JSC370 Final Project Report

The Reason Behind Homicide

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Introduction

Social stability and security can have a significant impact on our daily living conditions and quality. Living in a stable and secure social environment can positively affect people's health and well-being both physically and mentally, it can contribute to a stable economic environment and also provide people a sense of connection and belonging to the society.

The rate of homicides is a key indicator of social stability and security, and can also provide insights for social cohesion, governance and strength of law enforcement. Understanding the number of homicides can help to identify trends and patterns, as well as the factors correlated with the number of homicides can inform individual decisions, research and various political decisions related to law enforcement, public health, and social services.

The rate of homicides is also a key indicator of violence present in a certain area. Reducing the rate of homicides will reduce violence, and it is a key objective of the United Nations' Sustainable Development Goal (SDG) 16: Peace, Justice and Strong Institutions. In order to achieve this goal, understanding the root causes of violence actions such as healthcare resources, social inequalities and designing specific strategies to eliminate them is very important. Understanding the root causes behind the number of homicides makes a big step towards achieving SDG 16.

The World Health Organization (WHO) is an international public health agency of the United Nations, whose main objective is to promote health and well-being for all countries around the world. The WHO focuses on various health issues and factors that affect individual's well-being around the world. The rate of homicides is an important indicator considered by the WHO in its Global Health Observatory. In this project, we will use the estimates of rates of homicides per 100,000 population dataset provided by the WHO. WHO defines homicide to be the killing of a person by another person with the intention of causing death or serious injuries, and reckless or negligent cases are excluded in the dataset. The dataset is an estimate of the number of homicides per 100,000 population for different countries around the globe drawn from data provided from police of different countries, as well as data from the United Nations Office on Drugs and Crime (UNODC) and WHO's mortality database. It also provides estimates of the rate of homicides for male and female and contains information from 2000 to 2019.

In the report, we aim to answer the following two questions: "Is there a correlation between the number of homicide cases and the number of medical doctors in each country, and is there a correlation between the number of homicide cases and the number of medical doctors together with alcohol consumption level in each country?"

To do this, we will collect the number of medical doctors in each country through WHO's Global Health Workforce statistics database which extracts the national reporting in the National Health Workforce Accounts (NHWA) data platform, combining with various other sources such as National Census and Labour Force Surveys. This dataset contains information up to the year of 2000, and we will compare this information together with WHO's alcohol consumption situation for each country and region dataset (provided for HW2) to the rate of homicide per 100,000 population provided by the WHO, to determine if there is a statistically significant relationship.

Methods

Note: Some tables may be truncated in the report. For interactive plots, please refer to the website The first steps for this statistical report is to collect data that we would like to analyze and draw conclusions, then explore and clean the data collected to make sure that it fits our requirements for further analysis.

Data Collection

To collect the data of rates of homicides per 100,000 population, we simply need to navigate to the Global Health Observatory site from the WHO home website, and then click on "indicators" and search for this dataset. On the WHO website for this dataset, there are also visualizations, data previews, metadata information and related indicators to give a general information of this dataset. We can directly download the dataset from WHO's website as a .csv file and then read this data into R using the tidyverse library.

1. Homicides Data

Homicides table, which is shown below, demonstrates the top 6 rows of the homicide number data which were loaded into R from the downloaded homicides.csv file from WHO's website. This dataset contains estimates of homicides rate (per 100,000 population) from 2000 to 2019, and includes estimates for male, female and both sexes total for each country around the world. This dataset contains 10980 observations each of 34 variables, including information of the location of country (Location), the time period (Period), the estimates of homicides rate (per 100,000 population) (FactValueNumeric) together with a lower bound (FactValueNumericLow) and an upper bound (FactValueNumericHigh) of this estimate., as well as the sex corresponding to each estimate (Dim1) with values "Female", "Male" or "Both sexes".

