Introduction

According to the Centers for Disease Control and Prevention (CDC), "there were 20,958 firearm homicides across the United States in 2021, the most recent year for which complete data is available" (Gramlich 2023). Furthermore, "from 2019 to 2020, the overall firearm homicide rate increased 34.6% from 4.6 to 6.1 per 100,000 persons" (Kegler, et al. 2022). Clearly, a public health issue exists in the United States as the firearm homicide rate in the country eclipses the top 28 high-income countries of the world by a factor of 24.9 as measured using 2015 data from the WHO (Grinshteyn and Hemenway 2019). The number of solutions appears abundant in analyzing prescriptions from US politicians, but talk has failed to turn into action at a federal level and firearm homicides continue. Much of the research around firearm homicides has centered around firearm control through legislation or addressing severe mental health issues. This research note will instead focus on the '*why*' component of firearm homicide. Namely, what are the primary social, health, and economic factors that drive the firearm homicide rate in the United States?

Literature Review

To this author's knowledge, the existing social science research behind the social, health, and economic determinants of firearm homicides is relatively scant. Given the academic research available, it appears that much of the discussion around firearm homicide instead focuses on policy prescriptions for curbing firearm violence; namely, through gun control legislation or additional resource allocations for the mental health system. That said, the few studies that do exit offer valuable insights into the expected drivers of firearm homicide.

In Daniel Kim's publication entitled: *Social determinants of health in relation to firearm-related homicides in the United States: A nationwide multilevel cross-section study*, multiple independent variables and social determinants of health such as: social mobility, social capital, income inequality, racial and economic segregation, and social spending are measured at the census tract level and compared against firearm homicides. Ultimately, Kim uncovered through regression modeling that 'the rich-poor gap, level of citizens' trust in institutions, economic opportunity, and public welfare and spending are all related to firearm homicide rates in the US' (Kim 2019).

Kim's findings around income inequality's influence on firearm homicide are supported in a journal article entitled: *Income inequality and firearm homicide in the US: a county-level cohort study*. In addition to supporting Kim's work in mapping the association between income inequality and firearm homicide, the journal study also adds demography to the association; namely, that communities in which African Americans are the predominant race and income inequality is highest elicit a greater magnitude of firearm homicides (Rowhani-Rahbar, et al. 2019). Like Kim, authors from this study utilized regression modeling to understand the extent to which income inequality influences firearm homicides in the United States.

The findings in the Rowhani-Rahbar study were validated by a team of researchers examining the social determinants of firearm homicides in the state of Wisconsin through a journal article entitled: *Your neighborhood matters: and ecological social determinant study of the relationship between racial segregation and the risk of firearm fatalities.* The researchers in the Wisconsin study used multiple linear regression to validate the understanding that racial segregation and economic inequality are social determinants of firearm homicide (Shour, et al. 2023). Researchers in the study also provided a novel

contribution to the existing body of research by indicating that community resilience risk as measured by "an income-to-poverty ratio, single or zero caregiver households, crowding, communication barriers households without full-time year – round employment, disability, no health insurance, age of 65 or older, no vehicle access, and no broadband internet access" has an effect on firearm homicides (Shour, et al. 2023). Overall, moderate risk communities (1-2 community resilience risk factors) and high-risk communities (3 or more community resilience risk factors) saw their firearm fatalities increase by factors of 0.6 and 0.5 respectively (Shour, et al. 2023).

Finally, the journal article *Social and Structural Determinants of Community Firearm Violence and Community Trauma,* provides further context to how racial segregation, economic inopportunity, income inequality, and other social factors that manifest as firearm homicide through the lens of the 'Social Determinants of Health and Health Inequity Framework' (SDOH), developed by the World Health Organization (WHO). The authors cite that the social determinants within the SDOH framework "operate through multiple intermediary processes like: the availability of adequate housing, opportunities for healthy child development, sustainable livelihoods, nutritious food at the neighborhood, family, and individual levels to produce an unjust and disproportionate burden of firearm related harm and community trauma" (Buggs, Kravitz-Wirtz and Lund 2023). They add that the US SDOH Framework is situated in a concept called "Racial Capitalism, which asserts that the accumulation of capital and racialized systems of exploitation and oppression are interdependent and mutually constitutive" (Buggs, Kravitz-Wirtz and Lund 2023). Furthermore, they argue that past policies like redlining have made firearm homicides particularly acute for African American communities as the redlined communities typically experience underinvestment in community institutions like schools and public safety and private institutions that offer income and products like nutritious food. As a result, they argue that impoverished communities like the redlined ones experience structural and social determinants that are associated with greater rates of firearm homicide relative to communities that are better-off (Buggs, Kravitz-Wirtz and Lund 2023).

In reading the literature around the social determinants of firearm homicide, it's clear that: the topic is under-researched, the literature that does exist has concluded that economic opportunity plays a key role in firearm homicide, and that segregated communities often have poorer outcomes associated with local structural and social determinants of health inequities as they relate to firearm homicide.

Overall, I support the conclusions outlined in the existing academic literature. The regression tests executed in the first three studies (Kim, Rowhani-Rahbarl, and Shour, et al.) were valid and informative. They clearly pointed to associations between firearm homicides, income inequality, and racial segregation. Finally, I feel that the Buggs and Lund study successfully presents a theoretical framework in which social determinants influence health outcomes in the context of racial segregation. Taken together, I feel that this body of literature encapsulates a great working knowledge of how social determinants factor into firearm homicides.

