2015 Multinational Healthcare Analysis

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The Data

The data utilized in this analysis was downloaded from a World Health Statistics Dataset. More specifically, the following datasets were downloaded and imported:

- lifeExpectancyAtBirth.csv
- infantMortalityRate.csv
- crudeSuicideRates.csv
- uhcCoverage.csv
- population10%SDG3.8.2.csv

These datasets coverered the most recent health statistics in countries recognized by the WHO. I imported and cleaned these datasets for readability, while removing NA values and replacing the NA values with 0 in the *population10%SDG3.8.2.csv* dataset. I then merged these datasets into a singular, meta-dataset. Lastly, I wrangled this meta-data to represent the following variables per country in 2015 in order for consistent analyses: healthcare expenses, infant mortality rates, life expectancy rates, suicicde rates, and a Universal Healthcare Index. The first five lines of the data can be seen below:

```
head(all_data)
```

```
## # A tibble: 6 x 6
##   Location    pop_high_costs infant_mortality life_expectancy suicide_rate   uhc
##   <chr>                <dbl>            <dbl>           <dbl>        <dbl> <dbl>
## 1 Belarus               7.78             3.04            73.8         26.3    74
## 2 Bolivia (P~           6.02            25.1             71.5         12.4    64
## 3 Bosnia and~           8.18             5.42            76.3          8.9    60
## 4 Ethiopia              4.91            43.1             66.8          7.2    39
## 5 Gambia                0.2             39.8             64.1          5.2    45
## 6 Indonesia             3.61            23.3             70.6          3.4    53
```

The distribution of the variables can be seen below:

```
summary(all_data)
```

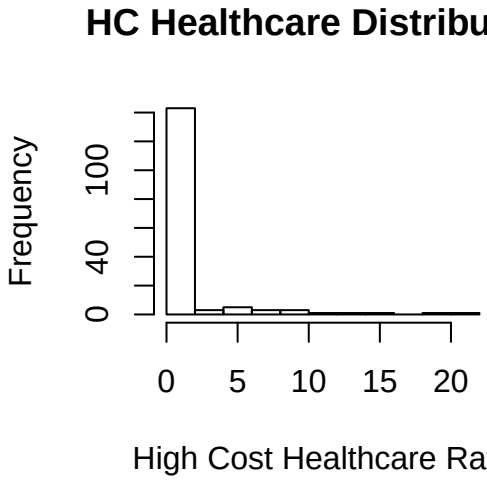
```
##    Location         pop_high_costs    infant_mortality life_expectancy
##  Length:162         Min.   : 0.0000   Min.   : 1.760   Min.   :47.67
##  Class :character   1st Qu.: 0.0000   1st Qu.: 6.535   1st Qu.:65.09
##  Mode  :character   Median : 0.0000   Median :14.525   Median :73.03
##                     Mean   : 0.9686   Mean   :23.541   Mean   :71.65
```

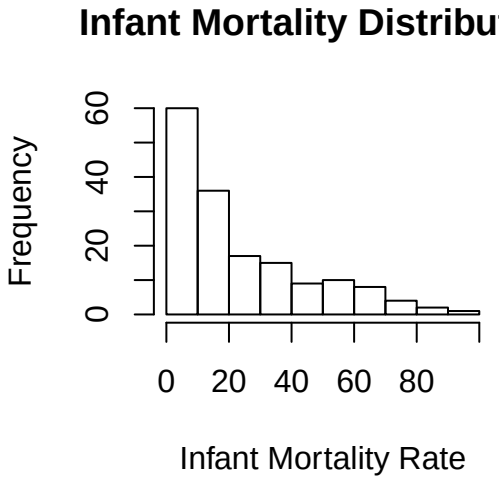
```
##                     3rd Qu.: 0.0000   3rd Qu.:35.665   3rd Qu.:77.38
##                     Max.   :21.7800   Max.   :94.170   Max.   :83.62
##   suicide_rate         uhc
##  Min.   : 0.700   Min.   :22.00
##  1st Qu.: 4.800   1st Qu.:49.00
##  Median : 8.100   Median :66.50
##  Mean   : 9.418   Mean   :62.63
##  3rd Qu.:12.475   3rd Qu.:75.00
##  Max.   :34.900   Max.   :88.00
```