IndicatorCode	Indicator	ValueType	ParentLocationC
VIOLENCE_HOMICIDERATE	Estimates of rates of homicides per 100 000 population	numeric	WPR
VIOLENCE_HOMICIDERATE	Estimates of rates of homicides per 100 000 population	numeric	EMR
VIOLENCE_HOMICIDERATE	Estimates of rates of homicides per 100 000 population	numeric	WPR
VIOLENCE_HOMICIDERATE	Estimates of rates of homicides per 100 000 population	numeric	WPR
VIOLENCE_HOMICIDERATE	Estimates of rates of homicides per 100 000 population	numeric	WPR
VIOLENCE_HOMICIDERATE	Estimates of rates of homicides per 100 000 population	numeric	WPR

2. Doctors Data

The number of medical doctors dataset can be collected also from WHO's official website. After navigating to the Global Health Observatory page, we can search for the theme of Global Health Workforce statistics and directly download the number of medical doctors for each country from the year 2000 - 2021 in a .csv format from the website. Then, this .csv file is also loaded into R using the tidyverse library.

Doctor table shown below contains the first 6 rows of the number of medical doctors in each country dataset which were loaded into R from the downloaded .csv file. This dataset contains estimates of each country's number of medical doctors per 10,000 population from the year 2000 to 2019. This dataset contains 2903 observations of 34 variables, including information of the continent or region location (ParentLocation) of each estimate, the country location (Location) of each estimate, the time period (Period), the estimates of the number of medical doctors per 10,000 population (FactValueNumeric).

IndicatorCode	Indicator	ValueType	ParentLocationCode	ParentLocation	Location.type	Spat
HWF_0001	Medical doctors (per 10,000)	numeric	AFR	Africa	Country	TCI
HWF_0001	Medical doctors (per 10,000)	numeric	AFR	Africa	Country	TGO
HWF_0001	Medical doctors (per 10,000)	numeric	WPR	Western Pacific	Country	PNG
HWF_0001	Medical doctors (per 10,000)	numeric	AFR	Africa	Country	BDI
HWF_0001	Medical doctors (per 10,000)	numeric	AFR	Africa	Country	MO
HWF_0001	Medical doctors (per 10,000)	numeric	AFR	Africa	Country	CMI

3. Alcohol Consumption Data

The WHO's alcohol consumption dataset can be directly downloaded from HW2 as a .csv file and loaded into R using the tidyverse library. Alcohol table shown below contains the first 6 rows of the WHO alcohol consumption in each country dataset which were loaded into R from the downloaded .csv file. This dataset contains estimates of each country's alcohol consumption in liters per capita from 2000 to 2019, including the WHO Region of the country (WHO.Region), the country name (Country), the year of the estimation (Year), sex of the estimation (Sex) with values "Both sexes", "Female" or "Male, as well as the estimates of alcohol consumption in liters per capita including a low and high estimation and a string representation.

WHO.Region.Code	WHO.Region	Country.Code	Country	Year	Sex	Alcohol.total.per.capita..
SEAR	South-East Asia	BGD	Bangladesh	2019	Both sexes	
SEAR	South-East Asia	BGD	Bangladesh	2019	Female	
SEAR	South-East Asia	BGD	Bangladesh	2019	Male	
EMR	Eastern Mediterranean	KWT	Kuwait	2019	Both sexes	
EMR	Eastern Mediterranean	KWT	Kuwait	2019	Female	
EMR	Eastern Mediterranean	KWT	Kuwait	2019	Male	

Data Cleaning

Firstly, I would check if there is any NA valued data in the dataset and keep only the necessary data columns needed for this project in the homicides table (Table 1), doctor table (Table 2), and alcohol table (Table 3). Since some columns contain NA values in all the rows in the doctor table and homicides table, I deleted those columns. Besides, for the convenience of reading and understanding the dataset, we need to change the column names in homicides table, doctor table and alcohol table to make them more readable.