That said, I feel that the existing studies are overly focused on a few variables while excluding others. I'd like to add to the existing research literature on this topic by doing the following: confirming/denying the conclusions reached in the existing literature and incorporating additional health and social metrics as possible determinants of firearm homicide. Furthermore, there is much talk in the existing public discourse around public policy that mental illness and opioid addiction are key drivers of firearm homicide. I'd like to approve/disprove these hypotheses through statistical means as I feel it's important

to understand if these two commonly cited sources of firearm homicides are statistically valid influencers of firearm homicides. Furthermore, I feel it would be beneficial to understand the impacts of variables like mental health and opioid addiction on firearm homicides relative to other social determinants.

Hypothesis

Given the existing body of research and my own theoretical expectations around firearm homicide, I hypothesize that firearm homicide increases given increases in racial segregation and unemployment in communities across the United States. I'll note that while my hypothesis doesn't include metrics related specifically to health, I will include health metrics in my analysis. I expect that the health metrics in my analysis (like mental illnesses) won't have a statistically significant impact on firearm homicides.

While I understand that my analysis won't account for all the variability in firearm homicide due to the lack of inclusion of important variables like firearm legislation, I do feel that it will add meaningfully to the '*why'* behind firearm homicide and the *reasons* for this type of violence in general. Furthermore, I feel that the combination of health, economic, and social factors will lend itself well to understanding how various variables in these categories work in conjunction to drive the firearm homicide rate from a statistical perspective.

Methods

The data to test the hypothesis of this research note originates from the City Health Dashboard. Creation of the City Health Dashboard originated from the NYU Grossman School of Medicine's department of Population Health with support from the Robert Wood Johnson Foundation. The data "contain 40 measures of health and drivers of health for over 900 cities across the US" (City Health Dashboard 2023).

The City Health Dashboard used in this research note's analysis encompasses 176,113 records. Descriptions of each variable can be found in **Table A**. Additional information about the variables can be found in the City Dashboard's Codebook. Additional information about each of the health metrics is listed in **Table B.** More information on these variables can be found in the City Dashboard's Technical Document. Please note that both **Table A** and **Table B** originate directly from the City Health Dashboard's documentation (City Health Dashboard 2023).

Table A

Variable Name	Variable Definition	Variable Type
state_abbr	State abbreviation	*string*
state_fips	State FIPS code	*numeric*
geo_fips	FIPS code for the city	*numeric*
geo_level	The geographic level of geo_fips (ex: city)	*string*
geo_name	Name of the city (ex: Olympia)	*string*
metric_name	Metric name	*string*
group_name	Demographic group	*string*
num	Numerator	*numeric*
denom	Denominator	*numeric*
est	Estimate	*numeric*
lci	Lower confidence interval	*numeric*

uci	Upper confidence interval	*numeric*
period_type	Estimate type (ex: 5 year estimate)	*string*
data_period	Year of data	*numeric*
source_name	Source name abbreviation	*string*
census_parent_shape_year	Year of the census that correlates with geographic boundaries (ex: 2020)	*numeric*
data_indicator	Information about unavailable data or data cautions	*string*
county_indicator	Information about county data	*string*
map_indicator	Information about Macon FIPS	*string*
agg_indicator	Information about data aggregation	*string*
multiplier_indicator	Information about data year	*string*
version	Date of data update	*string*

Table B

Domain	Metric Name	Metric Description	Data Source	Tract Estimates	Demographic Subgroups	Most Current Data Period
Clinical Care	Dental Care	Percentage of adults who report visiting a dentist in the past year	PLACES Project, Centers for Disease Control	Yes	Not Available	2020, 1 year modeled estimate
	Prenatal Care	Percentage of births for which prenatal care began in the first trimester	Natality Data, National Vital Statistics System, National Center for Health Statistics	No	Race/Ethnicity	2020, 3 year estimate
	Preventive Services, 65+	Percentage of adults ≥65 years who are up to date on a core set of clinical preventive services	PLACES Project, Centers for Disease Control	Yes	Sex	2020, 1 year modeled estimate
	Routine Checkup, 18+	Percentage of adults who report visiting a doctor for routine checkup in the past year	PLACES Project, Centers for Disease Control	Yes	Not Available	2020, 1 year modeled estimate
	Uninsured	Percentage of population ≤64 years without health insurance	American Community Survey, U.S. Census Bureau	Yes	Age, Sex, Race/Ethnicity	2021, 5 year estimate
Health Behavior	Binge Drinking	Percentage of adults who report binge drinking in the past 30 days	PLACES Project, Centers for Disease Control	Yes	Not Available	2020, 1 year modeled estimate
	Physical Inactivity	Percentage of adults who report no leisure-time physical activity in the past 30 days	PLACES Project, Centers for Disease Control	Yes	Not Available	2020, 1 year modeled estimate
	Smoking	Percentage of adults who report current smoking	PLACES Project, Centers for Disease Control	Yes	Not Available	2020, 1 year modeled estimate
	Teen Births	Births to females 15-19 years per 1,000 females in that age group	Natality Data, National Vital Statistics System, National Center for Health Statistics	No	Race/Ethnicity	2020, 3 year estimate
Health Outcomes	Breast Cancer Deaths	Deaths due to breast cancer in females per 100,000 female population	Multiple Cause of Death Data, National Vital Statistics System, National Center for Health Statistics	No	Race/Ethnicity	2020, 3 year estimate
	Cardiovascular Disease Deaths	Deaths due to cardiovascular disease per 100,000 population	Multiple Cause of Death Data, National Vital Statistics System, National Center for Health Statistics	No	Sex, Race/Ethnicity	2020, 3 year estimate
	Colorectal Cancer Deaths	Deaths due to colorectal cancer per 100,000 population	Multiple Cause of Death Data, National Vital Statistics System, National Center for Health Statistics	No	Sex, Race/Ethnicity	2020, 3 year estimate
	Diabetes	Percentage of adults who report having diabetes	PLACES Project, Centers for Disease Control	Yes	Not Available	2020, 1 year modeled estimate
	Firearm Homicides	Deaths due to firearm homicide per 100,000 population	Multiple Cause of Death Data, National Vital Statistics System, National Center for Health Statistics	No	Sex, Race/Ethnicity	2020, 5 year estimate