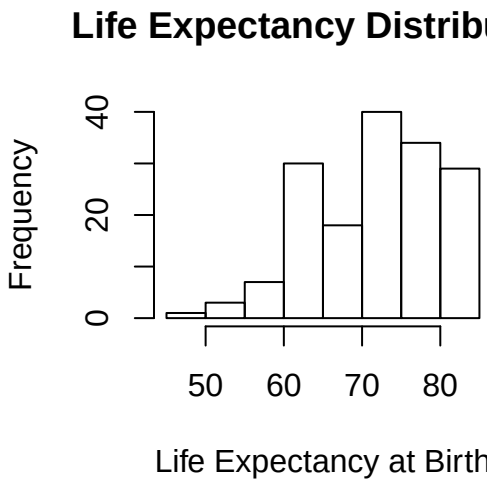
Variable Explanation

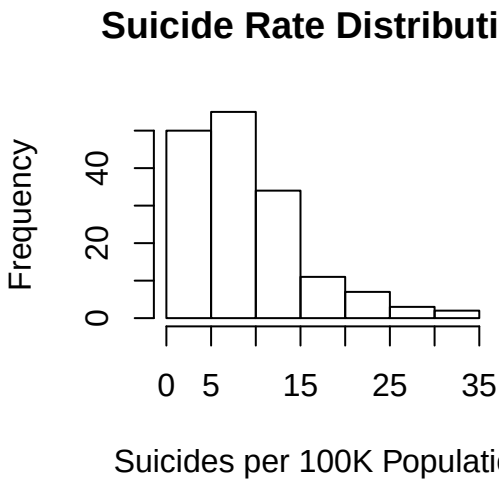
- pop_high_costs: Percent of country's population with healthcare costs > 10% of household expenses or income.
- infant_mortality: Probability of dying between birth and age 1 per 1000 live births for a single country.
- life_expectancy: A country's life expectancy at bith.
- suicide_rate: Suicides per 100k population for a single country.
- uhc: A country's Universal Healthcare Index is an indicator reported on a 0 to 100 scale that represents a country's ability to achieve universal health coverage including financial risk protection and access to quality healthcare services and essential, affordable medicines.

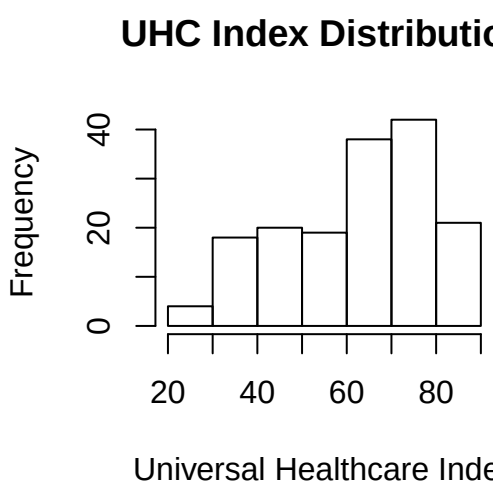
Histograms of Each Variable











Data Takeaways

- 162 countries were included in this meta-dataset. Some were removed due to missing data.
- Only 20 countries had non-zero values for population with healthcare costs $> 10\%$ of household expenses or income, which caused the variable to be positively skewed.
- The average number of suicides per 100k people across all countries included in the data is 9.4.
- The average infant mortality and life expectancy rates seem to be standard.
- Infant mortality and suicide rate are positively skewed, while life expectancy and Universal Healthcare Index are negatively skewed.

Top and Bottom 5 Countries for Each Variable

5 Countries with the Highest Percent of Households with High Healthcare Costs

```
## # A tibble: 5 x 2
##   Location            pop_high_costs
##   <chr>                        <dbl>
## 1 Republic of Korea             21.8
## 2 Republic of Moldova           18.5
## 3 Myanmar                       14.4
## 4 Poland                        13.7
## 5 Montenegro                    10.3
```

Top and Bottom 5 Countries with the Highest and Lowest Infant Mortality Rates

```
## # A tibble: 5 x 2
##   Location                 infant_mortality
##   <chr>                               <dbl>
## 1 Sierra Leone                         94.2
## 2 Central African Republic             89.7
## 3 Somalia                              82.8
## 4 Nigeria                              79.5
## 5 Chad                                 76.1
```

```
## # A tibble: 5 x 2
##   Location  infant_mortality
##   <chr>                <dbl>
## 1 Iceland               1.76
## 2 Japan                 2.01
## 3 Slovenia              2.01
## 4 Finland               2.03
## 5 Singapore             2.18
```

Top and Bottom 5 Countries with Highest and Lowest Life Expectancy

```
## # A tibble: 5 x 2
##   Location    life_expectancy
##   <chr>                 <dbl>
## 1 Japan                  83.6
## 2 Singapore              82.8
## 3 Switzerland            82.6
## 4 Spain                  82.3
## 5 Luxembourg             82.3
```

```
## # A tibble: 5 x 2
##   Location                 life_expectancy
##   <chr>                              <dbl>
## 1 Lesotho                             47.7
## 2 Central African Republic            50.5
## 3 Eswatini                            54.0
## 4 Somalia                             54.6
## 5 Mozambique                          56.0
```

Top and Bottom 5 Countries with Highest and Lowest Suicide Rates

```
## # A tibble: 5 x 2
##   Location           suicide_rate
##   <chr>                     <dbl>
## 1 Lithuania                  34.9
## 2 Russian Federation         32.1
## 3 Guyana                     29.1
## 4 Republic of Korea          28.3
## 5 Belarus                    26.3
```

```
## # A tibble: 5 x 2
##   Location             suicide_rate
##   <chr>                       <dbl>
## 1 Barbados                      0.7
## 2 Antigua and Barbuda           0.8
## 3 Grenada                       1.1
## 4 Bahamas                       1.8
## 5 Syrian Arab Republic          1.9
```

