

# Project-1-6372- Life Expectancy Analysis

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Link2Project

##R Pubs R Pubs

## Introduction and Objective

This project focuses on the analysis of life expectancy using WHO data to model country life expectancy based on economic and health factors using regression models. The primary aim is to explore key relationships using regression analysis and interpret these in a structured manner.

## Data Description and Processing

Data from WHO covering health and economic indicators were used. The dataset includes 2,848 records, each representing annual health and economic indicators for various countries. Variables such as Life Expectancy, Adult Mortality, Alcohol Consumption, GDP per Capita, and others were included. Preprocessing involved handling missing values, eliminating columns with a substantial number of missing values, and standardizing column names.

## Exploratory Data Analysis (EDA)

EDA revealed patterns and correlations. Key visualizations include box plots showing life expectancy variation by economy status and time, and correlation matrices. Scatter plots of selected variables against life expectancy were also used. These analyses provided foundational insights for model building.

## Objective 1: Regression Model Development and Analysis

1. **Model Fitting Approach:** Enhanced linear model with iterative refinement process, emphasizing statistically significant variables.
2. **Variable Selection:** Based on statistical significance and EDA, with notable predictors including Adult Mortality, BMI, and GDP per Capita.
3. **Feature Selection Summary:** Manual selection and statistical techniques ensured inclusion of significant predictors.
4. **Final Regression Model Definition:** Incorporated predictors like Adult Mortality, Alcohol Consumption, GDP per Capita, etc.
5. **Coefficients Summary Table:** Provided estimates, standard errors, and significance levels for each predictor.
6. **Regression Coefficient Interpretation:** Interpretations focused on magnitude and significance of key coefficients.
7. **Model Evaluation and Comparison:** Employed visualizations and statistical analyses like ANOVA for evaluation.

## Objective 2: Further Model Evaluation and Comparative Analysis

Evaluation and comparison of different regression models for life expectancy prediction, with a focus on predictive accuracy and suitability.

1. **Advanced Model Development and Iterative EDA:** Increased complexity of the model with sophisticated techniques and ongoing EDA.
2. **In-Depth Model Refinement:** Continuous integration of complex terms into the model based on EDA insights.

## Methodology and Decision Making

1. **Comprehensive Model Comparison:** Included enhanced linear models and nonparametric models like Random Forest or KNN.
2. **Extended Model Evaluation Metrics:** Employed MSE, R-squared/Adjusted R-squared, AIC, BIC, etc.
3. **Detailed Comparative Analysis and Final Recommendations:** Focused on performance, strengths, and limitations of models in the context of life expectancy prediction.
4. **Key Focuses of Our Approach:** Included iterative process, balance and flexibility, and data-driven decision-making.

## Conclusion

Model\_1 was identified as the best model for our analysis. RFE, VIF, AIC/BIC/MSE/RMSE/MAE/ANOVA/MANOVA processes were used to train, test, and validate the models.

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## Part A: Initial Exploration & Introduction to Dataset

### Dataset Composition

- **Observations:** 2,848 entries spanning from 2000 to 2015.
- **Variables:** 23, including both health-related and economic indicators.
- **Data Types:** Combination of categorical (Country, Region) and numerical (health indicators, economic measures).
- **Year Coverage:** Data spans from 2000 to 2015, median and mean year of 2008.
- **Country and Region:** 2,848 entries for each, showcasing geographical diversity.
- **Metrics:** Include economy status (developed: 1, undeveloped: 0), GDP per capita, population, income composition, and schooling years.

### Key Data Findings

#### Health Variables

1. **Life Expectancy:** Ranges from 39.4 to 83.8 years (Median: 71.45 years).
2. **Adult Mortality:** Median rate of 144 per 1000, range: 49.38 to 719.36.
3. **Alcohol Consumption:** Ranges from 0 to 17.87 liters/person/year (Average: 4.83 liters).
4. **Infant Deaths:** Minimum 1.8, maximum 138.1 per 1000 live births (Mean: 30.08).

5. **Vaccination Rates (Polio, Hepatitis B):** Range from 0% to 99%.
6. **Measles Cases:** 0 to 212,183 cases, indicating high variance.
7. **BMI:** Range from 0 to 79.3.
8. **Under-Five Deaths:** 0 to 2500 deaths.
9. **Diphtheria Vaccination Rate:** Range from 0% to 99%.
10. **HIV Incidence:** 0 to 43.5 cases per 1000 live births.
11. **Thinness in Teens/Children:** Maximum values at 27.7% and 28.6%.

## Economic Indicators

1. **GDP Per Capita:** \$255 to \$118,514.
2. **Healthcare Expenditure:** Wide variation, correlated with GDP.
3. **Schooling Years:** 0 to 20 years (Average: 12 years).
4. **Health Expenditure (% of GDP):** 0% to 17.6%.
5. **GDP per Capita:** 0 to 119,172.7 USD.
6. **Population:** 0 to ~1.29 billion.
7. **Income Composition/Schooling:** 0 to 0.948 and 1.1 to 14.1 years, respectively.
8. **Economy Status (Developed):** 20.79% of entries from developed economies.

## Data Cleaning Process

- **Missing Data:** Imputed with median for numerical (e.g., median GDP \$5,962) and mode for categorical.
- **Data Completeness:** All 23 variables retained post-cleaning.

## Overview

- The dataset comprises a diverse range of health indicators and socio-economic factors across various countries and regions from 2000 to 2015.
- Numerical variables cover a wide array of data points including year, economic status, life expectancy, adult mortality rates, and more.

## Key Statistics

- **Life Expectancy:** Median of 71.45 years, with a broad range.
- **Adult Mortality Rates:** Median of 163.28, maximum of 719.36.
- **Alcohol Consumption:** Average of 4.83 liters, demonstrating wide variability.
- **Economic Diversity:** Reflected in disparities in healthcare expenditure and GDP per capita.
- **Nutritional Status:** Indicated by a broad range of BMI values.
- **Health Outcomes:** Including infant/under-five deaths and disease incidences.
- **Socio-Economic Factors:** Like income composition and schooling, crucial for assessing development impacts on health.

## Data Readiness

- **Insight Potential:** The dataset is well-suited for trend analysis and predictive modeling, given its diversity in health outcomes and economic statuses.

## In Summary

- The dataset provides a comprehensive view of health and economic indicators across a diverse set of countries and regions, highlighting variations in life expectancy, mortality rates, disease prevalence, vaccination rates, health expenditures, and socio-economic factors over a 15-year period.

```
library(readr)
library(dplyr)
```

### 1. Library Optimization

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##   filter, lag

## The following objects are masked from 'package:base':
##
##   intersect, setdiff, setequal, union
```

```
library(ggplot2)
library(plotly)
```

```
##
## Attaching package: 'plotly'

## The following object is masked from 'package:ggplot2':
##
##   last_plot

## The following object is masked from 'package:stats':
##
##   filter

## The following object is masked from 'package:graphics':
##
##   layout
```

```
library(corrplot)
```

```
## corrplot 0.92 loaded
```

```
library(htmlwidgets)
library(caret)
```

```
## Loading required package: lattice
```

```
library(randomForest)
```

```
## randomForest 4.7-1.1
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```
##
```

```
## Attaching package: 'randomForest'
```

```
## The following object is masked from 'package:ggplot2':
```

```
##
```

```
##     margin
```

```
## The following object is masked from 'package:dplyr':
```

```
##
```

```
##     combine
```

```
library(kernlab)
```

```
##
```

```
## Attaching package: 'kernlab'
```

```
## The following object is masked from 'package:ggplot2':
```

```
##
```

```
##     alpha
```

```
library(MASS)
```

```
##
```

```
## Attaching package: 'MASS'
```

```
## The following object is masked from 'package:plotly':
```

```
##
```

```
##     select
```

```
## The following object is masked from 'package:dplyr':
```

```
##
```

```
##     select
```

```
library(lattice)
```

```
library(openxlsx)
```

```
library(jsonlite)
```

```
library(car)
```

```
## Loading required package: carData
```

```
##
```

```
## Attaching package: 'car'
```

```
## The following object is masked from 'package:dplyr':
```

```
##
```

```
##     recode
```

```
library(broom)
library(tidyr)
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v forcats 1.0.0      v stringr 1.5.1
## v lubridate 1.9.3    v tibble 3.2.1
## v purrr 1.0.2
```

```
## -- Conflicts ----- tidyverse_conflicts() --
```

```
## x kernlab::alpha()      masks ggplot2::alpha()
## x randomForest::combine() masks dplyr::combine()
## x purrr::cross()        masks kernlab::cross()
## x plotly::filter()      masks dplyr::filter(), stats::filter()
## x purrr::flatten()      masks jsonlite::flatten()
## x dplyr::lag()           masks stats::lag()
## x purrr::lift()         masks caret::lift()
## x randomForest::margin() masks ggplot2::margin()
## x car::recode()         masks dplyr::recode()
## x MASS::select()        masks plotly::select(), dplyr::select()
## x purrr::some()         masks car::some()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(webshot)
library(webshot2)
```

```
## Registered S3 method overwritten by 'webshot2':
##   method      from
##   print.webshot webshot
##
## Attaching package: 'webshot2'
##
## The following objects are masked from 'package:webshot':
##
##   appshot, resize, rmdshot, shrink, webshot
```

```
library(lattice)
library(car)
library(nnet) # for ANN
library(class) # for KNN
library(e1071) # for SVM
library(randomForest) # for RF
library(glmnet)
```

```
## Loading required package: Matrix
##
## Attaching package: 'Matrix'
##
## The following objects are masked from 'package:tidyr':
##
##   expand, pack, unpack
##
## Loaded glmnet 4.1-8
```

```
library(name)
```

```
data <- read_csv("lifev3.csv")
```

## 2. Data Loading

```
## Rows: 2848 Columns: 23
## -- Column specification -----
## Delimiter: ","
## chr (2): Country, Region
## dbl (21): Year, Economy_status_Developed, Life_expectancy, Adult_mortality, ...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
# Define a mode function for categorical imputation
```

```
mode <- function(x) {
  ux <- unique(x)
  ux[which.max(tabulate(match(x, ux)))]
} # Closing bracket added here
```

```
# Impute missing values
```

```
data <- data %>%
  mutate_if(is.numeric, ~ifelse(is.na(.), median(., na.rm = TRUE), .)) %>% # Impute numerical columns
  mutate_if(is.character, ~ifelse(is.na(.), mode(.), .)) # Impute categorical columns with mode
```

```
# 5. Drop columns with many missing values if needed
```

```
data <- data[, !(names(data) %in% c("ColumnsWithTooManyNAs"))]
```

```
# 6. Check result
```

```
summary(data)
```

```
##      Country      Region      Year      Economy_status_Developed
## Length:2848      Length:2848      Min.   :2000      Min.   :0.0000
## Class :character  Class :character  1st Qu.:2004      1st Qu.:0.0000
## Mode  :character  Mode  :character  Median :2008      Median :0.0000
##                                     Mean  :2008      Mean   :0.2079
##                                     3rd Qu.:2011      3rd Qu.:0.0000
##                                     Max.   :2015      Max.   :1.0000
## Life_expectancy Adult_mortality Infant_deaths  Alcohol_consumption
## Min.   :39.40      Min.   : 49.38      Min.   : 1.80      Min.   : 0.000
## 1st Qu.:62.90      1st Qu.:106.68      1st Qu.: 8.10      1st Qu.: 1.220
## Median :71.45      Median :163.28      Median :19.40      Median : 4.050
## Mean   :68.95      Mean   :190.90      Mean   :30.08      Mean   : 4.837
## 3rd Qu.:75.50      3rd Qu.:245.32      3rd Qu.:47.00      3rd Qu.: 7.810
## Max.   :83.80      Max.   :719.36      Max.   :138.10      Max.   :17.870
## percentage expenditure Hepatitis_B      Measles      BMI
## Min.   : 0.000      Min.   : 0.00      Min.   : 0      Min.   : 0.00
## 1st Qu.: 6.915      1st Qu.: 9.00      1st Qu.: 0      1st Qu.:18.80
```

```
## Median : 71.851      Median :86.00      Median : 15      Median :43.10
## Mean : 785.160      Mean :64.65      Mean : 2129      Mean :37.76
## 3rd Qu.: 470.529      3rd Qu.:96.00      3rd Qu.: 309      3rd Qu.:56.30
## Max. :19479.912      Max. :99.00      Max. :212183      Max. :79.30
## Under_five_deaths      Polio      Total expenditure      Diphtheria
## Min. : 0.00      Min. : 0.00      Min. : 0.000      Min. : 0.00
## 1st Qu.: 0.00      1st Qu.:76.75      1st Qu.: 3.640      1st Qu.:78.00
## Median : 3.00      Median :93.00      Median : 5.480      Median :92.00
## Mean : 40.05      Mean :80.96      Mean : 5.398      Mean :81.04
## 3rd Qu.: 24.25      3rd Qu.:97.00      3rd Qu.: 7.320      3rd Qu.:97.00
## Max. :2500.00      Max. :99.00      Max. :17.600      Max. :99.00
## Incidents_HIV      GDP_per_capita      Population_millions
## Min. : 0.000      Min. : 0.0      Min. :0.000e+00
## 1st Qu.: 0.100      1st Qu.: 370.9      1st Qu.:3.264e+04
## Median : 0.100      Median : 1479.4      Median :7.237e+05
## Mean : 1.634      Mean : 6772.3      Mean :1.016e+07
## 3rd Qu.: 0.600      3rd Qu.: 5194.7      3rd Qu.:4.678e+06
## Max. :43.500      Max. :119172.7      Max. :1.294e+09
## Thinness_ten_nineteen_years      Thinness_five_nine_years
## Min. : 0.000      Min. : 0.000
## 1st Qu.: 1.400      1st Qu.: 1.400
## Median : 3.100      Median : 3.200
## Mean : 4.709      Mean : 4.745
## 3rd Qu.: 7.100      3rd Qu.: 7.100
## Max. :27.700      Max. :28.600
## Income composition of resources      Schooling
## Min. :0.0000      Min. : 1.100
## 1st Qu.:0.4660      1st Qu.: 5.100
## Median :0.6655      Median : 7.900
## Mean :0.5954      Mean : 7.653
## 3rd Qu.:0.7790      3rd Qu.:10.300
## Max. :0.9480      Max. :14.100
```

```
# 7. List all column names to verify the existence of 'Status'
colnames(data)
```

```
## [1] "Country"      "Region"
## [3] "Year"         "Economy_status_Developed"
## [5] "Life_expectancy" "Adult_mortality"
## [7] "Infant_deaths" "Alcohol_consumption"
## [9] "percentage expenditure" "Hepatitis_B"
## [11] "Measles"      "BMI"
## [13] "Under_five_deaths" "Polio"
## [15] "Total expenditure" "Diphtheria"
## [17] "Incidents_HIV"   "GDP_per_capita"
## [19] "Population_millions" "Thinness_ten_nineteen_years"
## [21] "Thinness_five_nine_years" "Income composition of resources"
## [23] "Schooling"
```



## Part B: Data Visualization

### Overview Data Preparation, Cleaning & Visualization in Part B:

Methodology: Imputed missing values; ensured robust dataset ready for analysis. Visualization Techniques:

Strategies Used: Utilized ggplot2 and plotly for rich, interactive data visualizations. Key Visualizations:

Types and Insights:

1. **Economic Status and Life Expectancy** Analyzed life expectancy differences between developed and undeveloped economies. Boxplot Findings: Developed countries (label '1') show higher and less variable life expectancy than developing ones (label '0'). Revealed disparities in life expectancy between developed and undeveloped economies.
2. **Correlation Analysis** Strong Positive Correlations: GDP per capita with schooling. Strong Negative Correlations: Adult mortality with life expectancy. Weaker Correlations: Indicated by lighter colors in the correlation matrix. Showed strong positive and negative correlations between various health and economic factors.
3. **Life Expectancy Trends and Relationships** Trends Over Time: General upward trend in life expectancy over years. Bivariate Relationships: Explored through scatterplots for key factors like adult mortality and GDP per capita.
4. **Interactive Visualization** Utilized plotly for dynamic exploration of data, especially in regional life expectancy trends.
5. **Common Value Determination**: A function was developed to find the most common value (mode) in a column, aiding in imputing missing categorical data.
6. **Imputation of Missing Values**: Missing numerical values were imputed with the median of their respective columns, avoiding bias from mean values affected by outliers.
7. **Removal of Excessively Incomplete Columns**: To maintain analysis quality, columns with too many missing values were removed.
8. **Data Structure Verification**: Post-cleaning, the dataset's structure and key columns were confirmed as analysis-ready.
9. **Data Visualization and Analysis**
  - a. **Status Column Conversion and Boxplot**: The 'Economy\_status\_Developed' column was converted to a factor for categorical plotting. A boxplot was created to visualize life expectancy distribution by economic status, revealing significant differences.
  - b. **Correlation Matrix**: A static and then interactive correlation matrix were plotted to investigate relationships between all numeric variables, highlighting those strongly associated with life expectancy, like adult mortality and schooling.
  - c. **Life Expectancy Over Time**: A plot of life expectancy trends over time by country was created, likely showing a general upward trend.
  - d. **Pairwise Scatterplots**: These plots examined relationships between select variables like life expectancy, adult mortality, and GDP per capita.
  - e. **Interactive Boxplot with Faceting**: Faceting life expectancy data by region and plotting over time enabled comparison of regional trends and disparities in life expectancy.
10. **Model Fitting and Evaluation**
  - a. **Regression Model Construction**: Multiple regression models were built and compared for predicting life expectancy.

- b. Model Evaluation: Models were evaluated using criteria like AIC and BIC, with lower values indicating better fit.
- c. Residual Analysis: Residuals were analyzed for patterns suggesting model fit issues, like non-linearity or heteroscedasticity.

#### 11. Interactive Visualizations

- a. Enhancement to Interactivity: Static ggplot objects were transformed into interactive Plotly visualizations for an engaging data exploration experience.
- b. Transformation of Static Plots: Static ggplot objects were converted into interactive Plotly visualizations. This enhanced user engagement and information accessibility through features like hover-over details, allowing for a more dynamic exploration of the data.

#### 12. Model Summaries

- a. Detailed Reporting: Summaries of regression models were provided, including coefficients, significance, and diagnostics, crucial for interpreting which variables significantly predict life expectancy.
- b. Regression Model Insights: Detailed summaries of regression models were provided. These included coefficients, statistical significance, and model diagnostics, essential for understanding which variables significantly impact life expectancy.

#### 13. Specific Visualizations

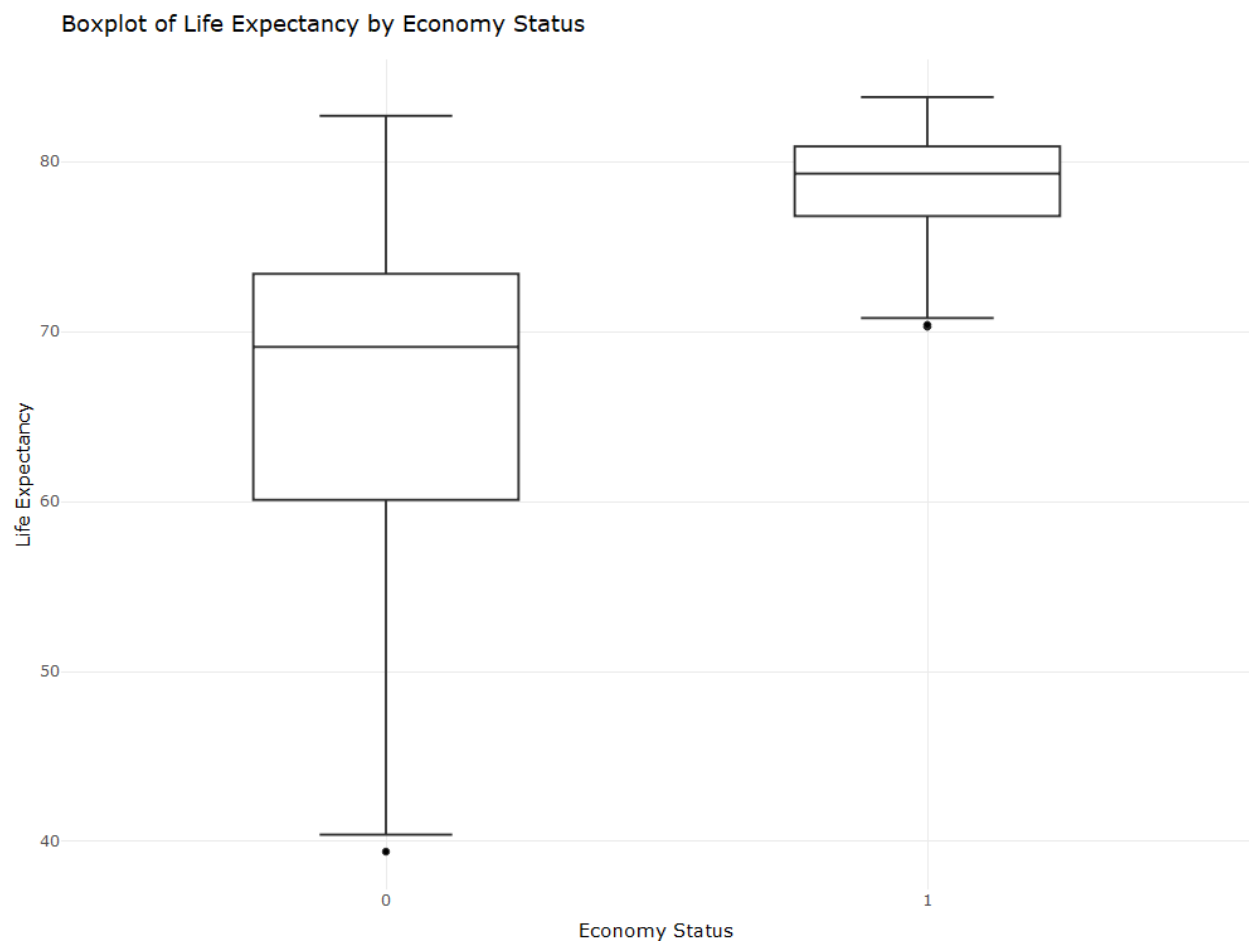
- a. Boxplot of Life Expectancy: Displayed differences in life expectancy between two groups, with the group labeled '1' showing higher and less variable life expectancy than '0'. This plot differentiated between two categories ('0' and '1'). The '0' category showed a broader range of life expectancy (40 to 80 years) with a median around 65 years and some outliers indicating very low life expectancy. In contrast, the '1' category had a narrower and higher range of life expectancy (55 to just below 80 years) with a median around 75 years and no outliers, suggesting higher and more consistent life expectancy in this group.
- b. Multiple Linear Regression Plots: A grid of scatter plots showing linear regressions between various variables. These plots consisted of a grid of scatter plots, each showing a linear regression between two variables. Different traces in the plots indicated variations in subsets or categories within the data. The plots effectively displayed pairwise linear relationships among selected variables.
- c. Life Expectancy Trends by Region: Line graphs for different global regions, showing life expectancy changes over time. Line graphs for various global regions depicted life expectancy trends from 2000 to around 2019. Each line represented a different country within a region, illustrating both individual country trends and overall regional trends in life expectancy.
- d. Correlation Heatmap: A heatmap displaying correlations between various health and socioeconomic indicators. This heatmap displayed correlations between various health and socioeconomic indicators, using color intensity to represent the strength of these correlations. The range of colors from blue (negative correlation) to red (positive correlation) allowed for quick visual identification of the nature and strength of the relationships.
- e. Life Expectancy Over Time by Country: A combined plot of all countries showing life expectancy trends. Combining data from all countries, this plot showed life expectancy trends from 2000 to around 2015. Each line represented a different country, highlighting the variability and overall trajectories of life expectancy across nations.
- f. Correlation Dot Matrix: A dot matrix emphasizing significant relationships with the size and color of dots. Similar to the heatmap, this dot matrix also showed correlation coefficients between various indicators. The size and color of the dots (blue for positive, red for negative) emphasized the strength and nature of the correlations, making the most significant relationships more visually prominent.

```

# 1. Status Column Conversion
data$Economy_status_Developed <- as.factor(data$Economy_status_Developed)
# 2. Plot the boxplot with the corrected column name
gg_boxplot <- ggplot(data, aes(x = Economy_status_Developed, y = Life_expectancy)) +
  geom_boxplot() +
  labs(title = "Boxplot of Life Expectancy by Economy Status",
        x = "Economy Status", y = "Life Expectancy") +
  theme_minimal()
ggsave("life_expectancy_by_status.png", plot = gg_boxplot, width = 10, height = 6)

# Convert to Plotly for interactive visualization
p_plotly <- ggplotly(gg_boxplot)
htmlwidgets::saveWidget(p_plotly, "Life_Expectancy_by_Status_Plotly.html")
webshot::webshot("Life_Expectancy_by_Status_Plotly.html", file = "Life_Expectancy_by_Status_Plotly.png")

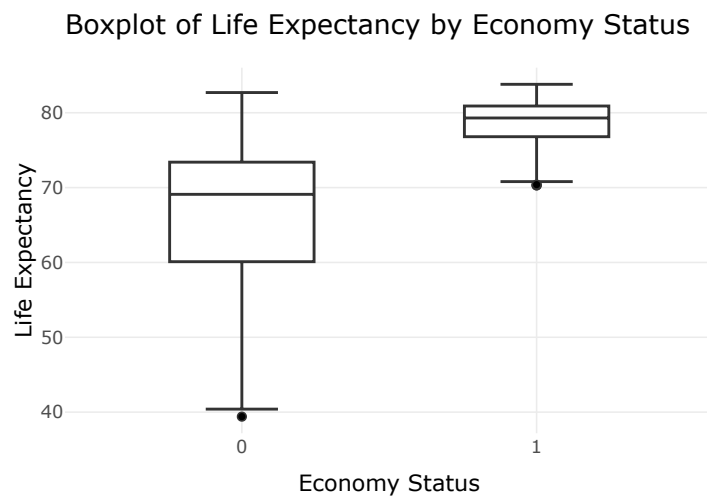
```



```

# Convert to Plotly for interactive visualization
p_plotly <- ggplotly(gg_boxplot)
p_plotly

```



```
# Plot static  
gg_boxplot <- ggplot(data, aes(x = Economy_status_Developed, y = Life_expectancy)) +
```

```

geom_boxplot() +
  labs(title = "Boxplot of Life Expectancy by Economy Status",
        x = "Economy Status", y = "Life Expectancy") +
  theme_minimal()
ggsave("life_expectancy_by_status.png", plot = gg_boxplot, width = 10, height = 6)

# Convert to Plotly for interactive visualization
p_plotly <- ggplotly(gg_boxplot)
htmlwidgets::saveWidget(p_plotly, "Life_Expectancy_by_Status_Plotly.html")

```

```

#### 3. Correlation Matrix
# Static Correlation Matrix
cor_matrix_static <- cor(data[, sapply(data, is.numeric)], use = "complete.obs")
png("correlation_matrix.png", width = 800, height = 800, res = 150)
corrplot::corrplot(cor_matrix_static, method = "circle")
dev.off()

```

```

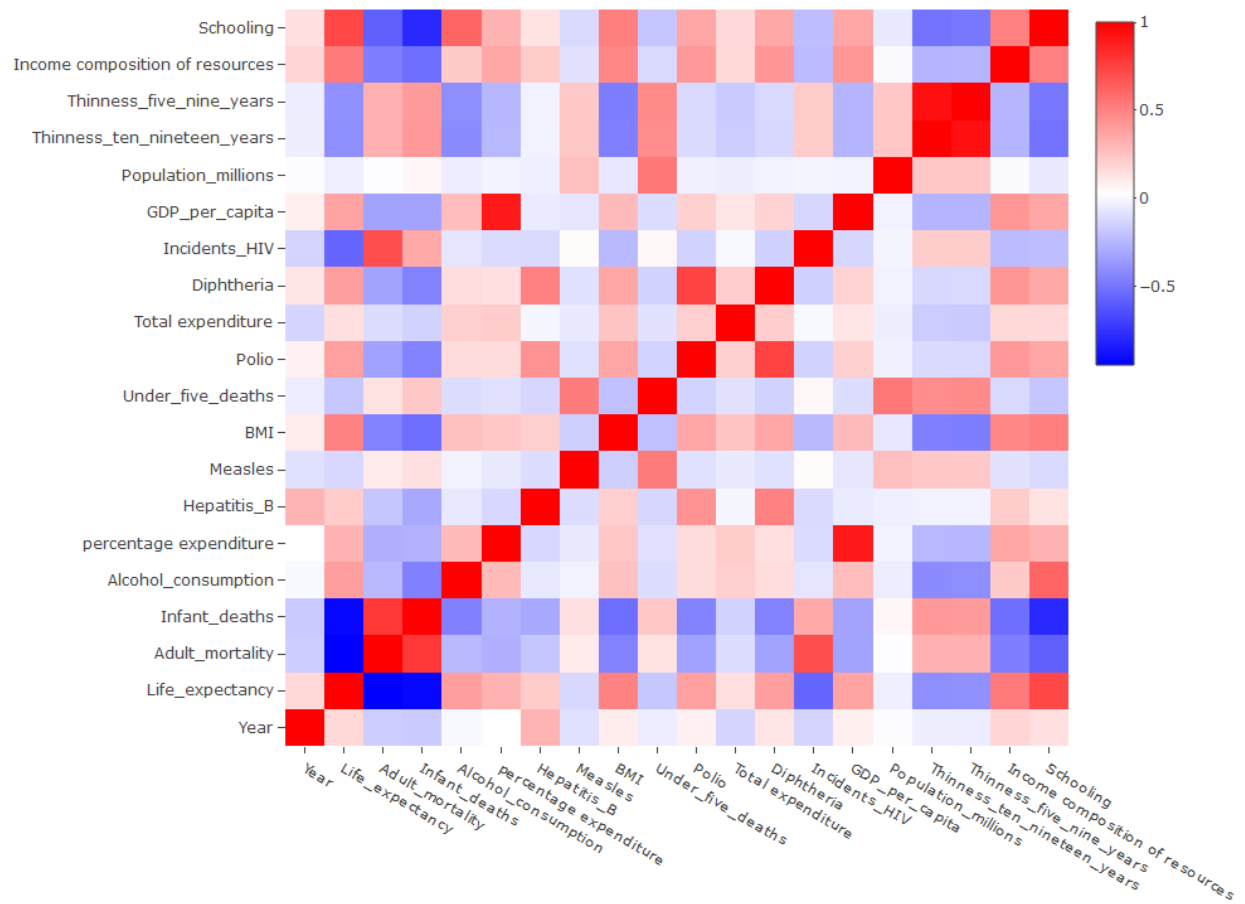
## pdf
## 2

```

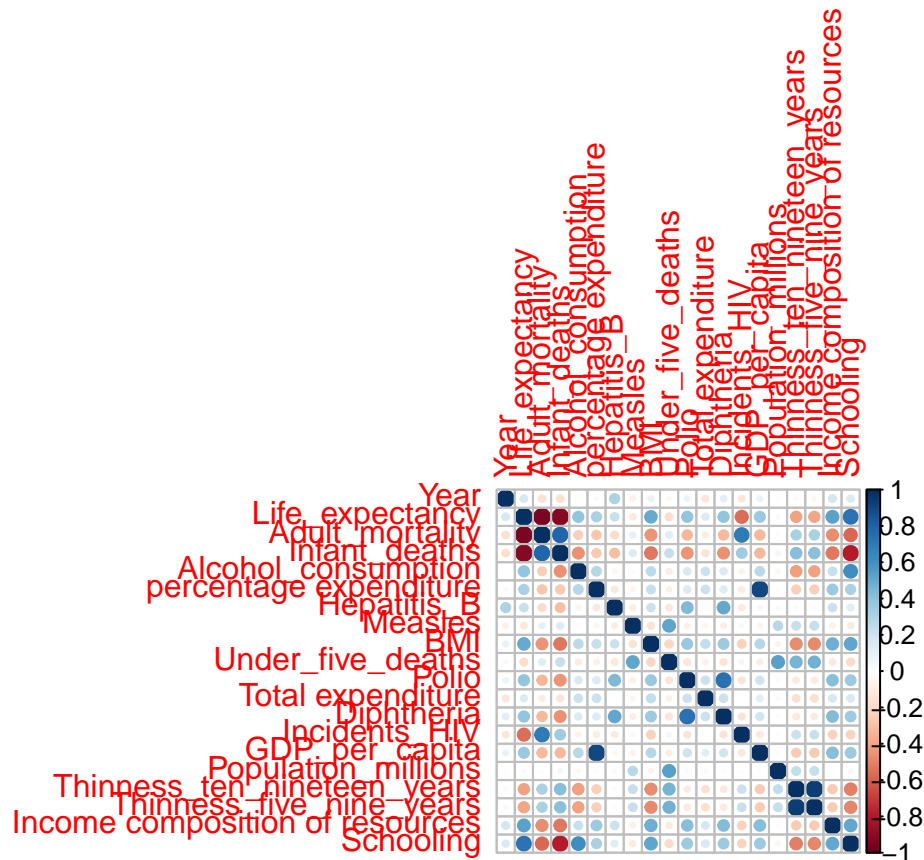
```

# Interactive Correlation Matrix with Plotly
cor_matrix_interactive <- cor(data %>% select_if(is.numeric), use = "complete.obs")
p_corr <- plot_ly(x = colnames(cor_matrix_interactive), y = colnames(cor_matrix_interactive), z = cor_m
                  type = "heatmap", colors = colorRamp(c("blue", "white", "red")))
htmlwidgets::saveWidget(p_corr, "Correlation_Matrix_Plotly.html")
webshot::webshot("Correlation_Matrix_Plotly.html", file = "Correlation_Matrix_Plotly.png")

```

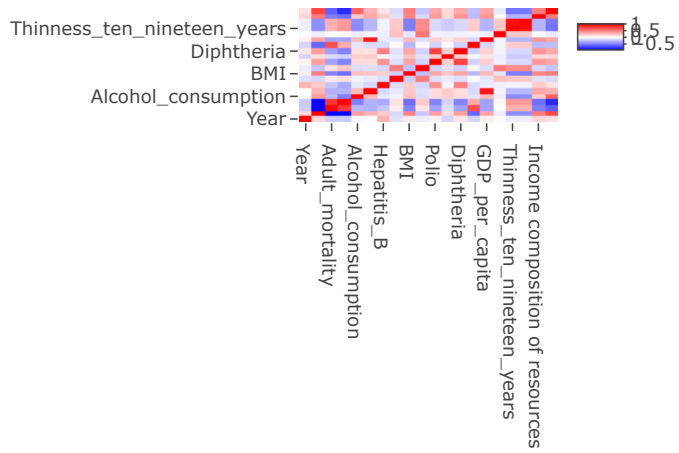


```
# Static Correlation Matrix
cor_matrix_static <- cor(data[, supply(data, is.numeric)], use = "complete.obs")
corrplot(cor_matrix_static, method = "circle")
```



```
# Interactive Correlation Matrix with Plotly
cor_matrix_interactive <- cor(data %>% dplyr::select_if(is.numeric), use = "complete.obs")
p_corr <- plot_ly(x = colnames(cor_matrix_interactive), y = colnames(cor_matrix_interactive), z = cor_matrix_interactive,
  type = "heatmap", colors = colorRamp(c("blue", "white", "red")))

