title: “ENV872 - Final” author: “Keanu Valibia” date: “2024-04-30” output: pdf_document: default html_document: df_print: paged

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Rationale and Research Questions

This data project utilizes data from the World Bank spanning child mortality rates, energy consumption, and

Dataset Information

Exploratory Analysis

```
glimpse(energyUse_mort)
```

```
## Rows: 186
## Columns: 8
## $ iso2c               <chr> "AE", "AE", "AE", "AE", "AE", "AE", "AE", "AE", "A~
## $ iso3c               <chr> "ARE", "ARE", "ARE", "ARE", "ARE", "ARE", "ARE", "~
## $ country             <chr> "United Arab Emirates", "United Arab Emirates", "U~
## $ date                <dbl> 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 19~
## $ Renewable_Consump   <dbl> 0.00, 0.00, 0.19, 0.15, 0.12, 0.11, 0.08, 0.08, 0.~
## $ Energy_Use          <dbl> 10748.655, 11694.922, 10564.510, 10576.052, 11186.~
## $ Total_GHG_Emissions <dbl> 78601.84, 87044.85, 85014.50, 89207.17, 97918.57, ~
## $ Mortality_Rate      <dbl> 16.5, 15.7, 14.9, 14.2, 13.6, 13.1, 12.6, 12.2, 11~
```

```
dim(energyUse_mort)
```

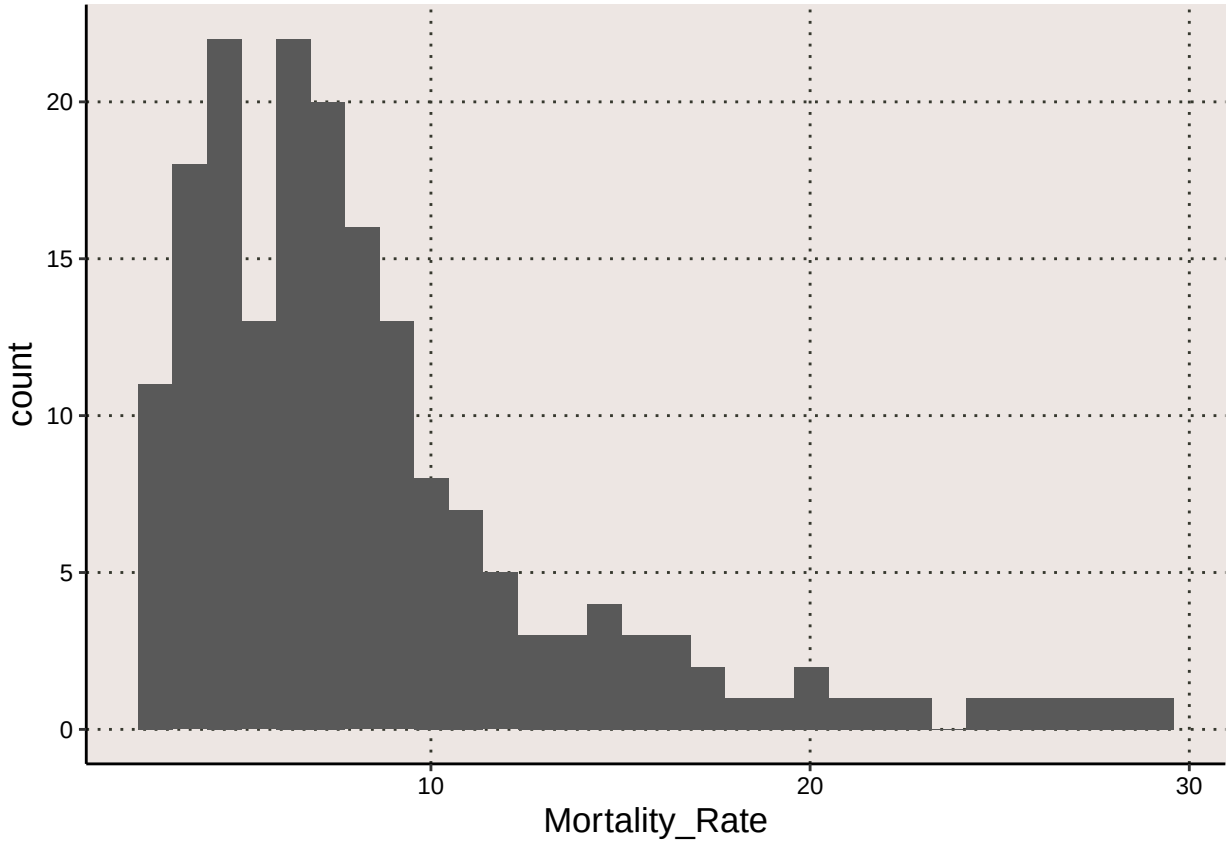
```
## [1] 186   8
```

```
summary(energyUse_mort)
```

```
##     iso2c              iso3c             country              date
##  Length:186         Length:186         Length:186         Min.   :1990
##  Class :character   Class :character   Class :character   1st Qu.:1997
##  Mode  :character   Mode  :character   Mode  :character   Median :2005
##                                                           Mean   :2005
##                                                           3rd Qu.:2013
##                                                           Max.   :2020
##
##  Renewable_Consump   Energy_Use    Total_GHG_Emissions Mortality_Rate
##  Min.   : 0.000    Min.   : 1411   Min.   :  78602     Min.   : 2.400
##  1st Qu.: 1.400    1st Qu.: 2830   1st Qu.: 328642     1st Qu.: 4.725
##  Median : 4.825    Median : 3711   Median : 520126     Median : 7.150
##  Mean   : 5.677    Mean   : 4869   Mean   :1525375     Mean   : 8.549
##  3rd Qu.: 8.805    3rd Qu.: 7662   3rd Qu.:1262850     3rd Qu.:10.025
##  Max.   :18.690    Max.   :11695   Max.   :6810656     Max.   :28.800
##                    NA's   :32
```