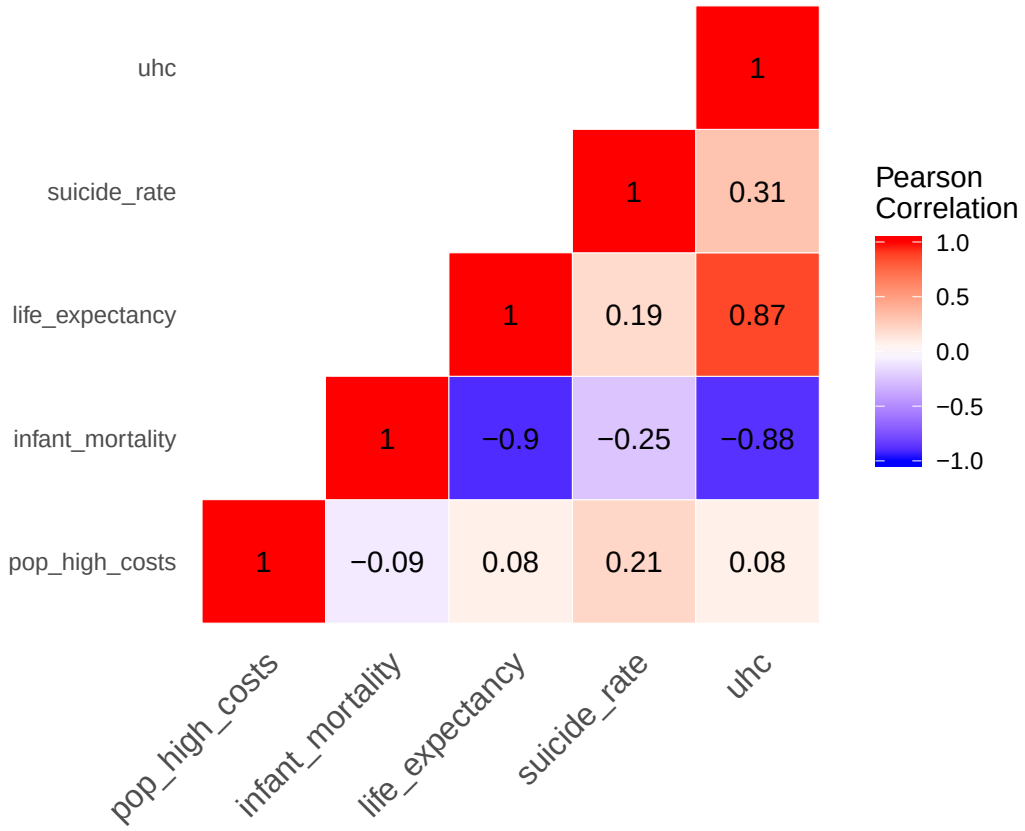
Top and Bottom 5 Countries with Highest and Lowest UHC Index

```
## # A tibble: 9 x 2
##   Location            uhc
##   <chr>             <dbl>
## 1 Canada               88
## 2 Australia            86
## 3 Norway               86
## 4 Republic of Korea    85
## 5 Iceland              85
## 6 Netherlands          85
## 7 New Zealand          85
## 8 Singapore            85
## 9 Sweden               85
```

```
## # A tibble: 5 x 2
##   Location                   uhc
##   <chr>                    <dbl>
## 1 Somalia                     22
## 2 Madagascar                  24
## 3 Chad                        27
## 4 South Sudan                 30
## 5 Central African Republic    32
```

Correlation Matrix

The below matrix delineates the Pearson's r correlation value between each of the continuous variables.



Discussion

We can see that there are high r values for the relationships between *life expectancy and infant mortality*, *Universal Healthcare Index and infant mortality*, and *Universal Healthcare Index and life expectancy*. This is to be expected, as better healthcare coverage will lead to lower infant mortality and higher life expectancy. There are also moderate relationships between *suicide rates and Universal Healthcare Index* and *suicide rates and infant mortality*. In the next section, we will examine the relationship on a deeper level between some of these variables through the construction of a couple of linear regression models.