Domain	Metric Name	Metric Description	Data Source	Tract Estimates	Demographic Subgroups	Most Current Data Period
	Firearm Suicides	Deaths due to firearm suicide per 100,000 population	Multiple Cause of Death Data, National Vital Statistics System, National Center for Health Statistics	No	Sex, Race/Ethnicity	2020, 5 year estimate
	Frequent Mental Distress	Percentage of adults who report ≥14 days of poor mental health in the past 30 days	PLACES Project, Centers for Disease Control	Yes	Not Available	2020, 1 year modeled estimate
	Frequent Physical Distress	Percentage of adults who report ≥14 days of poor physical health in the past 30 days	PLACES Project, Centers for Disease Control	Yes	Not Available	2020, 1 year modeled estimate
	High Blood Pressure	Percentage of adults who report high blood pressure	PLACES Project, Centers for Disease Control	Yes	Not Available	2019, 1 year modeled estimate
	Life Expectancy	Average years of life expectancy at birth	U.S. Small-area Life Expectancy Estimates Project (USALEEP)	Yes	Not Available	2015 6 year modeled estimate*
	Low Birthweight	Percentage of live births with low birthweight (<2500 grams)	Natality Data, National Vital Statistics System, National Center for Health Statistics	No	Race/Ethnicity	2020, 3 year estimate
	Obesity	Percentage of adults who report a body mass index (BMI) ≥30 kg/m2	PLACES Project, Centers for Disease Control	Yes	Not Available	2020, 1 year modeled estimate
	Opioid Overdose Deaths	Deaths due to opioid overdose per 100,000 population	Multiple Cause of Death Data, National Vital Statistics System, National Center for Health Statistics	No	Not Available	2020, 3 year estimate
	Premature Deaths (All Causes)	Years of potential life lost before age 75 per 100,000 population	Multiple Cause of Death Data, National Vital Statistics System, National Center for Health Statistics	No	Sex, Race/Ethnicity	2020, 3 year estimate
Physical Environment	Air Pollution - Ozone	Average daily maximum concentration (parts per billion) of ground-level ozone throughout a month	George Mason University	Yes	Not Available	12/2022, 1 month average estimate
	Air Pollution - Particulate Matter	Average daily concentration (μg/m³) of fine particulate matter (PM2.5) per cubic meter of air throughout a month	George Mason University	Yes	Not Available	12/2022, 1 month average estimate
	Housing with Potential Lead Risk	Percentage of housing stock with potential elevated lead risk	American Community Survey, U.S. Census Bureau	Yes	Not Available	2021, 5 year estimate
	Lead Exposure Risk Index	Index (1-10) reflecting poverty-adjusted risk of housing-based lead exposure	American Community Survey, U.S. Census Bureau	Yes	Not Available	2021, 5 year estimate
	Park Access	Percentage of population living within a 10 minute walk of green space	ParkServe®	Yes	Race/Ethnicity	2022 *
	Walkability	Index (0-100) reflecting amenities accessible by walking as calculated by Walk Score	Walk Score®	Yes	Not Available	2022 *

Domain	Metric Name	Metric Description	Data Source	Tract Estimates	Demographic Subgroups	Most Current Data Period
Social and Economic Factors	Absenteeism	Percentage of public school students who miss ≥15 days of school in an academic year. Note: this metric is at the city (not school district) level.	National Center for Education Statistics, Civil Rights Data Collection	No	Sex, Race/Ethnicity	School year ending in 2018 *
	Broadband Connection	Percentage of households with high speed broadband internet connection (cable, fiber optic, DSL)	American Community Survey, U.S. Census Bureau	Yes	Not Available	2021, 5 year estimate
	Children in Poverty	Percentage of children living in households ≤100% of the federal poverty level	American Community Survey, U.S. Census Bureau	Yes	Race/Ethnicity	2021, 5 year estimate
	Credit Insecurity Index	Index (0-100) reflecting community-level limited credit access	New York Fed Consumer Credit Panel/Equifax	Yes	Not Available	2020 *
	High School Completion	Percentage of adults ≥25 years with high school diploma or equivalent, or higher degree	American Community Survey, U.S. Census Bureau	Yes	Sex, Race/Ethnicity	2021, 5 year estimate
	Income Inequality	Index (-100 to +100) reflecting households with income at the extremes of the national income distribution (the top or bottom 20%)	American Community Survey, U.S. Census Bureau	Yes	Not Available	2021, 5 year estimate
	Neighborhood Racial/Ethnic Segregation	Index (0-100) reflecting the geographic clustering of racial/ethnic groups across the area	American Community Survey, U.S. Census Bureau	No	Not Available	2021, 5 year estimate
	Racial/Ethnic Diversity	Index (0-100) reflecting how evenly distributed the population is across the racial/ethnic groups living in this area	American Community Survey, U.S. Census Bureau	Yes	Not Available	2021, 5 year estimate
	Rent Burden	Percentage of households where ≥30% of income is spent on rent	American Community Survey, U.S. Census Bureau	Yes	Not Available	2021, 5 year estimate
	Third-Grade Reading Scores	Average reading test scores (in grade levels) of third graders in public schools. Note: this metric is at the city (not school district) level.	Stanford Education Data Archive	No	Sex, Race/Ethnicity	School year ending in 2018
	Unemployment - Annual, Neighborhood-Level	Percentage of population ≥16 years who are unemployed but seeking work	American Community Survey, U.S. Census Bureau	Yes	Sex, Race/Ethnicity	2021, 5 year estimate
	Unemployment - Current, City-Level	Percentage of civilian labor force who are unemployed, by month	Local Area Unemployment Statistics, U.S. Bureau of Labor Statistics	No	Not Available	12/2022, 1 month modeled estimate