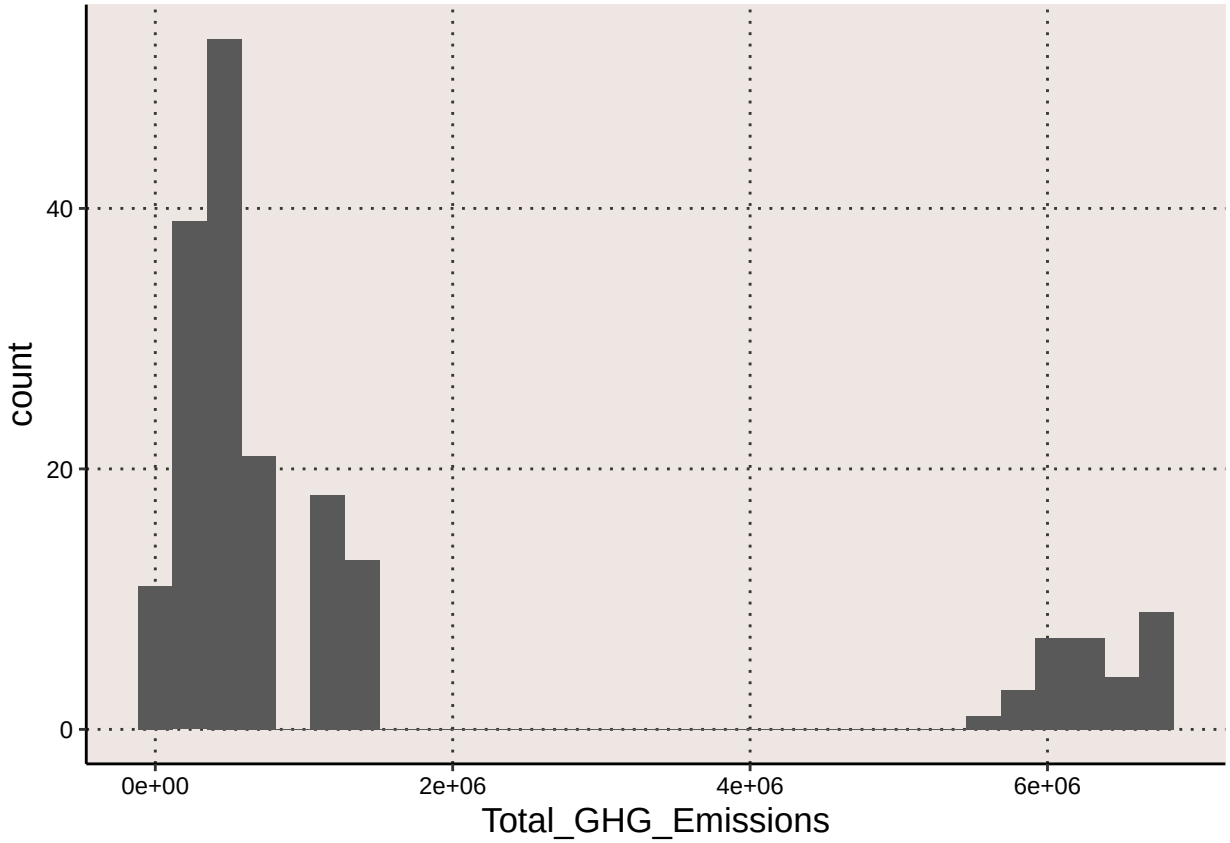
```
mortality_dist <- ggplot(energyUse_mort, aes(x = Mortality_Rate)) +
  geom_histogram()

mortality_dist
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
ghg_dist <- ggplot(energyUse_mort, aes(x = Total_GHG_Emissions)) +
  geom_histogram()

ghg_dist
```

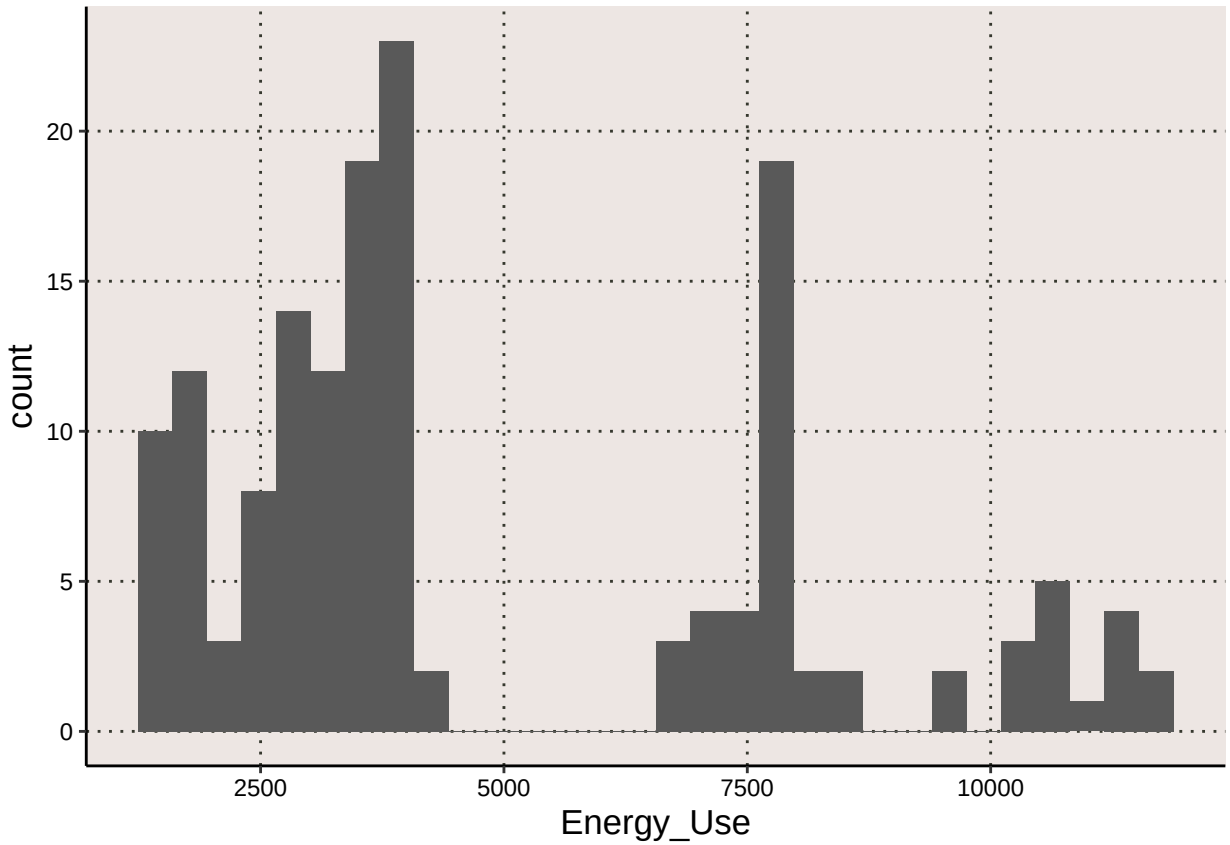
```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
EnergyUse_dist <- ggplot(energyUse_mort, aes(x = Energy_Use)) +
  geom_histogram()

EnergyUse_dist
```