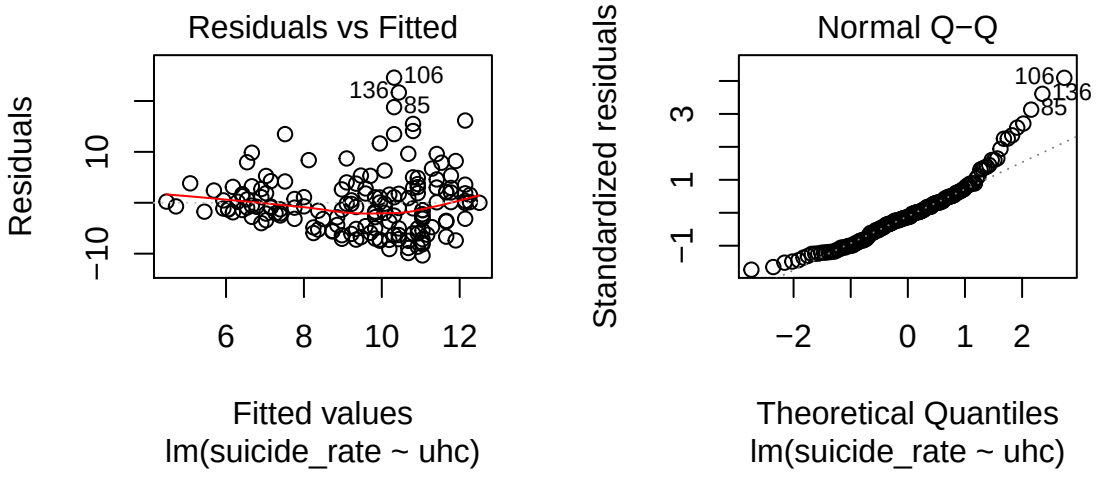
Linear Regression Analysis

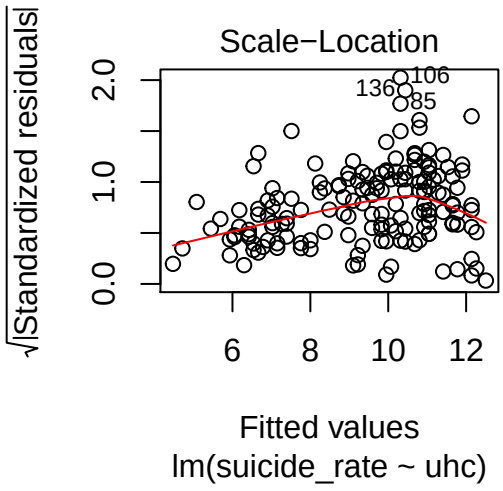
Assessing the Relationship Between Suicide Rate and UHC: Does UHC Index Predict Suicides?

We can see from the below regression model output that UHC Index is a significant predictor of suicide rate.

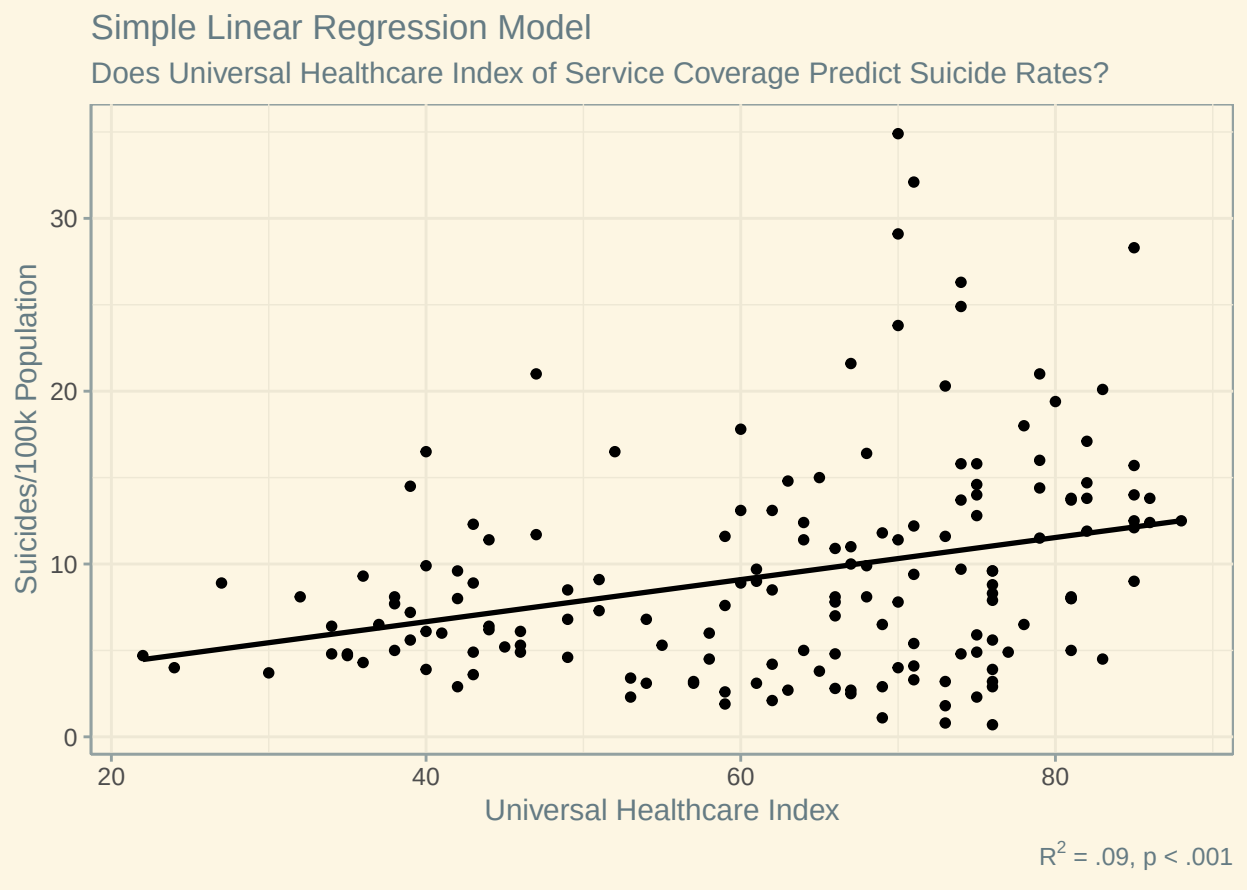
```
##
## Call:
## lm(formula = suicide_rate ~ uhc, data = all_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.3456  -3.9282  -0.7674   2.6761  24.5849
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.79356    1.91909   0.935    0.351
## uhc          0.12174    0.02969   4.100 6.57e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6.026 on 160 degrees of freedom
## Multiple R-squared:  0.09506,    Adjusted R-squared:  0.0894
## F-statistic: 16.81 on 1 and 160 DF,  p-value: 6.567e-05
```

The below plots assess the assumptions of the regression model. The first plot asseses the linearity assumption, the second plot asseses the normality assumption, and the third plot asseses the homogeneity of variance assumption. We can see there might be an issue with homogeneity of variance, which will we address further.





