Geographic and Demographic Characteristics of U.S. Gun Violence

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1. Overview

Gun violence in the United States claims tens of thousands of lives annually. Compared with other high-income countries, the firearm homicide rate in the U.S. is 24.9 times higher while the firearm suicide rate was 9.8 times higher.[1] Since 2020, the U.S. has been witnessing the collision of two overwhelming public health crises: COVID-19 and gun violence.[2] The country's gun violence is fiercely intensified during the pandemic, due to the unprecedented increases in gun sales, combined with economic distress and social isolation.

Research shows gun violence is the end result of a causative web of risk factors[3] generated both by individuals themselves and the geography where individuals find themselves.[4] Individuals may experience an increased probability of falling victim to gun violence simply by being in an area with certain geographic and socio-demographic characteristics.

This project aims to take a first look at the geographic and demographic aspects associated with U.S. gun violence with the data of gun violence incidents that occurred in the past year. The project is going to address the following questions:

1) What's the geographic distribution of the U.S. gun violence incidents?
2) Which counties have higher gun incident density? Are they associated with higher population density as well?
3) Taking a closer look by focusing on New York City and its surrounding areas, do gun violence incidents cluster in certain geographic areas? If so, is the number and density of gun violence incidents correlated with census-tract-level demographic variables?

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[1] Grinshteyn, Erin, and David Hemenway. "Violent death rates in the US compared to those of the other high-income countries, 2015." *Preventive Medicine 123*, ISSN 0091-7435(June 2019): 20-26. doi:10.1016/j.ypmed.2019.02.026.
[2] Everytown Research & Policy, "Gun Violence and COVID-19 in 2020: A Year of Colliding Crises." Everytown Research, May 7, 2021.
https://everytownresearch.org/report/gun-violence-and-covid-19-in-2020-a-year-of-colliding-crises
[3] Romelsjö, Anders. "Alcohol consumption and unintentional injury, suicide, violence, work performance, and inter-generational effects." *Alcohol and public policy: evidence and issues* (1995): 114-142.
[4] Branas, Charles C et al. "Urban-rural shifts in intentional firearm death: different causes, same results." *American journal of public health 94*, NO.10 (October 2004): 1750-5. doi:10.2105/ajph.94.10.1750

2. Methodology

2.1. Data Identification

2.1.1 Vectors

1) U.S. County Boundaries

Layer name			counties	
Description			U.S. counties (Generalized) represents the counties of the United States in the 50 states and the District of Columbia. The layer provides 2010 U.S. census demographic information and generalized county boundaries.	
Source			gisclass_Pro1e.zip, tutoring materials attached to *Mastering ArcGIS Pro, 1st edition*.	
Drawing Format			Polygon	
Unit of measure			Meters	
Number of Records			3142	
Key details	**Field**	**Name**	FIPS	SQMI
		Description	-The 5-digit number that uniquely identifies each U.S. county. -Used as the key for table join	-The areas of each county in square miles -Used as the denominator field to calculate population density after table join.
		Data Type	Nominal	
		Field Type	Text	

2) New York State Census Tract Boundaries

Layer name		New York State
Description		2019 The State of New York Census Tract Data
Source		The U.S. Census Bureau - MAF/TIGER geographic database https://www.census.gov/geographies/mapping-files/time-series/geo/cartographic-boundary.2019.html
Drawing Format		Polygon
Unit of measure		Degrees
Number of Records		4906
Key Field details	**Name**	GEOID
	Description	-Geographic Identifiers - a 20-digit number uniquely identifies each census tract; -Used as the key for table join
	Data Type	Nominal
	Field Type	Text