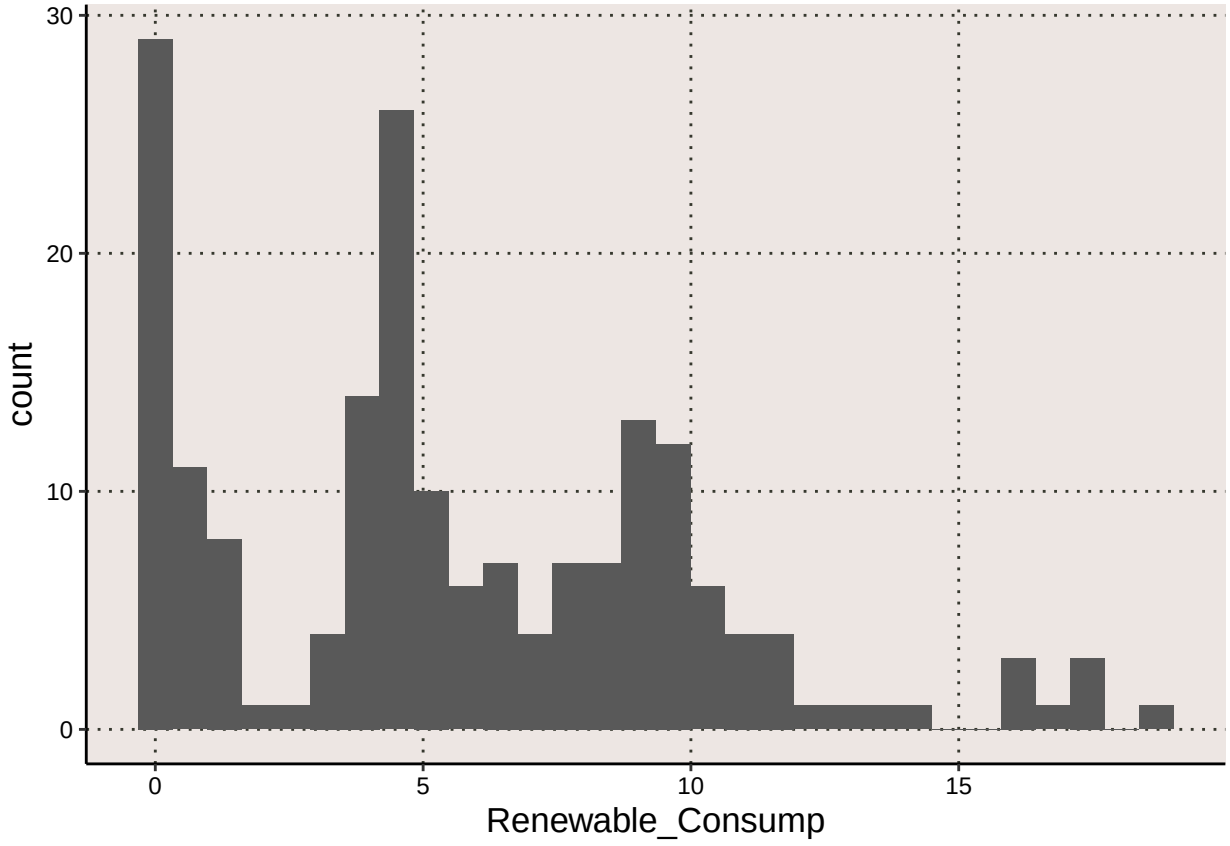
```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

```
## Warning: Removed 32 rows containing non-finite outside the scale range
## (`stat_bin()`).
```



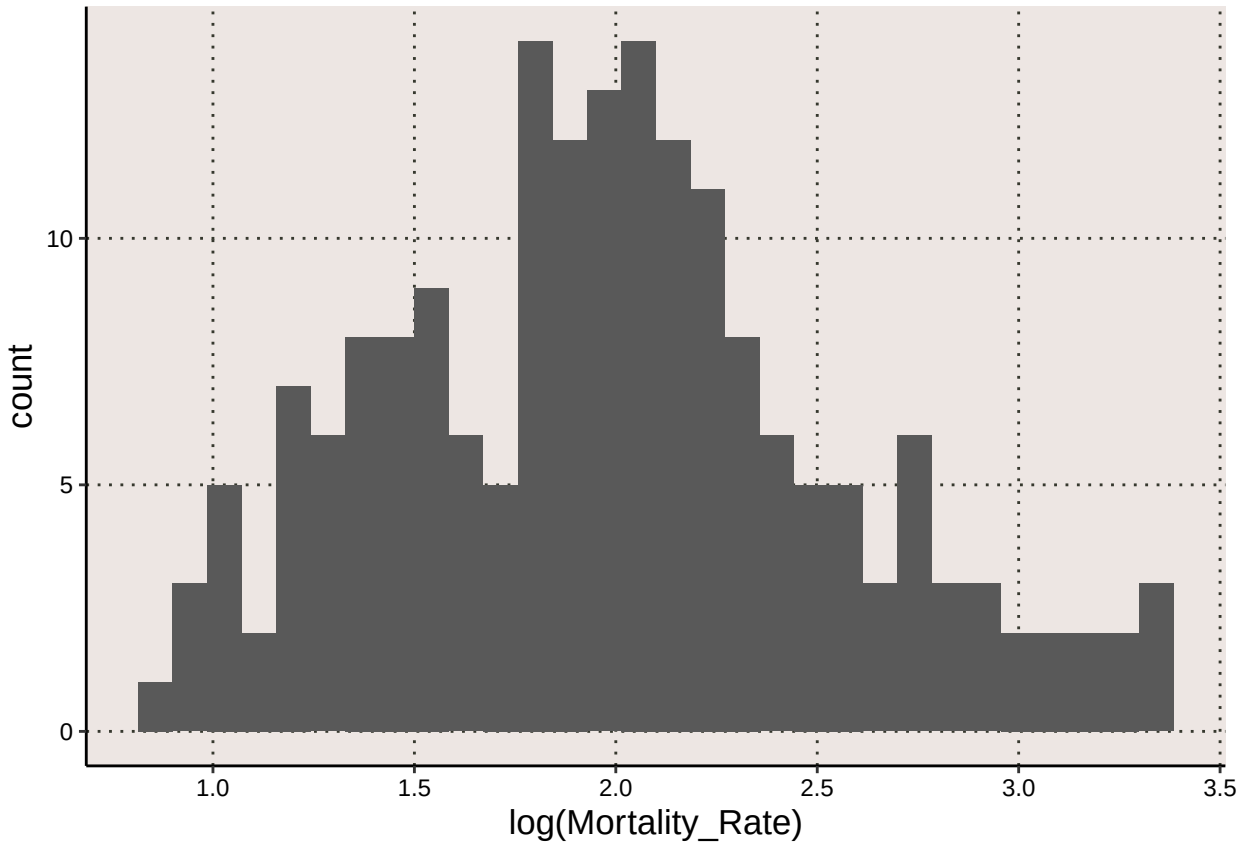