Before merging all data, the three tables with top 6 rows are shown below:

homicides table (after cleaning):

	ParentLocation	Location	Period	Sex	AverageValue
1	Western Pacific	Japan	2019	Female	0.18
2	Eastern Mediterranean	United Arab Emirates	2019	Female	0.21
4	Western Pacific	Singapore	2019	Female	0.22
5	Western Pacific	Japan	2019	Male	0.24
7	Eastern Mediterranean	Qatar	2019	Female	0.26
8	Eastern Mediterranean	Bahrain	2019	Female	0.28

alcohol table (after cleaning):

	WHO.Region.Code	WHO.Region	Country.Code	Country	Year	Sex	numeric
2	SEAR	South-East Asia	BGD	Bangladesh	2019	Female	0
3	SEAR	South-East Asia	BGD	Bangladesh	2019	Male	0
5	EMR	Eastern Mediterranean	KWT	Kuwait	2019	Female	0
6	EMR	Eastern Mediterranean	KWT	Kuwait	2019	Male	0
8	AFR	Africa	MRT	Mauritania	2019	Female	0
9	AFR	Africa	MRT	Mauritania	2019	Male	0

doctor table (after cleaning):

ParentLocation	Location	Period	FactValueNumeric
Africa	Chad	2021	0.58
Africa	Togo	2021	0.59
Western Pacific	Papua New Guinea	2021	0.63
Africa	Burundi	2021	0.65
Africa	Mozambique	2021	0.81
Africa	Cameroon	2021	1.24

Data Merging

Since we need to merge three tables together, we should first merge two tables and then merge the other one.

Firstly, we will merge the homicides table with alcohol table first with the "Location", "Period", "Sex", "ParentLocation" columns and then merge with the medical doctors table with "Location", "Period", and "ParentLocation" columns to get the new table called "met2".

Then, we need to change the column names to the corresponding names of the values.

After merging, the merge table reduced the number of countries and years, and we found out that some countries' data is not complete from 2000 to 2019 so we removed these countries and only kept those that have complete data from 2000 to 2019. The resulting data has only 40 countries from different continents left, and is called met_40.

Location	Period	ParentLocation	Sex	Homicides_value	Alcohol_numeric	doctor_num
Australia	2010	Western Pacific	Female	0.88	6.14	33.64
Australia	2011	Western Pacific	Female	0.89	5.95	33.14
Australia	2014	Western Pacific	Male	1.39	16.72	34.50
Australia	2012	Western Pacific	Male	1.77	17.64	33.11
Australia	2013	Western Pacific	Male	1.39	17.16	33.74
Australia	2013	Western Pacific	Female	0.82	5.58	33.74

We found out that some of the Asian countries such as China and Korea were mislabeled to Western Pacific by the WHO, so we manually changed their continent label.

After we performed the above cleaning step, there are Asian countries present in the dataset.

From the table below, we can see that there are six continents/regions with 40 countries in the merged dataset met_40. Europe has the most number of countries (29) and most of the other parent locations have 2-3 countries.

ParentLocation	Total_Countries
Africa	2
Americas	2
Asia	2
Eastern Mediterranean	2
Europe	29
Western Pacific	3

Data Exploration

After the data is cleaned and merged together, we can start to explore the data and plot the histogram for variables of interest and important values. The three histograms below demonstrate the values of the three important variables that we would like to use.