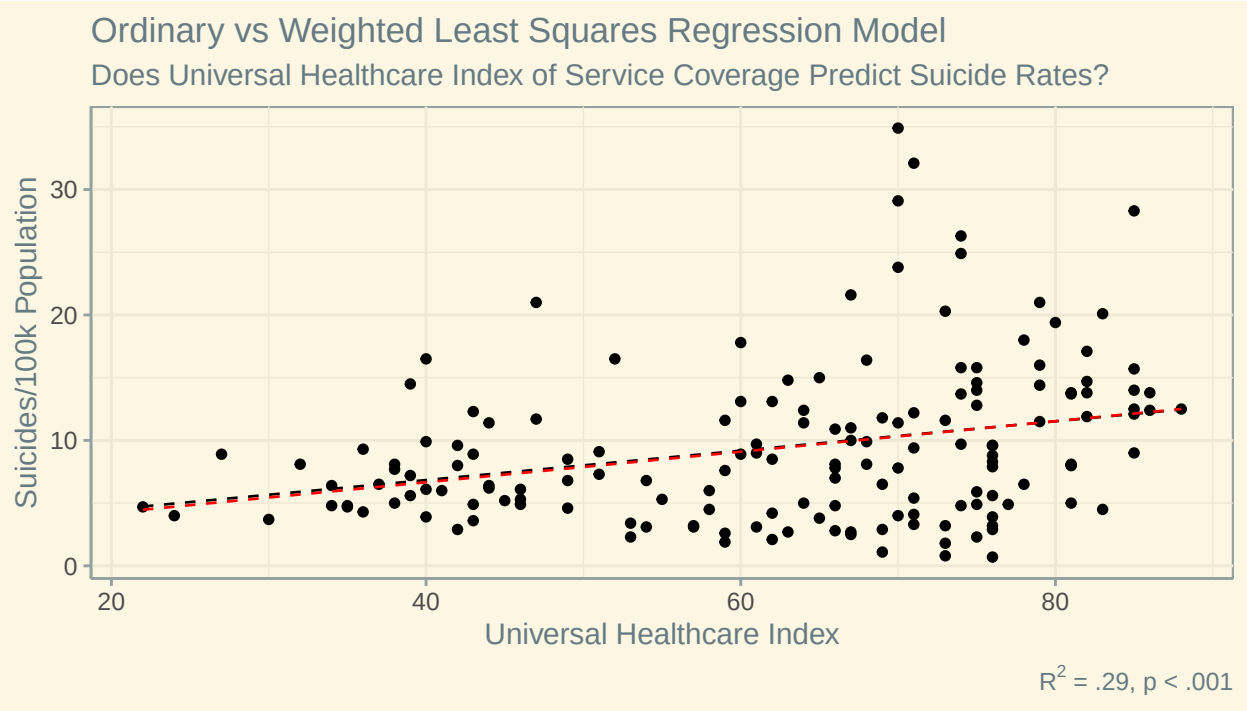
The below plot visualizes the regression model. We can see that, on average, as UHC Index increases, so does suicide rate. The R-squared value is small, but the relationship is significant.



Because there may be an issue with homogeneity of variance, a better approach might be to build a weighted least squares regression model. Weights were created for the residuals, and the output of the model can be seen below.

```
##
## Call:
## lm(formula = suicide_rate ~ uhc, data = all_data, weights = lm_weights)
##
## Weighted Residuals:
##      Min       1Q   Median       3Q      Max
## -0.30426 -0.13009 -0.03088  0.07113  0.62679
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  2.15580    0.46840   4.602 8.46e-06 ***
## uhc          0.11712    0.01433   8.172 8.69e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1783 on 160 degrees of freedom
## Multiple R-squared:  0.2945, Adjusted R-squared:  0.2901
## F-statistic: 66.79 on 1 and 160 DF,  p-value: 8.686e-14
```

Note that the predictor value is still significant, but the R-squared has increased to .29, reflecting a better fit. To visualize a comparison between the ordinary least squares regression model and the weighted lease squares regression model, we can create a plot comparing the respective models. The black dotted line represents the ordinary least squares model, and the red dotted line represents the weighted least squares model. Visually, there does not seem to be a noticable difference, but the R-squared values represent a difference in fit.