3) New Jersey State Census Tract Boundaries

Layer name		New Jersey State
Description		2019 The State of New Jersey Census Tract Data
Source		U.S. Census Bureau, MAF/TIGER geographic database https://www.census.gov/geographies/mapping-files/time-series/geo/cartographic-boundary.2019.html
Drawing Format		Polygon
Unit of measure		Degrees
Number of Records		2010
Key Field details	**Name**	GEOID
	Description	-Geographic Identifiers - a 20-digit number uniquely identifies each census tract; -Used as the key for table join
	Data Type	Nominal
	Field Type	Text

4) New York City Census Tract Boundaries

Layer name		nyc census tract
Description		2010 New York City Census Tracts. This polygon layer is a subset of the Census TIGER census tract file, re-projected to local state plane and modified by subtracting a subset of the Census TIGER water layer (nyu_2451_34507) from it to create land-based boundaries.
Source		New York University, NYC Geodatabase (version jan2016) https://geo.nyu.edu/catalog/nyu-2451-34505
Drawing Format		Polygon
Unit of measure		Degrees
Number of Records		2164
Key Field details	**Name**	GEOID
	Description	-Geographic Identifiers - a 20-digit number uniquely identifies each census tract; -Used as the key for table join
	Data Type	Nominal
	Field Type	Text

2.1.2 Standalone Tables

1) U.S. gun violence incidents

Table name		All_Gun_Incidents_60654		
Description		The gun incidents in the U.S. from 10/1/2020 - 09/30/2021		
Source		Gun Violence Archive https://www.gunviolencearchive.org/		
Number of Records		60654		
Key Field details	**Name**	State	City_Or_County	Address
	Purpose	Used for geocoding	Used for geocoding	Used for geocoding
	Data Type	Categorical	Categorical	Nominal
	Field Type	Text	Text	Text

2) 2020 population data by county

Table name		2020_Census_POP_by_County	
Description		Subset of 2020 Census Redistricting Data (Public Law 94-171)	
Source		U.S. Census Bureau, 2020 Census Redistricting Data (Public Law 94-171) https://data.census.gov/cedsci/table?q=United%20States&t=Populations%20and%20People&g=0100000US%2405000000&tid=DECENNIALPL2020.P1	
Number of Records		3221	
Key Field details	**Name**	GEOID	TOTAL POPULATION
	Description	-The 5-digit number that uniquely identifies each U.S. county. -Used as the key for table join.	Used for geocoding
	Data Type	Nominal	Numeric
	Field Type	Text	Long Integer

3) Income data of NYC and its surrounding areas by census tract

Table name	NYC Income
Description	The 2019 median household income data of census tracts in New York City and surrounding areas (7 counties in the State of New York: Kings, Queens, Bronx, Richmond, New York, Nassau, Westchester; 6 counties in the State of New Jersey: Bergen, Hudson Passaic, Union, Essex, Middlesex)
Source	U.S. Census Bureau - 2019: ACS 5-year Estimates Subject Tables

		https://data.census.gov/cedsci/table?t=Income%20and%20Poverty&g=0500000US36005%241400000&tid=ACSST5Y2019.S1901		
Number of Records		3612		
Key Field details	**Name**	GEOID	Total_Households	housemedian
	Description	-Geographic Identifiers - uniquely identify each census tract; -Used as the key for table join	Household units	Median household income
	Data Type	Nominal	Numeric	Numeric
	Field Type	Text	Double	Double

4) Age and sex data of NYC and its surrounding areas by census tract

Table name		NY Age and Sex		
Description		The 2019 age and sex data of census tracts in New York City and surrounding areas (7 counties in the State of New York: Kings, Queens, Bronx, Richmond, New York, Nassau, Westchester; 6 counties in the State of New Jersey: Bergen, Hudson Passaic, Union, Essex, Middlesex)		
Source		U.S. Census Bureau - 2019: ACS 5-year Estimates Subject Tables https://data.census.gov/cedsci/table?q=age%20and%20sex&g=0500000US36005%241400000&y=2019&tid=ACSST5Y2019.S0101		
Number of Records		3612		
Key Field details	**Name**	GEOID	Median_Age	Male percentage
	Description	-Geographic Identifiers - uniquely identify each census tract; -Used as the key for table join	Median age information	The proportion of male population in total population
	Data Type	Nominal	Numeric	Numeric
	Field Type	Text	Double	Double

2.2. Integration Steps and Methods

2.2.1 Step 1: Geocode the gun violence incidents

This step is to convert the street addresses into geographic coordinates, placing the gun violence incidents on a map.