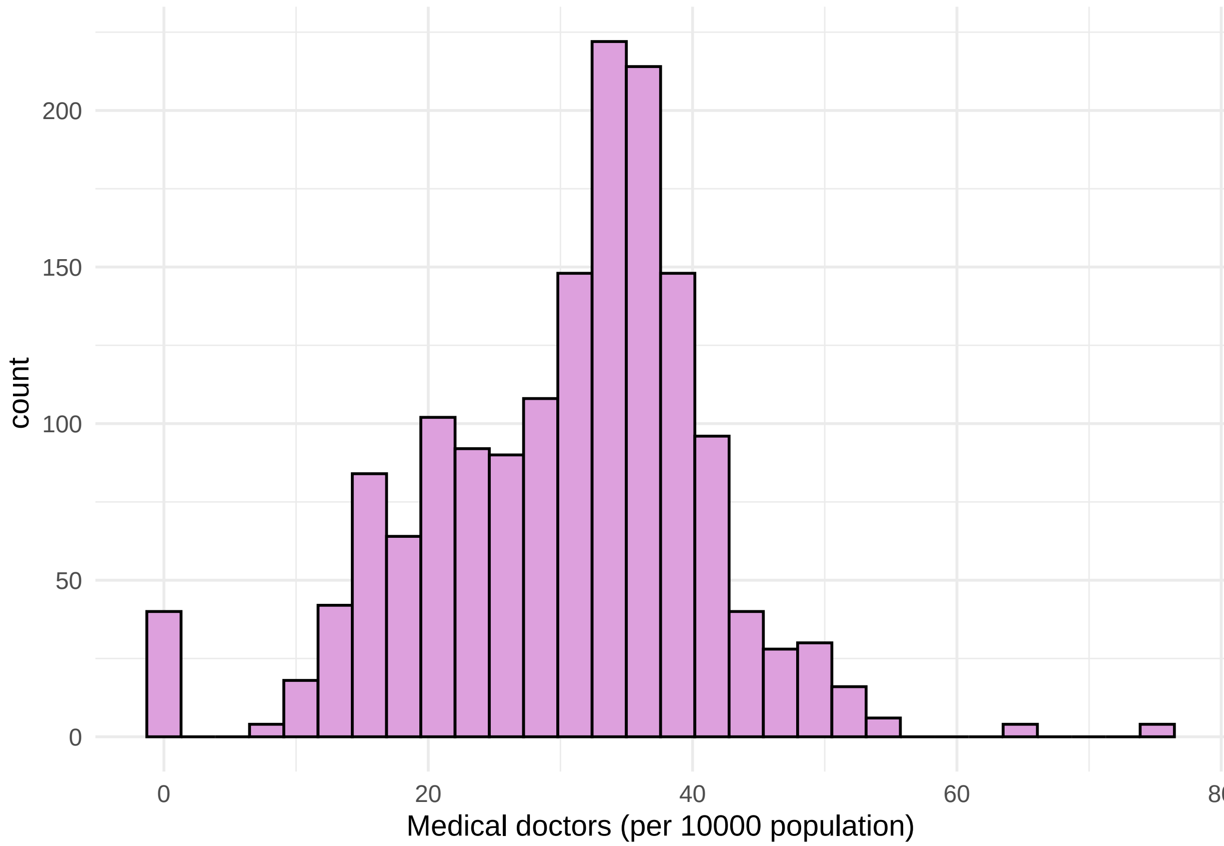
The first histogram(refer to Figer 1 in website) shows the frequency distribution of the estimate of rate of homicides (per 100,000 population) by different categories of sexes over all countries in every year from 2000 to 2019.

This animated histogram shows the homicides value in different countries in each year. In this animated histogram, there is a consistent right tail, and as the rates of homicides increase, the number of countries having the female homicides rate equal to this rate decreases, and most countries have the estimated rates of homicide in range [0, 5]. The minimum homicides rate value estimate in the met_40 is 0.003. Since the rate of homicides in some counties is too small and very close to zero, the histogram counts many countries in bin close to zero, but these are not the absolute zero values.

The second histogram(refer to Figure 2 in website) shows the frequency of the total alcohol assumption in liters per captia by different sexes over all countries in each year from 2000 to 2019.

From the above animated histogram, the estimate of alcohol consumption of females in each year is more concentrately distributed, and the estimate of alcohol consumption of male in each year is more spread out. The number of countries with estimate female alcohol consumption in range [0, 10] is higher than that of male alcohol consumption. However, in the range beyond 10 liters per capita, there are more countries with estimated male alcohol consumption equal to this rate compared with estimated female alcohol consumption.

The third histogram show the Medical doctors (per 10000 population) over all countries in each year from 2000 to 2019.



