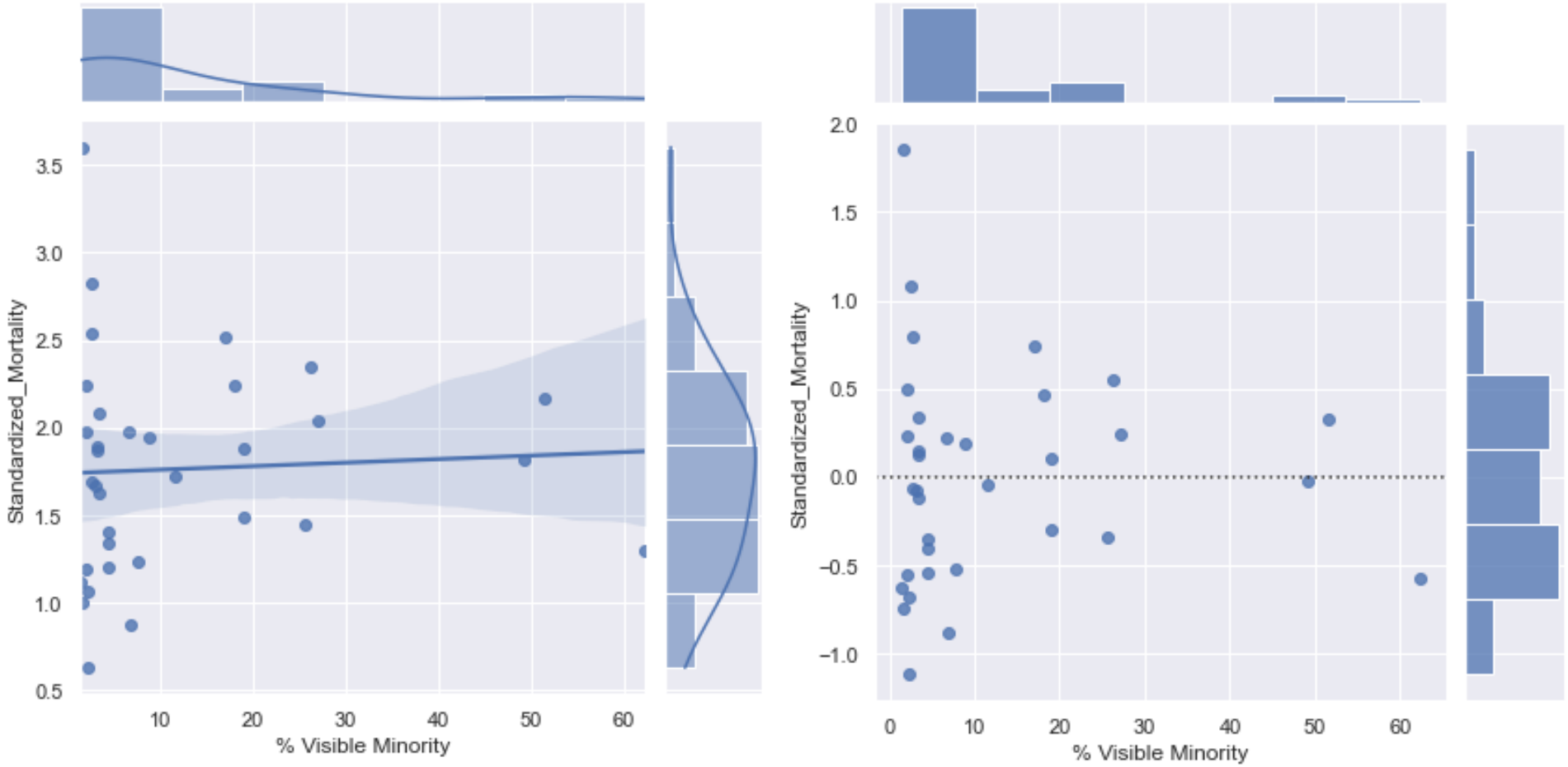
The correlation is based on Pearson's r, and the test of the hypothesis of no association is based on the t test from the regression for 32 degrees of freedom. The threshold for statistical significance is a P value of 0.05.