```
Renewable_Consump_dist <- ggplot(energyUse_mort, aes(x = Renewable_Consump)) +
  geom_histogram()

Renewable_Consump_dist
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



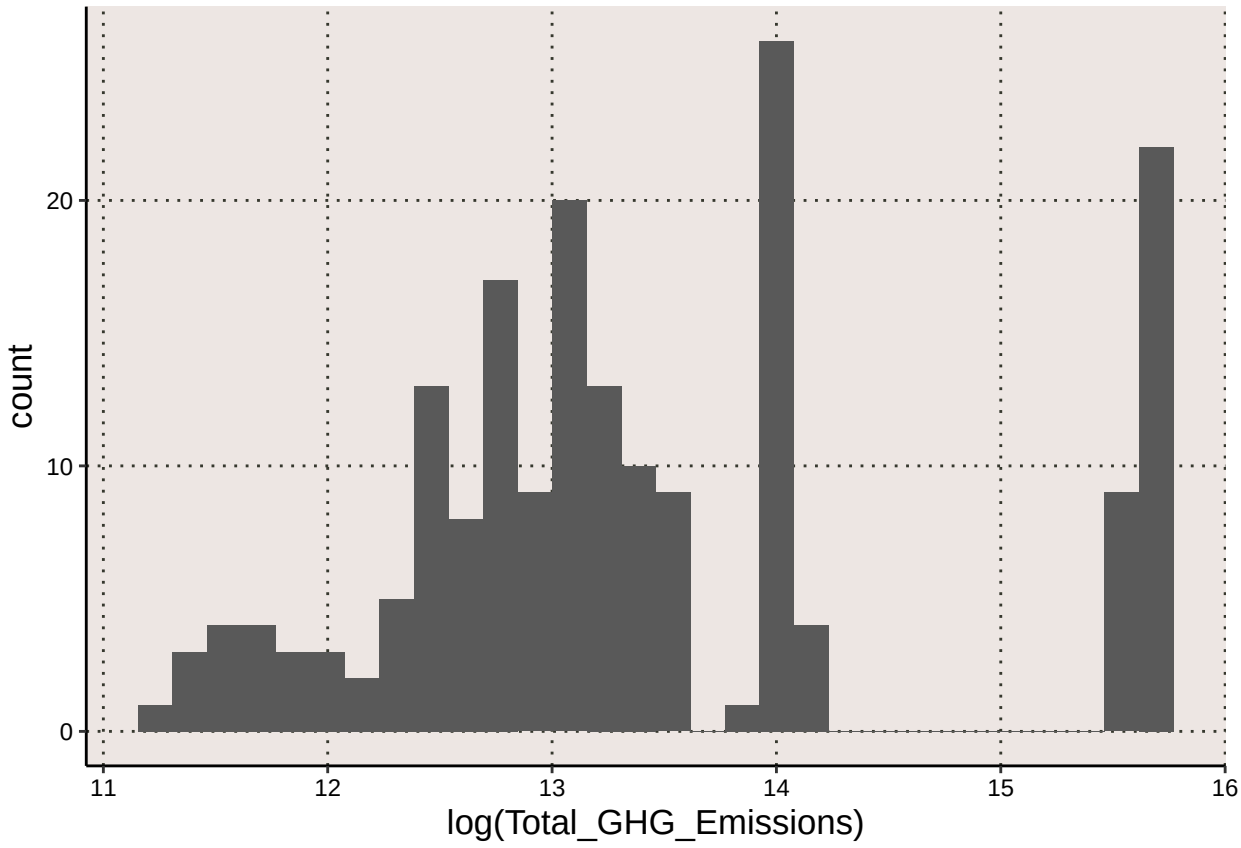

```
mortality_dist <- ggplot(energyUse_mort, aes(x = log(Mortality_Rate))) +
  geom_histogram()

mortality_dist
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
ghg_dist <- ggplot(energyUse_mort, aes(x = log(Total_GHG_Emissions))) +
  geom_histogram()

ghg_dist
```