** Only one year of data is available for this metric*

Results/Analysis

To analyze the impacts of social, health, and economic factors that are associated with increasing levels of firearm homicide in the United States, I chose to utilize a general multiple linear regression modeling approach. Given the data contained in Tables A and B, it's clear that the analysis had an abundance of data to consider. To narrow the vast amount of data, two primary steps were taken:

1. The demographic group associated with all measures was filtered to 'Total' so that the measures included data that accounted for the total city estimates instead of by demographic groups. This approach was chosen because firearm homicide contained data related to demographic groups while many of the other potential independent variables did not.
2. A correlation table was constructed to account for all potential independent variables relative to firearm homicides. From this table, correlations of >= .45 and <=-.45 were chosen as variables to include in the analysis. Furthermore, the following measures were removed as the presented problems of multicollinearity in the regression model: Premature Deaths (All Causes) and Life Expectancy. This step resulted in the following correlated table listed in **Table C**.

Table C

Metric Name	**Correlation w/Firearm Homicide**
Low Birthweight	0.73
Neighborhood Racial/Ethnic Segregation	0.61
Children in Poverty	0.59
Diabetes	0.58
High Blood Pressure	0.57
Credit Insecurity Index	0.54
Teen Births	0.52
Obesity	0.49
Smoking	0.47
Unemployment - Annual, Neighborhood-Level	0.47
Physical Inactivity	0.46
Income Inequality	-0.48
Broadband Connection	-0.50

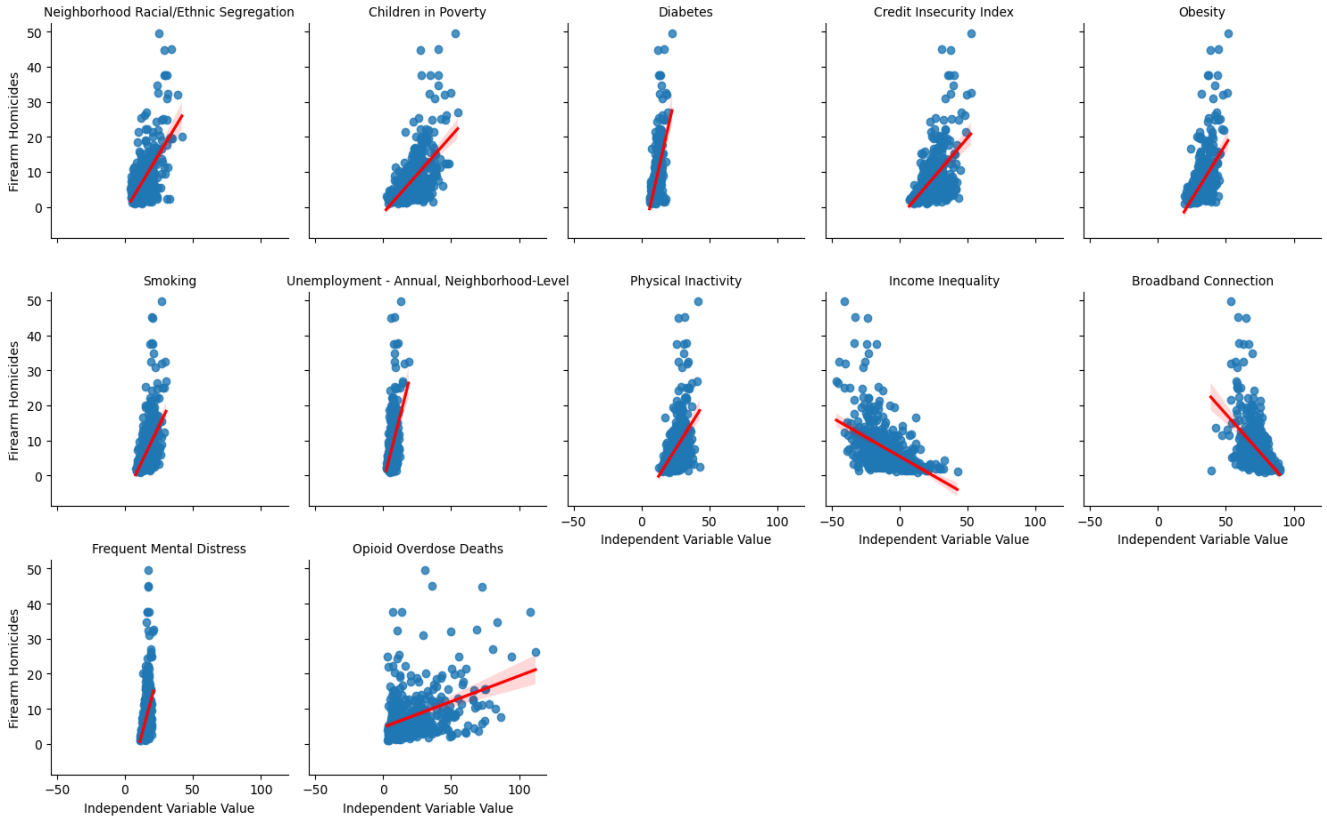
Next, measures with substantially less recorded observations relative to firearm homicide were removed from the analysis. Originally, the missing values were imputed only for the author to find that the imputation led to misleading results in the final regression output; namely, statistical significance for only the measures that were imputed. The measures that were removed from the analysis included: Low Birthweight, Teen Births, and High Blood Pressure. Furthermore, two additional independent variables associated with the current political debate in the United States around firearms were added despite their lower correlation scores because of their relevance in the public discourse: Frequent Mental Distress and Opioid Overdose Deaths. The resulting summary statistics for Firearm Homicide and the chosen independent variables are listed below in **Table D**.