Points of Interest:

- Figure 10 shows that each indicator is very weakly correlated to mortality.
- None of the indicators explain more than 0.004% of the variance in mortality, based on the R^2 values
- There is no statistically significant relationship to mortality in any of the given indicators.

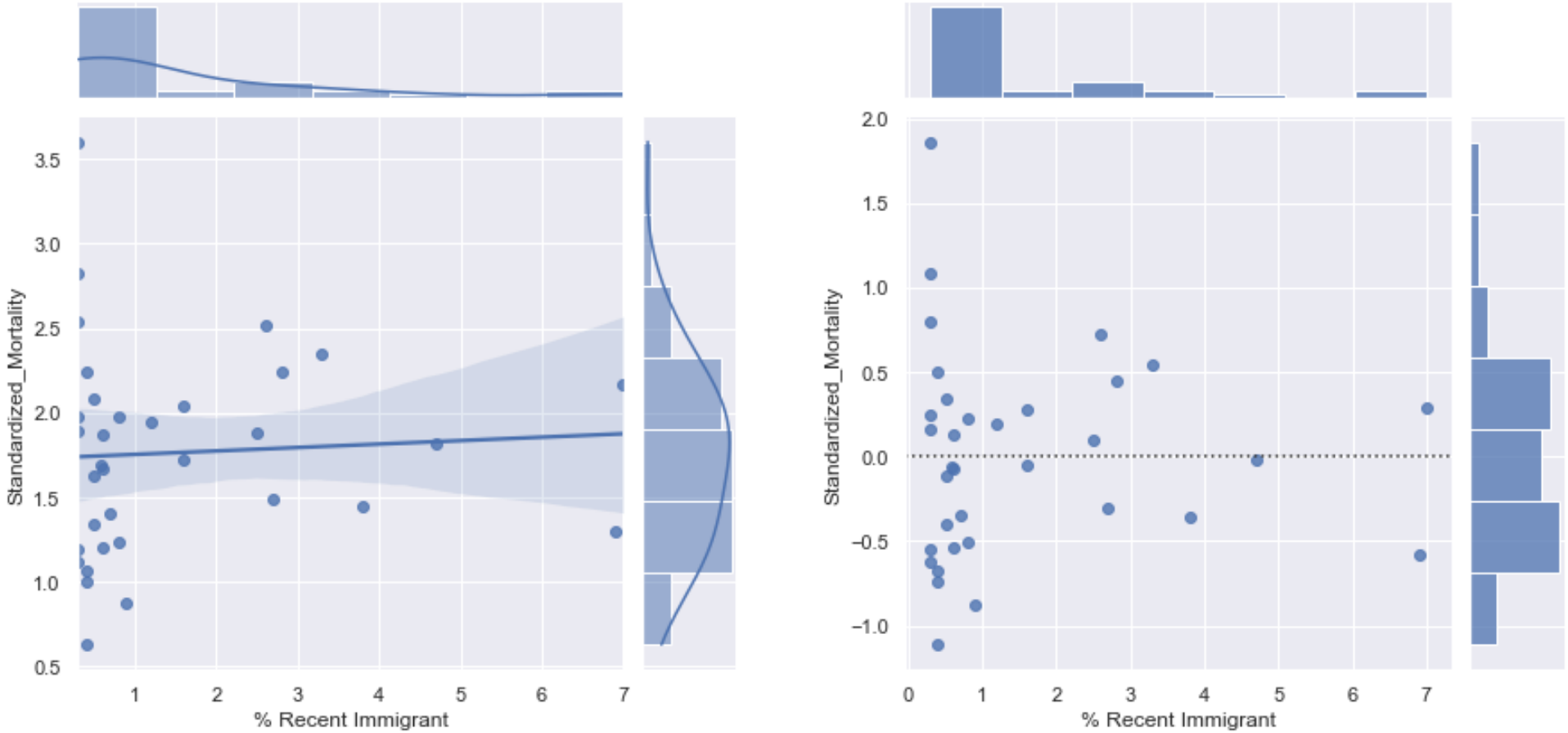
Figure 10: Correlation of Indicators with Standardized Mortality