# Embed Plotly plot directly
p_corr
```



# Life Expectancy Over Time

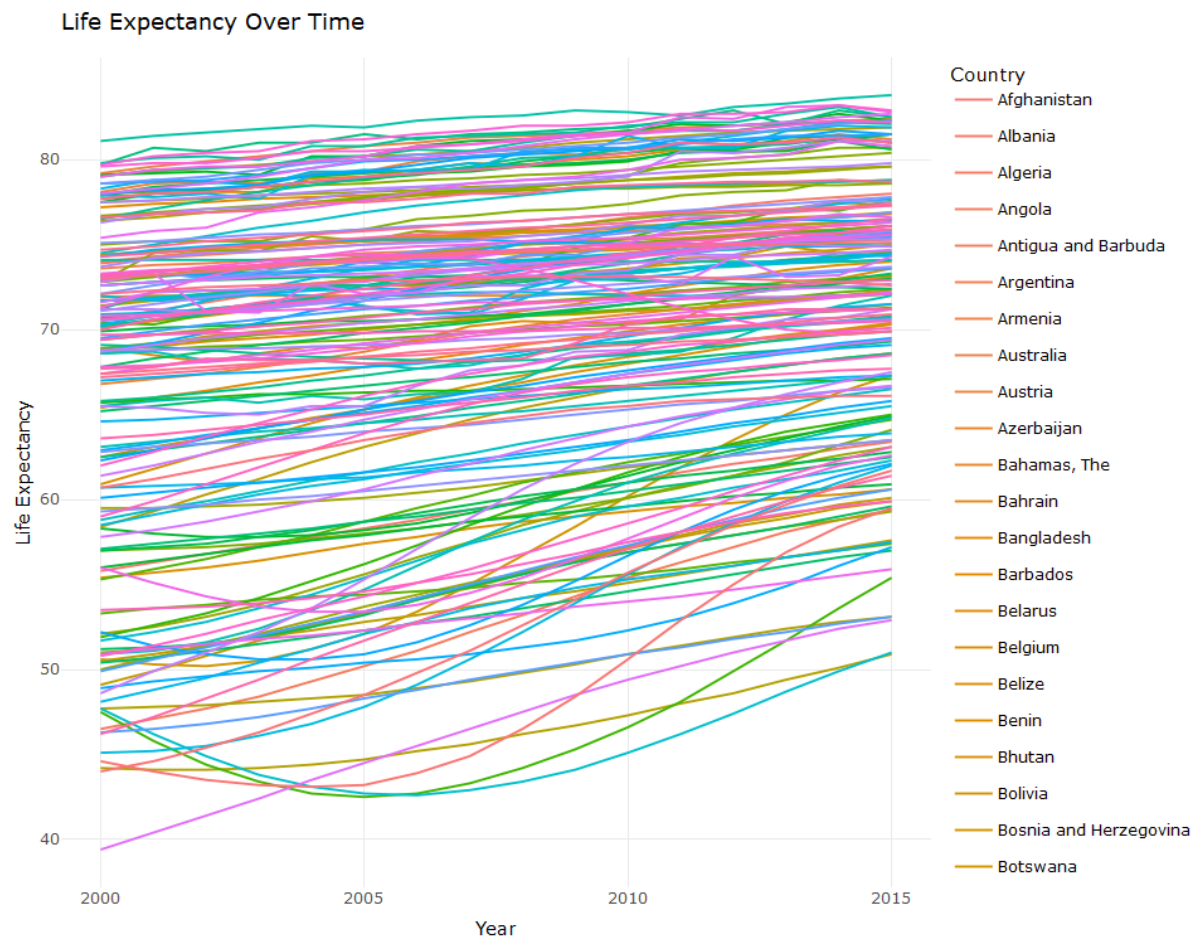


```

gg_life_expectancy <- ggplot(data, aes(x = Year, y = Life_expectancy, group = Country, color = Country)) +
  geom_line() +
  labs(title = "Life Expectancy Over Time",
       x = "Year", y = "Life Expectancy") +
  theme_minimal()
ggsave("life_expectancy_over_time.png", plot = gg_life_expectancy, width = 10, height = 6)

# Convert to Plotly for interactive visualization
p_plotly <- ggplotly(gg_life_expectancy)
htmlwidgets::saveWidget(p_plotly, "Life_Expectancy_Over_Time_Plotly.html")
webshot::webshot("Life_Expectancy_Over_Time_Plotly.html", file = "Life_Expectancy_Over_Time_Plotly.png")

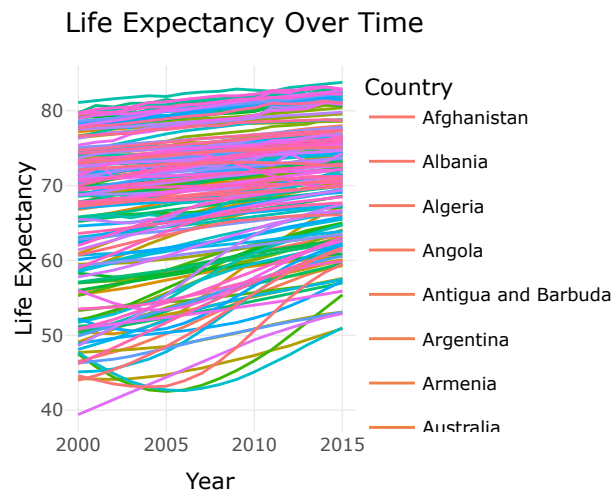
```



```

# Convert to Plotly for interactive visualization
p_life_expectancy <- ggplotly(gg_life_expectancy)
p_life_expectancy

```

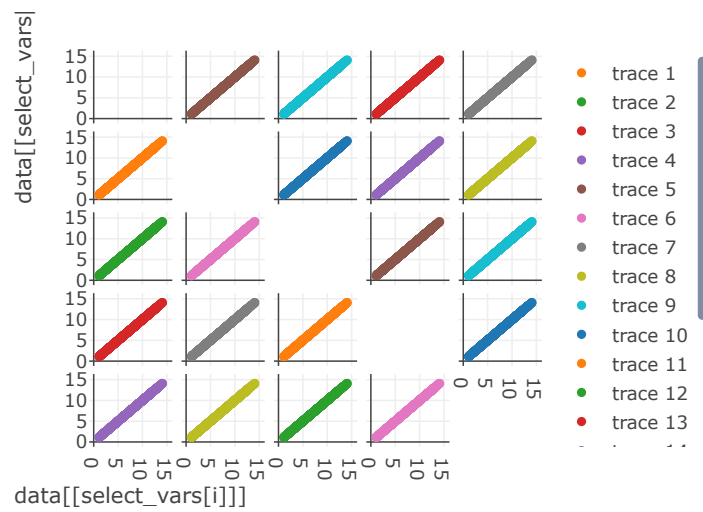


```
#### 5. Pairwise Scatterplots
select_vars <- c("Life_expectancy", "Adult_mortality", "Alcohol_consumption", "GDP_per_capita", "School_
```

```
png("Pairwise_Scatterplots.png", width = 1200, height = 800)
pairs(data[select_vars])
dev.off()
```

```
## pdf
## 2
```

```
# Convert to interactive Plotly scatter plot matrix
p_pairwise <- plot_ly(data = data, type = "scatter", mode = "markers")
for(i in 1:length(select_vars)) {
  for(j in 1:length(select_vars)) {
    if(i != j) {
      p_pairwise <- add_trace(p_pairwise, x = ~data[[select_vars[i]]], y = ~data[[select_vars[j]]],
                             xaxis = paste0("x", i), yaxis = paste0("y", j))
    }
  }
}
p_pairwise <- p_pairwise %>%
  layout(grid = list(rows = length(select_vars), columns = length(select_vars)))
p_pairwise
```



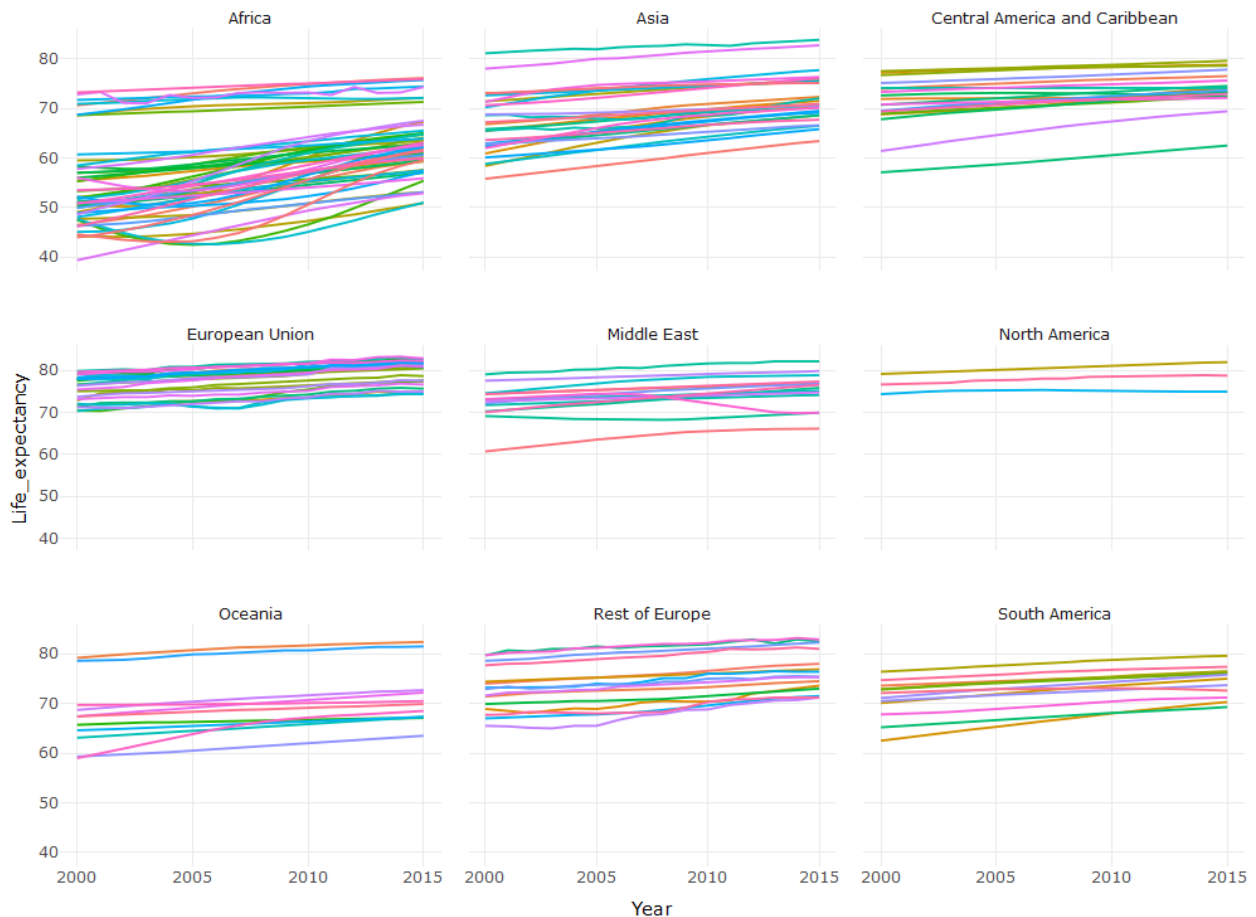
#### 6. Interactive Boxplot with Faceting

```

# Create a ggplot object with faceting
gg_facet_plot <- ggplot(data, aes(x = Year, y = Life_expectancy, color = Country)) +
  geom_line() +
  facet_wrap(~Region) + # Replace 'Region' with your actual faceting variable
  theme_minimal() +
  theme(legend.position = "none")

# Convert to a Plotly object for interactivity
p_facet_plotly <- ggplotly(gg_facet_plot)
htmlwidgets::saveWidget(p_facet_plotly, "Life_Expectancy_Faceted_Plot.html")
webshot::webshot("Life_Expectancy_Faceted_Plot.html", file = "Life_Expectancy_Faceted_Plot.png")

```

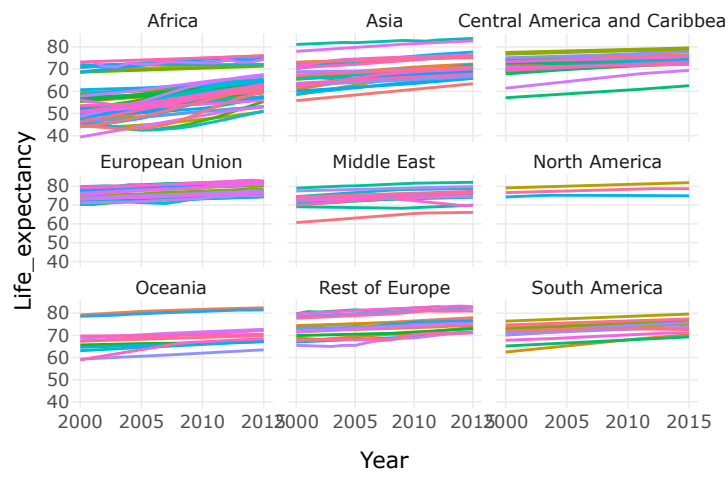


```

# Convert to a Plotly object for interactivity
p_facet_plotly <- ggplotly(gg_facet_plot)

# Display the interactive plot
p_facet_plotly

```



## Part C: Model Training

### Data Analysis & Findings From Part C:

#### 1. Enhanced Linear Model (LM) Analysis:

- The `enhanced_linear_model` shows a very high R-squared value of 0.9971, indicating that the model explains almost all the variability in life expectancy.
- The low residual standard error (0.5275) suggests good accuracy.
- However, with 197 predictors, the model could be overfitting.

#### 2. Variance Inflation Factor (VIF) Analysis:

- High VIFs in `vif_model_1` (e.g., `Alcohol_consumption`: 12.666473) suggest multicollinearity issues, which can distort the interpretation of coefficients.
- `vif_model_2` presents lower VIFs, indicating reduced multicollinearity for a simpler model.

#### 3. Model 2 (Simpler LM) Analysis:

- This model shows a lower but still strong R-squared of 0.9285.
- The RMSE for cross-validation (2.494402) and test data (2.644088) are quite consistent, indicating the model generalizes well.

#### 4. Generalized Linear Model (GLM) Analysis:

- The GLM with a logarithmic link function also performs well (AIC: 7849.5).
- Some coefficients (e.g., `Income composition of resources`: 6.039e-03) are significant, showing their impact on life expectancy.

#### 5. Artificial Neural Network (ANN) Analysis:

- The ANN model with 205 input features shows complexity in the weights, requiring careful interpretation.

#### 6. K-Nearest Neighbors (KNN) Analysis:

- The KNN model summary doesn't provide much detail, but it's important to choose the right 'k' value for optimal performance.

#### 7. Support Vector Machine (SVM) Analysis:

- The SVM model is another complex model, effective for capturing non-linear relationships.

#### 8. Random Forest (RF) Analysis:

- The RF model includes 500 trees and shows good performance in terms of mean squared error (MSE) and the coefficient of determination (R-squared).

#### 9. Comparative Analysis:

- Comparing actual and predicted values across models, the RMSE values vary, indicating the effectiveness of each model.
- Choosing the best model depends on the balance between complexity and predictive accuracy.

#### 10. Overall Insights:

- The high R-squared values in several models suggest good predictive capabilities.
- Care should be taken to avoid overfitting, especially in complex models like ANN and RF.
- Models like the simpler LM and RF can provide a good balance between accuracy and interpretability.

```
trainData <- read_csv("train_data.csv")
```

```
## Rows: 1996 Columns: 24
## -- Column specification -----
## Delimiter: ","
## chr (2): Country, Region
## dbl (22): Column1, Year, Economy_status_Developed, Life_expectancy, Adult_mo...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
enhanced_linear_model <- lm(Life_expectancy ~ ., data = trainData)
summary(enhanced_linear_model)
```

```
##
## Call:
## lm(formula = Life_expectancy ~ ., data = trainData)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.0695 -0.2235 -0.0037  0.1979  3.2671
##
## Coefficients: (9 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -2.365e+02  2.919e+01  -8.104 9.75e-16
## Column1       -6.173e-02  1.771e-02  -3.487 0.000501
## CountryAlbania  5.188e+00  4.578e-01  11.333 < 2e-16
## CountryAlgeria  5.725e+00  5.247e-01  10.911 < 2e-16
## CountryAngola  -1.650e+00  6.506e-01  -2.536 0.011304
## CountryAntigua and Barbuda  8.527e+00  8.877e-01   9.606 < 2e-16
## CountryArgentina  8.584e+00  1.065e+00   8.064 1.34e-15
## CountryArmenia   8.411e+00  1.292e+00   6.508 9.84e-11
## CountryAustralia  1.333e+01  1.501e+00   8.878 < 2e-16
## CountryAustria   1.319e+01  1.679e+00   7.855 6.85e-15
## CountryAzerbaijan  8.946e+00  1.783e+00   5.016 5.79e-07
## CountryBahamas, The  1.120e+01  1.957e+00   5.724 1.22e-08
## CountryBahrain   1.051e+01  2.151e+00   4.885 1.13e-06
## CountryBangladesh  1.023e+01  2.331e+00   4.389 1.20e-05
## CountryBarbados   1.685e+01  2.591e+00   6.504 1.01e-10
## CountryBelarus    1.372e+01  2.810e+00   4.883 1.14e-06
## CountryBelgium    1.782e+01  3.002e+00   5.936 3.50e-09
## CountryBelize     1.512e+01  3.189e+00   4.742 2.28e-06
## CountryBenin      1.028e+01  3.355e+00   3.065 0.002206
## CountryBhutan     1.519e+01  3.550e+00   4.279 1.98e-05
## CountryBolivia    1.518e+01  3.742e+00   4.055 5.22e-05
## CountryBosnia and Herzegovina  1.808e+01  3.977e+00   4.546 5.82e-06
## CountryBotswana   1.617e+01  4.160e+00   3.888 0.000105
## CountryBrazil     1.983e+01  4.356e+00   4.552 5.66e-06
## CountryBrunei Darussalam  1.823e+01  4.530e+00   4.025 5.94e-05
## CountryBulgaria   2.055e+01  4.733e+00   4.342 1.49e-05
## CountryBurkina Faso  1.409e+01  4.914e+00   2.867 0.004199
## CountryBurundi    1.569e+01  5.115e+00   3.067 0.002195
## CountryCabo Verde  2.025e+01  5.351e+00   3.784 0.000159
## CountryCambodia   1.957e+01  5.507e+00   3.553 0.000391
## CountryCameroon   1.919e+01  5.709e+00   3.361 0.000792
## CountryCanada     2.893e+01  5.954e+00   4.859 1.28e-06
```



## CountryCentral African Republic	2.005e+01	6.127e+00	3.273	0.001086
## CountryChad	1.881e+01	6.349e+00	2.962	0.003093
## CountryChile	2.963e+01	6.535e+00	4.534	6.16e-06
## CountryChina	2.618e+01	6.730e+00	3.890	0.000104
## CountryColombia	3.039e+01	6.905e+00	4.401	1.14e-05
## CountryComoros	2.504e+01	7.119e+00	3.517	0.000447
## CountryCongo, Dem. Rep.	2.401e+01	7.352e+00	3.266	0.001110
## CountryCongo, Rep.	2.622e+01	7.583e+00	3.457	0.000558
## CountryCosta Rica	3.403e+01	7.812e+00	4.356	1.40e-05
## CountryCroatia	3.269e+01	8.016e+00	4.078	4.73e-05
## CountryCuba	3.494e+01	8.229e+00	4.246	2.29e-05
## CountryCyprus	3.538e+01	8.448e+00	4.188	2.95e-05
## CountryCzechia	3.551e+01	8.668e+00	4.097	4.38e-05
## CountryDenmark	3.755e+01	8.881e+00	4.228	2.48e-05
## CountryDjibouti	3.182e+01	9.044e+00	3.518	0.000446
## CountryDominican Republic	3.713e+01	9.283e+00	4.000	6.60e-05
## CountryEcuador	3.870e+01	9.527e+00	4.062	5.07e-05
## CountryEgypt, Arab Rep.	3.611e+01	9.706e+00	3.721	0.000205
## CountryEl Salvador	3.857e+01	9.910e+00	3.892	0.000103
## CountryEquatorial Guinea	3.517e+01	1.009e+01	3.484	0.000505
## CountryEritrea	3.600e+01	1.032e+01	3.488	0.000498
## CountryEstonia	4.220e+01	1.057e+01	3.992	6.83e-05
## CountryEswatini	3.501e+01	1.079e+01	3.243	0.001204
## CountryEthiopia	3.827e+01	1.099e+01	3.481	0.000511
## CountryFiji	3.940e+01	1.121e+01	3.515	0.000450
## CountryFinland	4.714e+01	1.139e+01	4.138	3.66e-05
## CountryFrance	4.935e+01	1.158e+01	4.263	2.12e-05
## CountryGabon	4.092e+01	1.176e+01	3.481	0.000511
## CountryGambia	3.939e+01	1.196e+01	3.292	0.001012
## CountryGeorgia	4.610e+01	1.219e+01	3.783	0.000160
## CountryGermany	5.078e+01	1.243e+01	4.085	4.59e-05
## CountryGhana	4.289e+01	1.262e+01	3.399	0.000691
## CountryGreece	5.196e+01	1.280e+01	4.058	5.16e-05
## CountryGrenada	4.969e+01	1.306e+01	3.804	0.000147
## CountryGuatemala	5.068e+01	1.331e+01	3.807	0.000146
## CountryGuinea	4.474e+01	1.351e+01	3.312	0.000945
## CountryGuinea-Bissau	4.348e+01	1.368e+01	3.178	0.001511
## CountryGuyana	5.133e+01	1.391e+01	3.691	0.000230
## CountryHaiti	4.920e+01	1.410e+01	3.489	0.000496
## CountryHonduras	5.449e+01	1.436e+01	3.795	0.000152
## CountryHungary	5.599e+01	1.459e+01	3.838	0.000128
## CountryIceland	5.973e+01	1.479e+01	4.039	5.60e-05
## CountryIndia	5.433e+01	1.495e+01	3.634	0.000287
## CountryIndonesia	5.501e+01	1.519e+01	3.621	0.000301
## CountryIran	5.663e+01	1.535e+01	3.689	0.000232
## CountryIraq	5.628e+01	1.558e+01	3.612	0.000312
## CountryIreland	6.215e+01	1.576e+01	3.943	8.36e-05
## CountryIsrael	6.337e+01	1.594e+01	3.974	7.33e-05
## CountryItaly	6.430e+01	1.613e+01	3.985	7.02e-05
## CountryJamaica	6.211e+01	1.632e+01	3.806	0.000146
## CountryJapan	6.700e+01	1.650e+01	4.061	5.09e-05
## CountryJordan	6.143e+01	1.670e+01	3.677	0.000243
## CountryKazakhstan	6.302e+01	1.692e+01	3.724	0.000202
## CountryKenya	5.906e+01	1.710e+01	3.455	0.000563

## CountryKiribati	6.168e+01	1.729e+01	3.568	0.000369
## CountryKuwait	6.212e+01	1.748e+01	3.553	0.000391
## CountryKyrgyz Republic	6.582e+01	1.769e+01	3.722	0.000204
## CountryLao PDR	6.324e+01	1.788e+01	3.538	0.000414
## CountryLatvia	6.852e+01	1.814e+01	3.778	0.000163
## CountryLebanon	6.896e+01	1.833e+01	3.762	0.000174
## CountryLesotho	6.313e+01	1.852e+01	3.409	0.000667
## CountryLiberia	6.536e+01	1.872e+01	3.491	0.000493
## CountryLibya	6.840e+01	1.895e+01	3.610	0.000315
## CountryLithuania	7.237e+01	1.917e+01	3.775	0.000165
## CountryLuxembourg	7.509e+01	1.940e+01	3.871	0.000112
## CountryMadagascar	6.886e+01	1.957e+01	3.518	0.000445
## CountryMalawi	6.855e+01	1.981e+01	3.460	0.000552
## CountryMalaysia	7.353e+01	2.005e+01	3.667	0.000252
## CountryMaldives	7.375e+01	2.022e+01	3.647	0.000273
## CountryMali	6.675e+01	2.040e+01	3.272	0.001087
## CountryMalta	7.868e+01	2.060e+01	3.818	0.000139
## CountryMauritania	7.230e+01	2.082e+01	3.474	0.000526
## CountryMauritius	7.740e+01	2.103e+01	3.680	0.000240
## CountryMexico	7.935e+01	2.123e+01	3.737	0.000192
## CountryMicronesia, Fed. Sts.	7.368e+01	2.144e+01	3.437	0.000601
## CountryMoldova	7.825e+01	2.164e+01	3.616	0.000308
## CountryMongolia	7.852e+01	2.185e+01	3.593	0.000335
## CountryMontenegro	8.130e+01	2.204e+01	3.688	0.000232
## CountryMorocco	8.047e+01	2.224e+01	3.617	0.000306
## CountryMozambique	7.634e+01	2.238e+01	3.410	0.000663
## CountryMyanmar	7.835e+01	2.257e+01	3.471	0.000530
## CountryNamibia	7.898e+01	2.274e+01	3.473	0.000528
## CountryNepal	8.111e+01	2.293e+01	3.537	0.000415
## CountryNetherlands	8.787e+01	2.310e+01	3.804	0.000147
## CountryNew Zealand	8.914e+01	2.332e+01	3.822	0.000137
## CountryNicaragua	8.626e+01	2.355e+01	3.663	0.000257
## CountryNiger	7.872e+01	2.375e+01	3.314	0.000938
## CountryNigeria	8.064e+01	2.391e+01	3.373	0.000759
## CountryNorth Macedonia	8.759e+01	2.412e+01	3.632	0.000289
## CountryNorway	9.242e+01	2.427e+01	3.808	0.000145
## CountryOman	8.903e+01	2.451e+01	3.633	0.000288
## CountryPakistan	8.773e+01	2.468e+01	3.555	0.000388
## CountryPanama	9.356e+01	2.489e+01	3.758	0.000176
## CountryPapua New Guinea	8.595e+01	2.507e+01	3.429	0.000620
## CountryParaguay	9.245e+01	2.529e+01	3.656	0.000264
## CountryPeru	9.341e+01	2.548e+01	3.666	0.000253
## CountryPhilippines	9.341e+01	2.565e+01	3.642	0.000278
## CountryPoland	9.578e+01	2.584e+01	3.707	0.000216
## CountryPortugal	9.732e+01	2.601e+01	3.742	0.000188
## CountryQatar	9.674e+01	2.617e+01	3.697	0.000225
## CountryRomania	9.635e+01	2.640e+01	3.649	0.000270
## CountryRussian Federation	9.678e+01	2.663e+01	3.634	0.000286
## CountryRwanda	9.326e+01	2.679e+01	3.481	0.000512
## CountrySamoa	9.623e+01	2.702e+01	3.561	0.000379
## CountrySao Tome and Principe	9.556e+01	2.716e+01	3.519	0.000444
## CountrySaudi Arabia	9.781e+01	2.738e+01	3.572	0.000363
## CountrySenegal	9.509e+01	2.758e+01	3.448	0.000578
## CountrySerbia	1.005e+02	2.774e+01	3.623	0.000299

## CountrySeychelles	1.015e+02	2.791e+01	3.637	0.000283
## CountrySierra Leone	9.642e+01	2.804e+01	3.438	0.000599
## CountrySingapore	1.057e+02	2.825e+01	3.742	0.000188
## CountrySlovak Republic	1.040e+02	2.845e+01	3.655	0.000265
## CountrySlovenia	1.067e+02	2.860e+01	3.731	0.000196
## CountrySolomon Islands	1.032e+02	2.882e+01	3.580	0.000353
## CountrySomalia	9.953e+01	2.898e+01	3.434	0.000607
## CountrySouth Africa	1.048e+02	2.920e+01	3.588	0.000343
## CountrySpain	1.109e+02	2.945e+01	3.766	0.000171
## CountrySri Lanka	1.085e+02	2.969e+01	3.654	0.000265
## CountrySt. Lucia	1.103e+02	2.987e+01	3.692	0.000230
## CountrySt. Vincent and the Grenadines	1.089e+02	3.008e+01	3.619	0.000304
## CountrySuriname	1.084e+02	3.024e+01	3.584	0.000348
## CountrySweden	1.139e+02	3.042e+01	3.745	0.000186
## CountrySwitzerland	1.155e+02	3.059e+01	3.774	0.000166
## CountrySyrian Arab Republic	1.104e+02	3.075e+01	3.589	0.000341
## CountryTajikistan	1.090e+02	3.099e+01	3.516	0.000449
## CountryTanzania	1.080e+02	3.119e+01	3.464	0.000545
## CountryThailand	1.148e+02	3.145e+01	3.649	0.000271
## CountryTimor-Leste	1.118e+02	3.167e+01	3.531	0.000425
## CountryTogo	1.088e+02	3.184e+01	3.418	0.000646
## CountryTonga	1.123e+02	3.202e+01	3.508	0.000463
## CountryTrinidad and Tobago	1.169e+02	3.222e+01	3.628	0.000294
## CountryTunisia	1.168e+02	3.242e+01	3.603	0.000323
## CountryTurkiye	1.173e+02	3.259e+01	3.599	0.000328
## CountryTurkmenistan	1.161e+02	3.281e+01	3.538	0.000414
## CountryUganda	1.146e+02	3.297e+01	3.475	0.000522
## CountryUkraine	1.196e+02	3.313e+01	3.611	0.000314
## CountryUnited Arab Emirates	1.198e+02	3.336e+01	3.593	0.000336
## CountryUnited Kingdom	1.243e+02	3.356e+01	3.702	0.000220
## CountryUnited States	1.247e+02	3.377e+01	3.693	0.000228
## CountryUruguay	1.239e+02	3.394e+01	3.650	0.000270
## CountryUzbekistan	1.213e+02	3.414e+01	3.554	0.000389
## CountryVanuatu	1.203e+02	3.435e+01	3.501	0.000475
## CountryVenezuela, RB	1.245e+02	3.451e+01	3.608	0.000317
## CountryVietnam	1.261e+02	3.470e+01	3.635	0.000286
## CountryYemen, Rep.	1.232e+02	3.488e+01	3.532	0.000423
## CountryZambia	1.219e+02	3.502e+01	3.482	0.000510
## CountryZimbabwe	1.229e+02	3.521e+01	3.490	0.000495
## RegionAsia	NA	NA	NA	NA
## RegionCentral America and Caribbean	NA	NA	NA	NA
## RegionEuropean Union	NA	NA	NA	NA
## RegionMiddle East	NA	NA	NA	NA
## RegionNorth America	NA	NA	NA	NA
## RegionOceania	NA	NA	NA	NA
## RegionRest of Europe	NA	NA	NA	NA
## RegionSouth America	NA	NA	NA	NA
## Year	1.563e-01	1.455e-02	10.736	< 2e-16
## Economy_status_Developed	NA	NA	NA	NA
## Adult_mortality	-4.068e-02	8.717e-04	-46.660	< 2e-16
## Infant_deaths	-8.659e-02	2.967e-03	-29.187	< 2e-16
## Alcohol_consumption	-3.026e-02	1.570e-02	-1.927	0.054139
## `percentage expenditure`	-6.652e-07	1.642e-05	-0.041	0.967695
## Hepatitis_B	5.550e-04	5.861e-04	0.947	0.343852

## Measles	-9.369e-07	1.612e-06	-0.581	0.561117
## BMI	8.854e-04	1.012e-03	0.875	0.381592
## Under_five_deaths	-1.707e-04	3.146e-04	-0.542	0.587575
## Polio	9.574e-04	7.912e-04	1.210	0.226423
## `Total expenditure`	-2.594e-03	6.105e-03	-0.425	0.670945
## Diphtheria	1.477e-03	9.107e-04	1.622	0.104924
## Incidents_HIV	-1.797e-03	8.135e-03	-0.221	0.825241
## GDP_per_capita	1.626e-06	2.630e-06	0.618	0.536591
## Population_millions	6.987e-11	2.704e-10	0.258	0.796122
## Thinness_ten_nineteen_years	-1.623e-02	9.572e-03	-1.695	0.090199
## Thinness_five_nine_years	5.578e-03	9.455e-03	0.590	0.555294
## `Income composition of resources`	-3.038e-01	1.427e-01	-2.129	0.033393
## Schooling	-7.852e-02	3.852e-02	-2.039	0.041643
##				
## (Intercept)	***			
## Column1	***			
## CountryAlbania	***			
## CountryAlgeria	***			
## CountryAngola	*			
## CountryAntigua and Barbuda	***			
## CountryArgentina	***			
## CountryArmenia	***			
## CountryAustralia	***			
## CountryAustria	***			
## CountryAzerbaijan	***			
## CountryBahamas, The	***			
## CountryBahrain	***			
## CountryBangladesh	***			
## CountryBarbados	***			
## CountryBelarus	***			
## CountryBelgium	***			
## CountryBelize	***			
## CountryBenin	**			
## CountryBhutan	***			
## CountryBolivia	***			
## CountryBosnia and Herzegovina	***			
## CountryBotswana	***			
## CountryBrazil	***			
## CountryBrunei Darussalam	***			
## CountryBulgaria	***			
## CountryBurkina Faso	**			
## CountryBurundi	**			
## CountryCabo Verde	***			
## CountryCambodia	***			
## CountryCameroon	***			
## CountryCanada	***			
## CountryCentral African Republic	**			
## CountryChad	**			
## CountryChile	***			
## CountryChina	***			
## CountryColombia	***			
## CountryComoros	***			
## CountryCongo, Dem. Rep.	**			
## CountryCongo, Rep.	***			

## CountryCosta Rica	***
## CountryCroatia	***
## CountryCuba	***
## CountryCyprus	***
## CountryCzechia	***
## CountryDenmark	***
## CountryDjibouti	***
## CountryDominican Republic	***
## CountryEcuador	***
## CountryEgypt, Arab Rep.	***
## CountryEl Salvador	***
## CountryEquatorial Guinea	***
## CountryEritrea	***
## CountryEstonia	***
## CountryEswatini	**
## CountryEthiopia	***
## CountryFiji	***
## CountryFinland	***
## CountryFrance	***
## CountryGabon	***
## CountryGambia	**
## CountryGeorgia	***
## CountryGermany	***
## CountryGhana	***
## CountryGreece	***
## CountryGrenada	***
## CountryGuatemala	***
## CountryGuinea	***
## CountryGuinea-Bissau	**
## CountryGuyana	***
## CountryHaiti	***
## CountryHonduras	***
## CountryHungary	***
## CountryIceland	***
## CountryIndia	***
## CountryIndonesia	***
## CountryIran	***
## CountryIraq	***
## CountryIreland	***
## CountryIsrael	***
## CountryItaly	***
## CountryJamaica	***
## CountryJapan	***
## CountryJordan	***
## CountryKazakhstan	***
## CountryKenya	***
## CountryKiribati	***
## CountryKuwait	***
## CountryKyrgyz Republic	***
## CountryLao PDR	***
## CountryLatvia	***
## CountryLebanon	***
## CountryLesotho	***
## CountryLiberia	***

## CountryLibya	***
## CountryLithuania	***
## CountryLuxembourg	***
## CountryMadagascar	***
## CountryMalawi	***
## CountryMalaysia	***
## CountryMaldives	***
## CountryMali	**
## CountryMalta	***
## CountryMauritania	***
## CountryMauritius	***
## CountryMexico	***
## CountryMicronesia, Fed. Sts.	***
## CountryMoldova	***
## CountryMongolia	***
## CountryMontenegro	***
## CountryMorocco	***
## CountryMozambique	***
## CountryMyanmar	***
## CountryNamibia	***
## CountryNepal	***
## CountryNetherlands	***
## CountryNew Zealand	***
## CountryNicaragua	***
## CountryNiger	***
## CountryNigeria	***
## CountryNorth Macedonia	***
## CountryNorway	***
## CountryOman	***
## CountryPakistan	***
## CountryPanama	***
## CountryPapua New Guinea	***
## CountryParaguay	***
## CountryPeru	***
## CountryPhilippines	***
## CountryPoland	***
## CountryPortugal	***
## CountryQatar	***
## CountryRomania	***
## CountryRussian Federation	***
## CountryRwanda	***
## CountrySamoa	***
## CountrySao Tome and Principe	***
## CountrySaudi Arabia	***
## CountrySenegal	***
## CountrySerbia	***
## CountrySeychelles	***
## CountrySierra Leone	***
## CountrySingapore	***
## CountrySlovak Republic	***
## CountrySlovenia	***
## CountrySolomon Islands	***
## CountrySomalia	***
## CountrySouth Africa	***