Tool	Geocode Addresses	
Input table	All_Gun_Incidents_60654	
Locator	ArcGIS World Geocoding Services	
Input Address Field	Address or Place = Address City = City_Or_County State = State	
Number of Records	60654	
Matched Records	60649	
Output Layer	**Layer Name**	U.S. Gun Incidents Geocoded
	Description	A layer of U.S. gun violence incidents successfully matched in geocoding process

2.2.2 Step 2: Dissolve the boundaries of all counties

This step is to get a polygon layer of U.S contours, used as a base polygon to more clearly show the spatial distribution of gun incidents across the country. The associate map is the spatial distribution of U.S. gun violence incidents.

Tool	Dissolve Boundaries	
Input Table	counties	
Output Layer	**Layer Name**	United States of America
	Description	A polygon of U.S. contours

2.2.3 Step 3: Spatial Join the gun violence incidents into each county

This step is to get the gun incidents count of each county so that we can calculate the gun violence incident density of each county, and symbolize counties polygon layer by the value of gun violence incident density.

Tool	Spatial Join
Target Features	counties
Join Features	U.S. gun violence incidents
Output Feature Class	counties_by_incidents
Join Operation	Join one to one
Option	Check “Keep All Target Features”
Match Option	Intersect

2.2.4 Step 4: Join the population data table to counties polygon

This step is to link the population data with other attributes of each county in county layer so that we can calculate gun violence incident density and population density.

Tool	Add Join
Input Table	counties
Input Join Field	FIPS
Join Table	2020_Census_POP_by_County
Join Table Field	GEOID
Option	Check “Keep All Target Features”

2.2.5 Step 5: Merge to get a polygon of New York City Area

Starting from this step, we are going to integrate data for gun violence specifically in New York City and its surrounding areas. The selected areas include 7 counties in the State of New York and 6 counties in the State of New Jersey.

Selected Areas:

State	Associate Polygon Layer	County Name	County FIPS
State of New York	nyc census tract	Kings County	36047
		Queens County	36081
		Bronx County	36005
		Richmond County	36087
		New York County	36061
	New York State	Nassau County	36059
		Westchester County	36119
State of New Jersey	New Jersey	Bergen County	34003
		Hudson County	34017
		Passaic County	34031
		Union County	34039
		Essex County	34013
		Middlesex County	34023

1) Select the counties from New York State polygon and New Jersey polygon

This sub-step is to get two new polygon layers from New York State polygon layer and New Jersey polygon layer for merging.

Tool	Select By Attributes	
Input Rows	New York State	New Jersey State
Selection Type	New selection	New selection
Expression (sql)	COUNTYFP = '059' Or COUNTYFP = '119'	COUNTYFP10 = '003' Or COUNTYFP10 = '017' Or COUNTYFP10 = '031' Or

			COUNTYFP10 = '039' Or COUNTYFP10 = '013' Or COUNTYFP10 = '023'
Output Layer (from selection)	**Name**	NY_selected	NJ_selected
	Description	Polygon layer of census tracts in Nassau County and Westchester County	Polygon layer of census tracts in Bergen County, Hudson County, Passaic County, Union County, Essex County, and Middlesex County
	Number of Records	502	938

2) Merge

This sub-step is going to merge the three polygon layers into a single one as the area of "New York City and its surrounding areas"

Tool		Merge
Input Datasets		nyc census tract
		NY_selection
		NJ_selection
Output Dataset	**Name**	All census tracts
	Description	Census tracts polygon layer covering Kings County (NY), Queens County (NY), Bronx County (NY), Richmond County (NY), New York County (NY), Nassau County (NY), Westchester County (NY), Bergen County (NJ), Hudson County (NJ), Passaic County (NJ), Union County (NJ), Essex County (NJ), and Middlesex County (NJ).
	Number of records	3604

2.2.6 Step 6: Clip to get a point layer of incidents in New York City Area

This step is to get a subset of gun violence incidents specifically in New York City and its surrounding areas from all the geocoded gun incidents.