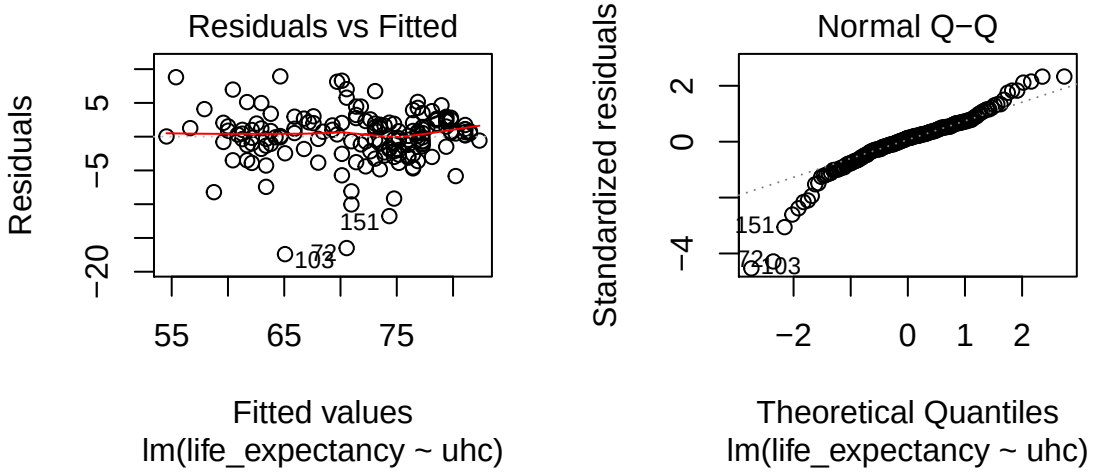


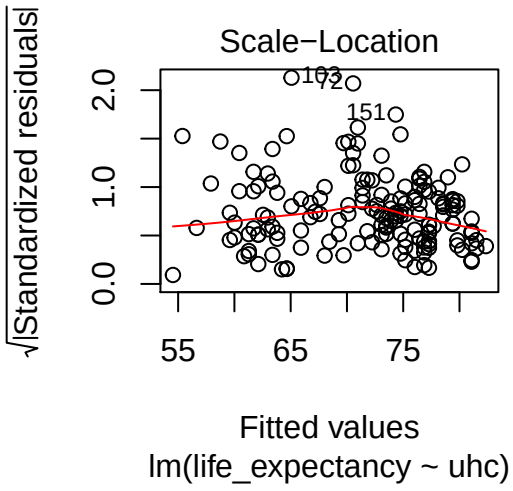
Assessing the Relationship Between UHC Index and Life Expectancy: Does UHC Index Predict Life Expectancy?

We can see from the below regression model output that UHC Index is a significant predictor of life expectancy.

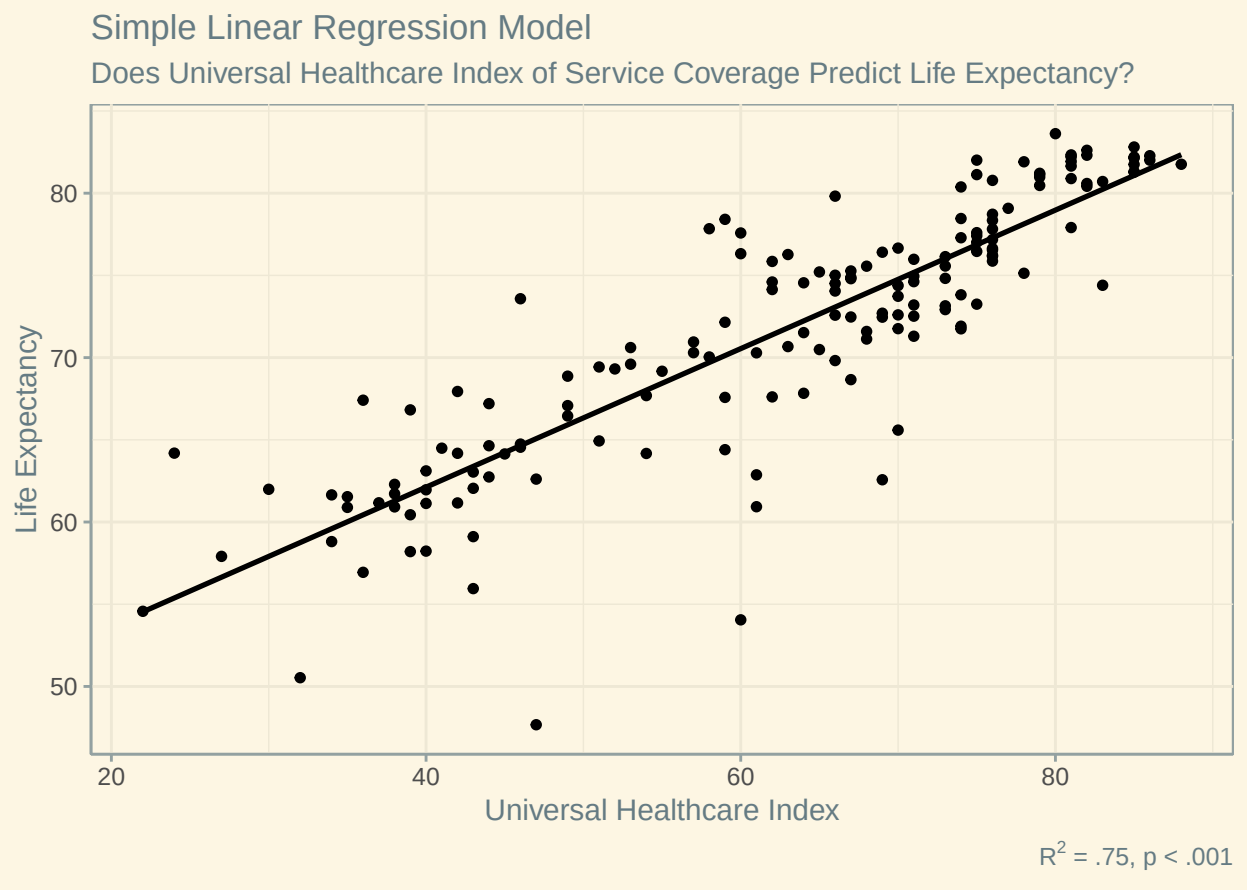
```
##
## Call:
## lm(formula = life_expectancy ~ uhc, data = all_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -17.3997  -1.4665   0.4924   2.0126   8.9316
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 45.26964    1.22994   36.81   <2e-16 ***
## uhc          0.42128    0.01903   22.14   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.862 on 160 degrees of freedom
## Multiple R-squared:  0.7538, Adjusted R-squared:  0.7523
## F-statistic:   490 on 1 and 160 DF,  p-value: < 2.2e-16
```