```

## CountrySpain ***
## CountrySri Lanka ***
## CountrySt. Lucia ***
## CountrySt. Vincent and the Grenadines ***
## CountrySuriname ***
## CountrySweden ***
## CountrySwitzerland ***
## CountrySyrian Arab Republic ***
## CountryTajikistan ***
## CountryTanzania ***
## CountryThailand ***
## CountryTimor-Leste ***
## CountryTogo ***
## CountryTonga ***
## CountryTrinidad and Tobago ***
## CountryTunisia ***
## CountryTurkiye ***
## CountryTurkmenistan ***
## CountryUganda ***
## CountryUkraine ***
## CountryUnited Arab Emirates ***
## CountryUnited Kingdom ***
## CountryUnited States ***
## CountryUruguay ***
## CountryUzbekistan ***
## CountryVanuatu ***
## CountryVenezuela, RB ***
## CountryVietnam ***
## CountryYemen, Rep. ***
## CountryZambia ***
## CountryZimbabwe ***
## RegionAsia
## RegionCentral America and Caribbean
## RegionEuropean Union
## RegionMiddle East
## RegionNorth America
## RegionOceania
## RegionRest of Europe
## RegionSouth America
## Year ***
## Economy_status_Developed
## Adult_mortality ***
## Infant_deaths ***
## Alcohol_consumption .
## `percentage expenditure`
## Hepatitis_B
## Measles
## BMI
## Under_five_deaths
## Polio
## `Total expenditure`
## Diphtheria
## Incidents_HIV
## GDP_per_capita

```

```

## Population_millions
## Thinness_ten_nineteen_years      .
## Thinness_five_nine_years
## `Income composition of resources` *
## Schooling                        *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5275 on 1798 degrees of freedom
## Multiple R-squared:  0.9971, Adjusted R-squared:  0.9968
## F-statistic: 3186 on 197 and 1798 DF, p-value: < 2.2e-16

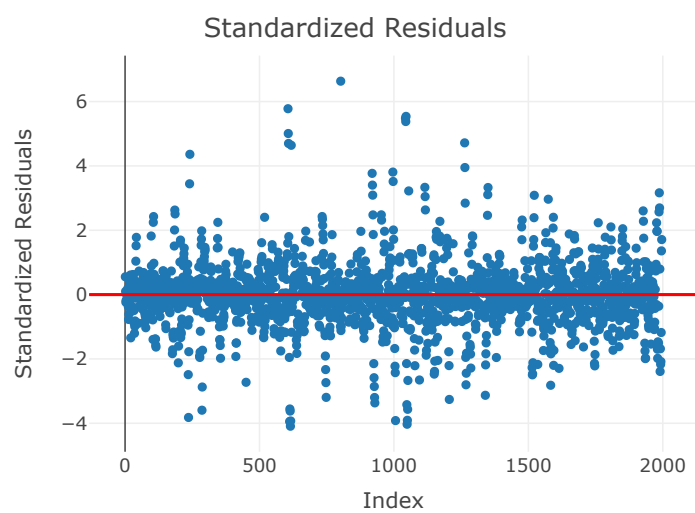
# Calculate Standardized Residuals
standardized_resids <- rstandard(enhanced_linear_model)

# Create an interactive plot of Standardized Residuals using plotly
p <- plot_ly(x = seq_along(standardized_resids), y = standardized_resids, type = 'scatter', mode = 'markers')
  layout(title = "Standardized Residuals",
    xaxis = list(title = "Index"),
    yaxis = list(title = "Standardized Residuals"),
    shapes = list(type = "line", line = list(color = "red", width = 2), x0 = 0, x1 = 1, xref = "paper", y0 = 0, y1 = 0))

# Display the plot
p

```





```
# Cook's Distance  
cooks_d <- cooks.distance(enhanced_linear_model)
```

```

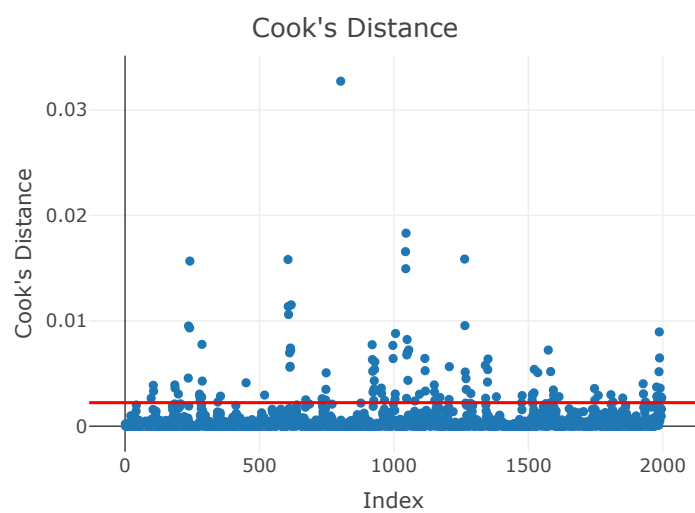
# Load plotly library

# Determine the threshold for influential points
influential_threshold <- 4 / (nrow(trainData) - length(coef(enhanced_linear_model)))

# Create an interactive plot of Cook's Distance using plotly
p <- plot_ly(x = seq_along(cooksd), y = cooksd, type = 'scatter', mode = 'markers') %>%
  layout(title = "Cook's Distance",
    xaxis = list(title = "Index"),
    yaxis = list(title = "Cook's Distance"),
    shapes = list(type = "line", line = list(color = "red", width = 2), x0 = 0, x1 = 1, xref = "paper", y0 = influential_threshold, y1 = 0, yref = "paper"))

# Display the plot
p

```



```
# Load the training data  
trainData <- read_csv("train_data.csv")
```

```
## Rows: 1996 Columns: 24
## -- Column specification -----
## Delimiter: ","
## chr (2): Country, Region
## dbl (22): Column1, Year, Economy_status_Developed, Life_expectancy, Adult_mo...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
# Build the enhanced linear model
enhanced_linear_model <- lm(Life_expectancy ~ ., data = trainData)
```

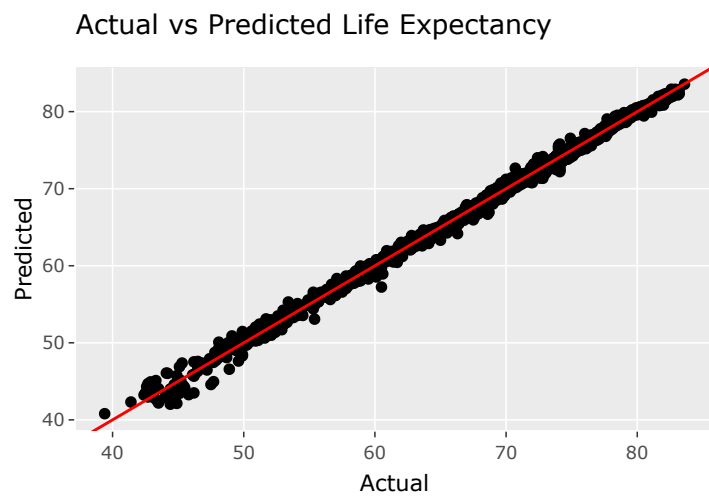
```
# Predict values using the model
trainData$Predicted <- predict(enhanced_linear_model, trainData)
```

```
## Warning in predict.lm(enhanced_linear_model, trainData): prediction from
## rank-deficient fit; attr(*, "non-estim") has doubtful cases
```

```
# Create a ggplot object for Actual vs Predicted values
actual_vs_predicted_plot <- ggplot(trainData, aes(x = Life_expectancy, y = Predicted)) +
  geom_point() +
  geom_abline(intercept = 0, slope = 1, color = "red") +
  labs(title = "Actual vs Predicted Life Expectancy", x = "Actual", y = "Predicted")
```

```
# Convert to a Plotly object for interactivity
actual_vs_predicted_plotly <- ggplotly(actual_vs_predicted_plot)

# Display the interactive plot
actual_vs_predicted_plotly
```



```
## Residuals
```

```

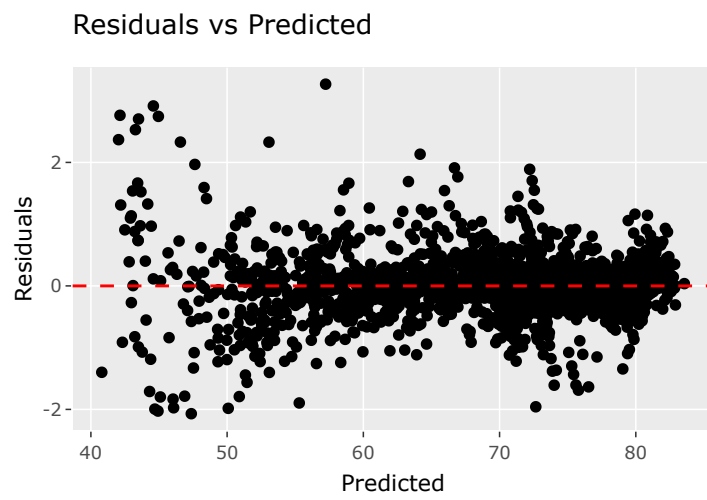
# Calculate residuals
trainData$Residuals <- residuals(enhanced_linear_model)

# Create a ggplot object for Residuals vs Predicted values
residuals_plot <- ggplot(trainData, aes(x = Predicted, y = Residuals)) +
  geom_point() +
  geom_hline(yintercept = 0, linetype = "dashed", color = "red") +
  labs(title = "Residuals vs Predicted", x = "Predicted", y = "Residuals")

# Convert to a Plotly object for interactivity
residuals_plotly <- ggplotly(residuals_plot)

# Display the interactive plot
residuals_plotly

```



```
### Part C2: Additional Model Training with Train-Test Split  
# Splitting the Data into Train and Test Sets
```

```

set.seed(123) # for reproducibility
index <- createDataPartition(data$Life_expectancy, p = 0.8, list = FALSE) # 80-20 split
train_data <- data[index, ]
test_data <- data[-index, ]

# Working with models 1,2,3
# Data Preparation

# Set seed for reproducibility
set.seed(123)

# Load and prepare your data (assuming 'data' is already loaded)
# Split the data into training and validation sets
indexes <- sample(1:nrow(data), size = 0.8 * nrow(data))
train_data <- data[indexes, ]
validation_data <- data[-indexes, ]
train_data_selected <- dplyr::select(train_data, -Country, -Region)

# Define and fit models
model_1 <- lm(Life_expectancy ~ . + I(Alcohol_consumption^2), data = train_data_selected)
model_2 <- lm(Life_expectancy ~ Year + Adult_mortality + Alcohol_consumption + BMI, data = train_data_s
model_3 <- glm(Life_expectancy ~ ., family = gaussian(link = "log"), data = train_data_selected)

# Generate predicted values for each model
predicted_values_1 <- predict(model_1, train_data_selected)
predicted_values_2 <- predict(model_2, train_data_selected)
predicted_values_3 <- predict(model_3, train_data_selected)

print(predicted_values_1)

```

```

##          1          2          3          4          5          6          7          8
## 82.79616 63.93140 72.22026 52.70523 65.86915 79.23622 73.44003 79.84081
##          9         10         11         12         13         14         15         16
## 79.94566 73.75418 76.98542 57.27434 80.41992 69.68095 79.07693 55.43794
##         17         18         19         20         21         22         23         24
## 61.38986 60.80130 79.86821 72.34108 75.43109 78.39988 73.13173 77.21674
##         25         26         27         28         29         30         31         32
## 74.01486 66.00677 74.71195 58.36540 43.32267 76.47009 50.60202 75.89302
##         33         34         35         36         37         38         39         40
## 82.31200 72.11063 65.89375 52.79388 78.99956 71.02117 67.92438 64.79326
##         41         42         43         44         45         46         47         48
## 80.35156 71.87374 75.37659 72.39222 64.69931 67.40594 61.34528 77.51329
##         49         50         51         52         53         54         55         56
## 80.56851 55.20049 70.21237 62.40722 57.49391 60.94488 72.68028 68.52506
##         57         58         59         60         61         62         63         64
## 63.17414 68.24749 73.69312 57.06605 51.77871 70.18277 70.53398 75.77637
##         65         66         67         68         69         70         71         72
## 50.47095 68.08813 76.65385 48.44125 61.57170 64.97179 69.01627 76.61882
##         73         74         75         76         77         78         79         80
## 71.43783 80.63199 64.62636 60.37748 63.85374 71.30177 53.56805 76.85221
##         81         82         83         84         85         86         87         88
## 77.98995 67.91362 72.17311 60.39251 72.40850 81.18010 72.67568 57.74852

```



##	89	90	91	92	93	94	95	96
##	64.90815	75.89962	72.36824	58.67052	71.78909	53.40825	76.65862	77.23452
##	97	98	99	100	101	102	103	104
##	51.57105	74.54579	81.52039	78.28181	81.09963	75.03672	59.81932	77.70889
##	105	106	107	108	109	110	111	112
##	75.97473	79.71919	60.86746	81.20769	56.37137	64.69516	69.48389	77.62359
##	113	114	115	116	117	118	119	120
##	61.25474	66.94702	64.78181	72.12171	71.93415	75.50302	61.67505	80.79385
##	121	122	123	124	125	126	127	128
##	65.39408	63.51330	80.01552	77.53444	80.31094	79.94787	55.77643	45.67732
##	129	130	131	132	133	134	135	136
##	75.01553	61.92917	54.11153	74.95370	40.29475	54.88312	80.29429	80.63845
##	137	138	139	140	141	142	143	144
##	55.72387	75.06713	61.88498	56.10273	60.08851	52.81627	60.34917	61.83604
##	145	146	147	148	149	150	151	152
##	70.55096	71.40961	75.86640	51.91505	63.50176	77.49596	74.12140	50.20529
##	153	154	155	156	157	158	159	160
##	78.02286	70.95172	79.58095	77.55578	77.55889	81.15758	79.63231	81.30599
##	161	162	163	164	165	166	167	168
##	53.21084	71.38074	73.76118	77.65708	63.07350	73.08493	54.50960	44.23301
##	169	170	171	172	173	174	175	176
##	70.49893	76.07269	68.59900	69.23348	67.88268	73.06091	65.88656	63.64746
##	177	178	179	180	181	182	183	184
##	55.21578	78.71697	53.72463	77.07928	72.19014	77.27316	60.17058	76.11672
##	185	186	187	188	189	190	191	192
##	77.42928	65.09598	48.35460	52.82062	70.07519	51.96045	71.66271	69.70049
##	193	194	195	196	197	198	199	200
##	62.23301	72.78949	64.63633	72.50045	71.02059	57.94542	59.05265	70.92269
##	201	202	203	204	205	206	207	208
##	58.33885	72.00427	72.71781	79.00005	59.92355	73.46465	49.99777	56.84134
##	209	210	211	212	213	214	215	216
##	77.18360	79.23312	62.25168	62.03126	69.69858	78.63262	75.76668	56.94527
##	217	218	219	220	221	222	223	224
##	73.82574	77.80358	66.52154	62.87173	72.85004	60.84048	80.25468	77.68553
##	225	226	227	228	229	230	231	232
##	55.96622	80.23567	75.00394	69.93831	58.55565	58.46206	72.25835	64.20723
##	233	234	235	236	237	238	239	240
##	80.01612	70.89193	78.91832	71.33672	78.17232	62.09831	70.84183	79.58639
##	241	242	243	244	245	246	247	248
##	73.72370	81.83804	78.34342	61.10207	80.26173	74.35368	69.63738	57.27466
##	249	250	251	252	253	254	255	256
##	68.25336	75.39835	46.92518	79.45181	80.14789	73.35311	59.59238	76.59062
##	257	258	259	260	261	262	263	264
##	71.06053	71.48676	73.06286	71.92382	50.54132	73.97869	69.09785	74.74566
##	265	266	267	268	269	270	271	272
##	63.53218	70.12078	54.26856	80.37379	81.12143	74.67481	60.91401	79.07980
##	273	274	275	276	277	278	279	280
##	65.02168	71.11545	64.10069	51.58692	58.45684	80.27188	80.74836	74.69003
##	281	282	283	284	285	286	287	288
##	68.18374	51.63295	73.73382	50.79340	49.87376	80.11080	75.03170	62.22196
##	289	290	291	292	293	294	295	296
##	69.42378	73.45196	64.92167	74.20948	75.65811	80.49702	71.74908	71.76844
##	297	298	299	300	301	302	303	304
##	82.02204	80.15710	63.58416	81.25855	76.02427	47.17551	63.35244	78.22115

##	305	306	307	308	309	310	311	312
##	73.13222	76.86626	76.12826	75.14534	79.97842	67.84134	73.82164	77.56335
##	313	314	315	316	317	318	319	320
##	75.86266	72.86013	72.41784	75.38116	63.26242	76.30435	74.62765	70.26105
##	321	322	323	324	325	326	327	328
##	51.86931	42.60999	79.53162	51.94142	69.72622	68.79834	71.47072	74.88838
##	329	330	331	332	333	334	335	336
##	80.28119	70.25966	80.38585	48.04928	63.30319	71.53177	62.83708	71.76323
##	337	338	339	340	341	342	343	344
##	73.99058	59.87750	72.80561	79.81130	77.82949	80.42811	51.52519	73.93917
##	345	346	347	348	349	350	351	352
##	58.63326	76.03851	70.80006	74.18498	67.62454	51.42193	56.11462	76.07843
##	353	354	355	356	357	358	359	360
##	72.24755	74.92319	73.34554	68.73621	80.31317	77.16698	80.20820	73.69463
##	361	362	363	364	365	366	367	368
##	61.04310	45.75694	75.47807	52.50478	77.54615	77.16714	52.61216	80.41330
##	369	370	371	372	373	374	375	376
##	69.64684	72.68508	61.09210	74.14086	42.76057	68.22824	60.73555	69.38508
##	377	378	379	380	381	382	383	384
##	60.13371	70.97001	57.94996	77.92544	76.41741	74.58770	77.47626	74.21498
##	385	386	387	388	389	390	391	392
##	77.35149	77.25078	70.40154	76.16876	73.99125	61.46623	43.75474	78.18275
##	393	394	395	396	397	398	399	400
##	74.99380	66.37176	77.55823	75.39866	65.91084	73.47182	74.54991	71.07138
##	401	402	403	404	405	406	407	408
##	77.70015	58.17020	69.37916	69.79696	72.79199	80.11194	45.58523	54.53288
##	409	410	411	412	413	414	415	416
##	60.13500	68.40010	46.06445	74.98885	79.07273	55.68570	75.99661	63.87176
##	417	418	419	420	421	422	423	424
##	77.22099	70.03348	47.24025	72.78771	64.83812	66.89051	73.61752	77.82192
##	425	426	427	428	429	430	431	432
##	67.22859	71.98039	54.99487	75.96085	76.05606	72.73682	66.91206	48.91839
##	433	434	435	436	437	438	439	440
##	60.61306	80.39183	60.49630	75.05778	77.41067	64.84529	68.71770	72.27899
##	441	442	443	444	445	446	447	448
##	58.54939	44.53224	79.23606	75.97171	69.67260	73.66136	50.52416	74.82157
##	449	450	451	452	453	454	455	456
##	70.98481	70.67527	73.78867	58.45611	72.75528	75.53484	76.20416	63.69680
##	457	458	459	460	461	462	463	464
##	79.85792	61.67477	73.37758	78.30741	62.81457	56.87246	75.83899	72.58874
##	465	466	467	468	469	470	471	472
##	44.56830	75.54018	62.48925	75.39554	79.90552	77.53016	58.11839	80.57396
##	473	474	475	476	477	478	479	480
##	54.67265	80.29056	59.01748	68.15879	77.72318	81.35624	62.95555	55.88157
##	481	482	483	484	485	486	487	488
##	79.25419	76.21283	58.67981	79.78920	65.46230	70.54660	73.21322	68.45141
##	489	490	491	492	493	494	495	496
##	50.49351	78.85153	70.64788	65.52687	57.92567	65.29315	79.44333	76.18579
##	497	498	499	500	501	502	503	504
##	59.87133	66.78628	69.88080	69.07950	78.32214	64.25863	70.58774	58.94954
##	505	506	507	508	509	510	511	512
##	70.20936	71.97870	68.96361	40.03333	61.00302	73.08240	70.58137	74.11942
##	513	514	515	516	517	518	519	520
##	52.43895	73.47796	77.47234	70.23144	55.22906	53.43385	57.89098	73.68420

##	521	522	523	524	525	526	527	528
##	74.96857	76.23368	58.17638	72.51503	70.76909	60.44997	72.69946	75.64245
##	529	530	531	532	533	534	535	536
##	56.47876	76.68069	78.90198	63.14116	60.23584	69.76832	62.77478	71.96781
##	537	538	539	540	541	542	543	544
##	55.43981	68.83347	63.63058	73.31949	43.65822	71.39433	67.45024	54.44795
##	545	546	547	548	549	550	551	552
##	45.34908	71.48538	67.53273	57.75191	79.38270	77.13028	48.54070	70.53518
##	553	554	555	556	557	558	559	560
##	71.70816	55.98973	67.95851	74.01707	75.69925	69.61239	49.37178	68.57553
##	561	562	563	564	565	566	567	568
##	51.36318	60.55543	79.78031	70.83176	74.45305	75.23645	58.40458	68.15358
##	569	570	571	572	573	574	575	576
##	77.92546	68.95698	81.02580	52.70100	69.80964	71.87033	58.98674	75.88827
##	577	578	579	580	581	582	583	584
##	74.00288	76.32360	68.61995	40.72896	60.09947	63.30304	79.48282	79.96247
##	585	586	587	588	589	590	591	592
##	73.33202	79.23639	63.51328	81.07678	76.74796	73.04324	79.48582	74.36258
##	593	594	595	596	597	598	599	600
##	64.68383	68.54660	61.54469	79.65858	80.68959	73.28822	68.91251	76.98398
##	601	602	603	604	605	606	607	608
##	66.71870	66.15604	71.60849	80.19873	62.48146	79.58801	75.90234	80.59991
##	609	610	611	612	613	614	615	616
##	79.07084	79.85023	76.64709	71.69302	77.28806	69.91636	69.37622	57.49677
##	617	618	619	620	621	622	623	624
##	72.89137	64.14265	75.92423	72.09473	70.37126	67.11615	57.63841	72.43526
##	625	626	627	628	629	630	631	632
##	79.22725	73.61724	72.51100	80.85446	74.19114	77.32096	41.62227	70.59699
##	633	634	635	636	637	638	639	640
##	73.93203	76.14946	80.34319	66.57527	61.04916	76.31276	59.70818	73.73236
##	641	642	643	644	645	646	647	648
##	71.92502	75.35527	73.97961	80.28177	66.07639	53.39120	57.22317	73.25777
##	649	650	651	652	653	654	655	656
##	67.65627	60.22919	81.36980	74.66147	80.99195	60.42656	68.57441	79.80622
##	657	658	659	660	661	662	663	664
##	67.73225	71.46948	70.23950	70.03349	63.49589	72.22202	52.16136	53.19618
##	665	666	667	668	669	670	671	672
##	74.19525	79.68740	73.13705	59.74778	50.54880	57.19237	72.27711	81.54318
##	673	674	675	676	677	678	679	680
##	59.26729	51.24103	75.99232	79.67290	55.47044	74.82495	72.46176	74.84994
##	681	682	683	684	685	686	687	688
##	70.42901	61.08696	68.79753	72.98241	63.49372	76.42500	66.32141	53.64419
##	689	690	691	692	693	694	695	696
##	78.71218	77.25103	70.45535	53.96545	79.29071	70.60553	79.14918	62.16440
##	697	698	699	700	701	702	703	704
##	73.03143	56.58549	75.24075	71.44795	73.49728	76.03475	72.35490	80.26590
##	705	706	707	708	709	710	711	712
##	68.69308	61.57356	80.55089	50.42303	55.61384	80.83114	70.85370	78.65814
##	713	714	715	716	717	718	719	720
##	68.86821	77.21379	70.00002	61.78026	76.30717	43.61983	76.94107	77.86775
##	721	722	723	724	725	726	727	728
##	71.42863	72.46825	78.71362	56.38878	69.91270	76.79983	70.61783	65.00106
##	729	730	731	732	733	734	735	736
##	72.00870	42.21015	57.96209	71.31780	77.47838	56.58053	70.79066	67.38166

##	737	738	739	740	741	742	743	744
##	75.64119	48.83063	56.36581	75.19586	64.16407	80.92105	59.62282	68.27584
##	745	746	747	748	749	750	751	752
##	80.16670	67.70930	75.18805	67.08861	61.43110	71.99489	65.47567	73.03743
##	753	754	755	756	757	758	759	760
##	72.28316	68.28711	53.14849	76.66732	76.71353	68.08021	48.46507	59.94169
##	761	762	763	764	765	766	767	768
##	78.54267	54.77238	71.98357	69.81681	72.57626	56.90142	73.54572	70.61512
##	769	770	771	772	773	774	775	776
##	80.07388	80.14232	72.57007	69.41713	54.77646	71.45568	70.73060	62.54821
##	777	778	779	780	781	782	783	784
##	75.96925	54.28106	66.97384	68.11366	75.13436	67.73748	80.00794	55.71917
##	785	786	787	788	789	790	791	792
##	73.67619	60.19702	68.26693	77.29921	80.31602	71.45317	64.28157	63.51097
##	793	794	795	796	797	798	799	800
##	74.92565	79.60036	72.60537	56.85337	53.02888	76.18748	60.53160	48.09800
##	801	802	803	804	805	806	807	808
##	74.84735	79.85738	49.33501	80.00782	77.23332	77.81777	60.45618	69.00062
##	809	810	811	812	813	814	815	816
##	65.70555	80.49230	54.22617	60.73471	74.42028	61.49589	76.76147	69.72530
##	817	818	819	820	821	822	823	824
##	75.97620	55.08917	80.53423	69.04784	52.71539	41.68391	68.37320	73.23101
##	825	826	827	828	829	830	831	832
##	78.24368	80.77474	73.24158	77.31427	60.54921	71.19753	53.95111	61.95216
##	833	834	835	836	837	838	839	840
##	71.55682	74.87679	70.76968	74.95433	67.99922	72.12375	72.44704	64.62882
##	841	842	843	844	845	846	847	848
##	77.43357	80.69810	80.63790	55.24789	71.12620	72.25187	78.44645	68.15355
##	849	850	851	852	853	854	855	856
##	71.71340	74.19142	79.96158	57.52197	77.56695	73.94264	72.80054	67.63030
##	857	858	859	860	861	862	863	864
##	73.82332	51.86852	75.14819	75.49538	76.29157	69.78602	76.02133	57.17808
##	865	866	867	868	869	870	871	872
##	72.18473	71.90285	74.65721	73.69422	68.26649	68.96903	69.01994	73.48879
##	873	874	875	876	877	878	879	880
##	77.17372	69.62828	76.75054	65.29204	80.20291	74.14448	72.55071	72.90758
##	881	882	883	884	885	886	887	888
##	65.32995	70.75276	70.45089	53.95754	71.83257	50.20226	70.84969	68.07969
##	889	890	891	892	893	894	895	896
##	62.47097	69.17099	72.17339	73.39224	80.86561	63.46941	66.55628	49.06203
##	897	898	899	900	901	902	903	904
##	79.53004	45.93265	79.91538	80.87230	63.33010	60.98687	50.66420	65.87417
##	905	906	907	908	909	910	911	912
##	76.86761	50.05117	72.39040	61.01216	77.92633	63.20082	65.46039	72.07760
##	913	914	915	916	917	918	919	920
##	75.90157	73.71396	72.52752	76.53965	62.65807	71.84702	71.08709	62.29571
##	921	922	923	924	925	926	927	928
##	57.66882	46.69744	53.46417	59.09437	63.25218	79.93871	53.73447	