Figure 11: Regression of Standardized Mortality and % Visible Minority



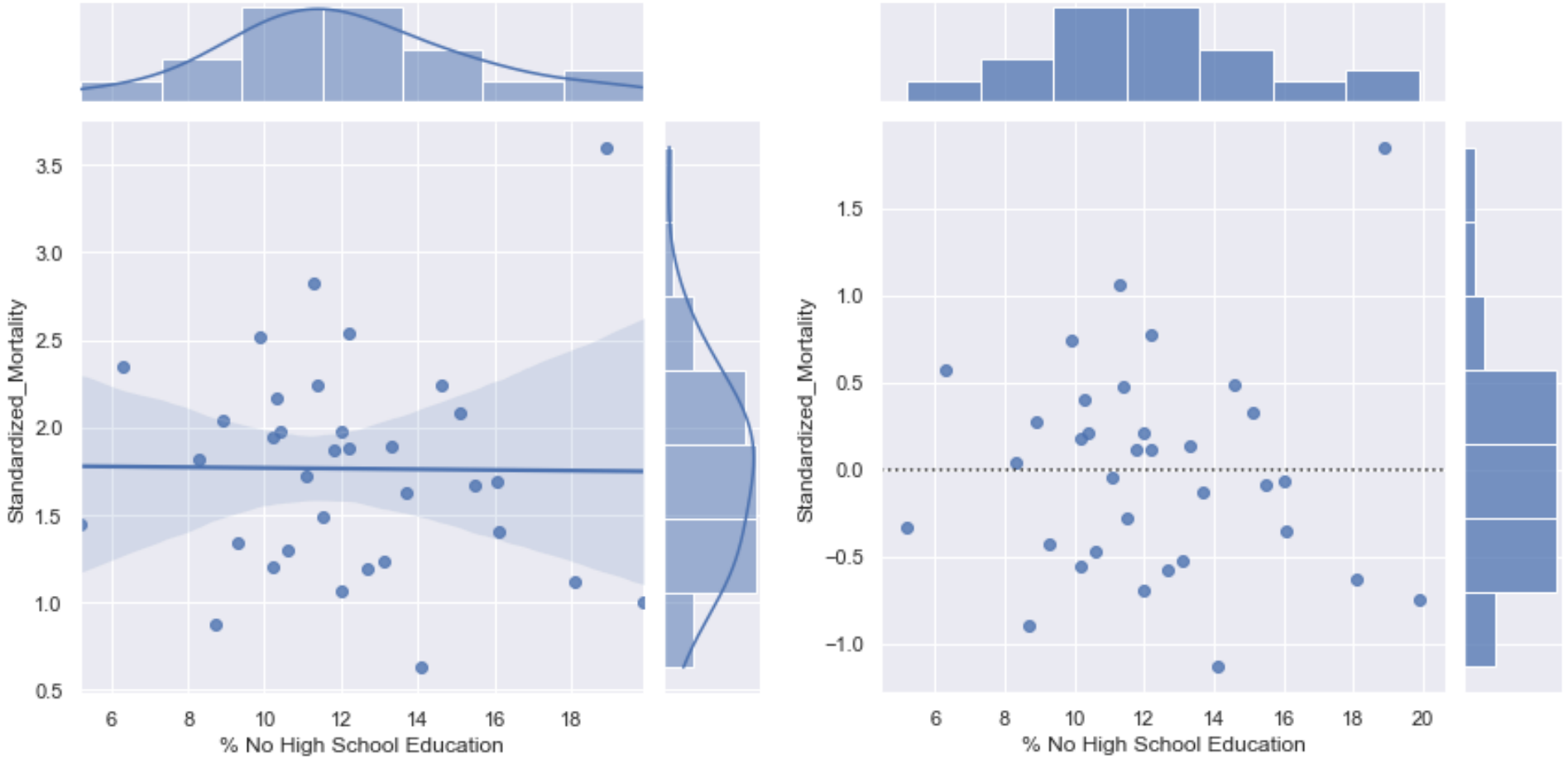
	Coefficient	Std Err	t	P>|t|	95% Confidence Interval	R^2 = 0.003
Intercept	1.7405	*0.135*	12.924	0.000	1.466 – 2.015	
Visible Minority	0.0020	*0.007*	0.291	0.773	-0.012 – 0.016	