Table D

Statistic	Firearm Homicides	Neighborhood Racial/Ethnic Segregation	Children in Poverty	Diabetes	Credit Insecurity Index	Obesity	Smoking	Unemployment - Annual, Neighborhood-Level	Physical Inactivity	Income Inequality	Broadband Connection	Frequent Mental Distress	Opioid Overdose Deaths
count	461.00	461.00	461.00	461.00	461.00	461.00	461.00	461.00	461.00	461.00	461.00	461.00	441.00
mean	7.77	13.73	21.61	10.89	23.63	33.84	17.22	6.40	25.53	-10.70	72.36	15.92	21.83
std	6.93	6.50	9.38	2.36	8.30	5.41	4.02	2.13	5.17	14.98	7.87	1.76	18.87
min	0.90	4.20	2.10	6.00	7.00	19.20	7.80	2.20	12.60	-46.60	38.90	11.00	2.80
25%	3.40	9.00	14.80	9.20	17.70	30.00	14.30	5.00	21.70	-21.60	67.50	14.80	8.70
50%	5.60	12.50	21.40	10.80	23.10	34.20	17.20	6.00	25.60	-12.80	73.10	16.00	14.60
75%	9.70	16.90	27.40	12.20	28.40	37.60	20.00	7.40	29.00	-1.30	78.00	17.10	28.70
max	49.60	41.90	54.80	22.50	52.40	51.60	30.20	18.60	42.80	42.40	89.60	21.00	112.10

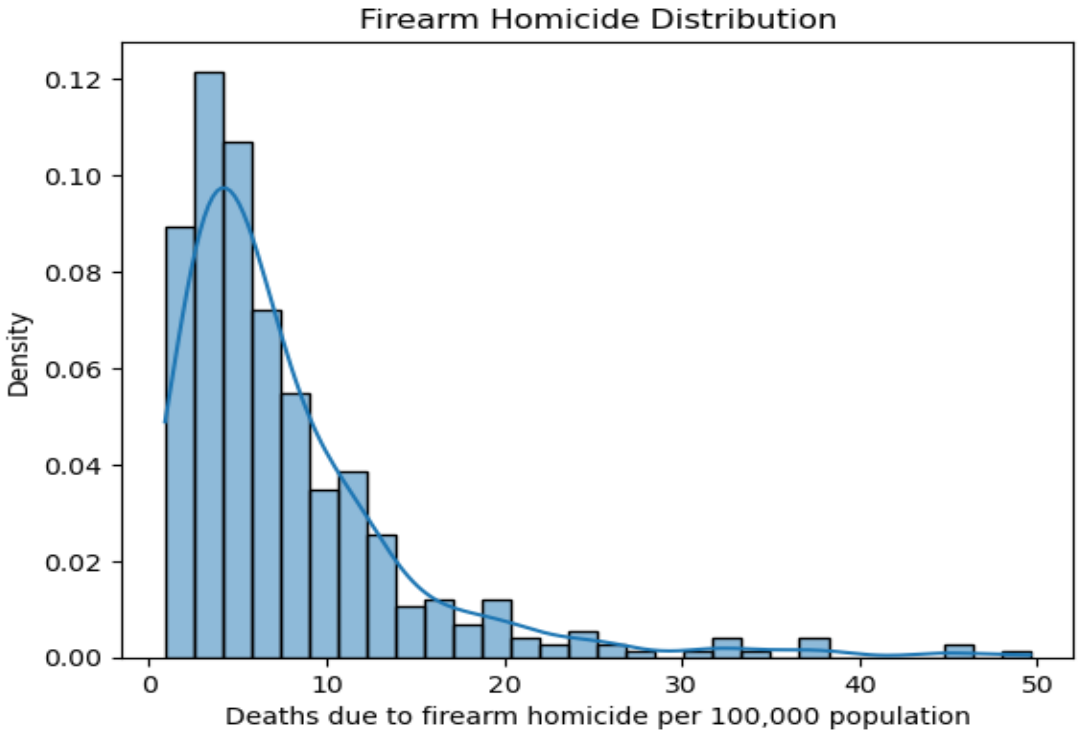
To visualize how the data for each independent variable looked relative to firearm homicides, a scatterplot was created and faceted. The results are shown in **Figure A**.

Figure A



Next, the dependent variable, Firearm Homicides, was plotted as a density histogram to better understand the distribution of data. Please take note of the right-skewness due to extreme values on the right-hand side of the distribution in **Figure B.**

Figure B



Finally, regression tests were conducted to understand the interaction of the independent variable terms with the dependent variable, Firearm Homicides. Before running the first regression test, VIF scores were taken across independent variables to assess multicollinearity risks. The output of the VIF analysis is listed in **Table E.**

Table E

Independent Variable	VIF Score
const	643.85
segregation	1.44
credit_insecurity	2.98
obesity	2.84
smoking	4.22
unemployment	1.65
physical_inactivity	3.46
income_inequality	5.92
broadband	3.52
mental_distress	2.47
opiod_overdose	1.49

At this point, variables with a VIF score greater than or equal to five were removed from the analysis. The only independent variable that met the criterion was Income Inequality.