72.30691
##	929	930	931	932	933	934	935	936
##	68.02975	70.55372	80.68433	71.07443	74.82870	73.50142	75.57469	68.79907
##	937	938	939	940	941	942	943	944
##	62.35671	64.63908	74.19960	77.67135	72.96971	80.13190	72.23360	73.74237
##	945	946	947	948	949	950	951	952
##	73.49450	75.43441	74.56268	60.82960	62.52529	80.91402	78.67779	72.72759

##	953	954	955	956	957	958	959	960
##	46.13298	68.97198	71.73142	66.20734	75.96324	80.09280	49.79718	53.75011
##	961	962	963	964	965	966	967	968
##	58.19332	55.85440	70.46218	75.77755	71.61849	75.48712	73.88533	73.39882
##	969	970	971	972	973	974	975	976
##	77.79343	52.38572	80.81786	70.69927	67.96027	75.93020	81.38935	71.42475
##	977	978	979	980	981	982	983	984
##	77.75631	75.25312	66.67824	71.29495	70.72327	76.10965	67.87352	41.62152
##	985	986	987	988	989	990	991	992
##	61.23991	69.36609	55.61467	77.79729	79.26651	70.65510	72.26456	73.39130
##	993	994	995	996	997	998	999	1000
##	64.78235	67.34269	74.79633	58.73532	66.38986	53.66679	53.50372	73.46822
##	1001	1002	1003	1004	1005	1006	1007	1008
##	40.41228	53.98991	61.35440	70.12164	64.15026	78.41599	66.45971	63.05130
##	1009	1010	1011	1012	1013	1014	1015	1016
##	81.39465	52.55009	57.51949	67.85256	75.97432	63.86010	61.50906	75.27310
##	1017	1018	1019	1020	1021	1022	1023	1024
##	62.51316	76.02990	70.71142	75.79857	77.84807	70.74211	48.06741	56.06098
##	1025	1026	1027	1028	1029	1030	1031	1032
##	70.95582	78.01928	58.96156	67.91979	81.11866	65.58385	53.94292	78.60145
##	1033	1034	1035	1036	1037	1038	1039	1040
##	78.73763	73.40430	62.37682	71.56300	76.77102	73.18832	71.62069	69.48927
##	1041	1042	1043	1044	1045	1046	1047	1048
##	73.27913	66.15914	73.95603	74.43844	79.34231	71.34031	62.11483	80.10554
##	1049	1050	1051	1052	1053	1054	1055	1056
##	50.09128	73.10777	69.06110	61.37230	78.15728	58.42477	76.48642	53.58480
##	1057	1058	1059	1060	1061	1062	1063	1064
##	55.55230	67.39119	66.71192	69.21181	53.22861	70.54874	46.84102	74.42990
##	1065	1066	1067	1068	1069	1070	1071	1072
##	56.49673	61.12903	70.03137	80.32919	79.87340	73.60108	71.90374	61.53200
##	1073	1074	1075	1076	1077	1078	1079	1080
##	65.57556	75.40928	50.24224	80.59684	63.15355	70.58388	52.12428	71.76400
##	1081	1082	1083	1084	1085	1086	1087	1088
##	67.93022	71.89879	61.24030	78.64472	80.47518	73.44552	66.47520	72.89526
##	1089	1090	1091	1092	1093	1094	1095	1096
##	60.06793	75.46262	55.99982	71.00623	71.48522	81.19725	74.47687	68.74402
##	1097	1098	1099	1100	1101	1102	1103	1104
##	59.29920	44.41297	63.54709	74.94845	72.99168	70.44098	66.12719	61.15558
##	1105	1106	1107	1108	1109	1110	1111	1112
##	74.37602	63.90546	52.84967	71.11293	62.60407	60.46528	81.64716	48.77784
##	1113	1114	1115	1116	1117	1118	1119	1120
##	67.22182	73.07604	80.74863	74.41387	73.84911	75.48906	67.77822	73.56100
##	1121	1122	1123	1124	1125	1126	1127	1128
##	81.09692	48.19135	79.60809	72.52935	71.63757	74.88169	79.74244	79.89738
##	1129	1130	1131	1132	1133	1134	1135	1136
##	70.54279	64.44837	72.12382	78.34651	72.38082	42.24008	47.65189	61.59144
##	1137	1138	1139	1140	1141	1142	1143	1144
##	74.25299	57.36637	41.08437	72.65909	79.15266	75.99545	65.25270	71.48787
##	1145	1146	1147	1148	1149	1150	1151	1152
##	75.27743	70.89448	78.84797	76.70750	63.21487	79.55746	69.41601	53.29399
##	1153	1154	1155	1156	1157	1158	1159	1160
##	70.87401	79.85696	74.78098	80.83003	76.34213	73.69145	78.06100	60.98419
##	1161	1162	1163	1164	1165	1166	1167	1168
##	47.52834	75.49853	63.31903	63.89737	72.11533	70.22708	65.14913	78.70381

##	1169	1170	1171	1172	1173	1174	1175	1176
##	76.21327	60.86704	60.12912	73.88088	60.54499	80.20092	68.89523	70.88013
##	1177	1178	1179	1180	1181	1182	1183	1184
##	68.58491	76.12609	67.81187	59.75116	63.70602	79.37636	77.70749	78.33830
##	1185	1186	1187	1188	1189	1190	1191	1192
##	53.14271	64.13778	61.03464	79.31951	72.06974	79.70280	71.91429	65.63489
##	1193	1194	1195	1196	1197	1198	1199	1200
##	52.18745	74.84436	74.89148	62.59255	63.71376	72.01584	50.92730	69.29115
##	1201	1202	1203	1204	1205	1206	1207	1208
##	55.05702	77.66356	65.42098	70.92921	73.21218	71.72052	77.09278	80.48919
##	1209	1210	1211	1212	1213	1214	1215	1216
##	46.30552	73.79601	76.14249	74.19103	67.39634	80.16435	70.27134	74.33222
##	1217	1218	1219	1220	1221	1222	1223	1224
##	69.65905	70.35835	72.35112	70.96270	74.29376	54.95376	72.86007	63.67329
##	1225	1226	1227	1228	1229	1230	1231	1232
##	80.02162	67.79557	79.34813	68.21997	59.61244	79.47794	62.11323	72.36682
##	1233	1234	1235	1236	1237	1238	1239	1240
##	60.87553	69.84454	69.90736	74.69745	70.19571	71.24073	70.30945	71.50414
##	1241	1242	1243	1244	1245	1246	1247	1248
##	71.06175	53.71694	75.36885	79.59009	75.16350	78.95049	75.81854	76.98379
##	1249	1250	1251	1252	1253	1254	1255	1256
##	66.89354	62.78488	73.86573	69.89255	65.16540	50.27966	58.33260	59.11040
##	1257	1258	1259	1260	1261	1262	1263	1264
##	80.69939	71.54924	76.28472	73.50193	55.63390	57.00989	70.71792	74.89643
##	1265	1266	1267	1268	1269	1270	1271	1272
##	63.63150	55.15727	69.46589	74.71925	74.93468	65.04917	51.39992	64.08226
##	1273	1274	1275	1276	1277	1278	1279	1280
##	57.48322	76.57777	62.81505	71.46040	80.36941	71.67912	69.33262	67.24046
##	1281	1282	1283	1284	1285	1286	1287	1288
##	73.94346	57.16584	56.22483	73.66806	75.85388	76.61492	79.56774	58.13033
##	1289	1290	1291	1292	1293	1294	1295	1296
##	58.52048	77.40895	70.88453	67.96754	73.41312	60.88970	62.33471	81.11107
##	1297	1298	1299	1300	1301	1302	1303	1304
##	50.86844	72.32831	65.06519	77.07672	73.27680	70.41056	73.90036	76.24924
##	1305	1306	1307	1308	1309	1310	1311	1312
##	63.87064	64.45919	68.72097	81.59707	72.45653	75.08041	80.87791	68.47691
##	1313	1314	1315	1316	1317	1318	1319	1320
##	54.90409	66.23405	56.68502	71.74399	72.36296	76.38039	67.43087	71.33083
##	1321	1322	1323	1324	1325	1326	1327	1328
##	43.94571	76.15169	78.12642	73.59823	80.03624	41.95712	55.04527	68.66290
##	1329	1330	1331	1332	1333	1334	1335	1336
##	66.27826	73.58153	60.05810	70.33736	69.16562	76.09919	66.09785	79.92556
##	1337	1338	1339	1340	1341	1342	1343	1344
##	79.86526	57.35895	78.85830	73.43566	57.93853	78.79704	72.65790	81.05354
##	1345	1346	1347	1348	1349	1350	1351	1352
##	53.26316	69.19582	73.91404	76.92334	74.48894	80.79055	60.74042	79.61482
##	1353	1354	1355	1356	1357	1358	1359	1360
##	43.56209	73.02441	69.88041	71.98780	59.45929	74.37944	56.07476	72.67520
##	1361	1362	1363	1364	1365	1366	1367	1368
##	80.47254	74.56175	71.95276	68.54311	80.71905	58.79965	58.31583	64.32513
##	1369	1370	1371	1372	1373	1374	1375	1376
##	69.44715	69.19987	77.34248	72.48985	74.31316	73.71100	78.75981	76.17545
##	1377	1378	1379	1380	1381	1382	1383	1384
##	78.63762	70.24396	71.31125	73.33737	80.91571	49.76183	72.87258	76.74591

##	1385	1386	1387	1388	1389	1390	1391	1392
##	75.33213	74.39546	80.11923	56.23633	51.19822	81.23209	67.83988	78.63776
##	1393	1394	1395	1396	1397	1398	1399	1400
##	75.76341	56.55613	72.25313	77.43126	50.14736	75.94157	71.30561	64.78608
##	1401	1402	1403	1404	1405	1406	1407	1408
##	77.79691	65.79836	57.40627	61.52914	76.94759	74.28193	77.00599	62.86593
##	1409	1410	1411	1412	1413	1414	1415	1416
##	74.79034	72.30536	80.37069	78.04084	76.10629	80.89894	73.30546	72.12373
##	1417	1418	1419	1420	1421	1422	1423	1424
##	62.00334	52.33572	70.94103	74.44131	72.83345	59.93734	81.48135	73.21984
##	1425	1426	1427	1428	1429	1430	1431	1432
##	50.30792	63.19137	73.18042	65.80031	78.61447	70.12925	69.56374	67.87919
##	1433	1434	1435	1436	1437	1438	1439	1440
##	76.24409	51.91396	76.83602	80.72077	65.77622	80.47943	64.76029	81.31447
##	1441	1442	1443	1444	1445	1446	1447	1448
##	73.51946	49.96483	72.72717	80.87613	59.66297	63.84731	58.04045	79.95352
##	1449	1450	1451	1452	1453	1454	1455	1456
##	73.87681	77.70332	79.23173	59.21764	61.41086	49.30101	72.59099	74.38440
##	1457	1458	1459	1460	1461	1462	1463	1464
##	79.01692	71.48931	68.84265	59.01368	68.89252	65.28223	70.68632	78.55293
##	1465	1466	1467	1468	1469	1470	1471	1472
##	80.38601	77.75160	70.50558	72.07828	73.73816	69.99319	64.18911	77.56583
##	1473	1474	1475	1476	1477	1478	1479	1480
##	79.78283	75.48247	77.33087	77.10953	63.73199	75.38795	61.70824	78.37579
##	1481	1482	1483	1484	1485	1486	1487	1488
##	53.74331	73.52129	68.60851	80.66695	75.82600	66.47054	69.54469	69.73788
##	1489	1490	1491	1492	1493	1494	1495	1496
##	68.90006	74.65070	67.29944	56.95774	46.57365	72.72355	71.78302	75.82552
##	1497	1498	1499	1500	1501	1502	1503	1504
##	77.29929	45.22717	53.14799	71.80236	78.47351	58.73485	68.65755	71.40617
##	1505	1506	1507	1508	1509	1510	1511	1512
##	69.35803	73.05635	54.08035	59.62159	73.38103	67.88370	77.55106	58.17541
##	1513	1514	1515	1516	1517	1518	1519	1520
##	65.71029	73.85116	63.77631	69.71341	54.01322	80.73748	80.90339	77.15216
##	1521	1522	1523	1524	1525	1526	1527	1528
##	77.80243	60.92775	53.35858	59.43341	75.29847	52.49628	70.86641	42.32344
##	1529	1530	1531	1532	1533	1534	1535	1536
##	73.31421	81.26407	72.22081	72.44363	71.56813	64.22269	64.14990	69.10343
##	1537	1538	1539	1540	1541	1542	1543	1544
##	79.98301	76.86056	54.50077	76.61581	67.30915	51.56299	78.75601	59.09228
##	1545	1546	1547	1548	1549	1550	1551	1552
##	65.24759	80.07454	55.49746	62.29462	67.59233	75.41408	69.07910	77.19451
##	1553	1554	1555	1556	1557	1558	1559	1560
##	67.88729	73.66751	71.19694	76.39089	70.94184	62.34594	43.81342	68.39675
##	1561	1562	1563	1564	1565	1566	1567	1568
##	79.75881	73.55283	52.35848	73.63036	76.19751	74.06802	69.08552	40.81242
##	1569	1570	1571	1572	1573	1574	1575	1576
##	66.76809	75.18706	71.47037	66.57084	67.00965	67.71059	70.25285	78.31799
##	1577	1578	1579	1580	1581	1582	1583	1584
##	72.49623	59.20981	59.83032	57.91901	60.42319	73.72161	42.41069	59.60330
##	1585	1586	1587	1588	1589	1590	1591	1592
##	78.88293	60.13107	81.78730	66.65653	79.62188	65.18320	68.19926	51.70178
##	1593	1594	1595	1596	1597	1598	1599	1600
##	61.98298	80.50173	75.02856	64.49665	77.89411	72.17512	76.00395	74.80124

##	1601	1602	1603	1604	1605	1606	1607	1608
##	65.30865	64.86156	79.61461	59.06149	72.71595	69.64196	69.94909	79.44678
##	1609	1610	1611	1612	1613	1614	1615	1616
##	73.54879	72.02641	76.19017	73.98742	63.81747	80.26112	78.03039	76.82858
##	1617	1618	1619	1620	1621	1622	1623	1624
##	49.42660	66.85516	70.25375	69.45848	62.99242	75.18453	52.69070	77.33066
##	1625	1626	1627	1628	1629	1630	1631	1632
##	79.08551	72.44503	53.56216	79.28879	67.26668	72.68461	70.48996	67.50847
##	1633	1634	1635	1636	1637	1638	1639	1640
##	56.53955	76.31652	72.84969	60.31649	76.61797	79.55440	49.13914	66.13093
##	1641	1642	1643	1644	1645	1646	1647	1648
##	67.34546	79.67984	66.27980	52.06968	72.43521	61.45445	80.30493	59.04981
##	1649	1650	1651	1652	1653	1654	1655	1656
##	46.59733	65.87949	80.32984	53.77316	76.06119	78.68544	66.59472	65.77120
##	1657	1658	1659	1660	1661	1662	1663	1664
##	73.83439	74.13884	76.80449	75.40392	41.99315	70.33018	70.03433	56.16149
##	1665	1666	1667	1668	1669	1670	1671	1672
##	73.72794	72.32125	49.32818	62.27114	72.78246	77.12396	72.81105	74.28663
##	1673	1674	1675	1676	1677	1678	1679	1680
##	55.25843	70.59665	76.86595	58.09865	72.65010	78.50062	56.08629	71.66866
##	1681	1682	1683	1684	1685	1686	1687	1688
##	69.76706	77.10867	56.90736	69.28229	71.68722	43.68556	80.77529	72.04435
##	1689	1690	1691	1692	1693	1694	1695	1696
##	59.60430	80.22421	73.90403	78.15110	71.72376	78.89833	68.98114	80.33663
##	1697	1698	1699	1700	1701	1702	1703	1704
##	52.23947	56.09378	72.97520	77.64062	62.90676	73.91778	63.65496	65.74984
##	1705	1706	1707	1708	1709	1710	1711	1712
##	60.62004	72.63666	74.41629	75.31506	70.92536	63.01707	61.96612	74.55817
##	1713	1714	1715	1716	1717	1718	1719	1720
##	78.88594	73.00552	80.21876	79.33276	79.41280	75.57379	74.40685	65.63798
##	1721	1722	1723	1724	1725	1726	1727	1728
##	59.21173	77.27452	70.32620	72.05949	74.27265	79.73789	71.62732	80.82988
##	1729	1730	1731	1732	1733	1734	1735	1736
##	68.41428	71.28476	73.66887	70.24441	77.06653	62.96921	80.04481	40.80649
##	1737	1738	1739	1740	1741	1742	1743	1744
##	74.13117	50.81923	80.75158	66.28338	79.71160	72.28664	77.43389	49.45242
##	1745	1746	1747	1748	1749	1750	1751	1752
##	70.85672	71.58650	71.56085	78.43978	51.75422	77.45568	77.66535	76.48223
##	1753	1754	1755	1756	1757	1758	1759	1760
##	73.51527	62.50652	73.88371	60.22023	72.97635	72.79928	80.01339	73.18845
##	1761	1762	1763	1764	1765	1766	1767	1768
##	78.04084	81.00356	73.09082	66.77128	69.92906	63.72394	73.63909	61.10860
##	1769	1770	1771	1772	1773	1774	1775	1776
##	75.74667	58.38334	60.80974	69.85196	77.03476	70.30517	63.29121	60.27677
##	1777	1778	1779	1780	1781	1782	1783	1784
##	70.61898	50.35129	63.86914	55.39217	52.26001	74.01637	67.52916	72.59445
##	1785	1786	1787	1788	1789	1790	1791	1792
##	75.73918	74.76674	60.69799	71.00707	59.49648	56.35554	60.52540	77.53896
##	1793	1794	1795	1796	1797	1798	1799	1800
##	75.45043	76.65871	58.72344	78.78310	79.13288	72.72330	74.61044	71.26959
##	1801	1802	1803	1804	1805	1806	1807	1808
##	64.60560	54.44107	79.73399	60.70904	71.90759	53.75122	76.08341	79.46619
##	1809	1810	1811	1812	1813	1814	1815	1816
##	77.18537	72.28712	72.70288	62.01091	80.25246	76.79651	75.99699	71.07902



##	1817	1818	1819	1820	1821	1822	1823	1824
##	64.51139	69.45604	57.68842	54.05962	56.69367	70.06668	81.64725	57.30229
##	1825	1826	1827	1828	1829	1830	1831	1832
##	81.24201	76.01688	63.98609	77.73748	70.78982	73.61112	61.35173	77.74627
##	1833	1834	1835	1836	1837	1838	1839	1840
##	76.71546	69.23365	68.75175	69.00616	56.83564	74.46972	53.43791	76.46141
##	1841	1842	1843	1844	1845	1846	1847	1848
##	54.59459	72.75816	78.02086	71.61721	64.58566	72.23548	74.19557	54.66123
##	1849	1850	1851	1852	1853	1854	1855	1856
##	78.32957	71.50677	56.49678	48.29268	74.90814	74.32159	45.48788	79.60971
##	1857	1858	1859	1860	1861	1862	1863	1864
##	57.84016	72.33875	69.65876	61.95590	69.53562	71.46066	74.51597	60.02693
##	1865	1866	1867	1868	1869	1870	1871	1872
##	74.30007	67.13087	73.04672	71.25829	71.78444	53.86805	79.46222	60.17411
##	1873	1874	1875	1876	1877	1878	1879	1880
##	49.85428	67.67901	80.67916	50.07309	58.53708	56.59410	73.00369	55.17318
##	1881	1882	1883	1884	1885	1886	1887	1888
##	70.09669	73.59853	79.57218	78.92233	69.90966	58.59792	47.25977	76.94515
##	1889	1890	1891	1892	1893	1894	1895	1896
##	77.31629	55.70942	55.01278	61.97641	77.15121	52.78185	75.25169	74.72759
##	1897	1898	1899	1900	1901	1902	1903	1904
##	70.36813	71.08798	69.52263	56.86296	68.74224	72.31672	65.24694	64.51641
##	1905	1906	1907	1908	1909	1910	1911	1912
##	62.47364	77.99289	76.56860	72.70647	64.49248	71.38205	59.91484	69.76022
##	1913	1914	1915	1916	1917	1918	1919	1920
##	48.33594	67.88025	63.86919	71.26245	61.43419	69.37643	61.77218	76.71428
##	1921	1922	1923	1924	1925	1926	1927	1928
##	71.19875	50.35595	79.89612	62.21873	68.39726	80.96836	75.15045	69.89338
##	1929	1930	1931	1932	1933	1934	1935	1936
##	73.82942	70.66249	66.00878	67.66761	63.98897	77.05680	75.53913	68.15897
##	1937	1938	1939	1940	1941	1942	1943	1944
##	77.81019	76.81595	76.48873	79.26652	54.61113	80.36080	72.69174	80.17182
##	1945	1946	1947	1948	1949	1950	1951	1952
##	76.18736	75.59017	73.57585	73.44512	58.78247	59.29043	68.56390	45.67150
##	1953	1954	1955	1956	1957	1958	1959	1960
##	48.10157	64.21426	72.13177	73.36820	68.70121	72.97056	73.65604	63.01601
##	1961	1962	1963	1964	1965	1966	1967	1968
##	45.44219	63.00640	65.94008	82.59609	68.19366	63.77337	75.60157	48.17685
##	1969	1970	1971	1972	1973	1974	1975	1976
##	75.72517	73.87813	80.37792	77.11113	68.74956	80.88893	75.44344	55.52798
##	1977	1978	1979	1980	1981	1982	1983	1984
##	72.32612	72.01262	69.19270	70.38633	62.33953	75.84898	79.00391	61.80455
##	1985	1986	1987	1988	1989	1990	1991	1992
##	79.25063	77.75797	59.46530	82.44207	65.29275	78.78332	79.51620	77.25886
##	1993	1994	1995	1996	1997	1998	1999	2000
##	80.54922	78.50862	70.07645	72.15913	67.53649	76.75056	72.23255	58.76185
##	2001	2002	2003	2004	2005	2006	2007	2008
##	75.48910	79.79343	72.50112	74.91424	70.92886	65.99165	43.01415	76.00084
##	2009	2010	2011	2012	2013	2014	2015	2016
##	73.94565	75.58853	56.24511	50.37868	72.83777	69.80243	70.39939	79.63116
##	2017	2018	2019	2020	2021	2022	2023	2024
##	72.81056	75.66936	76.47812	72.43695	78.98452	68.09166	72.56060	79.69418
##	2025	2026	2027	2028	2029	2030	2031	2032
##	57.35643	56.66776	71.11057	80.95104	73.57095	73.67226	62.15734	70.45236

##	2033	2034	2035	2036	2037	2038	2039	2040
##	71.25601	64.26450	78.41140	73.94160	69.20270	80.09133	68.72717	68.57155
##	2041	2042	2043	2044	2045	2046	2047	2048
##	62.95965	81.43751	55.64844	54.43111	38.33564	59.02788	61.13954	65.12463
##	2049	2050	2051	2052	2053	2054	2055	2056
##	72.44169	80.31374	72.84384	79.98401	61.71531	77.76761	73.44909	76.96094
##	2057	2058	2059	2060	2061	2062	2063	2064
##	71.73368	57.23140	56.28687	57.12453	72.17502	73.40728	73.20874	45.05902
##	2065	2066	2067	2068	2069	2070	2071	2072
##	76.22405	57.72598	68.36664	52.69287	77.14125	66.47213	68.75918	73.31383
##	2073	2074	2075	2076	2077	2078	2079	2080
##	76.55413	81.58319	73.35383	74.08757	80.16724	68.08213	70.27023	80.13773
##	2081	2082	2083	2084	2085	2086	2087	2088
##	74.52446	48.04987	73.49488	74.69873	67.34471	70.18207	45.80494	42.32912
##	2089	2090	2091	2092	2093	2094	2095	2096
##	67.77577	73.66087	54.83258	52.55884	71.42362	55.04795	59.16272	66.14960
##	2097	2098	2099	2100	2101	2102	2103	2104
##	70.02343	77.71870	72.27877	51.57936	73.49396	68.98964	62.12241	57.31237
##	2105	2106	2107	2108	2109	2110	2111	2112
##	74.03626	80.41603	52.21288	62.77081	75.48272	52.90634	68.34209	76.14927
##	2113	2114	2115	2116	2117	2118	2119	2120
##	49.22464	61.63923	68.56885	67.56135	66.61647	74.28750	73.12954	59.54184
##	2121	2122	2123	2124	2125	2126	2127	2128
##	76.32272	81.09483	70.63276	71.44992	74.56442	58.32149	66.24088	79.55659
##	2129	2130	2131	2132	2133	2134	2135	2136
##	42.66679	39.11969	62.81867	66.06086	66.68874	59.36733	60.79919	72.07430
##	2137	2138	2139	2140	2141	2142	2143	2144
##	69.67641	58.65452	77.92734	67.67089	72.75375	80.34025	80.11630	70.22986
##	2145	2146	2147	2148	2149	2150	2151	2152
##	76.62664	54.90137	68.75757	67.77225	75.06123	76.45938	67.80820	74.71868
##	2153	2154	2155	2156	2157	2158	2159	2160
##	71.76258	60.98190	65.32413	80.56066	76.37712	76.26668	73.05374	41.60674
##	2161	2162	2163	2164	2165	2166	2167	2168
##	60.30777	68.39344	71.20167	57.20539	62.39518	75.14376	68.08203	75.78699
##	2169	2170	2171	2172	2173	2174	2175	2176
##	76.59953	80.25449	78.82520	80.98998	75.88682	59.44091	81.08636	71.18928
##	2177	2178	2179	2180	2181	2182	2183	2184
##	62.66102	72.98423	80.45366	63.11531	79.78973	68.48763	81.22903	49.48424
##	2185	2186	2187	2188	2189	2190	2191	2192
##	67.56470	73.04631	71.05664	59.33142	66.71920	77.25823	67.06890	70.44867
##	2193	2194	2195	2196	2197	2198	2199	2200
##	77.28126	78.70289	80.66898	76.21587	73.85958	79.92146	68.36436	77.63212
##	2201	2202	2203	2204	2205	2206	2207	2208
##	77.71295	72.59564	73.87023	79.70576	75.98581	60.34357	63.08531	80.73490
##	2209	2210	2211	2212	2213	2214	2215	2216
##	73.35201	71.47572	68.64982	71.58042	67.15045	67.64148	75.19341	72.34064
##	2217	2218	2219	2220	2221	2222	2223	2224
##	61.05004	67.51790	60.23000	68.97849	76.44636	60.56830	52.21497	76.38825
##	2225	2226	2227	2228	2229	2230	2231	2232
##	80.78172	76.61240	79.27014	74.00638	60.03893	77.87427	72.99308	71.59085
##	2233	2234	2235	2236	2237	2238	2239	2240
##	77.58633	80.44864	71.29859	49.69634	71.74389	74.17269	72.36256	73.65998
##	2241	2242	2243	2244	2245	2246	2247	2248
##	72.86045	72.88518	79.74057	70.43843	73.69344	54.91572	78.82913	61.55988