Figure 12: Regression of Standardized Mortality and % Recent Immigrant



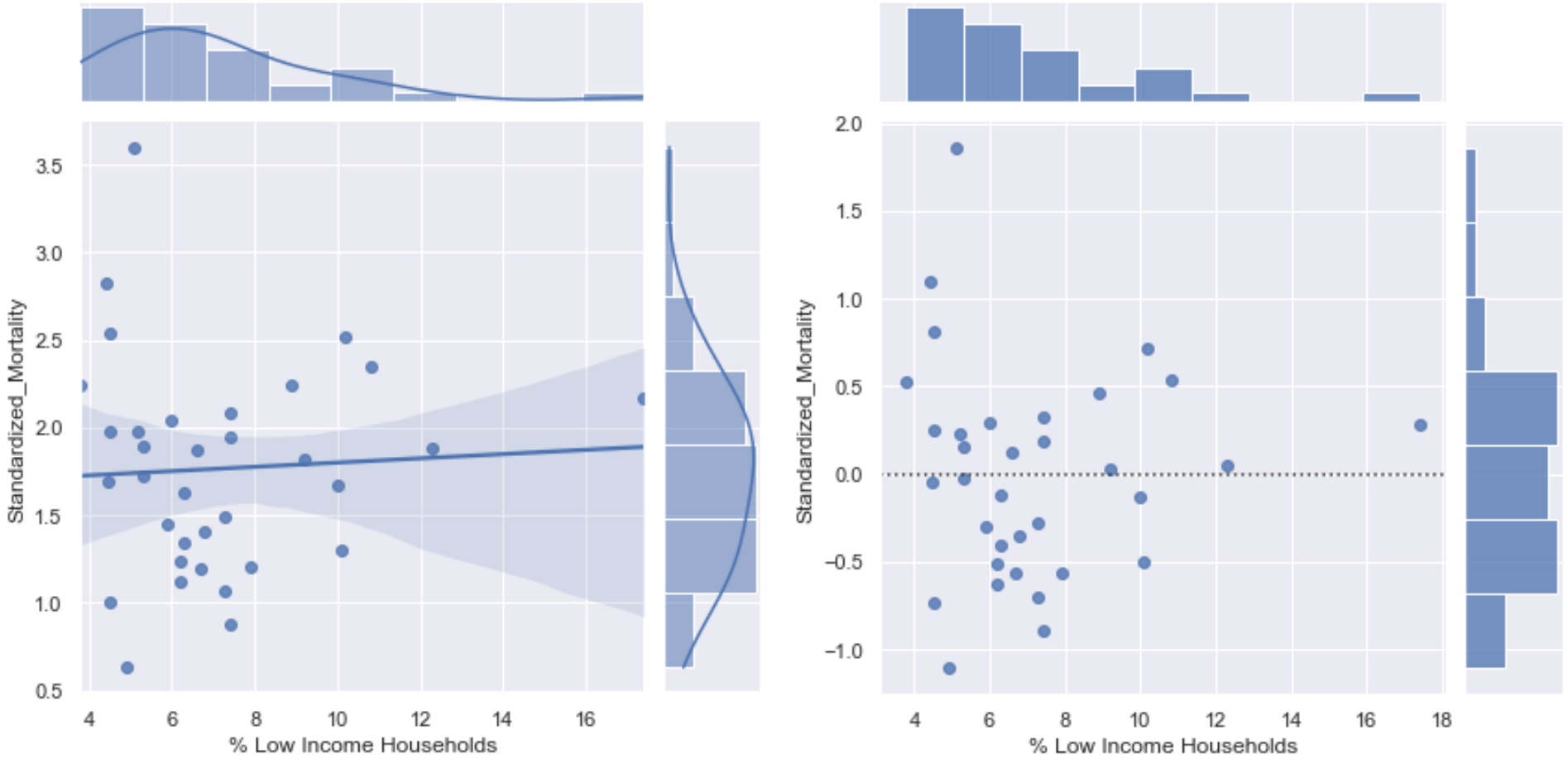
	Coefficient	Std Err	t	P>|t|	95% Confidence Interval	R^2 = 0.004
Intercept	1.7340	*0.139*	12.476	0.000	1.451 – 2.017	
Recent Immigrant	0.0203	*0.060*	0.341	0.735	-0.101– 0.142	