Form the above histogram, the plot of the medical doctors(per 10000 population) is symmetric and unimodal. Majority of the countries have 20-40 medical doctors per 10000 population and very few countries have less than 10 or more than 50 medical doctors per 10000 population.

Preliminary Results

The key question that we are interested in is if there is a correlation between the rate of homicide and the number of medical doctors together with alcohol consumption level in each country from 2000 - 2019.

We can analyze the data in two ways. Firstly, we can compare all data points collected in the same year for different countries around the globe. This analysis can help us understand whether homicide rates is correlated with the number of medical doctors in the same year in various countries.

The table below summarizes the mean and standard devication of the estimates of homicide cases, alcohol consumption, and the number of medical doctors across all countries in each year. We will use the mean values of estimates of homicide cases, alcohol consumption, and the number of medical doctors across all countries to understand the relationship between these three variables.

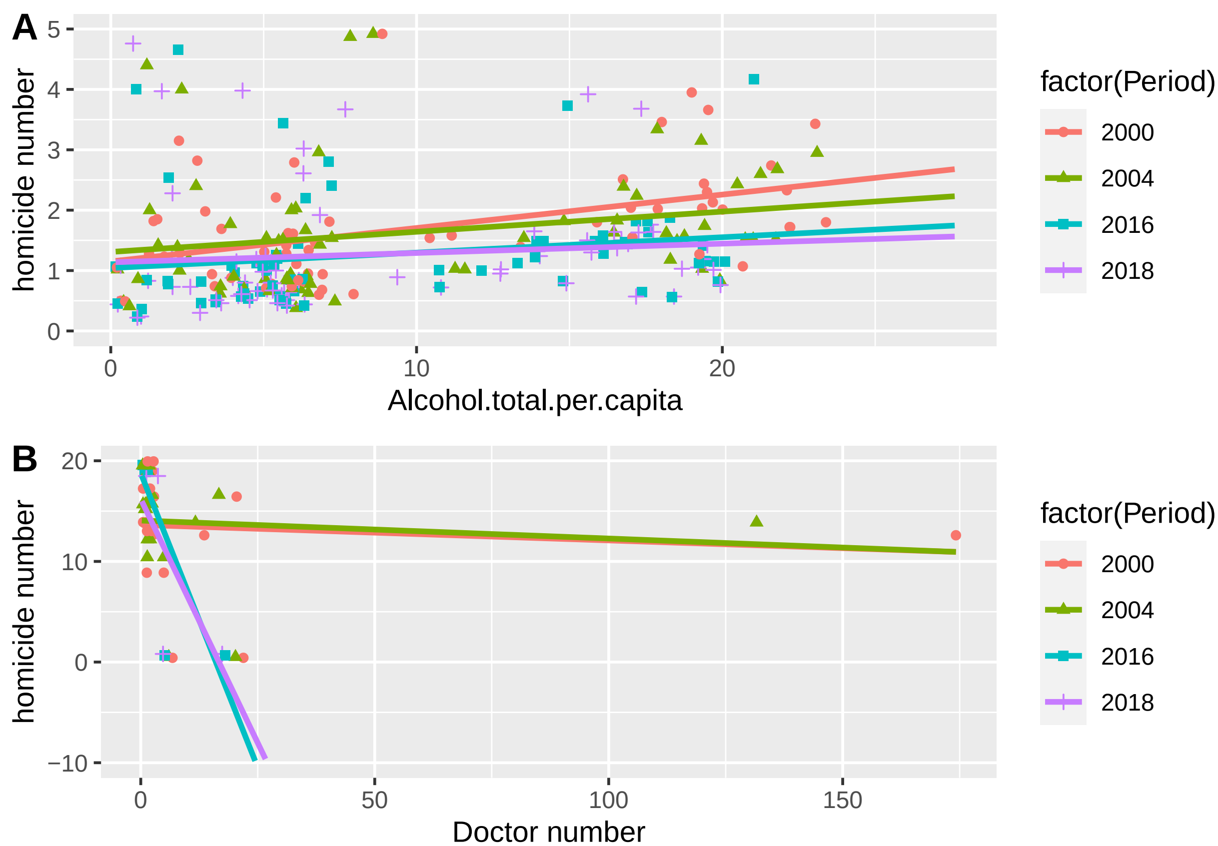
Period	mean_homicides	sd_homicides	mean_alcohol	sd_alcohol	mean_doctor	sd_doctor
2000	6.773125	20.431623	9.827625	7.438127	26.19575	9.693731
2001	6.846625	20.869130	9.827625	7.438127	26.51025	9.698075
2002	6.798625	21.406288	9.774375	7.410412	26.90450	9.855484
2003	6.020500	16.871013	9.798875	7.419781	27.33025	9.877903
2004	5.658250	15.780549	9.857375	7.422888	28.08400	9.984940
2005	5.355250	13.576778	9.984750	7.480996	28.43375	10.170166
2006	5.119250	13.328287	10.022500	7.471207	28.97975	10.345343