With the VIF score criterion reached, an initial regression model was created with the remaining independent variables relative to firearm homicide. Please take note of statistical insignificance across multiple variables in addition to the Jarque-Bera Test statistic. Overall, there are multiple coefficients that are not statistically valid at the 5% level, and the Jarque-Bera Test statistic indicates that non-normality of residuals is likely a major issue. The output from the first regression is listed in **Figure C.**

Figure C

OLS Regression Results

Dep. Variable:	firearm_homicides	R-squared:	0.561
Model:	OLS	Adj. R-squared:	0.553
Method:	Least Squares	F-statistic:	34.45
Date:	Mon, 07 Aug 2023	Prob (F-statistic):	3.85e-46
Time:	12:38:23	Log-Likelihood:	-1355.8
No. Observations:	461	AIC:	2732.
Df Residuals:	451	BIC:	2773.
Df Model:	9		
Covariance Type:	HC1		

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-7.2700	5.472	-1.329	0.184	-17.995	3.455
segregation	0.4551	0.057	7.984	0.000	0.343	0.567
credit_insecurity	0.0807	0.049	1.656	0.098	-0.015	0.176
obesity	0.3466	0.081	4.297	0.000	0.189	0.505
smoking	0.0016	0.111	0.014	0.989	-0.215	0.218
unemployment	0.6824	0.137	4.978	0.000	0.414	0.951
physical_inactivity	-0.1762	0.082	-2.151	0.031	-0.337	-0.016
broadband	-0.0493	0.055	-0.894	0.371	-0.157	0.059
mental_distress	-0.1587	0.225	-0.707	0.480	-0.599	0.281
opiod_overdose	0.0624	0.020	3.050	0.002	0.022	0.102

Omnibus:	172.009	Durbin-Watson:	1.755
Prob(Omnibus):	0.000	Jarque-Bera (JB):	901.992
Skew:	1.540	Prob(JB):	1.36e-196
Kurtosis:	9.121	Cond. No.	2.39e+03

Notes:
[1] Standard Errors are heteroscedasticity robust (HC1)
[2] The condition number is large, 2.39e+03. This might indicate that there are strong multicollinearity or other numerical problems.

Given the problematic regression output, four steps were taken:

1. Coefficients that did not reach a statistical significance threshold of 5% were removed from the analysis.
2. Residuals from the regression output were plotted to understand the inherent issues in the normality assumption as it applies to the independent variables of interest. The original residual plots are outlined in **Figure D.**
3. Next, a Box Cox transformation was applied to the dependent variable, Firearm Homicides, as the output from **Figure D** confirmed non-normality across many independent variables in a heteroskedastic pattern. The post Box Cox transformation residual output is shown in **Figure E.**

4. Coefficients with minimal impact to the adjusted R Squared value were removed from the analysis. This only included the Opioid Overdose variable. The removal of this variable decreased adjusted R Squared by 3%.

The steps listed above resulted in the regression output listed in **Figure F** and the QQ Plot for normality in **Figure G.**