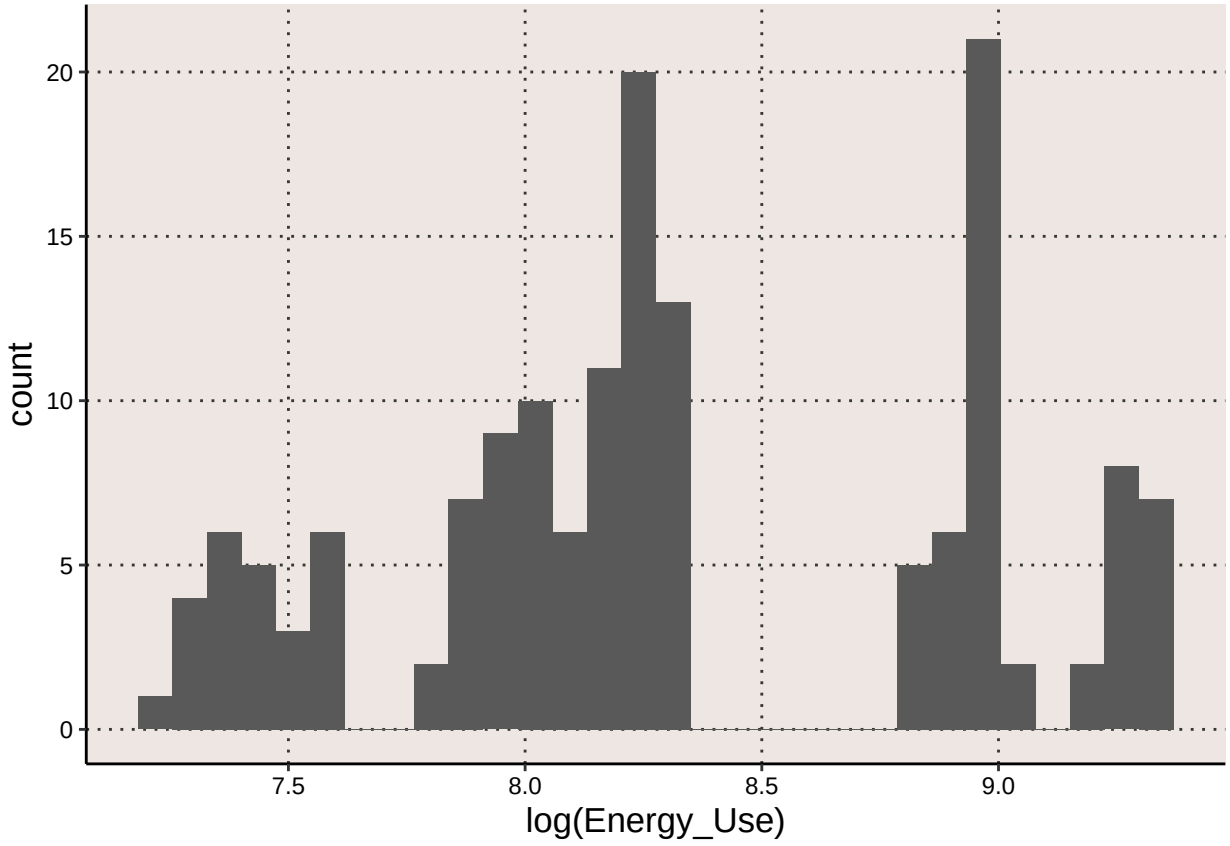
```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
EnergyUse_dist <- ggplot(energyUse_mort, aes(x = log(Energy_Use))) +
  geom_histogram()

EnergyUse_dist
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

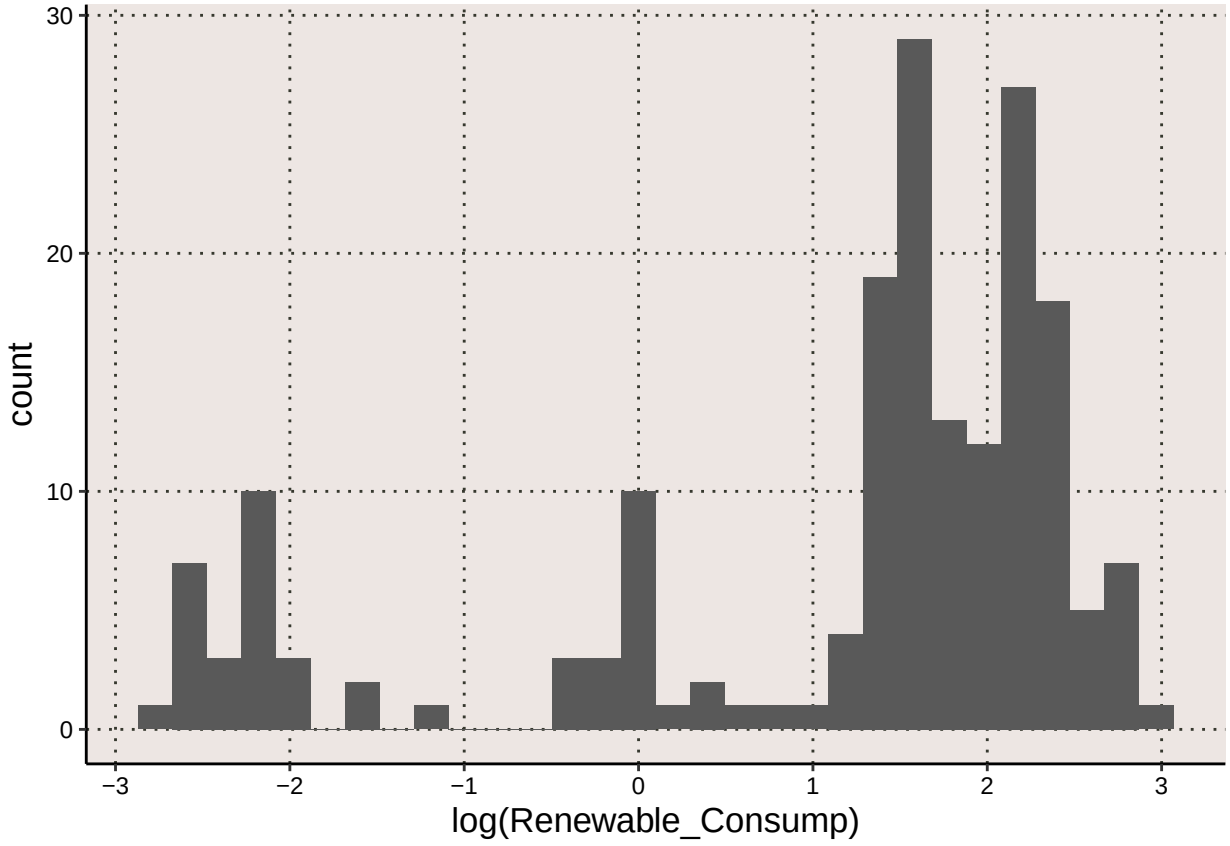
```
## Warning: Removed 32 rows containing non-finite outside the scale range
## (`stat_bin()`).
```



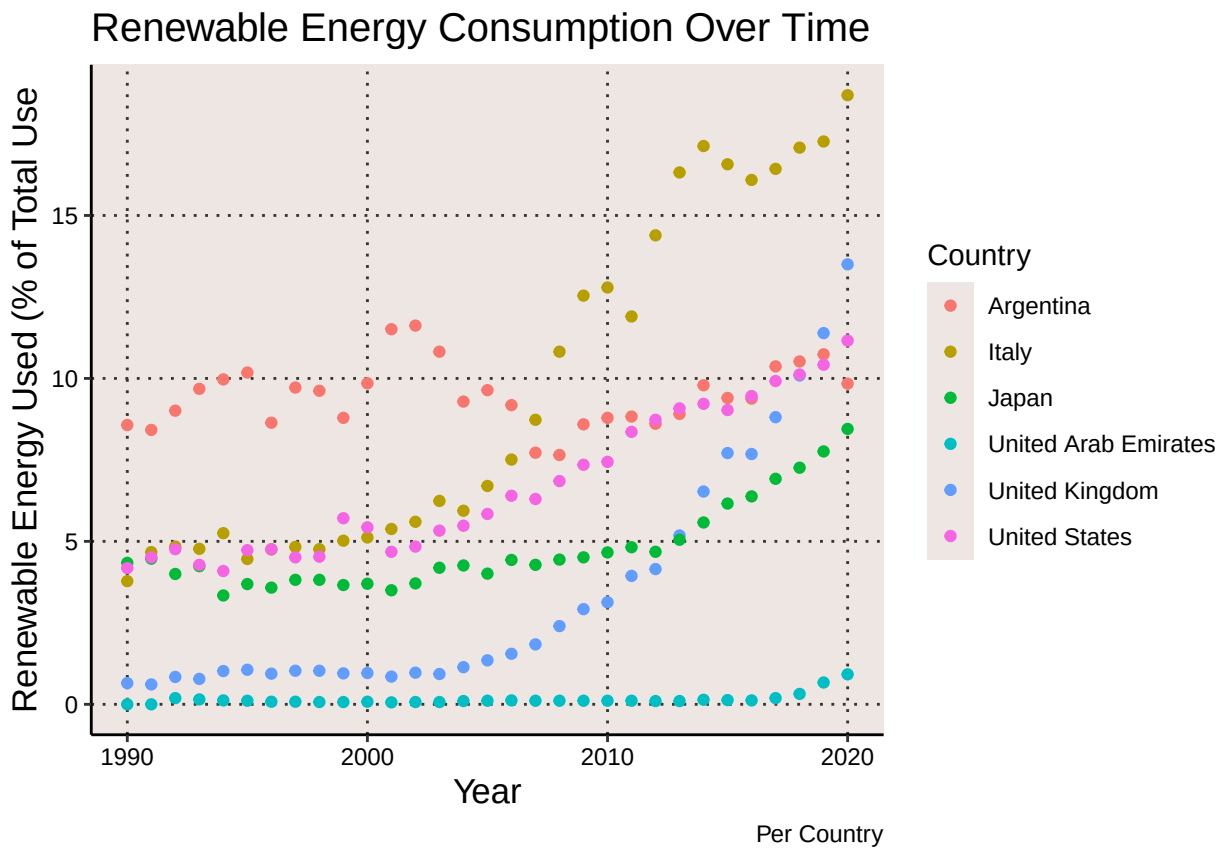