Tool		Clip
Input Datasets		U.S. gun violence incidents
Clip Features		NY_selection
Output Dataset	**Name**	NYC gun incidents
	Description	Point Layer of gun incidents in New York City and its surrounding areas
	Number of records	2658

2.2.7 Step 7: Join the demographic data tables to the merged polygon

This step is to assign the demographic attributes to the census tracts in the merged polygon layer so that we can display each census tract by median household income, median age, and sex composition.

Tool	Add Join	
Input Table	All census tracts	All census tracts
Input Join Field	GEOID	GEOID
Join Table	NYC Income	NYC Age and Sex
Join Table Field	GEOID	GEOID
Option	Check “Keep All Target Features”	Check “Keep All Target Features”

3. Assessment of Research

3.1 Results

The project studies the spatial distribution of gun violence both across the country and in New York City, as well as displays the correlations between gun violence and demographic variables to a spatial extent. There are two preliminary findings:

1) People living in counties with higher population density are slightly more likely to be the victims of gun violence.
2) In New York City and its surrounding areas, the census tracts with more gun incidents or a higher gun violence incident density are associated with lower median household income, lower median age, and lower male population proportion.

Below are the visualizations of gun violence and project findings. Figure 1 is a point map showing the spatial distribution of gun violence across the country. Figure 2 is a thematic map displaying county-level gun violence incident density. Figure 3-5 displays median household income, median age, and sex composition by census tract in New York City and its surrounding areas.