Period	mean_homicides	sd_homicides	mean_alcohol	sd_alcohol	mean_doctor	sd_doctor
2007	4.686500	12.376961	9.939500	7.433821	29.48650	10.418888
2008	4.725500	12.697525	9.663375	7.243034	30.02450	10.356815
2009	4.860625	14.398560	9.427375	7.033945	30.35650	10.480726
2010	4.694913	13.900324	9.301375	6.905815	30.69125	10.674367
2011	4.613875	13.074207	9.296500	6.897100	30.86375	10.294248
2012	4.315125	12.426179	9.232750	6.869188	31.13350	10.228461
2013	4.044000	11.573586	9.150375	6.810679	31.70275	10.055729
2014	3.726750	10.660572	9.117625	6.755246	32.23825	9.956507
2015	3.633750	10.096940	9.121000	6.712349	32.68800	9.971477
2016	3.577625	9.971703	9.056625	6.598502	33.35450	10.902363
2017	3.642125	10.042360	8.985500	6.487067	34.10950	10.816740
2018	3.454625	9.678705	8.944500	6.441333	34.85250	11.796345
2019	3.371000	9.488201	8.944500	6.441333	35.76250	11.699179

The plot below contains information of the change of the mean estimate of homicide cases, mean alcohol consumption and mean number of medical doctors over all countries from year 2000 to 2019.

From the plots in website(refer to Figure4, Figure5, Figure6), we can observe that both the mean estimate of rates of homicide, the mean alcohol consumption values and the average number of doctors in each country are fairly consistent over the years from 2000 to 2019. The mean estimate of rates of homicide as well as the mean estimate of the rate of alcohol consumption decrease over the years while the average number of doctors (per 10000) in each country increases. From this plot, we can see that the rate of homicide and rate of alcohol consumption might have a positive correlation, whilethe rate of homicide and the number of medical doctors (per 10000) might be negatively correlated. However, we cannot correctly judge whether alcohol consumption values and number of medical doctors are correlated with the number of homicide cases.

So we zoom in in to more specific year 2000, 2009, 2016, and 2018



That is why we need to focus on specific years and analyze if there is a trend between the number of homicide cases estimated and the number of medical doctors or alcohol consumption levels in different countries. Instead of using the mean value of the data points, we will analyze using individual data points collected for each country in these specific years.

The plot A above demonstrates the relationship between the number of alcohol consumption per capita in each country and the number of homicide cases for the years 2000, 2004, 2016, 2018. From the plot, we can see that in all four years, the country with higher alcohol consumption level corresponds to a higher homicide case number estimate, and we can infer that the number of homicide cases is positively correlated with the number of alcohol consumption per capita of each year.