The below plots assess the assumptions of the regression model. The first plot asseses the linearity assumption, the second plot asseses the normality assumption, and the third plot asseses the homogeneity of variance assumption.





The below plot visualizes the regression model. We can see that, on average, as UHC Index increases, so does life expectancy. The R-squared is large, and the relationship is significant.

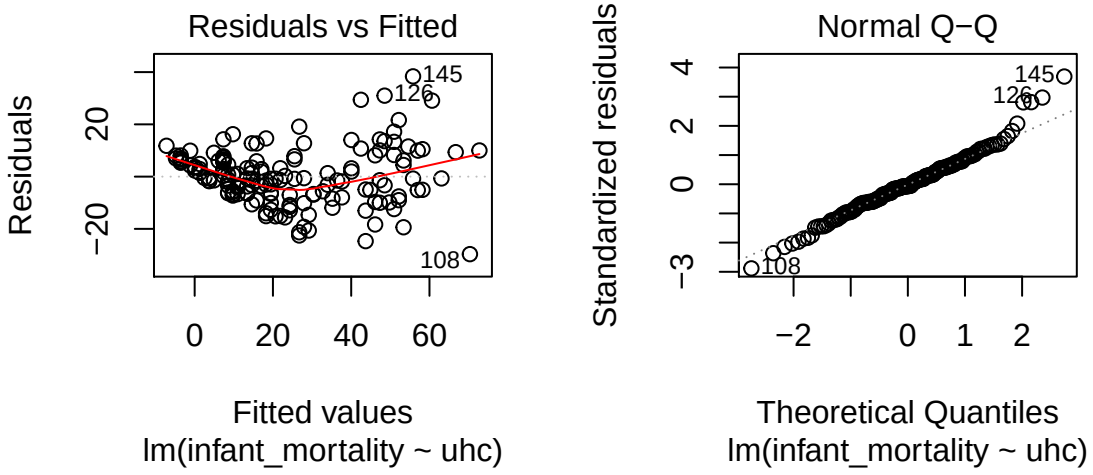


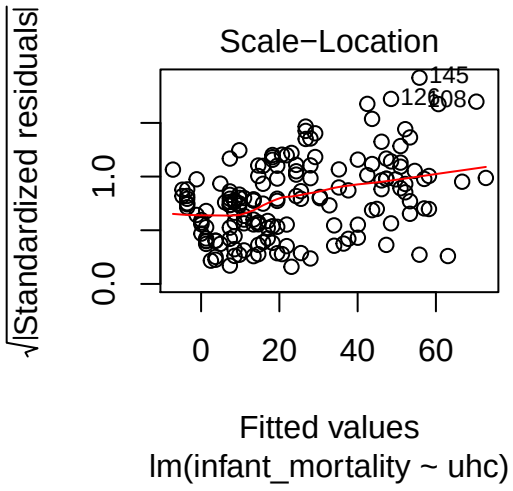
Assessing the Relationship Between UHC Index and Infant Mortality: Does UHC Index Predict Infant Mortality?

We can see from the below regression model output that UHC Index is a significant predictor of infant mortality.