```
Renewable_Consump_dist <- ggplot(energyUse_mort, aes(x = log(Renewable_Consump))) +
  geom_histogram()

Renewable_Consump_dist
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

```
## Warning: Removed 2 rows containing non-finite outside the scale range
## (`stat_bin()`).
```

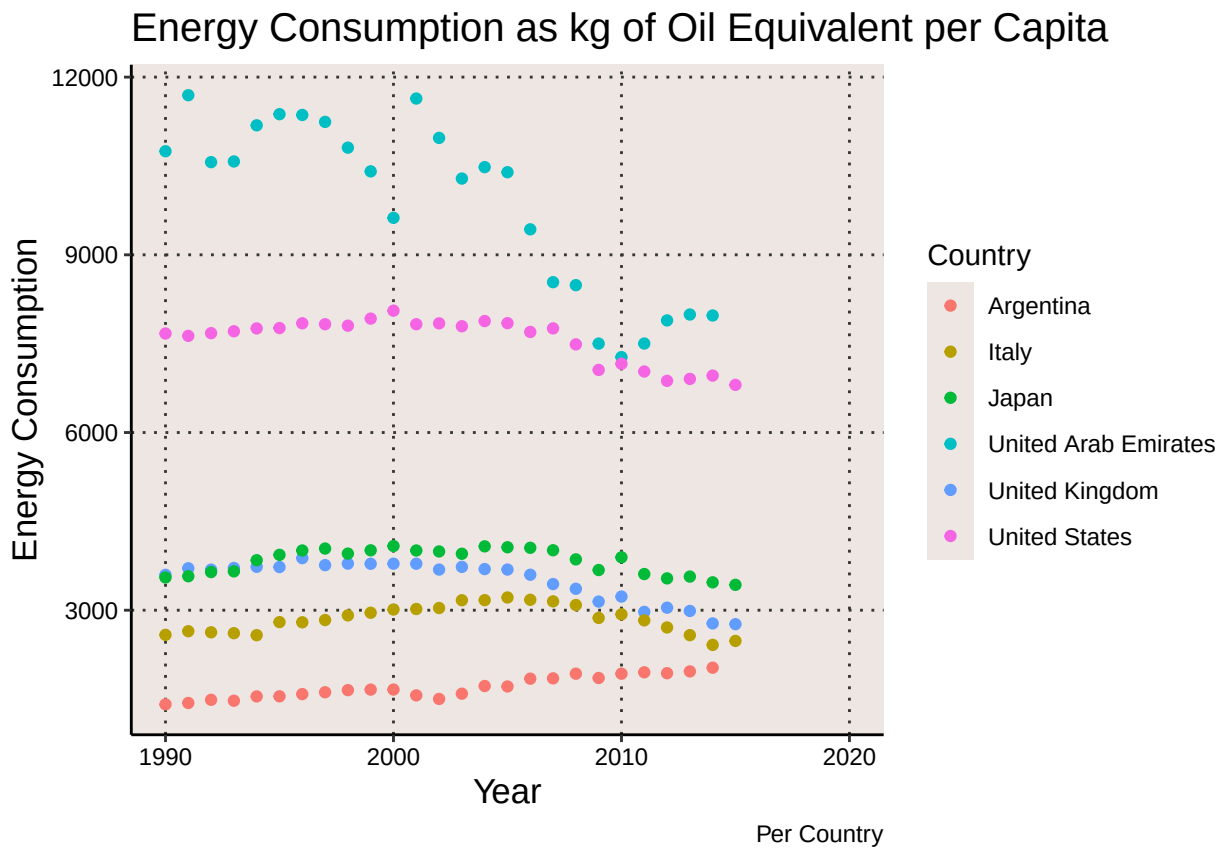



```
renewable_consump_time <- ggplot(energyUse_mort, aes(x = date, y = Renewable_Consump, color = country))
  geom_point() +
  labs(title = "Renewable Energy Consumption Over Time",
       caption = "Per Country",
       color = "Country") +
  xlab("Year") +
  ylab("Renewable Energy Used (% of Total Use")

renewable_consump_time
```