```
##      2249      2250      2251      2252      2253      2254      2255      2256
## 72.25351 66.64734 59.68107 80.58956 68.05239 79.55261 76.41722 72.74836
##      2257      2258      2259      2260      2261      2262      2263      2264
## 79.99926 57.07041 82.09591 76.82474 51.27811 59.26339 79.95163 76.05332
##      2265      2266      2267      2268      2269      2270      2271      2272
## 74.08504 67.37929 61.23438 52.90560 72.51155 80.76763 81.96581 72.42682
##      2273      2274      2275      2276      2277      2278
## 73.29486 71.23068 73.85480 69.91363 74.59727 80.07059
```

```
print(predicted_values_2)
```

```
##      1      2      3      4      5      6      7      8
## 81.96307 64.66639 70.74809 54.40137 67.90378 78.55564 73.37328 75.48277
##      9     10     11     12     13     14     15     16
## 79.71457 74.13742 76.05272 58.14017 80.55144 69.16296 78.51479 63.16508
##     17     18     19     20     21     22     23     24
## 61.41609 59.27420 79.45282 73.02345 74.88232 79.71768 69.72881 77.14414
##     25     26     27     28     29     30     31     32
## 74.43361 66.79023 74.80508 60.93467 47.70746 75.56028 56.49122 72.42549
##     33     34     35     36     37     38     39     40
## 79.01905 71.75224 68.11062 45.33906 78.84677 70.75199 68.04281 65.71628
##     41     42     43     44     45     46     47     48
## 81.89404 72.30909 76.62025 71.68153 64.52248 66.54921 64.32628 76.20417
##     49     50     51     52     53     54     55     56
## 81.45794 57.52245 71.40157 62.03983 60.16837 64.30272 73.51996 68.67289
##     57     58     59     60     61     62     63     64
## 64.54091 68.50313 72.74382 56.47918 52.75708 68.77983 72.37758 73.49104
##     65     66     67     68     69     70     71     72
## 45.50530 66.09463 76.31981 50.60649 63.12691 62.87069 66.03946 74.50373
##     73     74     75     76     77     78     79     80
## 71.05492 81.12943 62.99071 62.77041 63.40605 69.10538 48.59360 76.74525
##     81     82     83     84     85     86     87     88
## 75.49064 67.82111 71.75869 62.70836 70.77073 78.24725 71.75764 58.08807
##     89     90     91     92     93     94     95     96
## 62.58298 75.08718 72.17850 60.92094 71.98861 59.03503 76.56063 77.00534
##     97     98     99    100    101    102    103    104
## 50.00984 72.25757 81.57455 75.61173 81.48344 75.64564 59.91514 76.50823
##    105    106    107    108    109    110    111    112
## 79.91398 80.05611 59.07898 78.78278 57.42274 65.65083 70.67230 77.46437
##    113    114    115    116    117    118    119    120
## 64.22467 67.19637 65.23759 71.14961 71.93987 73.46778 66.63954 78.79890
##    121    122    123    124    125    126    127    128
## 65.59980 65.93359 80.24758 77.36080 80.31174 80.69962 54.86505 48.33968
##    129    130    131    132    133    134    135    136
## 71.63998 64.71080 56.69158 74.91212 45.88491 48.94708 81.47136 81.07476
##    137    138    139    140    141    142    143    144
## 56.28557 75.22264 59.55374 51.90520 59.85278 48.86188 61.71476 62.31068
##    145    146    147    148    149    150    151    152
## 69.48410 70.25801 76.58205 54.87465 63.22541 76.44515 73.89532 51.03690
##    153    154    155    156    157    158    159    160
## 78.14144 69.27848 78.99311 77.47096 77.33014 78.51916 78.99801 80.61721
##    161    162    163    164    165    166    167    168
## 54.95179 71.36398 70.38802 77.54424 66.82595 71.91965 55.88205 49.02520
##    169    170    171    172    173    174    175    176
```

##	70.52769	76.01219	66.53992	68.49137	68.49881	71.45902	66.78183	62.14704
##	177	178	179	180	181	182	183	184
##	59.50652	80.04523	50.59892	76.75215	71.43708	76.88862	63.14463	75.30448
##	185	186	187	188	189	190	191	192
##	76.71701	63.31980	52.43159	55.54669	70.00101	48.27911	69.95551	68.00541
##	193	194	195	196	197	198	199	200
##	64.39167	73.61833	67.14181	72.83039	68.21250	56.81138	57.04261	71.16054
##	201	202	203	204	205	206	207	208
##	61.54346	71.20308	73.49380	76.93122	57.96941	74.38922	41.95672	53.49697
##	209	210	211	212	213	214	215	216
##	76.40858	79.64144	62.08219	63.68298	70.10968	79.29878	74.17326	60.43810
##	217	218	219	220	221	222	223	224
##	73.72416	77.66714	65.31919	64.51982	72.01510	63.28928	78.64663	78.24684
##	225	226	227	228	229	230	231	232
##	59.61234	80.94994	75.23864	68.09985	56.16040	59.14269	71.68515	68.82775
##	233	234	235	236	237	238	239	240
##	79.11156	71.73335	78.97104	70.89223	80.00976	60.86352	67.45090	80.81991
##	241	242	243	244	245	246	247	248
##	73.96170	80.73705	79.28704	61.57981	78.34404	74.24166	70.08259	60.31063
##	249	250	251	252	253	254	255	256
##	68.40115	75.90661	43.14910	79.13135	78.14102	72.78268	60.01563	74.82683
##	257	258	259	260	261	262	263	264
##	67.50222	71.86042	71.56589	72.66153	45.37989	72.91995	65.92381	74.49400
##	265	266	267	268	269	270	271	272
##	64.29387	65.98949	59.01359	81.34875	80.21777	76.49134	60.71520	76.58300
##	273	274	275	276	277	278	279	280
##	65.29969	70.51494	63.39828	48.71294	62.77917	80.62773	78.73828	74.84192
##	281	282	283	284	285	286	287	288
##	68.36953	56.38561	74.26409	51.93904	54.69380	79.66257	74.29376	64.59159
##	289	290	291	292	293	294	295	296
##	68.60297	70.26603	66.67559	74.26814	75.49391	81.51316	72.44934	70.76488
##	297	298	299	300	301	302	303	304
##	80.47887	79.36054	67.11605	79.52565	77.02406	44.91914	65.73621	78.67502
##	305	306	307	308	309	310	311	312
##	73.36966	76.26351	75.05047	75.89375	79.99224	68.34182	72.81141	77.81401
##	313	314	315	316	317	318	319	320
##	74.99128	73.07640	70.46336	76.48961	64.26565	75.36108	73.37959	70.90193
##	321	322	323	324	325	326	327	328
##	53.10782	36.66990	79.04597	56.69374	70.24368	66.87693	71.49057	74.41205
##	329	330	331	332	333	334	335	336
##	80.56198	68.37382	79.29824	55.14357	64.58472	70.45911	60.70586	71.37112
##	337	338	339	340	341	342	343	344
##	73.73330	61.85991	71.20118	79.93880	79.44545	80.52160	47.53327	73.42877
##	345	346	347	348	349	350	351	352
##	61.01651	75.19927	69.42379	71.19446	67.64339	56.09126	59.65568	74.47578
##	353	354	355	356	357	358	359	360
##	71.06010	76.82360	72.04021	70.70030	81.21953	76.35309	80.96460	73.93511
##	361	362	363	364	365	366	367	368
##	63.35819	41.36272	74.59207	57.10497	76.93581	77.41526	56.00491	79.01292
##	369	370	371	372	373	374	375	376
##	68.33560	70.40702	62.05380	74.20716	33.11203	66.26722	63.78502	67.77469
##	377	378	379	380	381	382	383	384
##	62.72647	70.55715	60.57284	78.21962	77.33781	74.70250	76.97155	74.06136
##	385	386	387	388	389	390	391	392

##	77.87511	78.21212	70.70027	74.18607	74.76267	64.43975	35.63544	78.45465
##	393	394	395	396	397	398	399	400
##	75.13083	66.63564	76.84828	75.27832	66.63871	73.49715	74.83101	70.87623
##	401	402	403	404	405	406	407	408
##	77.17527	60.43288	69.36859	69.52736	73.59462	80.89764	40.93683	59.28887
##	409	410	411	412	413	414	415	416
##	62.29437	65.79648	51.33922	74.93121	79.90118	57.62699	74.53323	64.29169
##	417	418	419	420	421	422	423	424
##	76.51196	69.59549	53.53517	70.15735	66.92321	65.54539	73.38560	77.60929
##	425	426	427	428	429	430	431	432
##	67.79508	69.61702	53.28149	75.76617	74.47387	72.10306	67.19042	44.34438
##	433	434	435	436	437	438	439	440
##	61.11291	80.35126	60.20787	73.91011	79.74970	65.73663	68.82317	71.90075
##	441	442	443	444	445	446	447	448
##	58.99928	40.03835	79.91442	77.84492	70.47978	73.66025	45.57265	75.14220
##	449	450	451	452	453	454	455	456
##	69.79596	69.10529	73.22751	58.02246	73.16457	76.52823	74.28246	66.48828
##	457	458	459	460	461	462	463	464
##	77.60519	60.06373	73.71649	78.33582	63.79583	60.68755	75.26274	71.80443
##	465	466	467	468	469	470	471	472
##	40.87742	76.68325	64.48507	75.85220	80.96295	77.36470	61.35684	79.99766
##	473	474	475	476	477	478	479	480
##	57.44895	79.16167	60.78004	68.01044	74.99107	79.68431	63.38665	58.79342
##	481	482	483	484	485	486	487	488
##	78.69728	80.24977	62.02063	77.62809	63.82930	70.36312	71.34042	69.55695
##	489	490	491	492	493	494	495	496
##	56.30495	76.21766	70.29175	67.60020	61.06689	66.38641	79.15982	75.16745
##	497	498	499	500	501	502	503	504
##	57.81947	67.28856	69.75192	69.05450	78.02551	65.47454	70.53486	63.16559
##	505	506	507	508	509	510	511	512
##	68.50477	75.17643	66.97105	42.16647	61.45607	69.86954	68.76541	73.44850
##	513	514	515	516	517	518	519	520
##	45.49482	73.82034	74.47605	69.63550	55.40255	54.24566	61.14067	74.26265
##	521	522	523	524	525	526	527	528
##	74.46513	75.39347	60.90891	72.97279	71.84692	63.40577	71.32543	72.61442
##	529	530	531	532	533	534	535	536
##	61.06691	75.75402	77.97463	63.75701	60.00003	70.62599	61.12191	68.65803
##	537	538	539	540	541	542	543	544
##	56.10178	66.82144	66.27114	73.85347	45.88459	71.57413	66.01250	57.92953
##	545	546	547	548	549	550	551	552
##	40.62258	69.64461	66.14587	61.37486	80.52513	76.51072	49.54023	70.99739
##	553	554	555	556	557	558	559	560
##	70.98231	59.99670	67.31948	74.13930	75.29336	70.35598	53.84151	68.27108
##	561	562	563	564	565	566	567	568
##	52.62179	63.58264	80.97326	70.60672	75.35252	74.74335	60.53434	69.70802
##	569	570	571	572	573	574	575	576
##	78.05368	68.44893	81.94869	58.94393	69.73211	70.83373	55.76824	76.02494
##	577	578	579	580	581	582	583	584
##	71.68380	76.68051	67.00085	39.20511	60.93652	64.30109	77.17214	77.20202
##	585	586	587	588	589	590	591	592
##	71.63863	76.64081	65.96647	79.30980	75.71393	70.78973	79.76951	75.06733
##	593	594	595	596	597	598	599	600
##	65.99203	66.78442	60.74781	77.15931	80.27714	73.39688	67.22625	79.43610
##	601	602	603	604	605	606	607	608

##	67.45254	63.38478	71.39358	80.91409	63.96657	76.43272	77.79527	80.50749
##	609	610	611	612	613	614	615	616
##	79.53905	79.59943	76.18228	69.48379	76.24818	68.50964	69.22490	60.67622
##	617	618	619	620	621	622	623	624
##	73.59079	64.08378	75.22231	73.83382	70.73165	69.04402	60.52046	70.62645
##	625	626	627	628	629	630	631	632
##	80.33231	72.26017	70.72764	78.85386	74.10405	75.50576	37.80964	69.84105
##	633	634	635	636	637	638	639	640
##	73.28617	76.43898	80.50234	67.55297	61.02613	74.99621	57.14853	73.18369
##	641	642	643	644	645	646	647	648
##	72.77252	75.45597	73.69016	80.11279	66.50118	57.20617	59.97912	72.15651
##	649	650	651	652	653	654	655	656
##	67.66302	59.55794	80.71890	75.51941	80.79581	60.26150	68.96748	79.33671
##	657	658	659	660	661	662	663	664
##	69.33100	70.03062	68.33190	69.70526	68.24415	72.04297	53.37422	50.58710
##	665	666	667	668	669	670	671	672
##	72.49205	77.55344	71.88675	59.80798	51.88622	60.85717	71.25457	79.09198
##	673	674	675	676	677	678	679	680
##	61.44390	52.06396	77.61589	77.58259	58.39612	75.81716	71.45943	74.63207
##	681	682	683	684	685	686	687	688
##	69.60690	60.17507	66.11432	72.17480	63.82901	73.92863	67.74309	54.79832
##	689	690	691	692	693	694	695	696
##	79.87223	76.69294	71.92324	57.21924	79.76960	70.19306	79.23363	62.97449
##	697	698	699	700	701	702	703	704
##	73.77681	58.63868	74.15253	72.02986	74.23721	78.46237	72.94378	80.38104
##	705	706	707	708	709	710	711	712
##	68.29543	62.75050	81.90176	56.32697	60.70161	78.41641	71.28779	79.12281
##	713	714	715	716	717	718	719	720
##	68.30652	76.42875	68.76678	61.74678	74.67377	37.70399	76.54927	78.44889
##	721	722	723	724	725	726	727	728
##	72.06672	71.21967	79.35576	54.11896	70.66609	76.53911	70.51447	67.98310
##	729	730	731	732	733	734	735	736
##	71.36420	45.15357	61.48897	70.16550	76.66165	60.80024	71.02772	69.35632
##	737	738	739	740	741	742	743	744
##	73.00612	50.87331	60.23659	74.89594	65.42008	81.82719	62.79840	67.80420
##	745	746	747	748	749	750	751	752
##	80.76940	67.70344	73.23750	65.85531	58.53197	69.09498	64.63526	70.48491
##	753	754	755	756	757	758	759	760
##	71.88825	68.53665	48.29432	75.87271	74.68768	69.21887	43.61159	60.70361
##	761	762	763	764	765	766	767	768
##	81.06045	49.80047	70.43039	69.95616	71.89865	57.26144	74.12208	70.33865
##	769	770	771	772	773	774	775	776
##	79.64325	80.56001	73.43988	67.89690	57.78381	72.71450	70.46716	62.35641
##	777	778	779	780	781	782	783	784
##	76.64387	57.68774	65.39341	68.98223	75.95675	66.82246	79.61247	51.40590
##	785	786	787	788	789	790	791	792
##	75.05470	60.37630	67.75364	77.95600	80.11441	70.94512	64.80519	66.30451
##	793	794	795	796	797	798	799	800
##	73.80571	79.41240	70.39407	54.91201	59.24176	76.01719	58.46886	50.30203
##	801	802	803	804	805	806	807	808
##	74.73901	79.94895	55.40891	80.89835	76.75296	78.00636	62.28730	67.82249
##	809	810	811	812	813	814	815	816
##	68.25424	81.73700	52.33273	61.21754	73.08958	63.91387	77.82024	69.05918
##	817	818	819	820	821	822	823	824

##	74.86830	56.23709	81.35850	69.10513	56.73429	30.53687	66.41118	73.38624
##	825	826	827	828	829	830	831	832
##	78.69388	81.96397	70.23300	76.76186	58.68661	71.97263	58.02019	61.36123
##	833	834	835	836	837	838	839	840
##	70.45259	75.01795	71.25611	75.52186	67.23170	71.60396	73.02701	64.79356
##	841	842	843	844	845	846	847	848
##	76.46927	78.03862	79.28860	57.36934	69.22768	72.30191	80.21223	68.40185
##	849	850	851	852	853	854	855	856
##	71.35585	74.47408	78.18703	58.09920	77.40717	75.13687	73.44804	68.13154
##	857	858	859	860	861	862	863	864
##	72.40824	55.42104	74.34782	72.61397	75.75509	71.11192	76.33410	53.51545
##	865	866	867	868	869	870	871	872
##	72.33046	71.72472	75.15488	73.13532	67.90686	67.70695	68.76876	71.74944
##	873	874	875	876	877	878	879	880
##	76.01303	69.85955	76.78000	64.78199	81.83152	74.10581	73.20924	72.30851
##	881	882	883	884	885	886	887	888
##	66.14754	72.90020	71.99812	53.32748	71.36413	45.90541	70.74044	68.53698
##	889	890	891	892	893	894	895	896
##	60.99045	69.56681	69.87380	73.91974	80.18591	63.05408	67.41593	49.28434
##	897	898	899	900	901	902	903	904
##	77.74651	39.00126	79.96313	78.90024	67.94977	61.12044	45.72777	65.78570
##	905	906	907	908	909	910	911	912
##	77.73457	54.99223	72.94239	66.26792	77.14841	65.39665	66.32453	72.88554
##	913	914	915	916	917	918	919	920
##	75.10093	74.48542	71.96548	75.98531	65.18036	71.61604	70.65377	60.56050
##	921	922	923	924	925	926	927	928
##	59.99247	42.86072	57.72726	58.45602	65.78079	78.31455	56.31617	72.50561
##	929	930	931	932	933	934	935	936
##	68.39818	67.67017	80.94087	71.38543	75.19632	74.10268	74.28003	69.78626
##	937	938	939	940	941	942	943	944
##	62.72369	67.48702	71.10430	77.87085	71.45739	81.79695	71.20273	73.48225
##	945	946	947	948	949	950	951	952
##	72.94563	76.10938	75.64126	64.10978	64.83518	80.82769	79.54034	71.78757
##	953	954	955	956	957	958	959	960
##	50.91501	67.09676	71.37207	66.31187	76.13729	81.65507	58.28285	54.47282
##	961	962	963	964	965	966	967	968
##	56.25474	58.75382	71.26461	74.20801	71.94874	74.64853	73.16480	71.80572
##	969	970	971	972	973	974	975	976
##	78.11800	45.36896	78.72958	71.54675	68.76703	75.19142	78.55049	70.67165
##	977	978	979	980	981	982	983	984
##	79.20256	72.61042	66.86924	71.50013	69.10547	75.39226	66.55281	37.93657
##	985	986	987	988	989	990	991	992
##	61.82768	67.49784	53.30561	79.39036	80.32421	69.04476	71.54396	71.54666
##	993	994	995	996	997	998	999	1000
##	67.59313	68.23504	72.31918	60.82129	67.09438	57.18605	51.34760	71.64440
##	1001	1002	1003	1004	1005	1006	1007	1008
##	42.81307	59.41415	61.47137	70.39471	66.38977	78.24541	67.27038	65.44616
##	1009	1010	1011	1012	1013	1014	1015	1016
##	81.18143	59.02282	57.67298	67.69571	75.42378	62.29003	66.46177	75.33866
##	1017	1018	1019	1020	1021	1022	1023	1024
##	67.18396	77.62175	68.64124	75.22396	78.03451	70.60401	54.76675	51.24193
##	1025	1026	1027	1028	1029	1030	1031	1032
##	72.83031	78.75308	62.38697	67.23087	82.08137	66.55571	58.70071	79.26063
##	1033	1034	1035	1036	1037	1038	1039	1040

##	75.22901	74.24200	63.08636	70.68298	76.83608	72.66558	71.56955	68.82158
##	1041	1042	1043	1044	1045	1046	1047	1048
##	73.67328	66.72144	73.87518	73.37509	80.91723	69.35006	61.88521	80.37300
##	1049	1050	1051	1052	1053	1054	1055	1056
##	51.79384	71.94477	68.83303	62.00579	77.63858	55.10417	74.36873	58.80845
##	1057	1058	1059	1060	1061	1062	1063	1064
##	59.18647	68.62702	68.75640	67.83869	58.52057	69.18349	48.02727	74.15405
##	1065	1066	1067	1068	1069	1070	1071	1072
##	51.80804	56.70253	68.06144	79.73321	79.47837	73.78263	72.50717	59.30163
##	1073	1074	1075	1076	1077	1078	1079	1080
##	65.79761	76.25864	51.58258	78.50448	62.80413	70.27526	57.37258	70.84873
##	1081	1082	1083	1084	1085	1086	1087	1088
##	67.92199	70.60520	63.63776	78.40679	79.01575	71.02141	67.02365	73.28988
##	1089	1090	1091	1092	1093	1094	1095	1096
##	62.32496	75.08830	60.29217	71.78983	69.69638	80.39184	74.15363	67.42971
##	1097	1098	1099	1100	1101	1102	1103	1104
##	57.17235	47.52575	64.50958	72.47960	71.48570	68.80015	68.18735	62.91346
##	1105	1106	1107	1108	1109	1110	1111	1112
##	74.39033	65.53566	55.80519	69.55327	65.32791	59.11258	80.51911	40.65115
##	1113	1114	1115	1116	1117	1118	1119	1120
##	67.94588	71.91146	79.79815	75.21634	73.96459	76.09608	65.00550	73.79572
##	1121	1122	1123	1124	1125	1126	1127	1128
##	79.88554	51.10453	79.75158	72.45324	70.71965	75.37587	78.76861	81.00295
##	1129	1130	1131	1132	1133	1134	1135	1136
##	69.37075	66.79760	71.94197	76.96654	73.81421	31.99311	51.90844	62.69350
##	1137	1138	1139	1140	1141	1142	1143	1144
##	74.65250	61.67157	38.50386	72.30151	78.73633	75.69737	67.67665	70.99247
##	1145	1146	1147	1148	1149	1150	1151	1152
##	75.79546	69.03634	75.45395	74.99023	61.63449	79.97750	69.56568	56.97324
##	1153	1154	1155	1156	1157	1158	1159	1160
##	71.94717	78.27667	75.79189	78.20674	74.24114	73.81487	78.16656	62.70653
##	1161	1162	1163	1164	1165	1166	1167	1168
##	48.76999	74.07024	63.17353	61.43073	72.37508	68.42864	65.83070	80.19862
##	1169	1170	1171	1172	1173	1174	1175	1176
##	75.19039	63.72277	64.78483	73.89988	63.57198	81.18637	69.69654	72.20256
##	1177	1178	1179	1180	1181	1182	1183	1184
##	68.48067	74.63717	66.50800	63.92440	62.10813	80.61847	79.44416	79.51693
##	1185	1186	1187	1188	1189	1190	1191	1192
##	52.73458	64.04607	62.60210	80.84623	69.93826	77.48126	72.21062	63.78300
##	1193	1194	1195	1196	1197	1198	1199	1200
##	47.19262	74.04762	75.20975	63.36923	64.60380	70.66993	52.05876	69.63897
##	1201	1202	1203	1204	1205	1206	1207	1208
##	58.95979	75.75220	68.45098	70.83693	71.69214	71.41383	76.14459	80.32684
##	1209	1210	1211	1212	1213	1214	1215	1216
##	48.10205	73.10452	75.90564	74.44106	65.43809	80.59532	67.28054	70.39722
##	1217	1218	1219	1220	1221	1222	1223	1224
##	69.55071	70.25366	72.27437	70.64017	73.84985	51.38366	73.60490	64.29900
##	1225	1226	1227	1228	1229	1230	1231	1232
##	80.63033	64.89004	78.74789	68.51129	62.10702	78.95957	63.50784	71.98388
##	1233	1234	1235	1236	1237	1238	1239	1240
##	63.94685	69.81020	68.46337	71.85762	71.29568	71.76863	70.90249	71.56834
##	1241	1242	1243	1244	1245	1246	1247	1248
##	70.86377	49.21102	76.16825	80.51129	74.10780	79.41054	80.38633	76.73248
##	1249	1250	1251	1252	1253	1254	1255	1256



##	67.87213	62.54605	73.78285	70.06090	65.49238	55.29066	61.69752	61.91159
##	1257	1258	1259	1260	1261	1262	1263	1264
##	79.49938	71.12958	76.46392	73.12981	59.42371	60.38391	70.31303	74.05423
##	1265	1266	1267	1268	1269	1270	1271	1272
##	63.05052	59.66623	69.94672	72.29872	74.49569	63.57235	51.57592	65.22711
##	1273	1274	1275	1276	1277	1278	1279	1280
##	60.49136	74.85385	65.55435	69.96755	79.35537	72.16312	69.49368	67.67301
##	1281	1282	1283	1284	1285	1286	1287	1288
##	73.69367	59.66488	58.13972	74.54452	74.16249	76.41513	79.45822	61.03213
##	1289	1290	1291	1292	1293	1294	1295	1296
##	61.98947	77.18790	69.35741	68.14265	72.35196	64.51679	64.95412	80.27488
##	1297	1298	1299	1300	1301	1302	1303	1304
##	56.24508	72.49224	63.36390	77.15515	74.12301	71.19291	73.47695	75.56351
##	1305	1306	1307	1308	1309	1310	1311	1312
##	65.38704	67.29558	70.22451	80.10516	71.98466	75.60815	79.95039	68.68176
##	1313	1314	1315	1316	1317	1318	1319	1320
##	56.26390	67.28057	58.09321	69.98480	70.12134	75.71952	67.92065	68.84158
##	1321	1322	1323	1324	1325	1326	1327	1328
##	46.72602	75.68469	75.70483	72.08330	81.09888	44.36563	57.54956	66.28317
##	1329	1330	1331	1332	1333	1334	1335	1336
##	67.13974	73.13596	61.79463	68.02970	69.98275	75.42374	65.33871	79.36365
##	1337	1338	1339	1340	1341	1342	1343	1344
##	80.14517	61.11847	80.52129	72.89283	58.82540	78.92738	71.78269	78.54657
##	1345	1346	1347	1348	1349	1350	1351	1352
##	48.10431	67.59439	74.71375	77.49316	74.33028	80.96019	61.04354	80.82959
##	1353	1354	1355	1356	1357	1358	1359	1360
##	39.42327	72.30317	69.53282	71.33628	63.57348	74.91795	56.37136	70.36319
##	1361	1362	1363	1364	1365	1366	1367	1368
##	80.02064	74.67518	72.05358	68.77876	81.06372	59.66262	62.02572	62.87294
##	1369	1370	1371	1372	1373	1374	1375	1376
##	70.33257	70.01436	76.56902	71.89390	74.36514	72.68097	79.82649	78.12022
##	1377	1378	1379	1380	1381	1382	1383	1384
##	79.33346	70.82154	72.10610	72.25158	80.25703	49.58799	71.86087	75.51818
##	1385	1386	1387	1388	1389	1390	1391	1392
##	75.15980	74.07832	81.24425	59.82801	56.27545	80.67392	67.88844	77.67953
##	1393	1394	1395	1396	1397	1398	1399	1400
##	75.70698	60.36575	74.40012	77.69512	45.54806	74.43286	70.83904	62.30508
##	1401	1402	1403	1404	1405	1406	1407	1408
##	77.37218	67.29152	58.52995	61.47626	76.25669	75.38018	76.48864	62.59799
##	1409	1410	1411	1412	1413	1414	1415	1416
##	72.04576	71.25888	79.31460	76.88910	76.52541	80.59764	72.24655	73.37260
##	1417	1418	1419	1420	1421	1422	1423	1424
##	61.78902	56.59343	70.67981	74.73265	73.13863	63.20505	80.37414	73.84377
##	1425	1426	1427	1428	1429	1430	1431	1432
##	55.77232	62.89132	71.78575	68.11890	79.97547	69.01539	67.93997	65.88011
##	1433	1434	1435	1436	1437	1438	1439	1440
##	75.59810	57.82085	76.27480	80.63955	66.82986	79.83855	65.86778	81.40245
##	1441	1442	1443	1444	1445	1446	1447	1448
##	72.57175	46.77095	71.92139	79.39980	62.63701	64.77388	57.40242	79.59053
##	1449	1450	1451	1452	1453	1454	1455	1456
##	73.56894	77.49276	78.58854	55.54116	63.15346	53.03252	72.71396	71.41169
##	1457	1458	1459	1460	1461	1462	1463	1464
##	75.67371	70.03698	66.81229	61.80670	67.49361	68.02068	68.27280	78.22153
##	1465	1466	1467	1468	1469	1470	1471	1472

##	82.04389	75.58461	68.26238	69.93636	72.68625	71.11270	62.48687	77.23291
##	1473	1474	1475	1476	1477	1478	1479	1480
##	75.59756	78.92078	77.47123	79.49285	64.85176	76.13853	63.38909	80.22315
##	1481	1482	1483	1484	1485	1486	1487	1488
##	46.36316	73.58969	66.09027	82.55079	77.31196	64.99339	69.71419	69.55388
##	1489	1490	1491	1492	1493	1494	1495	1496
##	67.41994	73.76621	66.22988	59.54982	51.32435	72.19878	70.18338	73.79137
##	1497	1498	1499	1500	1501	1502	1503	1504
##	78.07090	41.69315	57.55446	73.63677	79.30457	61.57357	68.85601	69.30075
##	1505	1506	1507	1508	1509	1510	1511	1512
##	67.61359	72.52101	57.20511	61.35629	71.49474	68.50903	78.35655	56.19862
##	1513	1514	1515	1516	1517	1518	1519	1520
##	64.78476	74.48249	64.27119	70.43101	58.66589	80.66546	80.66937	76.30681
##	1521	1522	1523	1524	1525	1526	1527	1528
##	77.76258	62.23622	59.32941	62.17880	74.64252	45.35521	71.65488	47.67273
##	1529	1530	1531	1532	1533	1534	1535	1536
##	71.40783	79.37795	72.65827	70.85714	72.15567	64.22543	66.68913	67.19380
##	1537	1538	1539	1540	1541	1542	1543	1544
##	81.25623	75.70310	58.48999	75.44762	64.00885	49.92518	77.83221	60.91523
##	1545	1546	1547	1548	1549	1550	1551	1552
##	62.97251	79.42673	53.52335	65.10608	69.63316	74.27771	67.37414	78.31080
##	1553	1554	1555	1556	1557	1558	1559	1560
##	65.07425	76.25610	70.09181	75.59474	70.19054	62.17826	40.25147	69.58017
##	1561	1562	1563	1564	1565	1566	1567	1568
##	79.35820	71.55055	45.33626	74.65867	74.64296	73.56664	66.39379	43.43827
##	1569	1570	1571	1572	1573	1574	1575	1576
##	67.85643	74.56617	70.41410	67.43950	66.90864	64.95693	71.40902	80.55680
##	1577	1578	1579	1580	1581	1582	1583	1584
##	71.42991	62.55004	59.67239	60.45237	63.24687	73.94129	38.23957	61.72095
##	1585	1586	1587	1588	1589	1590	1591	1592
##	79.57179	61.89194	79.47574	66.95571	77.91417	64.91466	67.96716	55.89167
##	1593	1594	1595	1596	1597	1598	1599	1600
##	64.88533	79.91203	76.30699	65.21857	77.86435	72.77900	75.71130	74.81838
##	1601	1602	1603	1604	1605	1606	1607	1608
##	67.27878	65.12764	80.60654	59.25834	72.14786	69.17595	70.33953	76.89168
##	1609	1610	1611	1612	1613	1614	1615	1616
##	73.55437	72.53317	74.88967	74.41578	63.80454	78.39710	77.72163	75.63343
##	1617	1618	1619	1620	1621	1622	1623	1624
##	53.49491	68.96028	71.05818	68.01780	63.67213	72.36825	45.37273	77.83245
##	1625	1626	1627	1628	1629	1630	1631	1632
##	76.71874	72.95604	47.27719	80.36326	69.02036	71.50709	70.25654	67.92006
##	1633	1634	1635	1636	1637	1638	1639	1640
##	51.68513	77.28692	72.73225	62.23526	77.50978	80.66513	55.28552	67.19553
##	1641	1642	1643	1644	1645	1646	1647	1648
##	69.22863	77.22815	66.53911	56.94767	70.16167	64.85322	80.53505	62.21516
##	1649	1650	1651	1652	1653	1654	1655	1656
##	42.29491	68.45032	81.25741	58.61708	76.42595	80.29723	68.72976	66.27629
##	1657	1658	1659	1660	1661	1662	1663	1664
##	71.51947	73.85149	76.06318	75.87816	37.48721	70.23487	67.84941	60.69316
##	1665	1666	1667	1668	1669	1670	1671	1672
##	72.31416	75.06176	52.94766	62.18315	71.16407	76.84158	72.73540	73.82813
##	1673	1674	1675	1676	1677	1678	1679	1680
##	56.13435	70.27922	75.85428	56.11888	71.92779	77.35443	52.96856	71.12692
##	1681	1682	1683	1684	1685	1686	1687	1688

##	69.03970	75.34892	57.36454	67.83956	69.80547	39.36254	81.18715	69.32488
##	1689	1690	1691	1692	1693	1694	1695	1696
##	62.65007	81.09961	72.85002	77.92322	68.69940	79.03003	69.45600	80.62155
##	1697	1698	1699	1700	1701	1702	1703	1704
##	58.66357	60.38273	71.66548	77.65374	65.95493	72.54099	62.20913	64.46292
##	1705	1706	1707	1708	1709	1710	1711	1712
##	62.43656	69.98001	71.45548	74.37786	69.49137	64.83059	61.24973	74.48689
##	1713	1714	1715	1716	1717	1718	1719	1720
##	77.99341	72.13971	78.92823	80.00387	79.73829	77.56661	76.31097	66.61680
##	1721	1722	1723	1724	1725	1726	1727	1728
##	61.36438	76.91694	71.60536	70.15237	74.53923	76.95116	69.72299	81.20395
##	1729	1730	1731	1732	1733	1734	1735	1736
##	67.03315	69.99893	70.55653	70.91504	76.95024	62.48163	80.74137	37.52453
##	1737	1738	1739	1740	1741	1742	1743	1744
##	70.88691	52.74660	81.00346	67.01662	79.81201	73.80716	76.76308	53.11372
##	1745	1746	1747	1748	1749	1750	1751	1752
##	72.12025	70.45604	70.62003	78.57635	46.47600	77.80667	78.02261	74.33829
##	1753	1754	1755	1756	1757	1758	1759	1760
##	74.88608	64.50104	73.79545	60.75650	71.73137	70.25498	78.49269	74.33836
##	1761	1762	1763	1764	1765	1766	1767	1768
##	79.26341	80.96525	73.54978	68.47501	69.41375	65.34700	73.78586	65.57050
##	1769	1770	1771	1772	1773	1774	1775	1776
##	75.92181	59.35877	63.22980	68.15360	76.61197	69.21927	62.45957	57.42153
##	1777	1778	1779	1780	1781	1782	1783	1784
##	69.77741	49.32279	65.33384	56.61841	54.12452	72.57962	66.37084	71.66400
##	1785	1786	1787	1788	1789	1790	1791	1792
##	75.63740	73.24229	60.73562	69.72733	62.38993	57.14033	61.25100	77.35898
##	1793	1794	1795	1796	1797	1798	1799	1800
##	78.25998	76.84633	61.93060	78.49972	79.72600	72.87445	74.04521	71.85490
##	1801	1802	1803	1804	1805	1806	1807	1808
##	66.15171	57.09437	80.93132	62.47221	72.47447	58.54832	74.34720	79.50010
##	1809	1810	1811	1812	1813	1814	1815	1816
##	76.14861	71.23870	72.15106	61.94563	80.66865	76.20684	75.27157	71.04751
##	1817	1818	1819	1820	1821	1822	1823	1824
##	64.05210	68.96146	60.37129	55.47886	59.31818	69.45076	79.86296	60.71900
##	1825	1826	1827	1828	1829	1830	1831	1832
##	78.61428	73.63835	64.19375	77.79429	70.57434	74.21103	62.42937	77.74206
##	1833	1834	1835	1836	1837	1838	1839	1840
##	75.65479	68.97427	68.85630	69.04732	61.62543	71.55960	56.05448	74.75560
##	1841	1842	1843	1844	1845	1846	1847	1848
##	59.80436	70.82573	75.75815	70.87125	64.49474	73.79262	74.69333	58.84818
##	1849	1850	1851	1852	1853	1854	1855	1856
##	79.12939	70.74720	59.92359	44.64723	75.84783	75.01938	40.35873	81.60542
##	1857	1858	1859	1860	1861	1862	1863	1864
##	60.23757	70.83563	68.99982	59.90971	69.64020	70.53959	75.07247	63.17370
##	1865	1866	1867	1868	1869	1870	1871	1872
##	74.24427	65.73498	72.42164	69.77916	70.73968	51.97640	80.18722	60.03821
##	1873	1874	1875	1876	1877	1878	1879	1880
##	51.78458	68.28893	81.13330	42.54053	59.84050	59.32673	71.29735	53.20466
##	1881	1882	1883	1884	1885	1886	1887	1888
##	69.54503	72.88530	80.75349	79.73989	70.16547	58.21054	44.41384	79.17086
##	1889	1890	1891	1892	1893	1894	1895	1896
##	76.08158	59.43365	59.77061	66.81729	76.67077	54.08830	74.59544	73.08435
##	1897	1898	1899	1900	1901	1902	1903	1904

##	69.53051	69.94369	69.48246	59.03491	68.69425	71.06367	65.73496	66.93814
##	1905	1906	1907	1908	1909	1910	1911	1912
##	63.33435	78.87153	74.91300	73.31915	68.98500	70.97772	62.92236	70.13926
##	1913	1914	1915	1916	1917	1918	1919	1920
##	54.90899	69.30686	64.86724	71.08070	61.32460	69.15116	62.08585	74.98815
##	1921	1922	1923	1924	1925	1926	1927	1928
##	71.69396	52.27168	79.90522	65.02321	66.84124	79.15462	74.47800	70.47300
##	1929	1930	1931	1932	1933	1934	1935	1936
##	71.73484	69.53748	66.21201	67.58274	62.66258	77.55930	73.32756	68.10675
##	1937	1938	1939	1940	1941	1942	1943	1944
##	78.00324	76.48744	75.53937	80.76656	59.21393	78.47893	73.24691	78.02005
##	1945	1946	1947	1948	1949	1950	1951	1952
##	76.77987	75.48909	72.72782	71.87322	61.90448	59.95723	67.47671	42.56981
##	1953	1954	1955	1956	1957	1958	1959	1960
##	42.11918	64.76652	71.15625	71.34819	69.19579	70.49618	73.58186	64.68785
##	1961	1962	1963	1964	1965	1966	1967	1968
##	46.92749	63.42546	64.75501	81.73223	68.33993	63.64852	75.36083	50.41971
##	1969	1970	1971	1972	1973	1974	1975	1976
##	74.80931	72.07877	80.74688	76.38258	67.77363	79.90840	72.65210	51.20007
##	1977	1978	1979	1980	1981	1982	1983	1984
##	70.05633	69.90067	68.59293	69.87253	66.28863	77.73013	78.27103	62.90788
##	1985	1986	1987	1988	1989	1990	1991	1992
##	79.10141	79.73038	62.75745	81.58991	66.28624	78.38603	80.68883	74.49936
##	1993	1994	1995	1996	1997	1998	1999	2000
##	81.49763	79.22325	70.81887	71.86801	66.69244	76.26873	72.44960	61.08557
##	2001	2002	2003	2004	2005	2006	2007	2008
##	76.93257	77.61844	70.48425	74.27117	70.48137	68.66299	39.00412	73.92503
##	2009	2010	2011	2012	2013	2014	2015	2016
##	74.24024	75.02294	59.45001	50.84293	73.28921	68.32610	68.48410	80.17157
##	2017	2018	2019	2020	2021	2022	2023	2024
##	73.52810	76.45171	75.96046	71.53712	79.91216	66.57024	71.32439	79.13111
##	2025	2026	2027	2028	2029	2030	2031	2032
##	59.82056	59.71352	70.95043	78.45052	74.04979	71.88732	63.07016	69.93112
##	2033	2034	2035	2036	2037	2038	2039	2040
##	71.36437	63.75702	78.88269	70.63084	69.47472	79.73674	67.65254	67.23863
##	2041	2042	2043	2044	2045	2046	2047	2048
##	63.18096	81.54660	57.63670	54.45107	44.07705	62.03189	62.91420	67.96077
##	2049	2050	2051	2052	2053	2054	2055	2056
##	71.80461	79.95313	71.93429	78.32440	64.66350	78.86428	73.79706	76.77561
##	2057	2058	2059	2060	2061	2062	2063	2064
##	70.34075	55.08567	56.89683	57.23690	71.41683	72.95524	70.76581	49.70275
##	2065	2066	2067	2068	2069	2070	2071	2072
##	76.63290	54.91857	68.58513	57.86871	75.90948	65.89042	64.51355	72.18110
##	2073	2074	2075	2076	2077	2078	2079	2080
##	76.54160	81.52575	71.04965	73.94987	79.54163	68.14356	69.84500	79.26353
##	2081	2082	2083	2084	2085	2086	2087	2088
##	73.63981	50.54848	72.59622	71.97684	67.78599	68.27929	49.30501	31.35903
##	2089	2090	2091	2092	2093	2094	2095	2096
##	65.79095	74.97742	58.92271	53.25011	72.33872	50.04360	63.49395	66.38723
##	2097	2098	2099	2100	2101	2102	2103	2104
##	69.77643	75.55973	71.33054	44.46545	71.70423	68.02670	63.62353	54.07556
##	2105	2106	2107	2108	2109	2110	2111	2112
##	74.28788	79.43748	57.38411	63.47399	74.82488	59.00307	67.38342	73.98187
##	2113	2114	2115	2116	2117	2118	2119	2120

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## 53.58608 59.48874 65.96931 64.66685 66.79756 71.29840 73.29923 61.85543
##      2121      2122      2123      2124      2125      2126      2127      2128
## 76.21995 80.91061 71.53593 71.88142 74.52522 61.89257 64.14988 79.57528
##      2129      2130      2131      2132      2133      2134      2135      2136
## 38.27648 44.95555 62.72406 67.28432 67.73453 58.53539 66.07445 71.28561
##      2137      2138      2139      2140      2141      2142      2143      2144
## 68.29401 61.37187 75.34535 66.36653 72.52286 80.59717 78.68768 69.96976
##      2145      2146      2147      2148      2149      2150      2151      2152
## 74.56820 52.72303 66.54925 66.83808 73.17492 75.52429 64.07422 72.11851
##      2153      2154      2155      2156      2157      2158      2159      2160
## 72.34337 62.75491 67.78107 80.88616 75.85446 76.20024 72.45872 35.17931
##      2161      2162      2163      2164      2165      2166      2167      2168
## 63.63131 68.63224 67.76214 61.74062 65.28380 75.95183 65.27678 74.57928
##      2169      2170      2171      2172      2173      2174      2175      2176
## 78.72541 78.08664 78.52176 80.91207 73.48281 60.21483 81.41491 70.80896
##      2177      2178      2179      2180      2181      2182      2183      2184
## 65.51693 73.49285 78.65154 63.31123 77.72418 67.03160 80.49589 51.46494
##      2185      2186      2187      2188      2189      2190      2191      2192
## 67.55149 73.95707 68.75443 61.11644 66.73144 77.56403 67.55354 71.83831
##      2193      2194      2195      2196      2197      2198      2199      2200
## 76.29734 78.53406 78.85482 74.64613 73.39285 77.94422 68.79997 77.95604
##      2201      2202      2203      2204      2205      2206      2207      2208
## 78.10248 70.64454 74.37674 79.44882 74.50290 60.83495 64.06523 80.42100
##      2209      2210      2211      2212      2213      2214      2215      2216
## 71.35070 71.54426 68.34713 71.15763 67.25045 68.18603 73.11255 71.73849
##      2217      2218      2219      2220      2221      2222      2223      2224
## 63.99603 64.31819 58.28833 69.03487 77.25624 61.86020 47.42546 77.76607
##      2225      2226      2227      2228      2229      2230      2231      2232
## 80.16633 75.63137 79.37561 74.93292 56.79331 76.96125 72.11097 70.33255
##      2233      2234      2235      2236      2237      2238      2239      2240
## 75.88766 78.58538 70.97890 54.39537 72.59550 74.74830 71.01526 73.61445
##      2241      2242      2243      2244      2245      2246      2247      2248
## 73.50051 71.46317 79.63011 68.09753 73.18327 49.48715 80.14313 62.45313
##      2249      2250      2251      2252      2253      2254      2255      2256
## 71.53868 65.92179 60.14995 77.93087 69.78781 77.15626 74.83009 72.02574
##      2257      2258      2259      2260      2261      2262      2263      2264
## 80.08859 58.12709 80.56526 75.89800 56.83456 62.28280 79.94391 75.14882
##      2265      2266      2267      2268      2269      2270      2271      2272
## 74.57063 67.46894 61.27426 50.33286 72.15228 80.84743 80.34317 72.88566
##      2273      2274      2275      2276      2277      2278
## 73.54546 69.22347 74.07019 68.13378 74.54860 78.17684

```

```
print(predicted_values_3)
```

```

##      1      2      3      4      5      6      7      8
## 4.415996 4.151767 4.277883 3.972169 4.192859 4.366757 4.294545 4.378260
##      9     10     11     12     13     14     15     16
## 4.378776 4.300733 4.348855 4.044394 4.386554 4.245263 4.367816 4.008639
##     17     18     19     20     21     22     23     24
## 4.107045 4.089593 4.375762 4.277089 4.330655 4.367531 4.295651 4.358022
##     25     26     27     28     29     30     31     32
## 4.301363 4.185423 4.311418 4.065441 3.833776 4.343733 3.941138 4.339299
##     33     34     35     36     37     38     39     40
## 4.409415 4.270328 4.185389 3.955452 4.370874 4.259243 4.211517 4.160112

```

##	41	42	43	44	45	46	47	48
##	4.392700	4.274451	4.326797	4.283764	4.162586	4.215320	4.110902	4.366157
##	49	50	51	52	53	54	55	56
##	4.394936	4.007669	4.246171	4.134534	4.047899	4.099270	4.290214	4.227151
##	57	58	59	60	61	62	63	64
##	4.134306	4.214727	4.306107	4.043396	3.957682	4.253621	4.246777	4.339918
##	65	66	67	68	69	70	71	72
##	3.920366	4.215343	4.349221	3.894162	4.120357	4.174504	4.231202	4.347127
##	73	74	75	76	77	78	79	80
##	4.262805	4.381031	4.155959	4.087836	4.148625	4.257357	3.951441	4.351090
##	81	82	83	84	85	86	87	88
##	4.368553	4.209622	4.278661	4.090024	4.271329	4.400958	4.293105	4.050930
##	89	90	91	92	93	94	95	96
##	4.170562	4.331696	4.280585	4.058021	4.272488	3.977323	4.346288	4.344916
##	97	98	99	100	101	102	103	104
##	3.948581	4.316847	4.398989	4.371009	4.401120	4.316256	4.069239	4.348572
##	105	106	107	108	109	110	111	112
##	4.358486	4.380927	4.099318	4.386172	4.029281	4.163356	4.235365	4.349754
##	113	114	115	116	117	118	119	120
##	4.110782	4.205412	4.170566	4.280847	4.277219	4.332555	4.118813	4.387586
##	121	122	123	124	125	126	127	128
##	4.176839	4.146297	4.382561	4.361368	4.387687	4.383798	4.022554	3.848946
##	129	130	131	132	133	134	135	136
##	4.327910	4.120599	3.991708	4.316911	3.771634	3.980203	4.389993	4.390684
##	137	138	139	140	141	142	143	144
##	4.017870	4.319594	4.115943	4.008147	4.091082	3.959217	4.101154	4.122474
##	145	146	147	148	149	150	151	152
##	4.246250	4.268967	4.331821	3.951539	4.145769	4.352258	4.312288	3.930565
##	153	154	155	156	157	158	159	160
##	4.359778	4.257045	4.372822	4.362439	4.358759	4.395553	4.372598	4.400813
##	161	162	163	164	165	166	167	168
##	3.981697	4.260119	4.308228	4.364318	4.148519	4.294208	3.998255	3.834172
##	169	170	171	172	173	174	175	176
##	4.248152	4.327262	4.223881	4.237176	4.207805	4.290488	4.185135	4.152322
##	177	178	179	180	181	182	183	184
##	4.004568	4.372046	3.975560	4.342238	4.280625	4.357256	4.087212	4.336638
##	185	186	187	188	189	190	191	192
##	4.360012	4.162595	3.902254	3.967465	4.251032	3.945164	4.268713	4.239760
##	193	194	195	196	197	198	199	200
##	4.119561	4.286628	4.161465	4.286664	4.259240	4.056777	4.071339	4.255906
##	201	202	203	204	205	206	207	208
##	4.060738	4.272405	4.295148	4.377708	4.085419	4.296668	3.880073	4.031116
##	209	210	211	212	213	214	215	216
##	4.352070	4.373917	4.123081	4.124013	4.239047	4.368601	4.338831	4.030560
##	217	218	219	220	221	222	223	224
##	4.304505	4.352770	4.189976	4.131974	4.288492	4.097041	4.390590	4.353163
##	225	226	227	228	229	230	231	232
##	4.015023	4.386982	4.324196	4.243878	4.057740	4.065595	4.275903	4.153246
##	233	234	235	236	237	238	239	240
##	4.391893	4.260708	4.371464	4.269531	4.369010	4.112282	4.238759	4.382631
##	241	242	243	244	245	246	247	248
##	4.291693	4.401934	4.367011	4.107330	4.379712	4.312291	4.241424	4.048107
##	249	250	251	252	253	254	255	256
##	4.213935	4.330029	3.875074	4.373012	4.378282	4.299614	4.082546	4.333880