The plot B above demonghstrates the relationship between the number of medical doctors in each country and the number of homicide cases for the years 2000, 2004, 2016, 2018. From the plot, we can see that in all four years, the country with higher number of medical doctors has a lower homicide rate estimate, especially in the year 2016 and 2018 there are steep negative relationships between the number of medical doctors and the homicide rate estimate. From this plot, we can infer that the rate of homicide is negatively correlated with the number of alcohol consumption per capita of each year.

Both observations from the two plots align with our intuition.

The second way to fit a data model in the merged data set is to first build a model on the estimate rate of the homicide cases. Then, after finding a fittable model, we can test the accuracy of the model in one specific country over the years from 2000 to 2019.

```
## Analysis of Variance Table
##
## Model 1: Homicides_value ~ doctor_num
## Model 2: Homicides_value ~ Alcohol_numeric + doctor_num
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
```

```
## 1   1598 308510
## 2   1597 303161  1    5349.3 28.179 1.261e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Alcohol_numeric      doctor_num
##        1.087408        1.087408
```

From the ANOVA table we find out that the F-statistic is 28.179 and p-value is 1.261e-07. We found out that there is a small p-value and a large F value, so we can adopt the model 2. Also from the code above, all VIF factors are 1.087 which are less than 5, so there is no multicollinearity. Hence we will use the full model on specific countries to test the model accuracy.

```
##
## Call:
## lm(formula = Homicides_value ~ Alcohol_numeric + doctor_num,
##     data = Korea)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.30049 -0.08934  0.01125  0.06537  0.31713
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.334678   0.159508   14.64  < 2e-16 ***
## Alcohol_numeric  0.065464   0.004588   14.27  < 2e-16 ***
## doctor_num      -0.085848   0.007243  -11.85 3.67e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1528 on 37 degrees of freedom
## Multiple R-squared:  0.9241, Adjusted R-squared:   0.92
## F-statistic: 225.4 on 2 and 37 DF,  p-value: < 2.2e-16
```

```
##
## Call:
## lm(formula = Homicides_value ~ Alcohol_numeric + doctor_num,
##     data = spain)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.44959 -0.07930  0.01418  0.11683  0.40312
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      3.21171    0.37316   8.607 2.32e-10 ***
## Alcohol_numeric  0.05716    0.00491  11.641 6.23e-14 ***
## doctor_num      -0.08047    0.01002  -8.034 1.25e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2024 on 37 degrees of freedom
## Multiple R-squared:  0.8484, Adjusted R-squared:  0.8402
## F-statistic: 103.5 on 2 and 37 DF,  p-value: 6.971e-16
```

From the summary of the model for country Korea, we can see the R-squared is 92.41% and for the country Spain, we can see that the R-squared is 85%, which are both very high and implies that the prediction accuracy would be very high.

Conclusions

In this report, our primary guiding question was to analyze whether there is a correlation between how many estimated homicide rate in a country in a specific year for each sex and the number of medical doctors per 10,000 population in that country in that year together with estimated rate of alcohol consumption per capita for each sex in that country and year.

Based on the histogram, line chart and scatter plot computed in the previous sections, we can see that in a given country and a given year for each sex, the rate of homicide in that country and in that year of the given sex is correlated with the number of medical doctors per 10,000 population in the country together with the estimated rate of alcohol consumption per capita of a certain sex in the country and year.

Limitations

The most noticeable limitation of this research project is that the results of this project relies on the representativity of the data collected for each country in each year. After we performed data merging, the size of the dataset becomes small with only a few countries for each continent, which makes it hard for us to understand whether the above conclusion is a universal phenomenon across the world or problems for a few countries in the world.

Future Steps

One of the future steps that we can take after completing this report is to gather additional data so that we can conduct more in-depth analysis on the correlation between the estimated rate of homicide cases and a country's medical capabilities. Currently, we only have the data for the number of medical doctors, which is only one indicator of a country's overall medical capabilities, and we can collect data related to health infrastructure such as the number of hospitals and clinics, as well as the number of high technological equipment.

Additionally, other factors of social security and stability besides the number of homicide cases such as other crime and violence case rates, and preparedness of the country for violence and crimes.