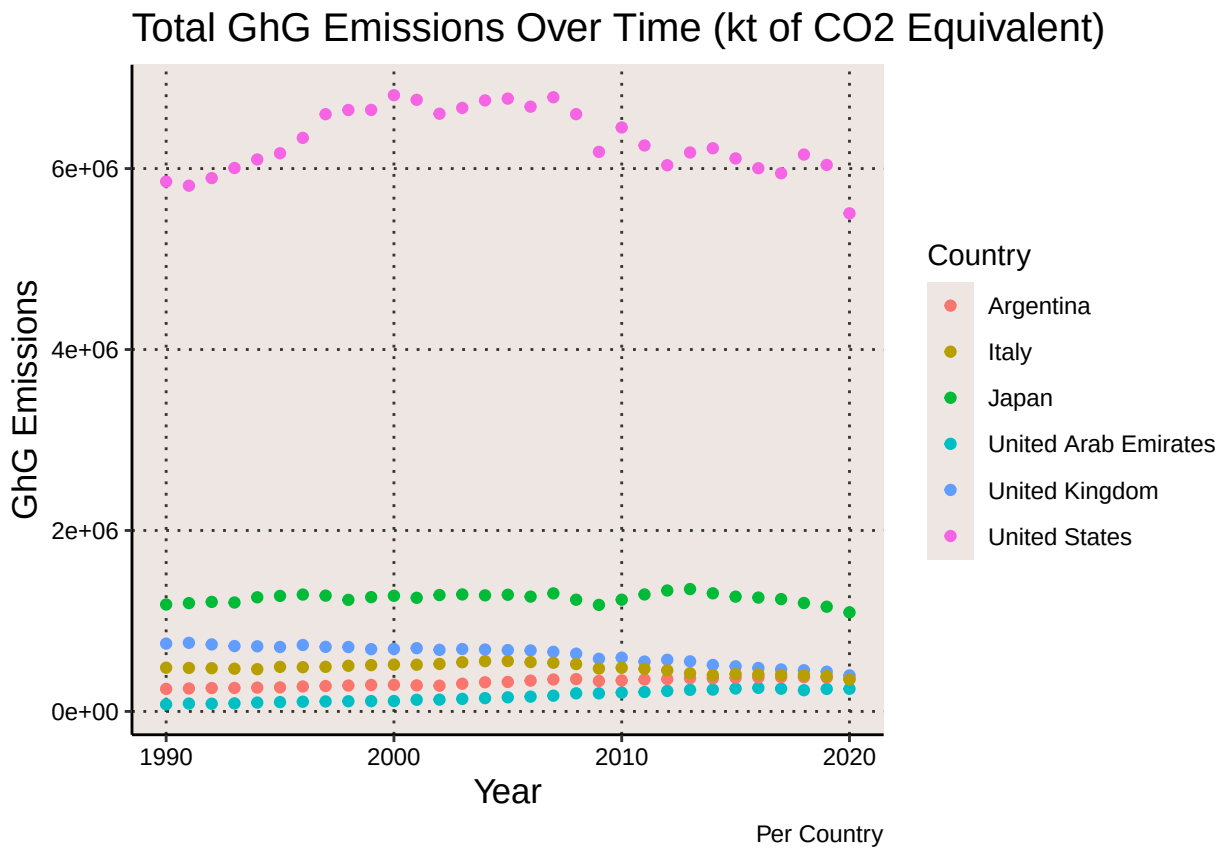



```
energy_consump_time <- ggplot(energyUse_mort, aes(x = date, y = Energy_Use, color = country)) +
  geom_point() +
  labs(title = "Energy Consumption as kg of Oil Equivalent per Capita",
       caption = "Per Country",
       color = "Country") +
  xlab("Year") +
  ylab("Energy Consumption")

energy_consump_time
```

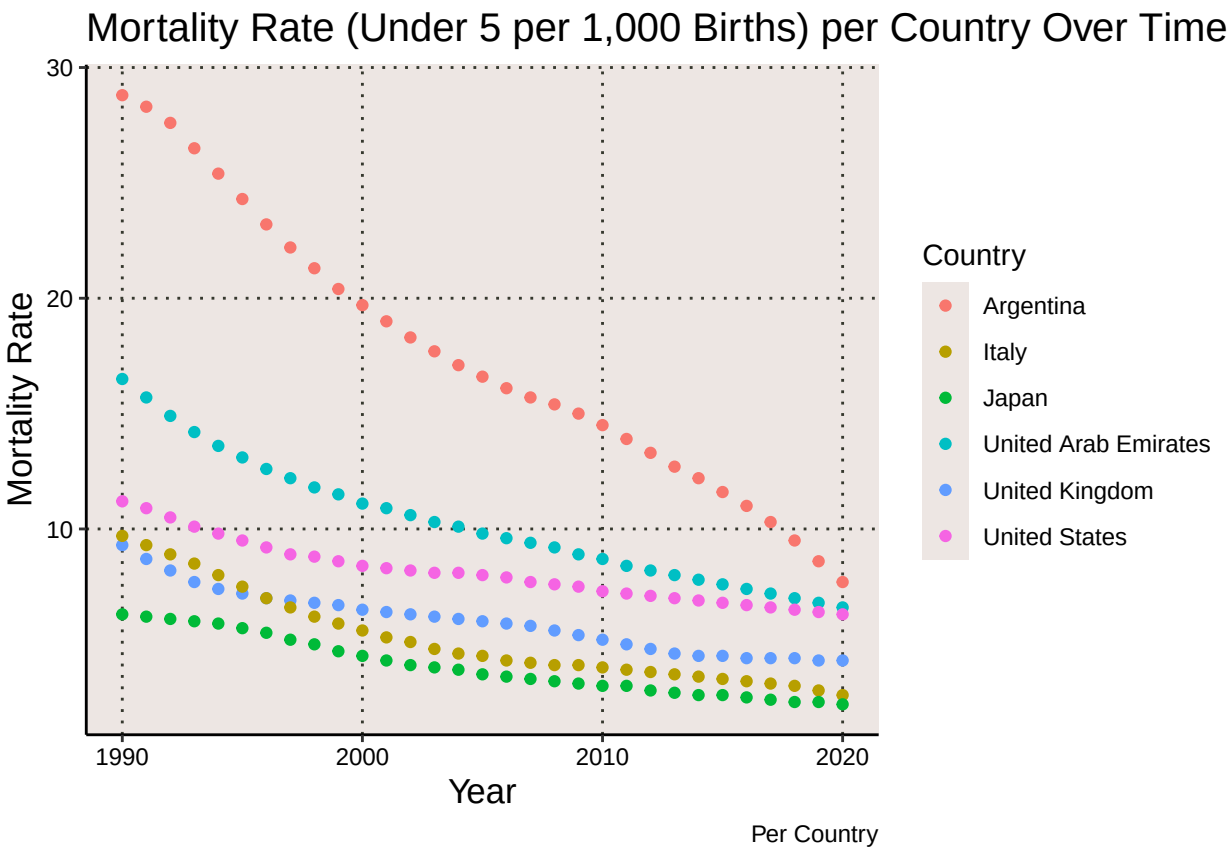
```
## Warning: Removed 32 rows containing missing values or values outside the scale range
## (`geom_point()`).
```




```
ghg_emissions_time <- ggplot(energyUse_mort, aes(x = date, y = Total_GHG_Emissions, color = country)) +
  geom_point() +
  labs(title = "Total GhG Emissions Over Time (kt of CO2 Equivalent)",
       caption = "Per Country",
       color = "Country") +
  xlab("Year") +
  ylab("GhG Emissions")

ghg_emissions_time
```




```
mortality_time <- ggplot(energyUse_mort, aes(x = date, y = Mortality_Rate, color = country)) +
  geom_point() +
  labs(title = "Mortality Rate (Under 5 per 1,000 Births) per Country Over Time",
       caption = "Per Country",
       color = "Country") +
  xlab("Year") +
  ylab("Mortality Rate")

mortality_time
```