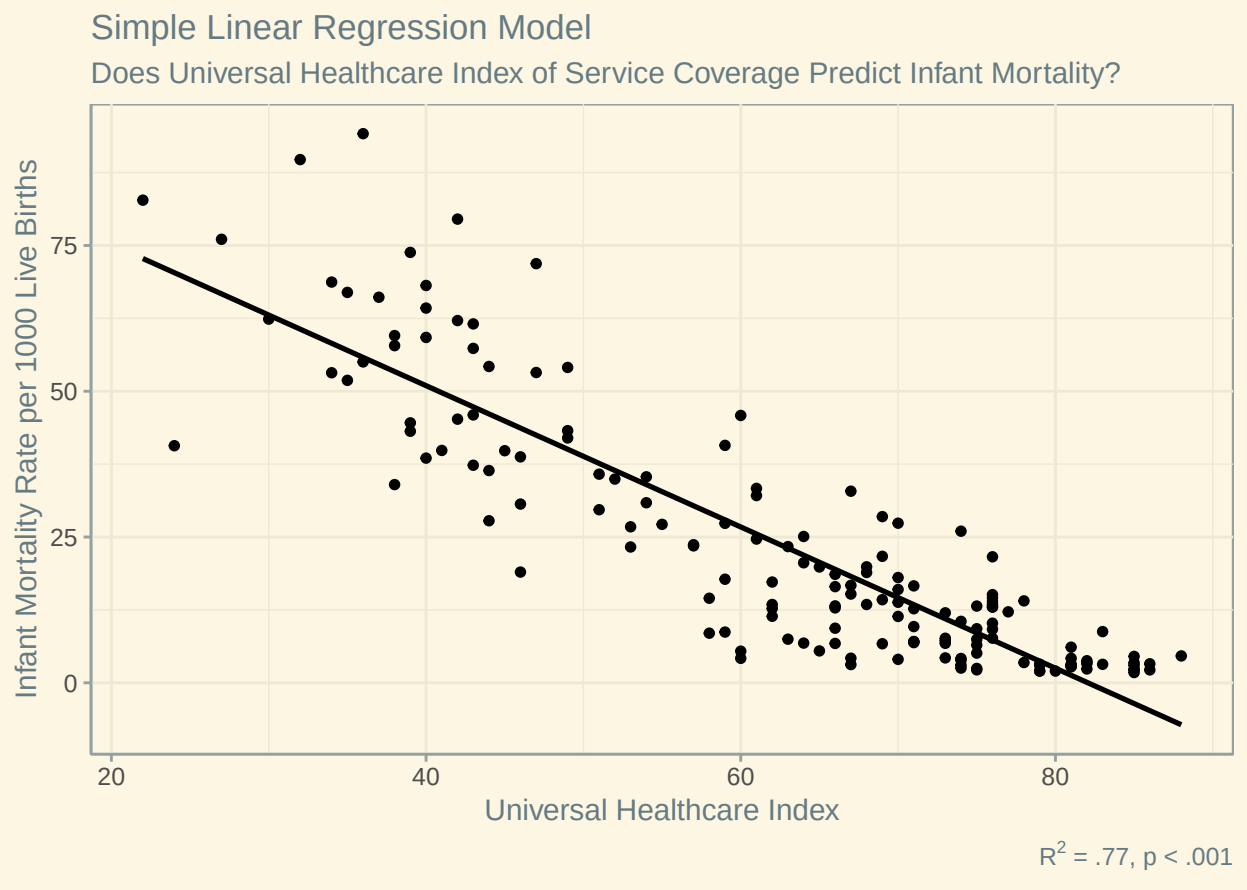
```
##
## Call:
## lm(formula = infant_mortality ~ uhc, data = all_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -29.677  -6.348  -0.680   6.080  38.370
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 99.40956    3.35024   29.67   <2e-16 ***
## uhc         -1.21138    0.05184  -23.37   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.52 on 160 degrees of freedom
## Multiple R-squared:  0.7734, Adjusted R-squared:  0.772
## F-statistic:   546 on 1 and 160 DF,  p-value: < 2.2e-16
```

The below plots assess the assumptions of the regression model. The first plot asseses the linearity assumption, the second plot asseses the normality assumption, and the third plot asseses the homogeneity of variance assumption.





The below plot visualizes the regression model. We can see that, on average, as UHC Index increases, infant mortality decreases. The R-squared is large, and the relationship is significant.



Discussion

Overall, the least squares linear regression model that measures the relationship between suicide rate and UHC index indicates that, when UHC Index increases by 1 point, suicides/100k population increase by about .12. Another way to interpret this is if UHC Index increase by 10 points, suicides/100k population increase by 12. Of course, the R-squared value in this model is only .29, so not all of the variation in UHC Index is represented in the suicides/100k population variable. However, a significant relationship still seems to be present. When thinking about why this might be, one possible explanation is that more developed countries with higher UHC indexes come with more middle class, white collar-type jobs. Moreover, a good UHC Index index does not always mean more access to affordable therapy.

The linear regression models that measure the relationships between UHC Index and life expectancy and infant mortality respectivaly are expected. Countries with more robust healthcare systems would of course be associated with higher life expectancy and lower infant mortality.

Lastly, it is important to understand that the above models have problems with the core assumptions (specifically the linear regression model that examines the relationship between). I am not endorsing any intervention based on the above findings. I'm still a beginner when it comes to statistics, so once I learn more complex skills, perhaps I can use different analyses to address the above relationships.

Future Research

Overall, I'd like to more closesly examine the relationship between suicides and a country's healthcare system by attempting to answer the following research questions:

- Are people more likely to committ suicide when their country does not provide a single-payer healthcare system?
- Are people more likely to committ suicide if their country's single-payer healthcare system does not offer free therapy?
- Is there a relationship between suicide rates and cost of therapy?