##	257	258	259	260	261	262	263	264
##	4.260959	4.267935	4.291218	4.271829	3.924469	4.305669	4.232374	4.318052
##	265	266	267	268	269	270	271	272
##	4.151097	4.243806	3.985405	4.392933	4.400991	4.321915	4.111387	4.366652
##	273	274	275	276	277	278	279	280
##	4.174061	4.264403	4.163443	3.938680	4.057923	4.387884	4.387439	4.320072
##	281	282	283	284	285	286	287	288
##	4.214961	3.955656	4.298834	3.944945	3.934248	4.379193	4.319408	4.120734
##	289	290	291	292	293	294	295	296
##	4.230656	4.300925	4.160165	4.312041	4.337449	4.396266	4.269890	4.271397
##	297	298	299	300	301	302	303	304
##	4.403567	4.394156	4.156339	4.390760	4.339942	3.875940	4.143137	4.362276
##	305	306	307	308	309	310	311	312
##	4.289632	4.335839	4.336185	4.325902	4.380876	4.214657	4.305549	4.358685
##	313	314	315	316	317	318	319	320
##	4.336482	4.288829	4.287361	4.324266	4.147441	4.339574	4.303761	4.247060
##	321	322	323	324	325	326	327	328
##	3.959022	3.773752	4.389816	3.960811	4.248952	4.226471	4.262190	4.310632
##	329	330	331	332	333	334	335	336
##	4.388290	4.243858	4.386280	3.898288	4.143986	4.267644	4.130158	4.272351
##	337	338	339	340	341	342	343	344
##	4.310765	4.093209	4.289430	4.379576	4.362964	4.386332	3.938233	4.301700
##	345	346	347	348	349	350	351	352
##	4.073264	4.334821	4.251537	4.311451	4.203615	3.959568	4.029391	4.324530
##	353	354	355	356	357	358	359	360
##	4.274962	4.326093	4.295100	4.227949	4.386976	4.351636	4.391864	4.299872
##	361	362	363	364	365	366	367	368
##	4.108207	3.843668	4.334033	3.970219	4.361580	4.345277	3.973346	4.380624
##	369	370	371	372	373	374	375	376
##	4.237432	4.285054	4.116633	4.313270	3.784617	4.217696	4.102380	4.235120
##	377	378	379	380	381	382	383	384
##	4.086198	4.264658	4.054706	4.357301	4.340037	4.317545	4.354154	4.314430
##	385	386	387	388	389	390	391	392
##	4.357095	4.351894	4.251562	4.340890	4.303748	4.114057	3.808030	4.359227
##	393	394	395	396	397	398	399	400
##	4.309837	4.182296	4.359241	4.334053	4.177271	4.297734	4.314762	4.257859
##	401	402	403	404	405	406	407	408
##	4.355459	4.049674	4.233270	4.239012	4.283209	4.387963	3.838325	3.998250
##	409	410	411	412	413	414	415	416
##	4.095926	4.217025	3.855759	4.324439	4.373158	4.014875	4.322180	4.155541
##	417	418	419	420	421	422	423	424
##	4.353388	4.253354	3.881495	4.296684	4.176861	4.204711	4.298609	4.362362
##	425	426	427	428	429	430	431	432
##	4.197808	4.273577	4.014819	4.321836	4.343873	4.289362	4.191626	3.892369
##	433	434	435	436	437	438	439	440
##	4.099911	4.383397	4.092800	4.308642	4.363611	4.166496	4.229681	4.276807
##	441	442	443	444	445	446	447	448
##	4.060101	3.808221	4.374584	4.339927	4.241103	4.301758	3.921442	4.319862
##	449	450	451	452	453	454	455	456
##	4.259852	4.260024	4.312990	4.063014	4.285955	4.326338	4.339865	4.148946
##	457	458	459	460	461	462	463	464
##	4.388702	4.112275	4.297500	4.358823	4.134407	4.037049	4.323930	4.290670
##	465	466	467	468	469	470	471	472
##	3.811590	4.325625	4.124728	4.329768	4.388810	4.349112	4.060459	4.386751

##	473	474	475	476	477	478	479	480
##	3.997040	4.384076	4.073097	4.224097	4.360738	4.392176	4.140300	4.025528
##	481	482	483	484	485	486	487	488
##	4.367618	4.361072	4.069903	4.378856	4.174527	4.250996	4.297810	4.228304
##	489	490	491	492	493	494	495	496
##	3.930840	4.363112	4.257233	4.172688	4.057274	4.175538	4.374339	4.340430
##	497	498	499	500	501	502	503	504
##	4.080055	4.193617	4.246780	4.229209	4.357958	4.151814	4.249744	4.065783
##	505	506	507	508	509	510	511	512
##	4.248760	4.301312	4.229643	3.768062	4.106849	4.293151	4.255253	4.304399
##	513	514	515	516	517	518	519	520
##	3.941065	4.293687	4.348377	4.245485	4.012397	3.982796	4.056552	4.296208
##	521	522	523	524	525	526	527	528
##	4.327127	4.338056	4.064353	4.284923	4.274526	4.097918	4.277551	4.333585
##	529	530	531	532	533	534	535	536
##	4.028169	4.345743	4.362021	4.144325	4.101418	4.233542	4.138209	4.276224
##	537	538	539	540	541	542	543	544
##	4.012869	4.227515	4.148024	4.293355	3.821365	4.272594	4.203343	4.009156
##	545	546	547	548	549	550	551	552
##	3.837076	4.273779	4.201390	4.054584	4.379918	4.352343	3.904236	4.261963
##	553	554	555	556	557	558	559	560
##	4.264624	4.021492	4.209555	4.295727	4.333119	4.230784	3.926138	4.219830
##	561	562	563	564	565	566	567	568
##	3.950011	4.098971	4.383390	4.262867	4.310401	4.312850	4.069273	4.224085
##	569	570	571	572	573	574	575	576
##	4.355711	4.232357	4.398840	3.961254	4.246864	4.275976	4.065721	4.334788
##	577	578	579	580	581	582	583	584
##	4.311918	4.336525	4.224900	3.755671	4.075059	4.142291	4.384321	4.372015
##	585	586	587	588	589	590	591	592
##	4.294249	4.364685	4.146843	4.388890	4.343016	4.298054	4.377527	4.310067
##	593	594	595	596	597	598	599	600
##	4.165660	4.219715	4.108562	4.368243	4.387058	4.290683	4.234167	4.358797
##	601	602	603	604	605	606	607	608
##	4.196569	4.179873	4.272322	4.389161	4.131254	4.368494	4.342518	4.387967
##	609	610	611	612	613	614	615	616
##	4.371424	4.377710	4.343076	4.268665	4.343040	4.242041	4.232401	4.038840
##	617	618	619	620	621	622	623	624
##	4.295984	4.156715	4.324515	4.293896	4.259470	4.200130	4.054056	4.280665
##	625	626	627	628	629	630	631	632
##	4.377931	4.304567	4.282072	4.385755	4.305280	4.341203	3.772959	4.254367
##	633	634	635	636	637	638	639	640
##	4.302836	4.326849	4.385480	4.196373	4.106342	4.338508	4.072206	4.305653
##	641	642	643	644	645	646	647	648
##	4.276441	4.323646	4.291844	4.387025	4.177517	3.991925	4.048016	4.299475
##	649	650	651	652	653	654	655	656
##	4.204252	4.072358	4.401758	4.319756	4.392934	4.095170	4.219356	4.374127
##	657	658	659	660	661	662	663	664
##	4.210362	4.268350	4.243236	4.241286	4.147965	4.279661	3.960234	3.976159
##	665	666	667	668	669	670	671	672
##	4.294350	4.373734	4.289928	4.090223	3.932824	4.034954	4.288319	4.389756
##	673	674	675	676	677	678	679	680
##	4.083355	3.952693	4.338372	4.382693	4.019581	4.314289	4.285142	4.319301
##	681	682	683	684	685	686	687	688
##	4.247403	4.098401	4.227897	4.289619	4.149291	4.350024	4.182690	3.982986



##	689	690	691	692	693	694	695	696
##	4.370715	4.343160	4.263104	3.984741	4.375987	4.248584	4.372449	4.123792
##	697	698	699	700	701	702	703	704
##	4.297109	4.038180	4.327596	4.263379	4.302170	4.336525	4.284725	4.386599
##	705	706	707	708	709	710	711	712
##	4.229265	4.119425	4.398836	3.927204	4.009962	4.390373	4.256690	4.365265
##	713	714	715	716	717	718	719	720
##	4.237862	4.360449	4.238093	4.120230	4.326892	3.792717	4.352327	4.355656
##	721	722	723	724	725	726	727	728
##	4.270791	4.276879	4.363620	4.038618	4.239748	4.351359	4.259733	4.164726
##	729	730	731	732	733	734	735	736
##	4.277187	3.805470	4.052255	4.268582	4.356821	4.019736	4.253083	4.202908
##	737	738	739	740	741	742	743	744
##	4.334755	3.901976	4.021145	4.323293	4.148110	4.396964	4.084312	4.215746
##	745	746	747	748	749	750	751	752
##	4.386454	4.205179	4.318306	4.208356	4.109092	4.259938	4.169967	4.290344
##	753	754	755	756	757	758	759	760
##	4.276644	4.218008	3.946545	4.344832	4.348682	4.209863	3.887995	4.072898
##	761	762	763	764	765	766	767	768
##	4.378201	3.986849	4.275710	4.247259	4.286750	4.034573	4.296198	4.250627
##	769	770	771	772	773	774	775	776
##	4.379158	4.383768	4.279583	4.237055	4.008481	4.283818	4.254413	4.128355
##	777	778	779	780	781	782	783	784
##	4.325666	4.002710	4.196991	4.210462	4.318895	4.206187	4.378255	4.012374
##	785	786	787	788	789	790	791	792
##	4.307891	4.091220	4.216000	4.345075	4.382057	4.262932	4.161937	4.148099
##	793	794	795	796	797	798	799	800
##	4.309453	4.377639	4.283348	4.035045	3.966614	4.325512	4.103093	3.887852
##	801	802	803	804	805	806	807	808
##	4.319684	4.382236	3.913108	4.385835	4.343134	4.353480	4.102440	4.236534
##	809	810	811	812	813	814	815	816
##	4.179114	4.395793	3.993306	4.101485	4.315459	4.121619	4.343843	4.235976
##	817	818	819	820	821	822	823	824
##	4.323674	4.006341	4.384029	4.227800	3.964130	3.760178	4.220039	4.295131
##	825	826	827	828	829	830	831	832
##	4.364063	4.399058	4.296353	4.353490	4.092918	4.268798	3.993590	4.122787
##	833	834	835	836	837	838	839	840
##	4.263679	4.322348	4.265678	4.323251	4.211362	4.281264	4.288384	4.166507
##	841	842	843	844	845	846	847	848
##	4.350890	4.387685	4.388416	4.009402	4.263839	4.275758	4.372122	4.219260
##	849	850	851	852	853	854	855	856
##	4.273788	4.298446	4.375465	4.052942	4.360463	4.308744	4.279398	4.203725
##	857	858	859	860	861	862	863	864
##	4.308547	3.961066	4.328898	4.318847	4.339513	4.240071	4.335856	4.036244
##	865	866	867	868	869	870	871	872
##	4.275238	4.273024	4.317879	4.307607	4.215782	4.234565	4.226708	4.298806
##	873	874	875	876	877	878	879	880
##	4.350404	4.239752	4.355481	4.176693	4.396028	4.310611	4.287701	4.292395
##	881	882	883	884	885	886	887	888
##	4.168564	4.260049	4.247044	3.987228	4.276861	3.914687	4.263510	4.219743
##	889	890	891	892	893	894	895	896
##	4.124945	4.245779	4.276510	4.295507	4.389945	4.143477	4.186385	3.915254
##	897	898	899	900	901	902	903	904
##	4.392997	3.844802	4.384389	4.388935	4.144965	4.104261	3.922429	4.190949

##	905	906	907	908	909	910	911	912
##	4.346686	3.937107	4.278020	4.108492	4.360175	4.140042	4.173263	4.280069
##	913	914	915	916	917	918	919	920
##	4.334100	4.305470	4.287211	4.344573	4.126888	4.276208	4.266342	4.129963
##	921	922	923	924	925	926	927	928
##	4.041199	3.857931	3.977620	4.074995	4.142219	4.384387	3.981341	4.282400
##	929	930	931	932	933	934	935	936
##	4.226282	4.251865	4.393277	4.257398	4.309699	4.293466	4.330588	4.233996
##	937	938	939	940	941	942	943	944
##	4.112393	4.161506	4.314904	4.349622	4.289852	4.384578	4.284012	4.299381
##	945	946	947	948	949	950	951	952
##	4.301851	4.329711	4.312646	4.097190	4.125631	4.386421	4.368665	4.283775
##	953	954	955	956	957	958	959	960
##	3.864552	4.227476	4.267905	4.193133	4.331181	4.395741	3.914935	3.992433
##	961	962	963	964	965	966	967	968
##	4.052033	4.028634	4.254637	4.333382	4.269009	4.317544	4.303834	4.295875
##	969	970	971	972	973	974	975	976
##	4.368174	3.940939	4.394566	4.257604	4.209529	4.341436	4.404343	4.262211
##	977	978	979	980	981	982	983	984
##	4.363437	4.327391	4.201172	4.262559	4.258580	4.340473	4.214393	3.776352
##	985	986	987	988	989	990	991	992
##	4.110159	4.235641	4.024497	4.365708	4.378152	4.255582	4.275016	4.299433
##	993	994	995	996	997	998	999	1000
##	4.164411	4.198895	4.324646	4.071597	4.184766	3.992661	3.968938	4.296706
##	1001	1002	1003	1004	1005	1006	1007	1008
##	3.773590	3.984788	4.113490	4.242380	4.149442	4.362731	4.192517	4.131054
##	1009	1010	1011	1012	1013	1014	1015	1016
##	4.397601	3.963192	4.050766	4.207968	4.338756	4.148507	4.116653	4.313795
##	1017	1018	1019	1020	1021	1022	1023	1024
##	4.132308	4.334560	4.256062	4.339947	4.357717	4.252219	3.901275	3.999810
##	1025	1026	1027	1028	1029	1030	1031	1032
##	4.281782	4.360729	4.066189	4.208609	4.400532	4.178737	3.983385	4.368608
##	1033	1034	1035	1036	1037	1038	1039	1040
##	4.377840	4.293479	4.132359	4.262101	4.347855	4.296525	4.264574	4.242447
##	1041	1042	1043	1044	1045	1046	1047	1048
##	4.291476	4.183361	4.303663	4.314470	4.379069	4.273765	4.119254	4.385440
##	1049	1050	1051	1052	1053	1054	1055	1056
##	3.934388	4.289830	4.238193	4.111889	4.355783	4.048984	4.338192	3.977395
##	1057	1058	1059	1060	1061	1062	1063	1064
##	4.020536	4.203394	4.193277	4.238610	3.975912	4.253879	3.877463	4.313007
##	1065	1066	1067	1068	1069	1070	1071	1072
##	4.017839	4.102272	4.251811	4.382860	4.378320	4.294902	4.275758	4.105756
##	1073	1074	1075	1076	1077	1078	1079	1080
##	4.183205	4.324063	3.929002	4.384906	4.138015	4.258478	3.964706	4.268502
##	1081	1082	1083	1084	1085	1086	1087	1088
##	4.208161	4.268572	4.104791	4.376248	4.386130	4.297545	4.189001	4.290585
##	1089	1090	1091	1092	1093	1094	1095	1096
##	4.084627	4.334335	4.024387	4.259495	4.268797	4.393281	4.300900	4.231311
##	1097	1098	1099	1100	1101	1102	1103	1104
##	4.081341	3.840210	4.146240	4.326277	4.289764	4.251830	4.190076	4.111879
##	1105	1106	1107	1108	1109	1110	1111	1112
##	4.300688	4.155289	3.964023	4.262719	4.132697	4.089683	4.397159	3.868116
##	1113	1114	1115	1116	1117	1118	1119	1120
##	4.206235	4.290695	4.396496	4.308238	4.306068	4.326030	4.206542	4.306280

##	1121	1122	1123	1124	1125	1126	1127	1128
##	4.395399	3.891608	4.377229	4.282499	4.266211	4.317513	4.386783	4.389426
##	1129	1130	1131	1132	1133	1134	1135	1136
##	4.250871	4.158509	4.276648	4.365979	4.277382	3.771673	3.890158	4.118399
##	1137	1138	1139	1140	1141	1142	1143	1144
##	4.305721	4.038898	3.762169	4.279978	4.368384	4.334712	4.167188	4.267692
##	1145	1146	1147	1148	1149	1150	1151	1152
##	4.325496	4.259031	4.378803	4.341266	4.145308	4.379431	4.235700	3.973639
##	1153	1154	1155	1156	1157	1158	1159	1160
##	4.255709	4.383263	4.315887	4.389548	4.340606	4.298122	4.369995	4.111020
##	1161	1162	1163	1164	1165	1166	1167	1168
##	3.876306	4.334193	4.140355	4.151125	4.274108	4.249034	4.160890	4.372914
##	1169	1170	1171	1172	1173	1174	1175	1176
##	4.344934	4.102141	4.083367	4.301539	4.099831	4.393250	4.219624	4.277413
##	1177	1178	1179	1180	1181	1182	1183	1184
##	4.226140	4.336332	4.216191	4.078583	4.141148	4.384403	4.362363	4.368383
##	1185	1186	1187	1188	1189	1190	1191	1192
##	3.972718	4.162378	4.110536	4.383577	4.273998	4.369881	4.274954	4.171168
##	1193	1194	1195	1196	1197	1198	1199	1200
##	3.926278	4.319664	4.314621	4.136340	4.153905	4.270272	3.939664	4.233598
##	1201	1202	1203	1204	1205	1206	1207	1208
##	4.012409	4.363118	4.170693	4.262000	4.297680	4.267618	4.345268	4.386082
##	1209	1210	1211	1212	1213	1214	1215	1216
##	3.858000	4.301512	4.336392	4.308340	4.203594	4.387591	4.249512	4.318478
##	1217	1218	1219	1220	1221	1222	1223	1224
##	4.243195	4.255637	4.276010	4.258343	4.316944	3.999203	4.300651	4.133648
##	1225	1226	1227	1228	1229	1230	1231	1232
##	4.385881	4.206378	4.369627	4.221493	4.087555	4.371888	4.129080	4.284294
##	1233	1234	1235	1236	1237	1238	1239	1240
##	4.104828	4.234484	4.241737	4.318807	4.269325	4.260286	4.247025	4.262718
##	1241	1242	1243	1244	1245	1246	1247	1248
##	4.264587	3.979770	4.322936	4.380426	4.314046	4.371358	4.362587	4.351917
##	1249	1250	1251	1252	1253	1254	1255	1256
##	4.192709	4.131454	4.298359	4.244124	4.158492	3.940811	4.063576	4.079420
##	1257	1258	1259	1260	1261	1262	1263	1264
##	4.390840	4.273718	4.350498	4.298580	4.005000	4.038790	4.259047	4.317081
##	1265	1266	1267	1268	1269	1270	1271	1272
##	4.155998	4.007105	4.228394	4.322971	4.316112	4.179069	3.940240	4.150676
##	1273	1274	1275	1276	1277	1278	1279	1280
##	4.040847	4.339346	4.136087	4.274258	4.385468	4.276310	4.230873	4.202057
##	1281	1282	1283	1284	1285	1286	1287	1288
##	4.303621	4.032126	4.027310	4.297813	4.332002	4.346955	4.372906	4.049809
##	1289	1290	1291	1292	1293	1294	1295	1296
##	4.066989	4.346410	4.259149	4.216863	4.301359	4.101027	4.127508	4.392432
##	1297	1298	1299	1300	1301	1302	1303	1304
##	3.942470	4.279830	4.168467	4.350754	4.295806	4.269763	4.302050	4.342807
##	1305	1306	1307	1308	1309	1310	1311	1312
##	4.156311	4.158634	4.223897	4.395323	4.277961	4.318369	4.394116	4.225658
##	1313	1314	1315	1316	1317	1318	1319	1320
##	4.004860	4.181394	4.031696	4.272908	4.279300	4.341435	4.201076	4.251864
##	1321	1322	1323	1324	1325	1326	1327	1328
##	3.825473	4.329706	4.370866	4.302924	4.386524	3.796386	4.005326	4.222784
##	1329	1330	1331	1332	1333	1334	1335	1336
##	4.192260	4.303374	4.092951	4.247340	4.228355	4.337007	4.183619	4.376642

##	1337	1338	1339	1340	1341	1342	1343	1344
##	4.381656	4.042177	4.378152	4.295808	4.057149	4.370694	4.291994	4.393386
##	1345	1346	1347	1348	1349	1350	1351	1352
##	3.944097	4.231176	4.308437	4.348565	4.316189	4.383718	4.101868	4.382402
##	1353	1354	1355	1356	1357	1358	1359	1360
##	3.806958	4.290570	4.248270	4.271505	4.073894	4.307101	4.026761	4.293662
##	1361	1362	1363	1364	1365	1366	1367	1368
##	4.385279	4.311053	4.270178	4.236353	4.383816	4.065174	4.055034	4.156357
##	1369	1370	1371	1372	1373	1374	1375	1376
##	4.232451	4.240380	4.358465	4.277270	4.307492	4.298250	4.368685	4.337895
##	1377	1378	1379	1380	1381	1382	1383	1384
##	4.370639	4.266923	4.267395	4.298471	4.395067	3.926905	4.288169	4.345602
##	1385	1386	1387	1388	1389	1390	1391	1392
##	4.313081	4.309575	4.382069	4.026620	3.945654	4.400358	4.215373	4.358738
##	1393	1394	1395	1396	1397	1398	1399	1400
##	4.339831	4.037338	4.298489	4.356386	3.915305	4.320022	4.270351	4.170521
##	1401	1402	1403	1404	1405	1406	1407	1408
##	4.362405	4.174525	4.044152	4.113122	4.348961	4.306433	4.353049	4.133356
##	1409	1410	1411	1412	1413	1414	1415	1416
##	4.325669	4.282414	4.386226	4.348352	4.336501	4.388709	4.291485	4.289693
##	1417	1418	1419	1420	1421	1422	1423	1424
##	4.120609	3.974620	4.254864	4.308384	4.284817	4.082484	4.396934	4.292438
##	1425	1426	1427	1428	1429	1430	1431	1432
##	3.933518	4.138370	4.292517	4.175883	4.371039	4.241831	4.239391	4.212863
##	1433	1434	1435	1436	1437	1438	1439	1440
##	4.339247	3.950264	4.347835	4.387971	4.171357	4.399325	4.164704	4.396737
##	1441	1442	1443	1444	1445	1446	1447	1448
##	4.302143	3.911464	4.290113	4.397323	4.079934	4.151284	4.054932	4.393228
##	1449	1450	1451	1452	1453	1454	1455	1456
##	4.308819	4.365631	4.369110	4.064900	4.113088	3.911002	4.281797	4.317626
##	1457	1458	1459	1460	1461	1462	1463	1464
##	4.380153	4.261890	4.225513	4.075858	4.227199	4.172480	4.252834	4.361918
##	1465	1466	1467	1468	1469	1470	1471	1472
##	4.388568	4.368377	4.252807	4.264337	4.301568	4.238180	4.148530	4.360444
##	1473	1474	1475	1476	1477	1478	1479	1480
##	4.380693	4.348757	4.354129	4.359956	4.143701	4.329933	4.119031	4.372361
##	1481	1482	1483	1484	1485	1486	1487	1488
##	3.983888	4.298244	4.221560	4.401178	4.331048	4.199208	4.236947	4.244921
##	1489	1490	1491	1492	1493	1494	1495	1496
##	4.233335	4.317713	4.208239	4.043917	3.872209	4.282366	4.273030	4.316250
##	1497	1498	1499	1500	1501	1502	1503	1504
##	4.356039	3.834157	3.980582	4.291300	4.369245	4.064286	4.223994	4.263882
##	1505	1506	1507	1508	1509	1510	1511	1512
##	4.241350	4.294777	3.997155	4.082819	4.295440	4.207391	4.354922	4.065638
##	1513	1514	1515	1516	1517	1518	1519	1520
##	4.177993	4.298546	4.154306	4.243411	3.982851	4.390071	4.391079	4.351276
##	1521	1522	1523	1524	1525	1526	1527	1528
##	4.352737	4.108116	3.972175	4.075166	4.316292	3.956666	4.261149	3.803517
##	1529	1530	1531	1532	1533	1534	1535	1536
##	4.296852	4.396442	4.273697	4.280085	4.271799	4.146531	4.152954	4.231705
##	1537	1538	1539	1540	1541	1542	1543	1544
##	4.387465	4.356089	4.003158	4.340662	4.198889	3.957271	4.359710	4.077706
##	1545	1546	1547	1548	1549	1550	1551	1552
##	4.174777	4.378309	4.014200	4.127755	4.209980	4.326307	4.229836	4.350164

##	1553	1554	1555	1556	1557	1558	1559	1560
##	4.209216	4.320736	4.258235	4.343271	4.259248	4.125163	3.809734	4.220617
##	1561	1562	1563	1564	1565	1566	1567	1568
##	4.374982	4.300206	3.941546	4.298665	4.343934	4.310995	4.225944	3.779476
##	1569	1570	1571	1572	1573	1574	1575	1576
##	4.190182	4.326186	4.262207	4.186537	4.191756	4.214509	4.242173	4.373788
##	1577	1578	1579	1580	1581	1582	1583	1584
##	4.278524	4.078122	4.084793	4.061753	4.097156	4.300286	3.788690	4.086140
##	1585	1586	1587	1588	1589	1590	1591	1592
##	4.369707	4.091910	4.393467	4.187221	4.379023	4.170608	4.213719	3.956928
##	1593	1594	1595	1596	1597	1598	1599	1600
##	4.122400	4.383489	4.327109	4.161834	4.366098	4.274764	4.328082	4.314999
##	1601	1602	1603	1604	1605	1606	1607	1608
##	4.184209	4.175598	4.381508	4.078553	4.290361	4.236226	4.243435	4.369365
##	1609	1610	1611	1612	1613	1614	1615	1616
##	4.300387	4.276969	4.334899	4.306683	4.155062	4.385236	4.358519	4.346828
##	1617	1618	1619	1620	1621	1622	1623	1624
##	3.919912	4.194109	4.250398	4.234721	4.142764	4.330371	3.949560	4.352486
##	1625	1626	1627	1628	1629	1630	1631	1632
##	4.379726	4.280147	3.962807	4.381958	4.201787	4.285524	4.250446	4.208257
##	1633	1634	1635	1636	1637	1638	1639	1640
##	4.030449	4.344186	4.284410	4.098541	4.343306	4.382003	3.917397	4.183057
##	1641	1642	1643	1644	1645	1646	1647	1648
##	4.207632	4.375309	4.194780	3.952313	4.281447	4.107654	4.383820	4.072351
##	1649	1650	1651	1652	1653	1654	1655	1656
##	3.868446	4.178815	4.387019	3.992202	4.338090	4.376181	4.190596	4.172510
##	1657	1658	1659	1660	1661	1662	1663	1664
##	4.309081	4.306843	4.346905	4.321644	3.782037	4.250718	4.242829	4.018656
##	1665	1666	1667	1668	1669	1670	1671	1672
##	4.304364	4.303373	3.910653	4.128246	4.284413	4.340432	4.288421	4.307365
##	1673	1674	1675	1676	1677	1678	1679	1680
##	4.008891	4.258771	4.347173	4.055243	4.291173	4.356179	4.011136	4.276164
##	1681	1682	1683	1684	1685	1686	1687	1688
##	4.240446	4.356001	4.038552	4.240442	4.277027	3.807051	4.392254	4.259069
##	1689	1690	1691	1692	1693	1694	1695	1696
##	4.081934	4.387908	4.301241	4.355623	4.253432	4.366561	4.225609	4.389443
##	1697	1698	1699	1700	1701	1702	1703	1704
##	3.954176	4.012432	4.289668	4.363760	4.127602	4.307260	4.143016	4.186660
##	1705	1706	1707	1708	1709	1710	1711	1712
##	4.103692	4.283642	4.315119	4.331710	4.255432	4.144349	4.116649	4.309099
##	1713	1714	1715	1716	1717	1718	1719	1720
##	4.361849	4.286498	4.381994	4.375685	4.374904	4.337200	4.318224	4.182606
##	1721	1722	1723	1724	1725	1726	1727	1728
##	4.066398	4.344034	4.243649	4.274713	4.304708	4.367461	4.267851	4.392320
##	1729	1730	1731	1732	1733	1734	1735	1736
##	4.225839	4.259744	4.304144	4.248639	4.355385	4.145005	4.382514	3.762594
##	1737	1738	1739	1740	1741	1742	1743	1744
##	4.313820	3.939192	4.393114	4.190053	4.380029	4.294628	4.357109	3.920563
##	1745	1746	1747	1748	1749	1750	1751	1752
##	4.252147	4.267512	4.264777	4.365787	3.924474	4.348857	4.351498	4.344229
##	1753	1754	1755	1756	1757	1758	1759	1760
##	4.304861	4.136901	4.306863	4.093584	4.291936	4.287908	4.377149	4.294417
##	1761	1762	1763	1764	1765	1766	1767	1768
##	4.363098	4.396147	4.288676	4.192827	4.247081	4.152496	4.302800	4.098956

##	1769	1770	1771	1772	1773	1774	1775	1776
##	4.339455	4.057989	4.095220	4.235957	4.338741	4.244053	4.137960	4.089293
##	1777	1778	1779	1780	1781	1782	1783	1784
##	4.249394	3.936645	4.153469	4.012964	3.965244	4.303619	4.212164	4.287545
##	1785	1786	1787	1788	1789	1790	1791	1792
##	4.319198	4.316390	4.099716	4.254841	4.079817	4.030437	4.098702	4.348453
##	1793	1794	1795	1796	1797	1798	1799	1800
##	4.343357	4.335551	4.067285	4.377717	4.372933	4.286094	4.314772	4.264658
##	1801	1802	1803	1804	1805	1806	1807	1808
##	4.154538	3.994327	4.384644	4.101762	4.270590	3.986618	4.337020	4.374799
##	1809	1810	1811	1812	1813	1814	1815	1816
##	4.358972	4.276194	4.283612	4.119409	4.387206	4.347525	4.334966	4.256539
##	1817	1818	1819	1820	1821	1822	1823	1824
##	4.160472	4.235200	4.055541	3.990761	4.041491	4.241375	4.398743	4.038577
##	1825	1826	1827	1828	1829	1830	1831	1832
##	4.395248	4.339787	4.156154	4.367151	4.255129	4.297013	4.117930	4.361563
##	1833	1834	1835	1836	1837	1838	1839	1840
##	4.342957	4.232038	4.230117	4.234920	4.029056	4.318329	3.977337	4.339338
##	1841	1842	1843	1844	1845	1846	1847	1848
##	3.994118	4.292062	4.371306	4.264478	4.164522	4.277428	4.304181	3.990314
##	1849	1850	1851	1852	1853	1854	1855	1856
##	4.364739	4.268403	4.031080	3.884404	4.323602	4.307904	3.822920	4.386974
##	1857	1858	1859	1860	1861	1862	1863	1864
##	4.059856	4.271956	4.243456	4.123312	4.235700	4.263512	4.309419	4.090592
##	1865	1866	1867	1868	1869	1870	1871	1872
##	4.309371	4.198472	4.297489	4.258776	4.274033	3.974488	4.377760	4.087250
##	1873	1874	1875	1876	1877	1878	1879	1880
##	3.922013	4.213301	4.391330	3.890437	4.067235	4.037878	4.287283	4.018595
##	1881	1882	1883	1884	1885	1886	1887	1888
##	4.240750	4.298675	4.381997	4.370991	4.247776	4.058319	3.877757	4.356802
##	1889	1890	1891	1892	1893	1894	1895	1896
##	4.354564	4.022718	4.000078	4.123560	4.355463	3.970214	4.327351	4.316189
##	1897	1898	1899	1900	1901	1902	1903	1904
##	4.252104	4.256217	4.242190	4.043052	4.223696	4.278960	4.177963	4.159686
##	1905	1906	1907	1908	1909	1910	1911	1912
##	4.129137	4.360570	4.345831	4.289043	4.157865	4.265721	4.086694	4.240699
##	1913	1914	1915	1916	1917	1918	1919	1920
##	3.903145	4.211896	4.156458	4.268424	4.093931	4.247781	4.100781	4.331348
##	1921	1922	1923	1924	1925	1926	1927	1928
##	4.263029	3.930675	4.381680	4.126198	4.226743	4.391152	4.319685	4.251454
##	1929	1930	1931	1932	1933	1934	1935	1936
##	4.304513	4.251117	4.193381	4.216244	4.157689	4.347008	4.311440	4.219753
##	1937	1938	1939	1940	1941	1942	1943	1944
##	4.353373	4.349477	4.340743	4.383891	3.997703	4.389161	4.286169	4.377054
##	1945	1946	1947	1948	1949	1950	1951	1952
##	4.334326	4.336979	4.308325	4.300756	4.071695	4.073003	4.227529	3.837183
##	1953	1954	1955	1956	1957	1958	1959	1960
##	3.881422	4.160241	4.279771	4.296392	4.223140	4.290430	4.303199	4.139689
##	1961	1962	1963	1964	1965	1966	1967	1968
##	3.854936	4.123282	4.177614	4.413238	4.212509	4.151373	4.317530	3.887641
##	1969	1970	1971	1972	1973	1974	1975	1976
##	4.333941	4.289211	4.387412	4.340763	4.221800	4.397399	4.330874	4.008514
##	1977	1978	1979	1980	1981	1982	1983	1984
##	4.286488	4.274384	4.229516	4.244390	4.120726	4.340183	4.363390	4.123314