Figure D

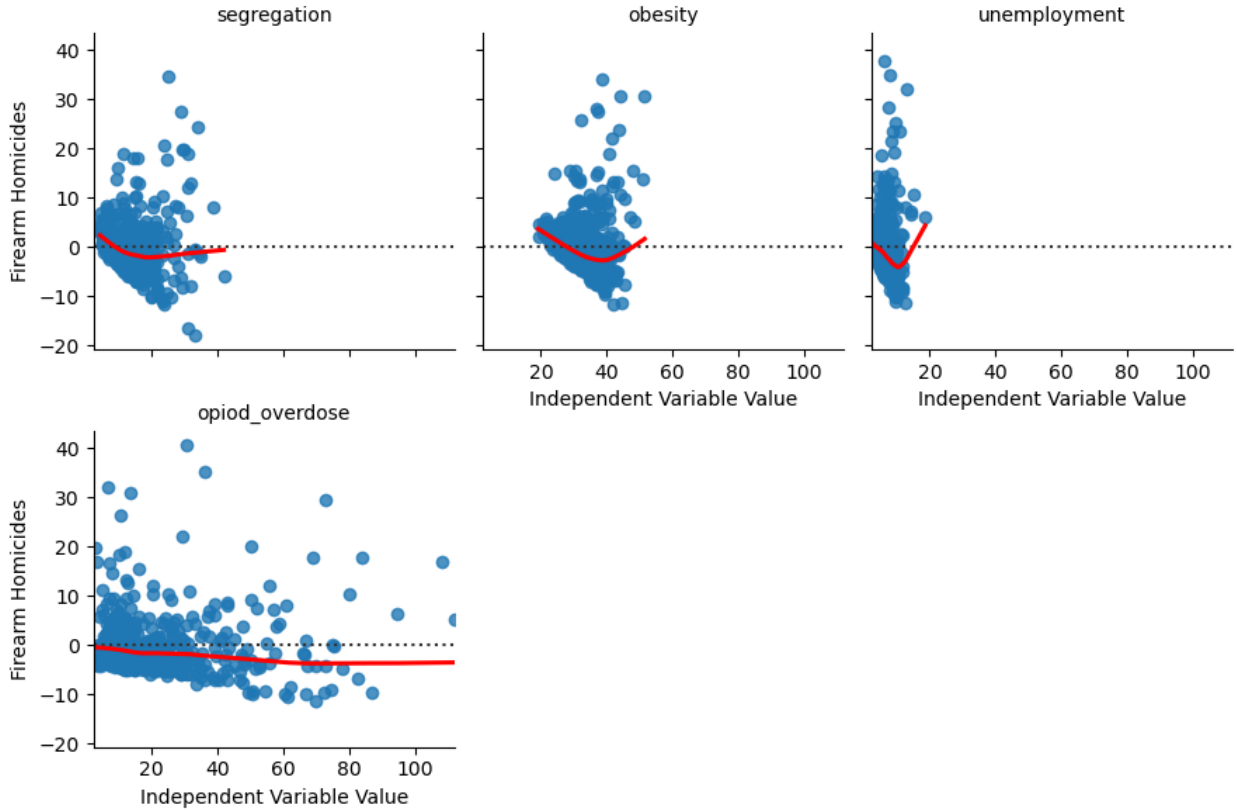


Figure E

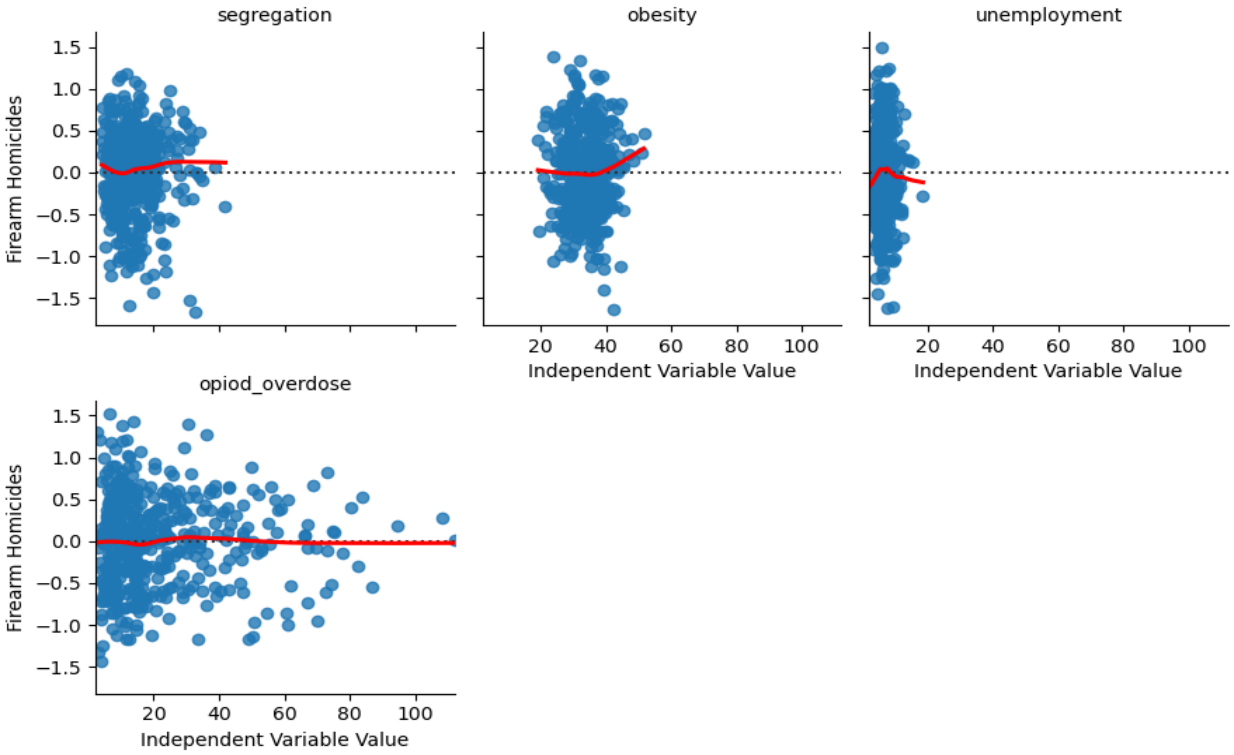


Figure F

OLS Regression Results

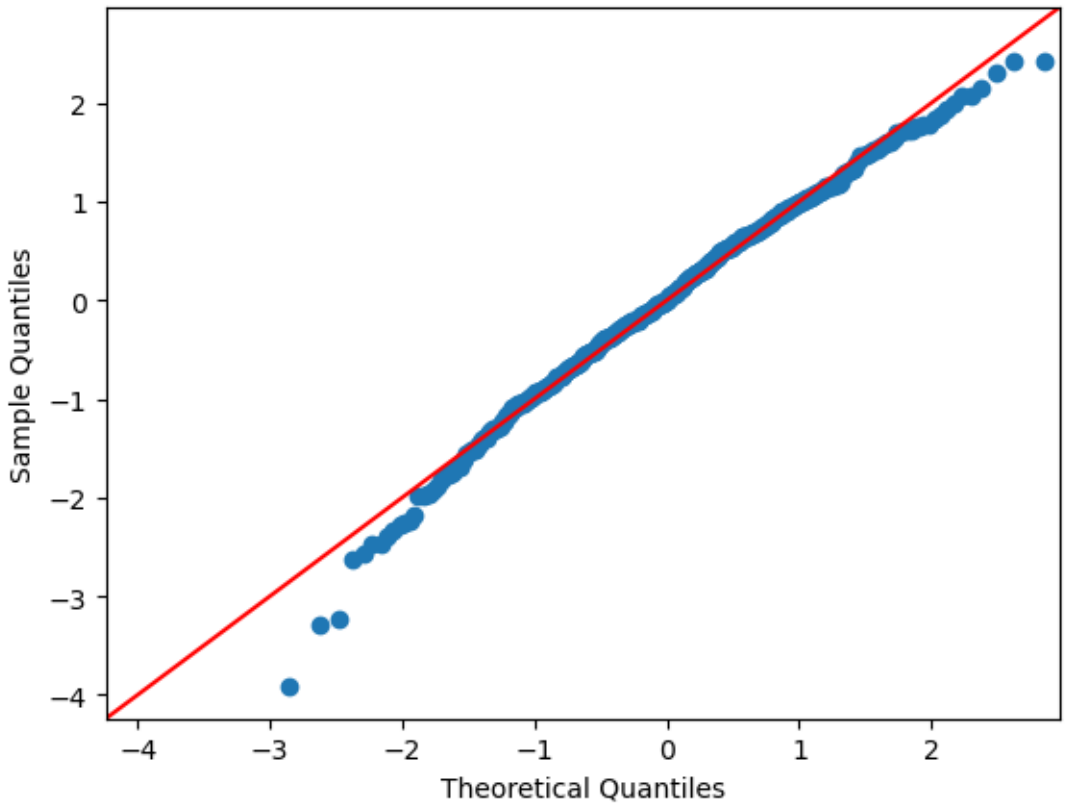
Dep. Variable:	firearm_homicides_box_cox	R-squared:	0.486
Model:	OLS	Adj. R-squared:	0.482
Method:	Least Squares	F-statistic:	143.9
Date:	Sat, 12 Aug 2023	Prob (F-statistic):	1.18e-65
Time:	22:16:20	Log-Likelihood:	-251.29
No. Observations:	461	AIC:	510.6
Df Residuals:	457	BIC:	527.1
Df Model:	3		
Covariance Type:	HC1		