Mortality Rate (Under 5 per 1,000 Births) per Country Over Time
Mortality Rate
30
20
10
1990
2000
2010
2020
Year
Per Country
Country
Argentina
Italy
Japan
United Arab Emirates
United Kingdom
United States

Analysis

```
AIC <- lm(data = energyUse_mort, log(Mortality_Rate) ~ Renewable_Consump + Energy_Use + Total_GHG_Emissi
AIC
```

```
##
## Call:
## lm(formula = log(Mortality_Rate) ~ Renewable_Consump + Energy_Use +
##     Total_GHG_Emissions, data = energyUse_mort)
##
## Coefficients:
##         (Intercept)    Renewable_Consump           Energy_Use
##           1.670e+00            3.391e-02            6.009e-05
## Total_GHG_Emissions
##          -4.932e-08
```

```
step(AIC)
```

```
## Start:  AIC=-186.93
## log(Mortality_Rate) ~ Renewable_Consump + Energy_Use + Total_GHG_Emissions
##
##                       Df Sum of Sq    RSS     AIC
## <none>                               43.432 -186.93
## - Total_GHG_Emissions  1    1.3188 44.751 -184.32
## - Renewable_Consump    1    1.4736 44.906 -183.79
## - Energy_Use           1    2.3502 45.783 -180.81

##
## Call:
## lm(formula = log(Mortality_Rate) ~ Renewable_Consump + Energy_Use +
##     Total_GHG_Emissions, data = energyUse_mort)
##
## Coefficients:
##         (Intercept)    Renewable_Consump           Energy_Use
##           1.670e+00            3.391e-02            6.009e-05
## Total_GHG_Emissions
##          -4.932e-08
```

```
AICmodel <- lm(data = energyUse_mort,  log(Mortality_Rate) ~ Renewable_Consump + Energy_Use + Total_GHG_
summary(AICmodel)
```

```
##
## Call:
## lm(formula = log(Mortality_Rate) ~ Renewable_Consump + Energy_Use +
##     Total_GHG_Emissions, data = energyUse_mort)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.10766 -0.32088  0.01821  0.26459  1.32740
##
```

```
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)           1.670e+00  1.528e-01  10.931   <2e-16 ***
## Renewable_Consump     3.391e-02  1.503e-02   2.256   0.0255 *
## Energy_Use            6.009e-05  2.109e-05   2.849   0.0050 **
## Total_GHG_Emissions -4.932e-08  2.311e-08  -2.134   0.0345 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5381 on 150 degrees of freedom
##   (32 observations deleted due to missingness)
## Multiple R-squared:  0.05606,    Adjusted R-squared:  0.03718
## F-statistic: 2.969 on 3 and 150 DF,  p-value: 0.03383
```

```
AICmodel
```

```
##
## Call:
## lm(formula = log(Mortality_Rate) ~ Renewable_Consump + Energy_Use +
##     Total_GHG_Emissions, data = energyUse_mort)
##
## Coefficients:
##         (Intercept)    Renewable_Consump           Energy_Use
##           1.670e+00            3.391e-02            6.009e-05
## Total_GHG_Emissions
##          -4.932e-08
```

Question 1: <insert specific question here and add additional subsections for additional questions below, if needed>

Question 2:

Summary and Conclusions

Although there is enough evidence to reject the null hypothesis, the regression coefficients seem to oddly indicate that increases in both renewable energy consumption and total energy use seems to correlate to increased mortality rates, while a decrease in total greenhouse gas emissions seem to correlate with a decrease in mortality rates for every increase in total greenhouse gas emissions.

All of these regression coefficients are statistically significant, with renewable consumption and total ghg emissions significant at the 5 percent level, and energy use significant at the 1 percent level.

However, there are a few things to point out. Quantitatively, the R-Squared is only 0.056, which means that only about 5.6% of variance in the model is explaned by this model, indicating drastic underfit of data. Additional data will be needed to raise this R-Squared to an acceptable level without overfitting the data.

Qualitatively, there are quite a few exogenous factors missing from the model that may help explain or even drastically change these results. Perhaps increases in energy consumption and energy use may correlate to higher mortality rates simply because of larger populations. Perhaps there are other factors within individual countries' economies that may explain higher mortality rates such as crime rates, poverty rates, etc. Negative correlation between mortality rates and ghg emissions may potentially be explained better by combination of factors including total population, total gdp, etc. Countries with higher greenhouse gas emissions may emit so much more than less developed countries that the data may be skewed. Industrial countries that pollute much more than smaller, less-developed countries tend to have more advanced infrastructure to support advanced medical facilities, etc. Thus, mortality rates cannot be explained soley by these three factors alone.

References

World Bank Data Mortality Rate: https://data.worldbank.org/indicator/SH.DYN.MORT Renewable Energy Consumption: https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS?view=chart Energy Use: https://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE?view=chart Total Greenhouse Gas Emissions: https://data.worldbank.org/indicator/EN.ATM.GHGT.KT.CE?view=chart