Figure 13: Regression of Standardized Mortality and % No High School Education



	Coefficient	Std Err	t	P>|t|	95% Confidence Interval	$R^2 = 0.000$
Intercept	1.7889	*0.411*	4.348	0.000	0.951 – 2.627	
No High School Education	-0.0020	*0.033*	-0.061	0.952	-0.068 – 0.064	

Figure 14: Regression of Standardized Mortality and Low Income Households



	Coefficient	Std Err	t	P>|t|	95% Confidence Interval	R^2 = 0.003
Intercept	1.6781	*0.296*	5.669	0.000	1.075 – 2.281	
Low Income Households	0.0122	*0.039*	0.313	0.756	-0.067 – 0.091	

Results and Key Findings

Association of Age Standardized Rates of Covid-19 and Social Determinants of Health

On the Ontario PHU level, visible minority population, recent immigrant population, population without high school education, and low income households have a statistically significant relationship with Covid rates.

- Visible minority and recent immigrant population both have material relationships to Covid rate, and a statistically significant relationship. They also explain a good amount of variance in Covid rates, having R^2 values of 0.484 and 0.460.
- Low income households and high school education have R^2 values of 0.126 and 0.178 respectively. That being the case, this linear model alone can not be used as a good predictor of Covid incidence, however, the relationships are still statistically significant enough to reject the null hypothesis.
- No high school education is the only one of the indicators that has a negative correlation to Covid rates.

On the basis of the strong relationship between both visible minority and immigrant population, and Covid rates, it is necessary to investigate the cause of this. It is quite interesting that decreased rate of high school education is negatively correlated with Covid rate, and this should also be further analyzed. Analysis of the data on a more disaggregated level and multiple regression may provide more insight into other hidden variables that influence the Covid rates.

Future modelling should consider more of the social determinants of health, as well as population density and type of employment. Furthermore, investigation on a more disaggregated level may provide more accurate and precise modelling.

Association of Age & Sex Standardized Mortality and Social Determinants of Health

On the Ontario PHU level, none of the selected indicators have any material or statistically significant relationship with Covid mortality. This is likely a result of Canada's socialized healthcare system, which allows people from all socioeconomic statuses access to the same level of care. This finding, alongside the fact that our mean mortality rate is less than the global average, reflects well on Ontario's healthcare system, representing an unbiased approach to patient treatment and a high quality of care across Ontario Public Health Regions.

At this level of aggregation, there is no indication that Covid death rate and minority population, or poor socioeconomic status in general, are linked. It remains true that minorities have a higher rate of death per capita due to Covid based purely on the increased incidence of the disease in their population, which is something that must be further investigated.

Bibliography

Subedi, R., Greenberg, L., & Turcotte, M. (2020, October 28). COVID-19 Mortality Rates in Canada's etho-cultural Neighbourhoods. Canada.

World Health Organization. (2021, June 18). *Coronavirus disease (COVID-19) pandemic*. Retrieved from World Health Organization: https://www.who.int/emergencies/diseases/novel-coronavirus-2019?adgroupsurvey={adgroupsurvey}&gclid=CjwKCAjwiLGGBhAqEiwAgq3q_tRjTsTRZGvf-Ff_biiLIQnYhxcwtx7bZbMjgYb44jmWFzzZz801aBoCR5IQAvD_BwE