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-0.5437	0.131	-4.144	0.000	-0.801	-0.287
segregation	0.0341	0.003	10.015	0.000	0.027	0.041
obesity	0.0363	0.005	7.999	0.000	0.027	0.045
unemployment	0.0606	0.010	5.866	0.000	0.040	0.081

Omnibus:	21.446	Durbin-Watson:	1.762
Prob(Omnibus):	0.000	Jarque-Bera (JB):	24.319
Skew:	-0.475	Prob(JB):	5.24e-06
Kurtosis:	3.602	Cond. No.	239.

Notes:
[1] Standard Errors are heteroscedasticity robust (HC1)

Figure G



Discussion

Overall, the final regression output largely supports the existing research around the social determinants of firearm homicide while adding additional variables to consider. Specifically, the regression output shows that segregation, obesity, and unemployment have a statistically significant relationship with firearm homicides. The values of the independent variables imply that a one unit increase of each elicits the following increases in firearm homicide respectively after reversing the Box Cox transformation on Firearm Homicides with a lambda value of -0.13326 (1.03477, 1.03706, 1.06273). It's clear that firearm homicides in the observable data generally increase when each of the independent variables increases and decreases when each of the independent variables decreases.

Given the definitions of the metrics of the observable data, this means that an increase in the Neighborhood Racial/Ethnic Segregation index of 1 increases the number of firearm homicides per 100,000 people by 1.03477. As a reminder, the Racial/Ethnic Segregation index is "a reflection of the geographic clustering of racial/ethnic groups across the area" (City Health Dashboard n.d.). The regression of the obesity coefficient implies that if the "percentage of adults who report a body mass index (BMI) greater than or equal to 30 kg/m2" increases by 1%, the firearm homicides increase by 1.03706 per 100,00 (City Health Dashboard n.d.). Finally, the regression output for annual unemployment implies that as the "percentage of population greater than or equal to 16 years who are unemployed and seeking work" increases by 1%, the firearm homicides per 100,000 increases by 1.06273 (City Health Dashboard n.d.).

Limitations

The data collected for this analysis was not recorded from a randomized control trial. Furthermore, because the observed data did not have a clear delineation for the definition of what constitutes a treatment for the continuous independent variables used in the analysis, methods to limit bias like propensity score analysis were not used. Therefore, it's likely that bias exists in this study as confounding variables were not fully accounted for. Future studies could mitigate this problem by using data containing a clear binary treatment associated with the independent variables above in conjunction with propensity score analysis to limit bias in the analysis output.

Furthermore, the final regression output still indicates that potential issues with nonnormality could exist. This research note's review of the likely reasons for this indicates outliers as a possible explanation. Additional research could explore the outliers in further detail to understand if there were any potential errors in collecting the data.

It's also worth mentioning that the City Health Dashboard dataset generally includes city data where the city population is greater than or equal to 50,000 people. As a result, it's likely that data for understanding the determinants of firearm homicide is missing thus biasing regression estimates.

Finally, as noted earlier, firearm homicide data was not collected for every city of the City Health Dashboard dataset and some potential independent variables like Teen Births, High Blood Pressure, and Low Blood pressure did not contain sufficient data for the regression analysis. It's possible that the exclusion of these potentially important independent variables and missing data for firearm homicides biased the final regression result. Additional research should account for this by seeking additional data.

Conclusion

The analysis conducted for this research note validates the existing academic research that racial segregation and economic disadvantages in the form of unemployment are positively associated with firearm homicides. Furthermore, the analysis adds an additional variable to the academic research, obesity, as variable that is positively associated with firearm homicide.

The research associated with note also indicates that one commonly cited variable in the firearm homicide public policy debate, mental illness, was not associated with increased firearm homicides to a statistically significant degree. Furthermore, the observable data in this analysis indicate that while the relationship between opioid overdose deaths and firearm homicides is statistically significant, opioid overdose deaths don't explain a great deal of the variability in firearm homicides (~3%) for the observable data. I feel that both findings are impactful to the current firearm homicide debate occurring in the United States.

Further Research

While increasing rates of obesity in a population are indicative of increasing firearm homicides for the observable data, it's very unlikely that obesity alone impacts firearm homicides. It's much more likely that other variables that influence obesity like food deserts, lack of public health infrastructure, and diminished economic capacity to procure healthy foods drive firearm homicides due to their influence on nutrition and physical development. Future research could examine additional health variables

associated with nutrition and development to understand the links between firearm homicides and physical health resulting from nutrition and exercise.

Furthermore, additional research could examine the link between segregated neighborhoods, race, and firearm homicides. The Rowhani-Rahbarl study indicated that communities in which African Americans are highly segregated and economically disadvantaged also experience a greater magnitude of firearm homicides relative to other races is a claim that should be explored with additional research to determine the causal mechanisms driving the associations. This research note could not explore this as sufficient demographic data was not available.

Finally, additional research could explore the complete picture of firearm homicide. This research note only sought to better understand the social determinants of firearm homicide. Future research could include variables like gun control legislation coupled with social determinants to better explain the variability in firearm homicides across the country.

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