##	1985	1986	1987	1988	1989	1990	1991	1992
##	4.367816	4.365520	4.073738	4.410472	4.169158	4.363811	4.382094	4.345035
##	1993	1994	1995	1996	1997	1998	1999	2000
##	4.381039	4.365966	4.249213	4.274524	4.212208	4.346350	4.276711	4.062550
##	2001	2002	2003	2004	2005	2006	2007	2008
##	4.326064	4.379588	4.286517	4.322881	4.262673	4.180748	3.798382	4.342344
##	2009	2010	2011	2012	2013	2014	2015	2016
##	4.302399	4.336740	4.031669	3.921231	4.286676	4.234913	4.251022	4.381600
##	2017	2018	2019	2020	2021	2022	2023	2024
##	4.295521	4.327793	4.340718	4.282989	4.370630	4.213423	4.287756	4.373376
##	2025	2026	2027	2028	2029	2030	2031	2032
##	4.035732	4.040231	4.267252	4.391918	4.296521	4.300667	4.129299	4.254507
##	2033	2034	2035	2036	2037	2038	2039	2040
##	4.265553	4.156304	4.364926	4.310627	4.231607	4.379365	4.230416	4.228197
##	2041	2042	2043	2044	2045	2046	2047	2048
##	4.135872	4.394594	4.017865	3.997356	3.740207	4.077719	4.108945	4.168827
##	2049	2050	2051	2052	2053	2054	2055	2056
##	4.281920	4.383520	4.295723	4.376287	4.118274	4.360870	4.294645	4.349360
##	2057	2058	2059	2060	2061	2062	2063	2064
##	4.265868	4.051851	4.033605	4.039357	4.283568	4.299913	4.296801	3.847853
##	2065	2066	2067	2068	2069	2070	2071	2072
##	4.334971	4.044585	4.216097	3.972549	4.360744	4.195466	4.224736	4.296672
##	2073	2074	2075	2076	2077	2078	2079	2080
##	4.333296	4.399285	4.295046	4.308177	4.379627	4.210714	4.253497	4.378914
##	2081	2082	2083	2084	2085	2086	2087	2088
##	4.319633	3.885460	4.295503	4.323410	4.202878	4.254152	3.861179	3.760906
##	2089	2090	2091	2092	2093	2094	2095	2096
##	4.209858	4.307956	4.009346	3.974094	4.275956	3.985119	4.068800	4.179070
##	2097	2098	2099	2100	2101	2102	2103	2104
##	4.242394	4.367035	4.263458	3.918119	4.303009	4.233795	4.116868	4.028223
##	2105	2106	2107	2108	2109	2110	2111	2112
##	4.304970	4.386947	3.963416	4.137540	4.331681	3.969121	4.224547	4.340615
##	2113	2114	2115	2116	2117	2118	2119	2120
##	3.923744	4.112041	4.221055	4.203341	4.185739	4.316447	4.289665	4.072719
##	2121	2122	2123	2124	2125	2126	2127	2128
##	4.336861	4.393767	4.271779	4.264852	4.311333	4.055702	4.191349	4.375043
##	2129	2130	2131	2132	2133	2134	2135	2136
##	3.793754	3.749643	4.136216	4.176004	4.188298	4.074467	4.105179	4.277176
##	2137	2138	2139	2140	2141	2142	2143	2144
##	4.239802	4.058397	4.363921	4.205169	4.284541	4.388104	4.378773	4.246130
##	2145	2146	2147	2148	2149	2150	2151	2152
##	4.340627	3.993258	4.224178	4.218230	4.313573	4.349760	4.205619	4.323366
##	2153	2154	2155	2156	2157	2158	2159	2160
##	4.272854	4.097478	4.176593	4.389351	4.340143	4.328199	4.295882	3.759716
##	2161	2162	2163	2164	2165	2166	2167	2168
##	4.087661	4.215541	4.244478	4.039023	4.129253	4.319800	4.211466	4.334098
##	2169	2170	2171	2172	2173	2174	2175	2176
##	4.351772	4.386306	4.367883	4.396618	4.337305	4.079526	4.395358	4.262297
##	2177	2178	2179	2180	2181	2182	2183	2184
##	4.133466	4.295863	4.382096	4.140803	4.371718	4.225213	4.396225	3.915041
##	2185	2186	2187	2188	2189	2190	2191	2192
##	4.203739	4.289774	4.260193	4.083976	4.201299	4.353503	4.198237	4.245767
##	2193	2194	2195	2196	2197	2198	2199	2200
##	4.348117	4.365704	4.384183	4.346040	4.307737	4.377320	4.222056	4.349104

```
##      2201      2202      2203      2204      2205      2206      2207      2208
## 4.361066 4.289748 4.301243 4.377914 4.320972 4.095306 4.138460 4.388615
##      2209      2210      2211      2212      2213      2214      2215      2216
## 4.294820 4.263151 4.221962 4.269149 4.195497 4.212066 4.307239 4.300999
##      2217      2218      2219      2220      2221      2222      2223      2224
## 4.105236 4.202260 4.094909 4.231065 4.340943 4.100621 3.952458 4.342050
##      2225      2226      2227      2228      2229      2230      2231      2232
## 4.387159 4.343466 4.374262 4.310690 4.082142 4.353297 4.298190 4.263588
##      2233      2234      2235      2236      2237      2238      2239      2240
## 4.354452 4.382401 4.260829 3.931390 4.268834 4.306271 4.279922 4.297116
##      2241      2242      2243      2244      2245      2246      2247      2248
## 4.289056 4.287237 4.376965 4.251701 4.297715 4.002457 4.373538 4.119371
##      2249      2250      2251      2252      2253      2254      2255      2256
## 4.272383 4.198198 4.082281 4.386107 4.213843 4.374503 4.339998 4.285792
##      2257      2258      2259      2260      2261      2262      2263      2264
## 4.379419 4.040231 4.405311 4.345119 3.949827 4.073403 4.379655 4.334899
##      2265      2266      2267      2268      2269      2270      2271      2272
## 4.304176 4.199723 4.110756 3.958871 4.279133 4.390814 4.402326 4.279999
##      2273      2274      2275      2276      2277      2278
## 4.295647 4.261643 4.298895 4.242816 4.316569 4.379516
```

```
# Combine actual and predicted values into a data frame for comparison
comparison_df <- data.frame(
  Actual = train_data_selected$Life_expectancy,
  Predicted_Model_1 = predicted_values_1,
  Predicted_Model_2 = predicted_values_2,
  Predicted_Model_3 = predicted_values_3
)
summary(comparison_df)
```

```
##      Actual      Predicted_Model_1 Predicted_Model_2 Predicted_Model_3
## Min.   :40.40   Min.   :38.34      Min.   :30.54      Min.   :3.740
## 1st Qu.:62.90   1st Qu.:62.96      1st Qu.:63.92      1st Qu.:4.136
## Median :71.40   Median :71.45      Median :70.75      Median :4.266
## Mean   :68.95   Mean   :68.95      Mean   :68.95      Mean   :4.224
## 3rd Qu.:75.50   3rd Qu.:75.97      3rd Qu.:75.46      3rd Qu.:4.335
## Max.   :83.80   Max.   :82.80      Max.   :82.55      Max.   :4.416
```

```
# Convert to long format for plotting
comparison_long <- comparison_df %>%
  pivot_longer(cols = starts_with("Predicted"), names_to = "Model", values_to = "Predicted")

# Create and display the plot
p <- ggplot(comparison_long, aes(x = Actual, y = Predicted, color = Model)) +
  geom_point() +
  geom_abline(slope = 1, intercept = 0, linetype = "dashed") +
  theme_minimal() +
  labs(title = "Actual vs Predicted Life Expectancy",
       x = "Actual Life Expectancy",
       y = "Predicted Life Expectancy")

# Save the ggplot object as a Plotly plot
p_plotly <- ggplotly(p)
```



```

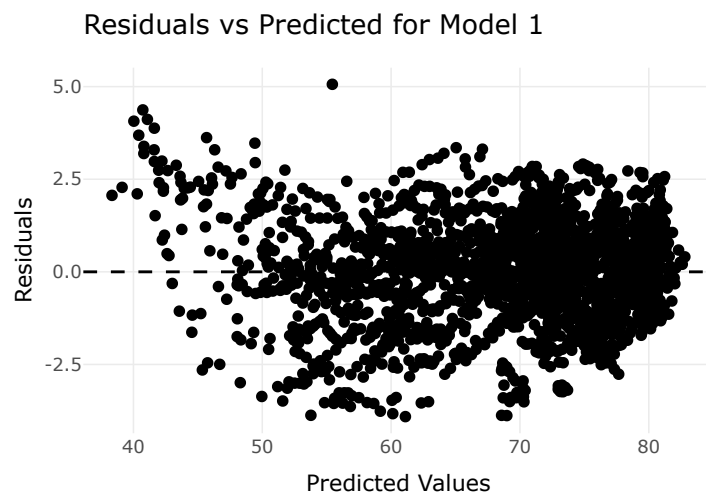
htmlwidgets::saveWidget(p_plotly, "comparison_plot.html", selfcontained = TRUE)

# Function to create a residual plot
plot_residuals <- function(model, predicted_values, model_name) {
  data.frame(Predicted = predicted_values, Residuals = residuals(model)) %>%
    ggplot(aes(x = Predicted, y = Residuals)) +
    geom_point() +
    geom_hline(yintercept = 0, linetype = "dashed") +
    theme_minimal() +
    labs(title = paste("Residuals vs Predicted for", model_name),
         x = "Predicted Values", y = "Residuals")
}

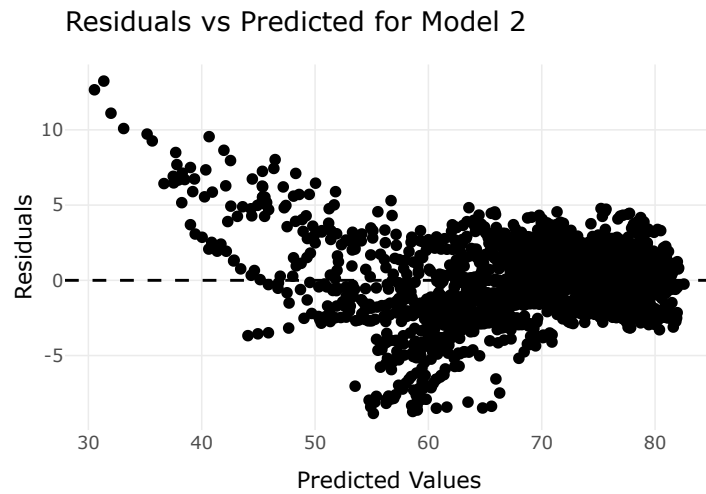
# Creating residual plots for each model
p1 <- plot_residuals(model_1, predicted_values_1, "Model 1")
p2 <- plot_residuals(model_2, predicted_values_2, "Model 2")
p3 <- plot_residuals(model_3, predicted_values_3, "Model 3")

# Displaying the plots
ggplotly(p1)

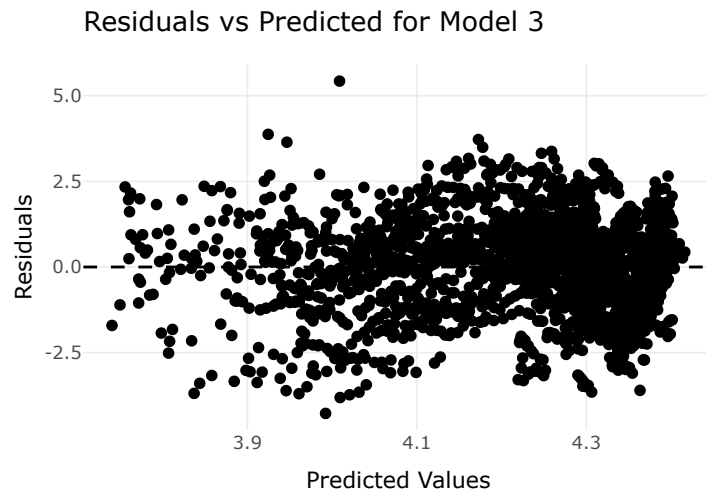
```



```
ggplotly(p2)
```



```
ggplotly(p3)
```



```
# VIF for models (note: model_3 requires special handling)
```

```
vif_model_1 <- vif(model_1)
vif_model_2 <- vif(model_2)
print(vif_model_1)
```

```
##              Year              Economy_status_Developed
##              1.213286              2.928424
##      Adult_mortality              Infant_deaths
##              7.408889              6.726964
##      Alcohol_consumption      `percentage expenditure`
##              12.666473              6.441773
##      Hepatitis_B              Measles
##              1.781966              1.413280
##              BMI              Under_five_deaths
##              1.841716              2.070058
##              Polio      `Total expenditure`
##              2.425933              1.286638
##      Diphtheria              Incidents_HIV
##              2.655741              2.865866
##      GDP_per_capita              Population_millions
##              6.579939              1.327210
##      Thinness_ten_nineteen_years      Thinness_five_nine_years
##              8.830352              8.747775
##      `Income composition of resources`      Schooling
##              1.860939              4.097411
##      I(Alcohol_consumption^2)
##              12.025778
```

```
print(vif_model_2)
```

```
##              Year      Adult_mortality Alcohol_consumption      BMI
##              1.031425              1.297990              1.105874      1.298448
```

```
# Cross-validation for Model 2
```

```
cv_model_2 <- train(Life_expectancy ~ Year + Adult_mortality + Alcohol_consumption + BMI,
  data = train_data_selected,
  method = "lm",
  trControl = trainControl(method = "cv", number = 10))
print(cv_model_2$results)
```

```
##      intercept      RMSE Rsquared      MAE      RMSESD RsquaredSD      MAESD
## 1      TRUE 2.494402 0.9292166 1.858111 0.1622994 0.008222832 0.1098502
```

```
# Prediction and Evaluation for Model 2 on test data
```

```
predictions_test_2 <- predict(model_2, newdata = validation_data)
mse_test_2 <- mean((validation_data$Life_expectancy - predictions_test_2)^2)
rmse_test_2 <- sqrt(mse_test_2)
print(paste("Test Data RMSE:", rmse_test_2))
```

```
## [1] "Test Data RMSE: 2.64408840697961"
```

```
# Summaries for model significance
summary(model_1)
```

```
##
## Call:
## lm(formula = Life_expectancy ~ . + I(Alcohol_consumption^2),
##     data = train_data_selected)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -3.9086 -0.8758  0.0753  0.8747  5.0621
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   5.781e+01  1.377e+01   4.200 2.78e-05 ***
## Year          1.123e-02   6.865e-03   1.636  0.10206
## Economy_status_Developed1 1.082e+00  1.211e-01   8.930 < 2e-16 ***
## Adult_mortality -5.038e-02   6.892e-04 -73.090 < 2e-16 ***
## Infant_deaths  -1.277e-01   2.724e-03 -46.867 < 2e-16 ***
## Alcohol_consumption 3.054e-01   2.567e-02  11.895 < 2e-16 ***
## `percentage expenditure` 6.983e-05   3.535e-05   1.975  0.04836 *
## Hepatitis_B      3.721e-04   9.720e-04   0.383  0.70187
## Measles          3.837e-06   3.317e-06   1.157  0.24751
## BMI             -4.666e-03   1.891e-03  -2.468  0.01367 *
## Under_five_deaths -2.337e-04   2.631e-04  -0.888  0.37466
## Polio           -2.914e-03   1.739e-03  -1.675  0.09398 .
## `Total expenditure` 2.586e-02   1.103e-02   2.345  0.01910 *
## Diphtheria       9.519e-05   1.828e-03   0.052  0.95849
## Incidents_HIV     4.244e-02   1.101e-02   3.854  0.00012 ***
## GDP_per_capita    8.784e-07   5.325e-06   0.165  0.86900
## Population_millions 1.200e-09   6.704e-10   1.790  0.07366 .
## Thinness_ten_nineteen_years -1.385e-02   1.898e-02  -0.730  0.46554
## Thinness_five_nine_years  2.665e-02   1.849e-02   1.441  0.14967
## `Income composition of resources` 6.863e-01   1.536e-01   4.467 8.32e-06 ***
## Schooling        1.019e-01   1.828e-02   5.574 2.78e-08 ***
## I(Alcohol_consumption^2) -2.023e-02   1.993e-03 -10.147 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.367 on 2256 degrees of freedom
## Multiple R-squared:  0.9787, Adjusted R-squared:  0.9785
## F-statistic: 4936 on 21 and 2256 DF, p-value: < 2.2e-16
```

```
summary(model_2)
```

```
##
## Call:
## lm(formula = Life_expectancy ~ Year + Adult_mortality + Alcohol_consumption +
##     BMI, data = train_data_selected)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
```

```
## -8.8436 -1.4367 0.1004 1.5188 13.2410
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -4.574e+01  2.320e+01  -1.971  0.0488 *
## Year           6.240e-02  1.155e-02   5.402 7.28e-08 ***
## Adult_mortality -7.155e-02  5.264e-04 -135.911 < 2e-16 ***
## Alcohol_consumption 4.063e-01  1.384e-02  29.356 < 2e-16 ***
## BMI            2.993e-02  2.897e-03  10.333 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.495 on 2273 degrees of freedom
## Multiple R-squared:  0.9285, Adjusted R-squared:  0.9284
## F-statistic: 7383 on 4 and 2273 DF, p-value: < 2.2e-16
```

```
summary(model_3)
```

```
##
## Call:
## glm(formula = Life_expectancy ~ ., family = gaussian(link = "log"),
##      data = train_data_selected)
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   3.802e+00  1.926e-01  19.734 < 2e-16 ***
## Year          3.077e-04  9.608e-05   3.203 0.001381 **
## Economy_status_Developed1 1.355e-03  1.573e-03   0.862 0.389044
## Adult_mortality -7.732e-04  1.072e-05 -72.100 < 2e-16 ***
## Infant_deaths  -2.114e-03  4.331e-05 -48.815 < 2e-16 ***
## Alcohol_consumption 1.275e-03  1.665e-04   7.657 2.80e-14 ***
## `percentage expenditure` 1.402e-06  4.492e-07   3.120 0.001831 **
## Hepatitis_B      3.148e-06  1.337e-05   0.235 0.813864
## Measles          3.738e-08  5.436e-08   0.688 0.491805
## BMI             -1.193e-04  2.567e-05  -4.649 3.54e-06 ***
## Under_five_deaths -2.197e-08  4.127e-06  -0.005 0.995754
## Polio           -4.283e-05  2.575e-05  -1.663 0.096361 .
## `Total expenditure` 4.313e-04  1.528e-04   2.822 0.004816 **
## Diphtheria       1.446e-05  2.673e-05   0.541 0.588614
## Incidents_HIV    -6.595e-04  1.870e-04  -3.527 0.000428 ***
## GDP_per_capita  -2.074e-07  6.816e-08  -3.043 0.002368 **
## Population_millions 2.121e-11  9.821e-12   2.159 0.030928 *
## Thinness_ten_nineteen_years -5.591e-04  2.918e-04  -1.916 0.055495 .
## Thinness_five_nine_years  7.947e-04  2.853e-04   2.786 0.005386 **
## `Income composition of resources` 6.039e-03  2.138e-03   2.824 0.004780 **
## Schooling        1.267e-03  2.593e-04   4.887 1.10e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 1.818202)
##
##      Null deviance: 197971.5  on 2277  degrees of freedom
## Residual deviance:  4103.7   on 2257  degrees of freedom
## AIC: 7849.5
```

```
##
## Number of Fisher Scoring iterations: 4

# Plotting Actual vs Predicted values for all three models
p <- ggplot(comparison_df %>%
  pivot_longer(cols = starts_with("Predicted"), names_to = "Model", values_to = "Predicted",
  aes(x = Actual, y = Predicted, color = Model)) +
  geom_point() +
  geom_abline(slope = 1, intercept = 0, linetype = "dashed") +
  theme_minimal() +
  labs(title = "Actual vs Predicted Life Expectancy",
  x = "Actual Life Expectancy",
  y = "Predicted Life Expectancy")

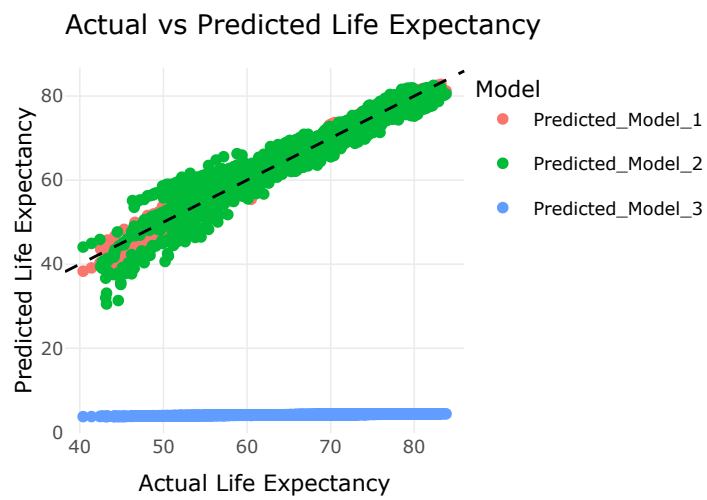
# Convert ggplot object to plotly for interactive plot
p_interactive <- ggplotly(p)

# Save the plot as a PNG file
ggsave("comparison_plot.png", plot = p, width = 10, height = 8)

# Plotting Actual vs Predicted values for all three models
p <- ggplot(comparison_df %>%
  pivot_longer(cols = starts_with("Predicted"), names_to = "Model", values_to = "Predicted",
  aes(x = Actual, y = Predicted, color = Model)) +
  geom_point() +
  geom_abline(slope = 1, intercept = 0, linetype = "dashed") +
  theme_minimal() +
  labs(title = "Actual vs Predicted Life Expectancy",
  x = "Actual Life Expectancy",
  y = "Predicted Life Expectancy")

ggplotly(p)
```





```
#### Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC)
## Compute AIC and BIC for Model 1
```

```

aic_model_1 <- AIC(model_1)
bic_model_1 <- BIC(model_1)

## Compute AIC and BIC for Model 2
aic_model_2 <- AIC(model_2)
bic_model_2 <- BIC(model_2)

## Compute AIC and BIC for Model 3
aic_model_3 <- AIC(model_3)
bic_model_3 <- BIC(model_3)

## Print the results
cat("AIC for Model 1:", aic_model_1, "\n")

## AIC for Model 1: 7913.546

cat("BIC for Model 1:", bic_model_1, "\n\n")

## BIC for Model 1: 8045.36

cat("AIC for Model 2:", aic_model_2, "\n")

## AIC for Model 2: 10636.96

cat("BIC for Model 2:", bic_model_2, "\n\n")

## BIC for Model 2: 10671.35

cat("AIC for Model 3:", aic_model_3, "\n")

## AIC for Model 3: 7849.485

cat("BIC for Model 3:", bic_model_3, "\n")

## BIC for Model 3: 7975.568

# Machine Learning Models
# Calculate MSE
calculateMSE <- function(model, test_data) {
  predictions <- predict(model, test_data)
  return(mean((predictions - test_data$Life_expectancy)^2))
}

# Artificial Neural Network (ANN)
ann_model <- readRDS("C:/Users/Jessica M/Desktop/project16372/ann_model.rds")
summary(ann_model)

```

```

## a 205-3-1 network with 622 weights
## options were - decay=0.01
## b->h1 i1->h1 i2->h1 i3->h1 i4->h1 i5->h1 i6->h1 i7->h1
## -0.83 0.33 -0.38 0.03 -0.22 -0.07 -0.22 -0.20
## i8->h1 i9->h1 i10->h1 i11->h1 i12->h1 i13->h1 i14->h1 i15->h1
## -0.11 -0.01 0.30 -0.03 -0.43 -0.24 0.03 -0.08
## i16->h1 i17->h1 i18->h1 i19->h1 i20->h1 i21->h1 i22->h1 i23->h1
## 0.74 0.01 -0.01 0.28 0.05 0.02 -0.20 0.89
## i24->h1 i25->h1 i26->h1 i27->h1 i28->h1 i29->h1 i30->h1 i31->h1
## 0.34 -0.02 -0.02 -0.28 0.26 0.02 -0.10 0.02
## i32->h1 i33->h1 i34->h1 i35->h1 i36->h1 i37->h1 i38->h1 i39->h1
## 0.00 0.50 0.64 -0.25 0.02 0.03 -0.03 0.23
## i40->h1 i41->h1 i42->h1 i43->h1 i44->h1 i45->h1 i46->h1 i47->h1
## 1.02 0.44 -0.02 0.05 0.11 0.02 -0.46 -0.49
## i48->h1 i49->h1 i50->h1 i51->h1 i52->h1 i53->h1 i54->h1 i55->h1
## -0.06 -0.04 -0.03 0.01 0.15 0.03 0.05 0.04
## i56->h1 i57->h1 i58->h1 i59->h1 i60->h1 i61->h1 i62->h1 i63->h1
## -0.11 -0.26 0.04 -0.01 0.03 -0.10 0.03 -0.15
## i64->h1 i65->h1 i66->h1 i67->h1 i68->h1 i69->h1 i70->h1 i71->h1
## 0.72 -0.48 -0.03 -0.01 0.33 0.06 -0.28 0.07
## i72->h1 i73->h1 i74->h1 i75->h1 i76->h1 i77->h1 i78->h1 i79->h1
## -0.09 0.21 -0.15 -0.20 0.35 -0.03 -0.06 -0.20
## i80->h1 i81->h1 i82->h1 i83->h1 i84->h1 i85->h1 i86->h1 i87->h1
## -1.26 -0.11 0.06 -0.38 0.02 0.29 0.63 -0.06
## i88->h1 i89->h1 i90->h1 i91->h1 i92->h1 i93->h1 i94->h1 i95->h1
## 0.16 -0.31 0.15 0.01 0.00 -0.10 -0.16 -0.17
## i96->h1 i97->h1 i98->h1 i99->h1 i100->h1 i101->h1 i102->h1 i103->h1
## 0.04 -0.02 0.50 0.04 -0.01 -0.08 -0.01 -0.32
## i104->h1 i105->h1 i106->h1 i107->h1 i108->h1 i109->h1 i110->h1 i111->h1
## -0.67 0.60 0.34 -0.06 0.31 -0.22 -0.01 0.10
## i112->h1 i113->h1 i114->h1 i115->h1 i116->h1 i117->h1 i118->h1 i119->h1
## 0.04 0.26 -0.14 -0.11 -0.07 -0.01 0.01 -0.07
## i120->h1 i121->h1 i122->h1 i123->h1 i124->h1 i125->h1 i126->h1 i127->h1
## -0.07 0.09 0.02 -0.23 0.03 -0.11 -0.06 -0.24
## i128->h1 i129->h1 i130->h1 i131->h1 i132->h1 i133->h1 i134->h1 i135->h1
## 0.20 -0.02 -0.24 0.09 -0.43 0.11 -0.17 0.78
## i136->h1 i137->h1 i138->h1 i139->h1 i140->h1 i141->h1 i142->h1 i143->h1
## 0.10 0.23 0.39 0.06 -0.03 -0.25 0.42 0.26
## i144->h1 i145->h1 i146->h1 i147->h1 i148->h1 i149->h1 i150->h1 i151->h1
## -0.63 0.03 -0.02 -0.22 -0.59 -0.21 0.20 -0.04
## i152->h1 i153->h1 i154->h1 i155->h1 i156->h1 i157->h1 i158->h1 i159->h1
## -0.15 -0.17 -0.42 0.34 0.09 -0.47 0.09 -0.01
## i160->h1 i161->h1 i162->h1 i163->h1 i164->h1 i165->h1 i166->h1 i167->h1
## 0.30 -0.15 -0.15 -0.09 0.30 0.03 -0.35 -0.11
## i168->h1 i169->h1 i170->h1 i171->h1 i172->h1 i173->h1 i174->h1 i175->h1
## 0.04 0.00 -0.14 -0.32 0.34 -0.01 -1.09 0.03
## i176->h1 i177->h1 i178->h1 i179->h1 i180->h1 i181->h1 i182->h1 i183->h1
## 0.02 -0.01 -0.36 -0.19 0.47 0.11 -0.73 0.61
## i184->h1 i185->h1 i186->h1 i187->h1 i188->h1 i189->h1 i190->h1 i191->h1
## 0.11 -0.31 -0.07 -0.39 1.74 1.10 -0.08 0.06
## i192->h1 i193->h1 i194->h1 i195->h1 i196->h1 i197->h1 i198->h1 i199->h1
## -0.05 0.06 -0.02 0.11 -0.02 0.06 0.01 0.82
## i200->h1 i201->h1 i202->h1 i203->h1 i204->h1 i205->h1
## 0.08 0.02 0.11 0.18 0.37 -0.10

```

##	b->h2	i1->h2	i2->h2	i3->h2	i4->h2	i5->h2	i6->h2	i7->h2
##	-0.65	0.09	-0.41	-0.01	-0.36	-0.16	-0.09	-0.10
##	i8->h2	i9->h2	i10->h2	i11->h2	i12->h2	i13->h2	i14->h2	i15->h2
##	-0.03	0.02	0.12	0.00	-0.28	-0.04	0.24	-0.02
##	i16->h2	i17->h2	i18->h2	i19->h2	i20->h2	i21->h2	i22->h2	i23->h2
##	0.02	0.00	-0.08	-0.08	-0.55	0.04	-0.47	0.09
##	i24->h2	i25->h2	i26->h2	i27->h2	i28->h2	i29->h2	i30->h2	i31->h2
##	0.46	0.03	-0.01	0.22	0.44	-0.02	-0.04	-0.01
##	i32->h2	i33->h2	i34->h2	i35->h2	i36->h2	i37->h2	i38->h2	i39->h2
##	0.02	0.16	0.28	-0.26	0.04	0.03	0.01	0.02
##	i40->h2	i41->h2	i42->h2	i43->h2	i44->h2	i45->h2	i46->h2	i47->h2
##	0.24	-0.03	-0.02	0.57	0.04	-0.02	-0.43	-0.61
##	i48->h2	i49->h2	i50->h2	i51->h2	i52->h2	i53->h2	i54->h2	i55->h2
##	0.11	0.04	0.01	0.01	-0.06	-0.01	-0.01	0.54
##	i56->h2	i57->h2	i58->h2	i59->h2	i60->h2	i61->h2	i62->h2	i63->h2
##	-0.01	-0.06	0.02	0.00	0.09	-0.03	0.02	-0.05
##	i64->h2	i65->h2	i66->h2	i67->h2	i68->h2	i69->h2	i70->h2	i71->h2
##	-0.31	-0.09	-0.02	-0.02	0.30	0.00	-0.16	-0.02
##	i72->h2	i73->h2	i74->h2	i75->h2	i76->h2	i77->h2	i78->h2	i79->h2
##	0.00	0.24	-0.21	-0.23	0.32	0.00	0.01	-0.07
##	i80->h2	i81->h2	i82->h2	i83->h2	i84->h2	i85->h2	i86->h2	i87->h2
##	-0.22	-0.04	0.00	-0.36	0.00	0.08	0.05	-0.20
##	i88->h2	i89->h2	i90->h2	i91->h2	i92->h2	i93->h2	i94->h2	i95->h2
##	0.08	-0.53	-0.25	-0.03	0.02	0.86	-0.54	-0.03
##	i96->h2	i97->h2	i98->h2	i99->h2	i100->h2	i101->h2	i102->h2	i103->h2
##	0.01	-0.02	-0.01	0.03	0.02	0.00	0.02	-0.16
##	i104->h2	i105->h2	i106->h2	i107->h2	i108->h2	i109->h2	i110->h2	i111->h2
##	-0.65	0.45	-0.32	0.63	0.16	-0.15	0.00	0.04
##	i112->h2	i113->h2	i114->h2	i115->h2	i116->h2	i117->h2	i118->h2	i119->h2
##	-0.02	0.24	-0.03	-0.11	0.03	-0.03	-0.03	-0.03
##	i120->h2	i121->h2	i122->h2	i123->h2	i124->h2	i125->h2	i126->h2	i127->h2
##	-0.01	0.55	-0.03	-0.14	0.02	-0.06	0.13	-0.44
##	i128->h2	i129->h2	i130->h2	i131->h2	i132->h2	i133->h2	i134->h2	i135->h2
##	0.06	-0.01	0.02	0.17	0.09	0.12	0.03	0.72
##	i136->h2	i137->h2	i138->h2	i139->h2	i140->h2	i141->h2	i142->h2	i143->h2
##	0.06	0.18	0.10	-0.61	0.02	-0.03	0.34	0.06
##	i144->h2	i145->h2	i146->h2	i147->h2	i148->h2	i149->h2	i150->h2	i151->h2
##	-1.05	0.01	0.02	-0.09	-0.42	-0.55	0.34	0.57
##	i152->h2	i153->h2	i154->h2	i155->h2	i156->h2	i157->h2	i158->h2	i159->h2
##	0.01	-0.02	-0.34	0.48	-0.01	-0.48	0.04	-0.02
##	i160->h2	i161->h2	i162->h2	i163->h2	i164->h2	i165->h2	i166->h2	i167->h2
##	0.64	-0.05	-0.15	-0.08	0.24	-0.02	0.15	-0.02
##	i168->h2	i169->h2	i170->h2	i171->h2	i172->h2	i173->h2	i174->h2	i175->h2
##	-0.15	0.05	-0.16	0.67	0.40	0.36	-0.46	-0.02
##	i176->h2	i177->h2	i178->h2	i179->h2	i180->h2	i181->h2	i182->h2	i183->h2
##	-0.02	-0.04	0.45	-1.03	0.22	0.00	-0.69	0.94
##	i184->h2	i185->h2	i186->h2	i187->h2	i188->h2	i189->h2	i190->h2	i191->h2
##	-0.28	-0.26	0.12	0.06	2.86	1.94	-0.02	-0.15
##	i192->h2	i193->h2	i194->h2	i195->h2	i196->h2	i197->h2	i198->h2	i199->h2
##	0.07	-0.02	0.01	0.43	0.06	-0.02	-0.05	-0.09
##	i200->h2	i201->h2	i202->h2	i203->h2	i204->h2	i205->h2		
##	-0.29	-0.11	0.15	-0.44	-0.43	0.18		
##	b->h3	i1->h3	i2->h3	i3->h3	i4->h3	i5->h3	i6->h3	i7->h3
##	-4.94	0.05	0.11	0.00	-0.04	-0.32	-0.15	0.16

```

## i8->h3 i9->h3 i10->h3 i11->h3 i12->h3 i13->h3 i14->h3 i15->h3
## 0.45 -0.15 -0.73 -0.70 0.06 1.32 0.22 0.54
## i16->h3 i17->h3 i18->h3 i19->h3 i20->h3 i21->h3 i22->h3 i23->h3
## 1.89 0.01 0.02 -0.31 0.02 0.00 -0.08 -0.78
## i24->h3 i25->h3 i26->h3 i27->h3 i28->h3 i29->h3 i30->h3 i31->h3
## -0.91 0.01 -0.02 -0.74 -0.03 0.01 0.10 -0.06
## i32->h3 i33->h3 i34->h3 i35->h3 i36->h3 i37->h3 i38->h3 i39->h3
## -0.01 0.29 -0.86 0.21 -0.02 0.03 -0.04 0.85
## i40->h3 i41->h3 i42->h3 i43->h3 i44->h3 i45->h3 i46->h3 i47->h3
## -1.32 0.41 0.20 -0.20 -0.80 -0.01 0.49 0.38
## i48->h3 i49->h3 i50->h3 i51->h3 i52->h3 i53->h3 i54->h3 i55->h3
## -0.23 -0.26 -0.02 0.00 -1.01 -0.07 0.00 -0.11
## i56->h3 i57->h3 i58->h3 i59->h3 i60->h3 i61->h3 i62->h3 i63->h3
## 0.46 1.00 0.02 -0.02 -0.22 0.42 0.00 0.74
## i64->h3 i65->h3 i66->h3 i67->h3 i68->h3 i69->h3 i70->h3 i71->h3
## -0.86 0.22 0.01 0.00 -0.07 -0.03 -0.05 -0.92
## i72->h3 i73->h3 i74->h3 i75->h3 i76->h3 i77->h3 i78->h3 i79->h3
## 0.14 -0.01 0.13 -0.56 0.08 0.28 0.13 0.87
## i80->h3 i81->h3 i82->h3 i83->h3 i84->h3 i85->h3 i86->h3 i87->h3
## -1.52 0.20 -0.19 -0.33 -0.02 -0.31 -1.55 -0.27
## i88->h3 i89->h3 i90->h3 i91->h3 i92->h3 i93->h3 i94->h3 i95->h3
## -0.03 -0.88 0.94 -0.01 -0.02 -0.57 -0.72 0.24
## i96->h3 i97->h3 i98->h3 i99->h3 i100->h3 i101->h3 i102->h3 i103->h3
## -0.02 0.01 0.36 -0.50 -0.01 0.52 0.00 0.30
## i104->h3 i105->h3 i106->h3 i107->h3 i108->h3 i109->h3 i110->h3 i111->h3
## -0.36 -0.20 0.01 -0.20 -0.20 -0.78 0.02 -0.01
## i112->h3 i113->h3 i114->h3 i115->h3 i116->h3 i117->h3 i118->h3 i119->h3
## -0.02 -0.03 0.37 0.15 -0.46 -0.02 0.01 -0.63
## i120->h3 i121->h3 i122->h3 i123->h3 i124->h3 i125->h3 i126->h3 i127->h3
## 0.13 0.59 -0.02 0.62 0.00 0.09 0.00 -0.10
## i128->h3 i129->h3 i130->h3 i131->h3 i132->h3 i133->h3 i134->h3 i135->h3
## -0.43 0.17 1.27 -1.13 0.02 -0.05 -0.16 -0.05
## i136->h3 i137->h3 i138->h3 i139->h3 i140->h3 i141->h3 i142->h3 i143->h3
## -1.12 0.02 -0.21 0.62 0.00 1.48 -0.93 -0.27
## i144->h3 i145->h3 i146->h3 i147->h3 i148->h3 i149->h3 i150->h3 i151->h3
## -0.07 0.03 0.00 0.96 -0.02 0.13 -1.06 0.12
## i152->h3 i153->h3 i154->h3 i155->h3 i156->h3 i157->h3 i158->h3 i159->h3
## 0.50 0.11 0.08 -0.33 -0.03 1.28 -0.01 0.00
## i160->h3 i161->h3 i162->h3 i163->h3 i164->h3 i165->h3 i166->h3 i167->h3
## -0.18 0.07 -0.20 0.81 -0.06 0.00 0.27 -0.55
## i168->h3 i169->h3 i170->h3 i171->h3 i172->h3 i173->h3 i174->h3 i175->h3
## 0.23 -0.20 0.31 -0.32 0.05 -0.32 0.29 -0.02
## i176->h3 i177->h3 i178->h3 i179->h3 i180->h3 i181->h3 i182->h3 i183->h3
## 0.00 -0.03 -0.26 0.88 -1.75 -0.72 -0.40 -0.73
## i184->h3 i185->h3 i186->h3 i187->h3 i188->h3 i189->h3 i190->h3 i191->h3
## -0.27 0.32 0.23 1.12 -4.37 -1.26 0.19 0.18
## i192->h3 i193->h3 i194->h3 i195->h3 i196->h3 i197->h3 i198->h3 i199->h3
## -0.02 0.04 -0.03 1.14 0.02 0.02 -0.14 0.19
## i200->h3 i201->h3 i202->h3 i203->h3 i204->h3 i205->h3
## 0.01 0.13 0.18 0.00 0.21 0.20
## b->o h1->o h2->o h3->o
## 0.56 -8.06 -6.19 5.31