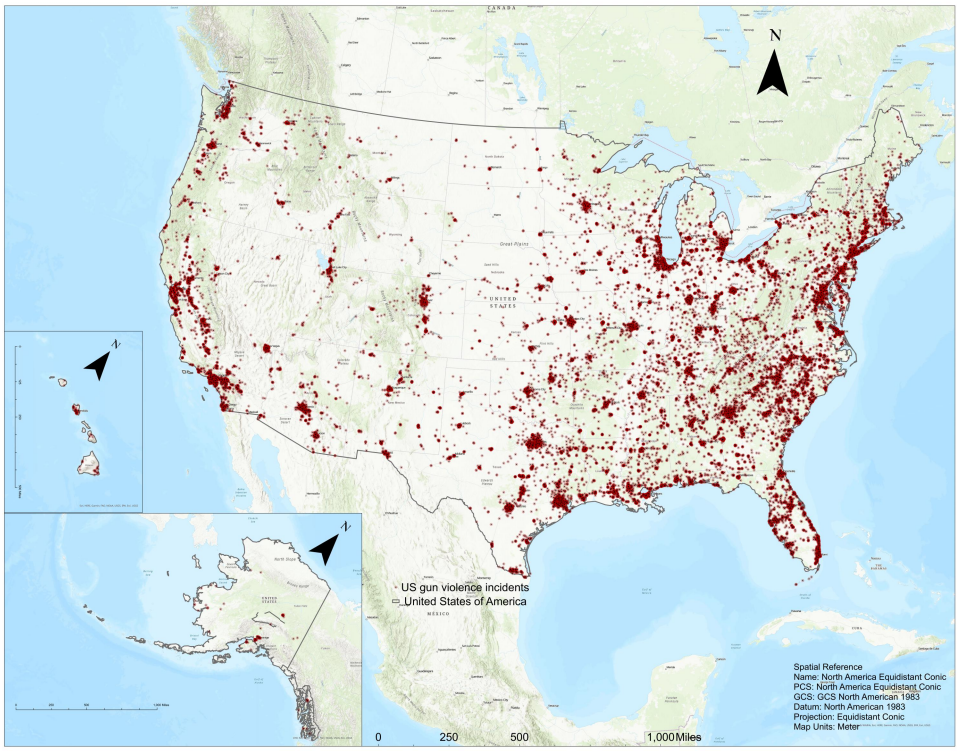

Figure 1 U.S. Gun Violence Incidents

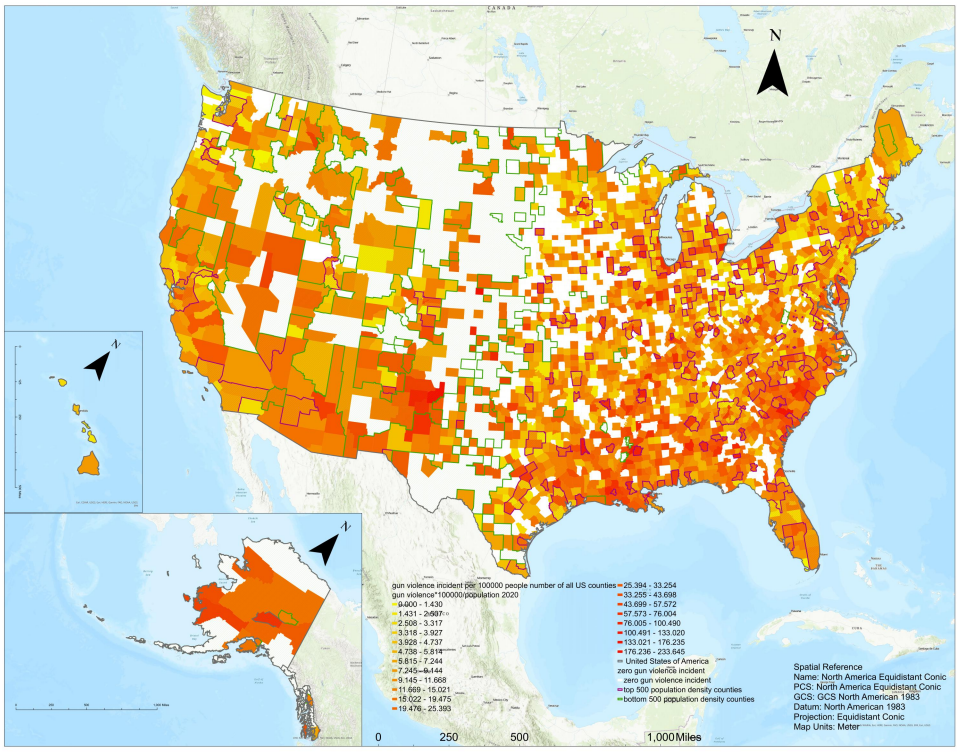

Figure 2 County-level Gun Violence Incident Density

Note: The merged areas with purple outlines are consist of 500 the most densely-populated counties while those with green outlines include 500 the least densely-populated counties.

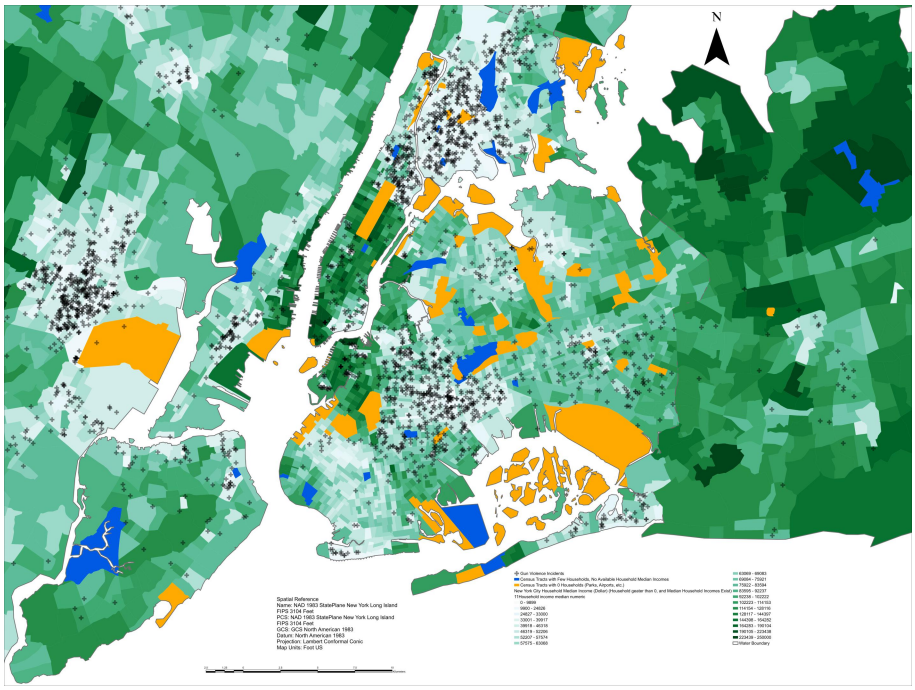

Figure 3 Gun Violence Incidents and Median Household Income

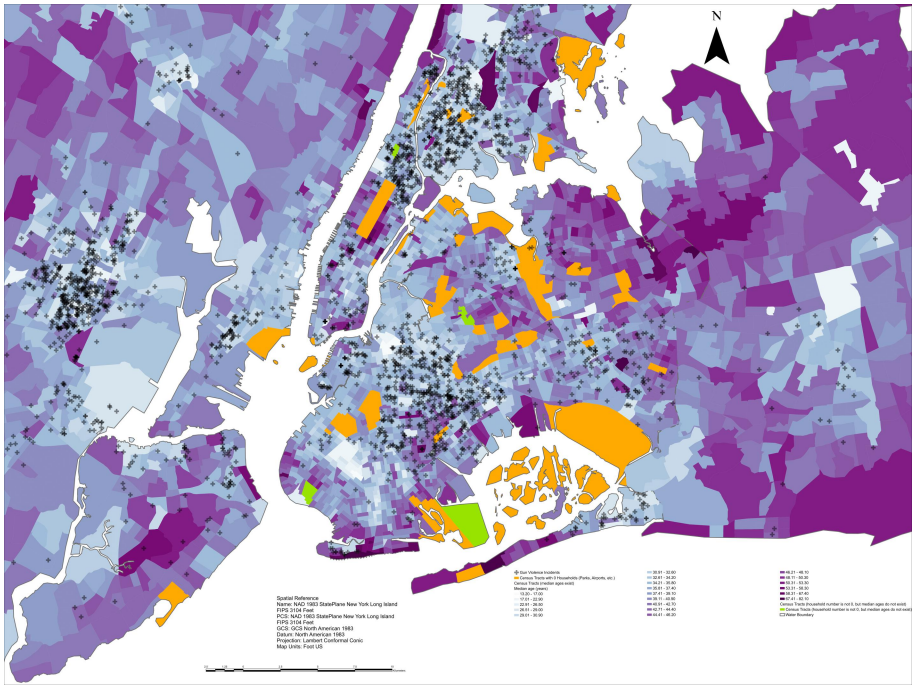

Figure 4 Gun Violence Incidents and Median Age

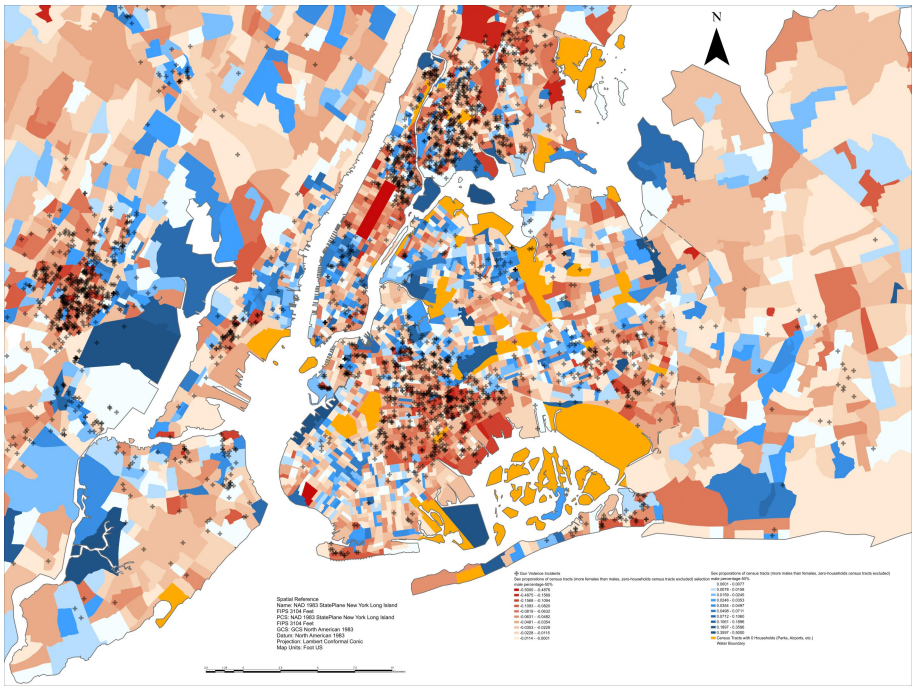

Figure 5 Gun Violence Incidents and Sex Composition

Note: Blue areas are census tracts where the male population is larger than the female population while red areas represent the opposite. The deeper the color, the bigger the difference in the relative population size between males and females.

Though not completely fitted, we can see from figure 2 that areas with high population density are associated with high gun violence incident density in general. In New York City and its surrounding areas (shown by Figure 3-5), gun violence incidents typically cluster in areas with lower median household income, lower median age, and more female population. These visually perceived relationships are further testified by correlation analysis (table 1 and table 2).

Table 1 Correlation table of gun violence with population density (U.S. data by county)

Pearson correlation coefficient, n = 3142			
	Count	**Incident Density**	**Population Density**
Count	1		
Incident Density	0.39	1	
Population Density	0.29	0.12	1

Table 2 Correlation table of gun violence with demographic variables (NYC area data by census tract)

Pearson correlation coefficient, n = 3523*					
	Count	**Incident Density**	**Median Household Income**	**Median Age**	**Male Percentage**
Count	1.00				
Incident Density	0.83	1.00			
Median Household Income	-0.35	-0.27	1.00		
Median Age	-0.27	-0.20	0.38	1.00	
Male Percentage	-0.18	-0.11	0.11	-0.08	1.00

* 81 records are removed from the test due to the missing value in any of the involving variables.

As the correlation tables suggest, the gun violence incident count and density are positively correlated to population density at the county level and negatively correlated with median household income, median age, and the percentage of the male population at the census-tract level.

3.2 Limitations

1) 13.1% (7948) of the 60649 records which we see as matched in geocoding process are initially tied records. They were not assessed individually and reassigned manually to remove any uncertainty, which might damage data quality and the validity of the further analysis.

2) This visualization-focused project only studies the correlations between gun violence and geographic segmentation and socio-demographic variables in a certain period. The results do not indicate any causality. More practical implications require further studies with larger data sizes and statistical control.

4. Data Sources

Price, Maribeth H. gisclass_Pro1e.zip, Dubuque, IA: Mastering ArcGIS Pro (1st ed), McGraw-Hill Higher Education, Accessed 2020.

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