```

```
# K Nearest Neighbors (KNN)
```

```
knn_model <- readRDS("C:/Users/Jessica M/Desktop/project16372/knn_model.rds")  
summary(knn_model)
```

```
##           Length Class      Mode  
## learn         2  -none-    list  
## k              1  -none-    numeric  
## theDots        0  -none-    list  
## xNames       205  -none-    character  
## problemType    1  -none-    character  
## tuneValue      1 data.frame list  
## obsLevels      1  -none-    logical  
## param          0  -none-    list
```

```
# Support Vector Machine (SVM)
```

```
svm_model <- readRDS("C:/Users/Jessica M/Desktop/project16372/svm_model.rds")  
summary(svm_model)
```

```
## Length Class Mode  
##      1   ksvm   S4
```

```
# Random Forest (RF)
```

```
rf_model <- readRDS("C:/Users/Jessica M/Desktop/project16372/rf_model.rds")  
summary(rf_model)
```

```
##           Length Class      Mode  
## call         4  -none-    call  
## type          1  -none-    character  
## predicted    1996 -none-    numeric  
## mse          500  -none-    numeric  
## rsq          500  -none-    numeric  
## oob.times    1996 -none-    numeric  
## importance   205  -none-    numeric  
## importanceSD  0  -none-    NULL  
## localImportance 0  -none-    NULL  
## proximity     0  -none-    NULL  
## ntree         1  -none-    numeric  
## mtry          1  -none-    numeric  
## forest       11  -none-    list  
## coefs         0  -none-    NULL  
## y            1996 -none-    numeric  
## test          0  -none-    NULL  
## inbag         0  -none-    NULL  
## xNames       205  -none-    character  
## problemType    1  -none-    character  
## tuneValue      1 data.frame list  
## obsLevels      1  -none-    logical  
## param          0  -none-    list
```

```
# LM Modelproject16372/
```

```
lm_model <- readRDS("C:/Users/Jessica M/Desktop/project16372/lm_model.rds")  
summary(lm_model)
```

```
##
## Call:
## lm(formula = .outcome ~ ., data = dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.1432 -0.2178 -0.0087  0.2001  3.2582
##
## Coefficients: (9 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -1.444e+02  1.247e+01 -11.585 < 2e-16
## CountryAlbania     4.483e+00  4.119e-01  10.882 < 2e-16
## CountryAlgeria     4.325e+00  3.387e-01  12.769 < 2e-16
## CountryAngola     -3.686e+00  2.875e-01 -12.821 < 2e-16
## `CountryAntigua and Barbuda`  5.789e+00  4.153e-01  13.941 < 2e-16
## CountryArgentina     5.171e+00  4.196e-01  12.323 < 2e-16
## CountryArmenia     4.184e+00  4.493e-01   9.313 < 2e-16
## CountryAustralia     8.410e+00  5.166e-01  16.280 < 2e-16
## CountryAustria     7.605e+00  5.048e-01  15.066 < 2e-16
## CountryAzerbaijan    2.912e+00  4.317e-01   6.746 2.05e-11
## `CountryBahamas, The`  4.576e+00  4.691e-01   9.756 < 2e-16
## CountryBahrain     3.131e+00  3.895e-01   8.037 1.65e-15
## CountryBangladesh    2.157e+00  2.676e-01   8.062 1.35e-15
## CountryBarbados     7.937e+00  4.219e-01  18.811 < 2e-16
## CountryBelarus     4.068e+00  4.810e-01   8.457 < 2e-16
## CountryBelgium     7.493e+00  4.911e-01  15.259 < 2e-16
## CountryBelize     4.106e+00  4.327e-01   9.490 < 2e-16
## CountryBenin     -1.378e+00  2.601e-01  -5.298 1.31e-07
## CountryBhutan     2.846e+00  2.645e-01  10.762 < 2e-16
## CountryBolivia     2.183e+00  3.431e-01   6.362 2.52e-10
## `CountryBosnia and Herzegovina`  4.277e+00  3.768e-01  11.349 < 2e-16
## CountryBotswana     1.734e+00  3.943e-01   4.398 1.16e-05
## CountryBrazil     4.694e+00  3.570e-01  13.147 < 2e-16
## `CountryBrunei Darussalam`  2.498e+00  3.956e-01   6.313 3.44e-10
## CountryBulgaria     4.124e+00  4.555e-01   9.054 < 2e-16
## `CountryBurkina Faso` -3.015e+00  3.020e-01  -9.983 < 2e-16
## CountryBurundi     -2.121e+00  2.705e-01  -7.841 7.57e-15
## `CountryCabo Verde`  1.627e+00  3.186e-01   5.106 3.64e-07
## CountryCambodia     3.921e-01  2.839e-01   1.381 0.167402
## CountryCameroon    -6.909e-01  2.825e-01  -2.446 0.014560
## CountryCanada     8.249e+00  5.088e-01  16.212 < 2e-16
## `CountryCentral African Republic` -1.277e+00  3.426e-01  -3.728 0.000199
## CountryChad     -3.304e+00  2.928e-01 -11.286 < 2e-16
## CountryChile     6.895e+00  4.214e-01  16.362 < 2e-16
## CountryChina     2.755e+00  3.772e-01   7.303 4.21e-13
## CountryColombia     6.350e+00  3.719e-01  17.077 < 2e-16
## CountryComoros     2.386e-01  2.796e-01   0.853 0.393554
## `CountryCongo, Dem. Rep.` -1.601e+00  2.739e-01  -5.845 5.99e-09
## `CountryCongo, Rep.` -2.011e-01  2.921e-01  -0.688 0.491259
## `CountryCosta Rica`  6.824e+00  3.868e-01  17.642 < 2e-16
## CountryCroatia     4.793e+00  4.730e-01  10.133 < 2e-16
## CountryCuba     6.291e+00  4.407e-01  14.274 < 2e-16
## CountryCyprus     5.977e+00  4.940e-01  12.100 < 2e-16
## CountryCzechia     5.342e+00  5.156e-01  10.359 < 2e-16
```

## CountryDenmark	6.643e+00	5.465e-01	12.155	< 2e-16
## CountryDjibouti	2.983e-01	2.638e-01	1.131	0.258315
## `CountryDominican Republic`	4.787e+00	3.401e-01	14.076	< 2e-16
## CountryEcuador	5.508e+00	3.660e-01	15.050	< 2e-16
## `CountryEgypt, Arab Rep.`	2.293e+00	3.319e-01	6.908	6.79e-12
## `CountryEl Salvador`	4.038e+00	3.294e-01	12.258	< 2e-16
## `CountryEquatorial Guinea`	-3.056e-03	3.246e-01	-0.009	0.992490
## CountryEritrea	2.898e-02	2.695e-01	0.108	0.914382
## CountryEstonia	5.387e+00	5.367e-01	10.038	< 2e-16
## CountryEswatini	-2.606e+00	3.574e-01	-7.293	4.52e-13
## CountryEthiopia	-4.381e-02	2.734e-01	-0.160	0.872736
## CountryFiji	3.497e-01	4.126e-01	0.848	0.396739
## CountryFinland	7.462e+00	4.974e-01	15.000	< 2e-16
## CountryFrance	9.023e+00	4.919e-01	18.342	< 2e-16
## CountryGabon	-4.392e-02	3.532e-01	-0.124	0.901043
## CountryGambia	-2.311e+00	2.614e-01	-8.843	< 2e-16
## CountryGeorgia	3.649e+00	4.784e-01	7.626	3.90e-14
## CountryGermany	7.488e+00	5.551e-01	13.490	< 2e-16
## CountryGhana	-1.094e+00	3.005e-01	-3.639	0.000282
## CountryGreece	7.346e+00	4.509e-01	16.292	< 2e-16
## CountryGrenada	4.166e+00	3.766e-01	11.062	< 2e-16
## CountryGuatemala	4.272e+00	3.018e-01	14.156	< 2e-16
## CountryGuinea	-2.348e+00	2.732e-01	-8.594	< 2e-16
## `CountryGuinea-Bissau`	-4.219e+00	2.697e-01	-15.642	< 2e-16
## CountryGuyana	2.860e+00	3.594e-01	7.959	3.05e-15
## CountryHaiti	4.762e-02	2.763e-01	0.172	0.863145
## CountryHonduras	4.442e+00	3.080e-01	14.421	< 2e-16
## CountryHungary	5.164e+00	4.977e-01	10.374	< 2e-16
## CountryIceland	8.192e+00	4.758e-01	17.218	< 2e-16
## CountryIndia	2.246e+00	6.111e-01	3.675	0.000245
## CountryIndonesia	2.062e+00	3.486e-01	5.914	3.99e-09
## CountryIran	3.118e+00	3.669e-01	8.498	< 2e-16
## CountryIraq	1.965e+00	3.098e-01	6.343	2.84e-10
## CountryIreland	7.224e+00	5.262e-01	13.728	< 2e-16
## CountryIsrael	7.808e+00	5.158e-01	15.139	< 2e-16
## CountryItaly	8.065e+00	4.459e-01	18.089	< 2e-16
## CountryJamaica	5.235e+00	3.883e-01	13.480	< 2e-16
## CountryJapan	9.508e+00	4.991e-01	19.051	< 2e-16
## CountryJordan	3.205e+00	4.044e-01	7.926	3.94e-15
## CountryKazakhstan	4.048e+00	4.657e-01	8.693	< 2e-16
## CountryKenya	-5.323e-01	3.039e-01	-1.752	0.079960
## CountryKiribati	1.419e+00	3.410e-01	4.162	3.31e-05
## CountryKuwait	1.172e+00	3.650e-01	3.211	0.001347
## `CountryKyrgyz Republic`	4.175e+00	4.209e-01	9.918	< 2e-16
## `CountryLao PDR`	9.224e-01	2.720e-01	3.391	0.000711
## CountryLatvia	5.314e+00	5.002e-01	10.624	< 2e-16
## CountryLebanon	5.057e+00	3.772e-01	13.408	< 2e-16
## CountryLesotho	-1.428e+00	3.351e-01	-4.260	2.15e-05
## CountryLiberia	9.269e-02	2.744e-01	0.338	0.735512
## CountryLibya	2.348e+00	3.381e-01	6.946	5.22e-12
## CountryLithuania	5.546e+00	5.088e-01	10.901	< 2e-16
## CountryLuxembourg	7.481e+00	5.102e-01	14.663	< 2e-16
## CountryMadagascar	6.305e-01	2.879e-01	2.190	0.028662
## CountryMalawi	-5.144e-01	2.918e-01	-1.763	0.078127



## CountryMalaysia	3.634e+00	3.920e-01	9.268	< 2e-16
## CountryMaldives	3.258e+00	3.094e-01	10.530	< 2e-16
## CountryMali	-4.365e+00	2.703e-01	-16.151	< 2e-16
## CountryMalta	6.856e+00	4.446e-01	15.418	< 2e-16
## CountryMauritania	-2.627e-01	2.632e-01	-0.998	0.318367
## CountryMauritius	4.083e+00	3.570e-01	11.438	< 2e-16
## CountryMexico	5.330e+00	3.766e-01	14.154	< 2e-16
## `CountryMicronesia, Fed. Sts.`	-1.049e+00	3.337e-01	-3.143	0.001698
## CountryMoldova	2.811e+00	4.511e-01	6.230	5.79e-10
## CountryMongolia	2.347e+00	3.933e-01	5.967	2.90e-09
## CountryMontenegro	4.468e+00	4.667e-01	9.574	< 2e-16
## CountryMorocco	2.921e+00	3.061e-01	9.540	< 2e-16
## CountryMozambique	-1.696e+00	2.912e-01	-5.824	6.79e-09
## CountryMyanmar	-3.364e-01	2.578e-01	-1.305	0.191993
## CountryNamibia	-3.068e-01	3.268e-01	-0.939	0.348035
## CountryNepal	1.166e+00	2.608e-01	4.472	8.25e-06
## CountryNetherlands	7.346e+00	5.097e-01	14.412	< 2e-16
## `CountryNew Zealand`	7.837e+00	5.069e-01	15.460	< 2e-16
## CountryNicaragua	4.158e+00	3.186e-01	13.050	< 2e-16
## CountryNiger	-4.093e+00	2.610e-01	-15.681	< 2e-16
## CountryNigeria	-2.700e+00	4.076e-01	-6.624	4.59e-11
## `CountryNorth Macedonia`	3.522e+00	4.089e-01	8.613	< 2e-16
## CountryNorway	7.814e+00	5.145e-01	15.186	< 2e-16
## CountryOman	3.589e+00	3.559e-01	10.083	< 2e-16
## CountryPakistan	1.694e+00	2.901e-01	5.841	6.14e-09
## CountryPanama	6.779e+00	4.067e-01	16.668	< 2e-16
## `CountryPapua New Guinea`	-1.443e+00	2.850e-01	-5.064	4.54e-07
## CountryParaguay	4.283e+00	3.582e-01	11.958	< 2e-16
## CountryPeru	4.587e+00	3.985e-01	11.511	< 2e-16
## CountryPhilippines	3.999e+00	3.840e-01	10.415	< 2e-16
## CountryPoland	5.713e+00	5.057e-01	11.296	< 2e-16
## CountryPortugal	6.660e+00	4.210e-01	15.819	< 2e-16
## CountryQatar	5.516e+00	4.257e-01	12.958	< 2e-16
## CountryRomania	4.313e+00	4.510e-01	9.563	< 2e-16
## `CountryRussian Federation`	3.956e+00	5.118e-01	7.729	1.79e-14
## CountryRwanda	-1.542e-01	2.927e-01	-0.527	0.598448
## CountrySamoa	2.027e+00	4.185e-01	4.843	1.39e-06
## `CountrySao Tome and Principe`	8.803e-01	3.200e-01	2.751	0.006001
## `CountrySaudi Arabia`	2.359e+00	3.687e-01	6.397	2.01e-10
## CountrySenegal	-1.066e+00	2.628e-01	-4.058	5.15e-05
## CountrySerbia	3.804e+00	4.621e-01	8.232	3.50e-16
## CountrySeychelles	4.223e+00	3.882e-01	10.878	< 2e-16
## `CountrySierra Leone`	-1.345e+00	3.076e-01	-4.372	1.30e-05
## CountrySingapore	7.227e+00	4.614e-01	15.662	< 2e-16
## `CountrySlovak Republic`	4.809e+00	4.926e-01	9.762	< 2e-16
## CountrySlovenia	7.023e+00	5.086e-01	13.808	< 2e-16
## `CountrySolomon Islands`	2.697e+00	3.142e-01	8.582	< 2e-16
## CountrySomalia	-1.505e+00	3.183e-01	-4.727	2.45e-06
## `CountrySouth Africa`	2.959e+00	4.071e-01	7.269	5.38e-13
## CountrySpain	8.244e+00	4.385e-01	18.800	< 2e-16
## `CountrySri Lanka`	4.997e+00	4.218e-01	11.848	< 2e-16
## `CountrySt. Lucia`	6.133e+00	4.253e-01	14.421	< 2e-16
## `CountrySt. Vincent and the Grenadines`	3.995e+00	4.003e-01	9.980	< 2e-16
## CountrySuriname	2.942e+00	3.647e-01	8.066	1.32e-15

## CountrySweden	7.865e+00	5.185e-01	15.170	< 2e-16
## CountrySwitzerland	8.810e+00	5.376e-01	16.389	< 2e-16
## `CountrySyrian Arab Republic`	3.145e+00	3.214e-01	9.783	< 2e-16
## CountryTajikistan	9.304e-01	4.081e-01	2.280	0.022724
## CountryTanzania	-6.966e-01	3.372e-01	-2.066	0.039011
## CountryThailand	5.117e+00	3.408e-01	15.014	< 2e-16
## `CountryTimor-Leste`	1.401e+00	2.606e-01	5.375	8.64e-08
## CountryTogo	-2.190e+00	2.770e-01	-7.905	4.64e-15
## CountryTonga	6.899e-01	4.393e-01	1.570	0.116492
## `CountryTrinidad and Tobago`	4.556e+00	4.152e-01	10.973	< 2e-16
## CountryTunisia	3.784e+00	3.425e-01	11.049	< 2e-16
## CountryTurkiye	3.668e+00	3.283e-01	11.174	< 2e-16
## CountryTurkmenistan	1.694e+00	3.970e-01	4.268	2.08e-05
## CountryUganda	-3.604e-01	3.580e-01	-1.007	0.314180
## CountryUkraine	4.122e+00	4.705e-01	8.762	< 2e-16
## `CountryUnited Arab Emirates`	3.545e+00	4.136e-01	8.572	< 2e-16
## `CountryUnited Kingdom`	7.254e+00	5.238e-01	13.849	< 2e-16
## `CountryUnited States`	6.984e+00	5.275e-01	13.242	< 2e-16
## CountryUruguay	5.565e+00	3.925e-01	14.176	< 2e-16
## CountryUzbekistan	2.307e+00	4.156e-01	5.551	3.26e-08
## CountryVanuatu	5.053e-01	3.358e-01	1.505	0.132595
## `CountryVenezuela, RB`	4.202e+00	4.107e-01	10.230	< 2e-16
## CountryVietnam	5.166e+00	3.181e-01	16.239	< 2e-16
## `CountryYemen, Rep.`	1.582e+00	2.670e-01	5.923	3.77e-09
## CountryZambia	-1.639e-01	3.285e-01	-0.499	0.617992
## CountryZimbabwe	1.227e-01	3.919e-01	0.313	0.754261
## RegionAsia	NA	NA	NA	NA
## `RegionCentral America and Caribbean`	NA	NA	NA	NA
## `RegionEuropean Union`	NA	NA	NA	NA
## `RegionMiddle East`	NA	NA	NA	NA
## `RegionNorth America`	NA	NA	NA	NA
## RegionOceania	NA	NA	NA	NA
## `RegionRest of Europe`	NA	NA	NA	NA
## `RegionSouth America`	NA	NA	NA	NA
## Year	1.103e-01	6.206e-03	17.777	< 2e-16
## Economy_status_Developed	NA	NA	NA	NA
## Adult_mortality	-4.070e-02	8.744e-04	-46.543	< 2e-16
## Infant_deaths	-8.724e-02	2.970e-03	-29.374	< 2e-16
## Alcohol_consumption	-3.304e-02	1.573e-02	-2.100	0.035832
## `\\`percentage expenditure\\`	-1.900e-06	1.647e-05	-0.115	0.908163
## Hepatitis_B	7.493e-04	5.853e-04	1.280	0.200613
## Measles	-1.464e-06	1.610e-06	-0.910	0.363115
## BMI	7.429e-04	1.014e-03	0.733	0.463870
## Under_five_deaths	-1.894e-04	3.155e-04	-0.600	0.548396
## Polio	9.009e-04	7.935e-04	1.135	0.256373
## `\\`Total expenditure\\`	-3.285e-03	6.120e-03	-0.537	0.591500
## Diphtheria	1.349e-03	9.127e-04	1.478	0.139682
## Incidents_HIV	-1.435e-03	8.160e-03	-0.176	0.860402
## GDP_per_capita	1.824e-06	2.637e-06	0.692	0.489321
## Population_millions	6.917e-11	2.712e-10	0.255	0.798742
## Thinness_ten_nineteen_years	-1.631e-02	9.602e-03	-1.699	0.089475
## Thinness_five_nine_years	3.936e-03	9.473e-03	0.415	0.677840
## `\\`Income composition of resources\\`	-2.886e-01	1.431e-01	-2.017	0.043844
## Schooling	-7.888e-02	3.863e-02	-2.042	0.041340

##	
## (Intercept)	***
## CountryAlbania	***
## CountryAlgeria	***
## CountryAngola	***
## `CountryAntigua and Barbuda`	***
## CountryArgentina	***
## CountryArmenia	***
## CountryAustralia	***
## CountryAustria	***
## CountryAzerbaijan	***
## `CountryBahamas, The`	***
## CountryBahrain	***
## CountryBangladesh	***
## CountryBarbados	***
## CountryBelarus	***
## CountryBelgium	***
## CountryBelize	***
## CountryBenin	***
## CountryBhutan	***
## CountryBolivia	***
## `CountryBosnia and Herzegovina`	***
## CountryBotswana	***
## CountryBrazil	***
## `CountryBrunei Darussalam`	***
## CountryBulgaria	***
## `CountryBurkina Faso`	***
## CountryBurundi	***
## `CountryCabo Verde`	***
## CountryCambodia	
## CountryCameroon	*
## CountryCanada	***
## `CountryCentral African Republic`	***
## CountryChad	***
## CountryChile	***
## CountryChina	***
## CountryColombia	***
## CountryComoros	
## `CountryCongo, Dem. Rep.`	***
## `CountryCongo, Rep.`	
## `CountryCosta Rica`	***
## CountryCroatia	***
## CountryCuba	***
## CountryCyprus	***
## CountryCzechia	***
## CountryDenmark	***
## CountryDjibouti	
## `CountryDominican Republic`	***
## CountryEcuador	***
## `CountryEgypt, Arab Rep.`	***
## `CountryEl Salvador`	***
## `CountryEquatorial Guinea`	
## CountryEritrea	
## CountryEstonia	***

## CountryEswatini	***
## CountryEthiopia	
## CountryFiji	
## CountryFinland	***
## CountryFrance	***
## CountryGabon	
## CountryGambia	***
## CountryGeorgia	***
## CountryGermany	***
## CountryGhana	***
## CountryGreece	***
## CountryGrenada	***
## CountryGuatemala	***
## CountryGuinea	***
## `CountryGuinea-Bissau`	***
## CountryGuyana	***
## CountryHaiti	
## CountryHonduras	***
## CountryHungary	***
## CountryIceland	***
## CountryIndia	***
## CountryIndonesia	***
## CountryIran	***
## CountryIraq	***
## CountryIreland	***
## CountryIsrael	***
## CountryItaly	***
## CountryJamaica	***
## CountryJapan	***
## CountryJordan	***
## CountryKazakhstan	***
## CountryKenya	.
## CountryKiribati	***
## CountryKuwait	**
## `CountryKyrgyz Republic`	***
## `CountryLao PDR`	***
## CountryLatvia	***
## CountryLebanon	***
## CountryLesotho	***
## CountryLiberia	
## CountryLibya	***
## CountryLithuania	***
## CountryLuxembourg	***
## CountryMadagascar	*
## CountryMalawi	.
## CountryMalaysia	***
## CountryMaldives	***
## CountryMali	***
## CountryMalta	***
## CountryMauritania	
## CountryMauritius	***
## CountryMexico	***
## `CountryMicronesia, Fed. Sts.`	**
## CountryMoldova	***

## CountryMongolia	***
## CountryMontenegro	***
## CountryMorocco	***
## CountryMozambique	***
## CountryMyanmar	
## CountryNamibia	
## CountryNepal	***
## CountryNetherlands	***
## `CountryNew Zealand`	***
## CountryNicaragua	***
## CountryNiger	***
## CountryNigeria	***
## `CountryNorth Macedonia`	***
## CountryNorway	***
## CountryOman	***
## CountryPakistan	***
## CountryPanama	***
## `CountryPapua New Guinea`	***
## CountryParaguay	***
## CountryPeru	***
## CountryPhilippines	***
## CountryPoland	***
## CountryPortugal	***
## CountryQatar	***
## CountryRomania	***
## `CountryRussian Federation`	***
## CountryRwanda	
## CountrySamoa	***
## `CountrySao Tome and Principe`	**
## `CountrySaudi Arabia`	***
## CountrySenegal	***
## CountrySerbia	***
## CountrySeychelles	***
## `CountrySierra Leone`	***
## CountrySingapore	***
## `CountrySlovak Republic`	***
## CountrySlovenia	***
## `CountrySolomon Islands`	***
## CountrySomalia	***
## `CountrySouth Africa`	***
## CountrySpain	***
## `CountrySri Lanka`	***
## `CountrySt. Lucia`	***
## `CountrySt. Vincent and the Grenadines`	***
## CountrySuriname	***
## CountrySweden	***
## CountrySwitzerland	***
## `CountrySyrian Arab Republic`	***
## CountryTajikistan	*
## CountryTanzania	*
## CountryThailand	***
## `CountryTimor-Leste`	***
## CountryTogo	***
## CountryTonga	

```

## `CountryTrinidad and Tobago`      ***
## CountryTunisia                     ***
## CountryTurkiye                     ***
## CountryTurkmenistan                ***
## CountryUganda                      ***
## CountryUkraine                     ***
## `CountryUnited Arab Emirates`      ***
## `CountryUnited Kingdom`            ***
## `CountryUnited States`             ***
## CountryUruguay                     ***
## CountryUzbekistan                  ***
## CountryVanuatu                     ***
## `CountryVenezuela, RB`             ***
## CountryVietnam                     ***
## `CountryYemen, Rep.`               ***
## CountryZambia                      ***
## CountryZimbabwe                    ***
## RegionAsia                         ***
## `RegionCentral America and Caribbean`
## `RegionEuropean Union`
## `RegionMiddle East`
## `RegionNorth America`
## RegionOceania
## `RegionRest of Europe`
## `RegionSouth America`
## Year                               ***
## Economy_status_Developed
## Adult_mortality                     ***
## Infant_deaths                       ***
## Alcohol_consumption                 *
## `\\`percentage expenditure\\`
## Hepatitis_B
## Measles
## BMI
## Under_five_deaths
## Polio
## `\\`Total expenditure\\`
## Diphtheria
## Incidents_HIV
## GDP_per_capita
## Population_millions
## Thinness_ten_nineteen_years        .
## Thinness_five_nine_years
## `\\`Income composition of resources\\` *
## Schooling                           *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5291 on 1799 degrees of freedom
## Multiple R-squared:  0.9971, Adjusted R-squared:  0.9968
## F-statistic: 3183 on 196 and 1799 DF, p-value: < 2.2e-16

```

```
# Collect and summarize from models
```

```
ML_results <- resamples(list(linear = lm_model, knn = knn_model, ann = ann_model, svm = svm_model, rf =
```

```

print(ML_results)

##
## Call:
## resamples.default(x = list(linear = lm_model, knn = knn_model, ann =
##   ann_model, svm = svm_model, rf = rf_model))
##
## Models: linear, knn, ann, svm, rf
## Number of resamples: 10
## Performance metrics: MAE, RMSE, Rsquared
## Time estimates for: everything, final model fit

#### Ensure 'Economy_status_Developed' is numeric if it was numeric during model training
test_data$Economy_status_Developed <- as.numeric(as.factor(test_data$Economy_status_Developed))
# Then re-run the model evaluation
mse_ann <- calculateMSE(ann_model, test_data)

# Model Evaluation
# Evaluation Function
calculateMSE <- function(model, test_data) {
  predictions <- predict(model, test_data)
  return(mean((predictions - test_data$Life_expectancy)^2))
}

# Evaluate Models
mse_ann <- calculateMSE(ann_model, test_data)
mse_knn <- calculateMSE(knn_model, test_data) # Update this as per KNN's output format
mse_svm <- calculateMSE(svm_model, test_data)
mse_rf <- calculateMSE(rf_model, test_data)

#### Print MSE of Models
print(list(MSE_ANN = mse_ann, MSE_KNN = mse_knn, MSE_SVM = mse_svm, MSE_RF = mse_rf))

## $MSE_ANN
## [1] 4842.958
##
## $MSE_KNN
## [1] 4853.757
##
## $MSE_SVM
## [1] 4870.081
##
## $MSE_RF
## [1] 0.3710017

#### Predictions
#Predictions per model
actual_values <- test_data$Life_expectancy
print(actual_values)

## [1] 55.8 56.8 59.9 74.0 74.3 74.6 78.0 75.4 48.4 52.2 57.2 73.9 74.4 75.0 76.0

```

```
## [16] 73.8 74.8 75.9 72.5 74.1 74.3 74.5 79.6 79.9 80.5 82.3 82.4 78.7 80.4 80.6
## [31] 81.1 81.5 68.2 70.2 72.0 72.0 72.0 75.0 66.9 70.9 71.5 78.0 78.7 68.9 70.4
## [46] 72.5 79.7 80.0 80.4 81.3 70.0 71.1 73.5 74.0 55.7 59.6 59.8 60.1 66.0 67.3
## [61] 68.4 68.8 70.4 64.8 69.5 70.3 74.6 74.9 75.3 75.8 76.2 50.2 52.1 55.0 61.9
## [76] 63.5 67.3 72.6 73.3 74.5 74.7 73.3 73.6 74.0 74.9 75.0 75.1 71.8 72.1 74.3
## [91] 50.5 54.8 59.5 51.7 54.9 59.1 72.1 60.3 62.2 63.9 66.6 68.6 51.2 79.9 80.2
## [106] 80.7 45.6 47.3 50.9 51.9 52.4 52.8 53.1 78.3 73.8 74.4 74.7 75.0 75.6 74.0
## [121] 59.5 59.6 60.4 57.4 58.8 54.7 55.6 77.6 78.0 79.2 75.2 75.8 77.5 78.0 78.4
## [136] 78.5 79.6 75.2 77.4 78.6 78.2 78.4 63.2 69.7 70.0 70.8 73.4 74.1 75.7 76.1
## [151] 69.1 69.3 69.8 70.7 70.9 70.1 53.6 54.8 55.3 56.6 61.0 72.6 72.7 77.1 77.6
## [166] 46.6 49.9 56.2 60.6 66.0 78.4 78.7 79.9 80.5 79.2 79.3 80.2 80.8 81.1 82.1
## [181] 82.3 58.0 57.8 60.6 62.2 62.9 63.6 56.0 58.7 59.3 70.5 71.2 72.4 77.9 78.2
## [196] 78.7 79.8 80.6 57.2 59.2 78.6 79.0 72.8 73.1 72.9 70.1 72.2 53.2 54.1 57.9
## [211] 58.4 59.0 50.7 53.6 55.6 68.6 57.7 60.9 73.3 73.8 72.3 72.3 79.7 81.0 81.5
## [226] 81.8 64.9 65.8 67.0 67.3 68.5 69.9 70.2 70.2 71.3 72.6 69.1 68.1 69.4 69.9
## [241] 77.6 80.7 80.7 79.4 80.6 80.8 74.1 74.1 74.1 74.0 82.3 82.6 83.6 71.7 72.8
## [256] 66.2 52.4 57.5 58.8 61.9 63.1 64.7 65.0 65.8 66.1 73.1 73.2 74.7 68.0 67.7
## [271] 66.5 70.8 71.3 73.1 73.6 74.5 74.5 75.5 76.9 78.4 78.5 78.7 43.8 43.4 51.7
## [286] 55.4 60.1 70.9 71.9 71.9 71.8 73.9 74.3 78.0 77.7 80.6 81.0 58.5 61.2 61.7
## [301] 62.5 57.2 61.0 73.2 75.1 76.7 77.7 54.8 55.7 56.1 79.8 79.6 80.2 60.7 61.8
## [316] 62.8 74.2 75.2 75.2 74.9 65.1 66.3 66.6 67.2 67.4 67.5 68.0 70.6 71.0 63.8
## [331] 64.2 64.7 65.1 65.5 66.9 68.6 69.1 73.8 76.2 68.7 69.8 71.1 73.0 75.0 75.2
## [346] 50.1 50.4 51.3 52.3 57.2 61.3 61.6 64.9 50.6 51.6 53.8 58.1 64.7 68.0 69.2
## [361] 78.2 79.7 80.3 79.5 80.4 70.6 73.2 50.6 54.2 56.6 58.1 58.8 46.8 47.7 48.3
## [376] 72.9 73.0 73.8 74.4 75.0 75.1 74.9 78.8 79.0 80.0 80.6 81.0 82.1 76.4 64.7
## [391] 65.3 65.8 75.9 77.4 59.5 60.2 61.7 71.9 72.3 72.5 71.9 74.7 69.0 70.1 73.7
## [406] 74.2 74.5 74.6 75.2 76.2 76.7 77.1 78.3 80.4 79.4 72.2 72.6 72.6 74.9 65.1
## [421] 65.0 48.6 60.6 64.5 66.9 67.5 70.1 70.9 71.7 72.4 61.4 62.7 65.9 66.4 72.6
## [436] 73.3 73.4 58.2 59.9 63.6 72.3 72.7 72.8 73.4 73.6 72.7 73.2 73.2 73.1 40.4
## [451] 44.5 80.4 80.8 82.7 75.1 76.0 77.2 78.8 67.8 68.8 70.1 51.5 52.3 52.7 54.0
## [466] 55.5 53.7 57.7 79.9 81.5 73.8 75.0 74.4 75.3 70.8 71.8 71.9 68.3 69.9 70.5
## [481] 70.7 71.0 71.2 80.5 80.7 81.8 82.0 80.4 82.2 82.8 82.9 73.1 74.4 72.9 70.6
## [496] 67.4 50.8 51.4 54.3 70.6 71.4 75.0 76.1 59.0 67.5 68.2 53.5 53.7 54.6 55.6
## [511] 69.7 70.1 70.2 69.4 71.0 71.2 72.8 75.7 75.9 64.1 66.7 48.3 52.8 58.1 59.0
## [526] 60.7 61.4 67.8 68.1 71.2 75.6 76.0 76.1 76.3 79.2 80.9 81.0 78.4 78.6 78.7
## [541] 76.6 76.9 77.4 67.2 67.9 68.4 70.7 67.8 68.2 68.4 69.6 72.1 72.6 73.1 73.9
## [556] 74.1 74.9 75.0 75.1 65.3 65.5 65.8 66.1 46.3 47.4 51.1 60.8 55.0
```

#### #### Predictions

```
predictions_ann <- predict(ann_model, test_data)
predictions_svm <- predict(svm_model, test_data)
predictions_rf <- predict(rf_model, test_data)
predictions_knn <- predict(knn_model, test_data)
predictions_lm <- predict(lm_model, test_data)
```

```
## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases
```

```
print(predictions_ann)
```

```
##           1           2           3           4           5           6
## 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01
##           7           8           9          10          11          12
```



##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	13	14	15	16	17	18
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	19	20	21	22	23	24
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	25	26	27	28	29	30
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	31	32	33	34	35	36
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	37	38	39	40	41	42
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	43	44	45	46	47	48
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	49	50	51	52	53	54
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	55	56	57	58	59	60
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.127453e-06
##	61	62	63	64	65	66
##	1.001680e-01	1.001680e-01	1.001680e-01	1.127453e-06	1.127453e-06	1.127453e-06
##	67	68	69	70	71	72
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	73	74	75	76	77	78
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	79	80	81	82	83	84
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	85	86	87	88	89	90
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	91	92	93	94	95	96
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	97	98	99	100	101	102
##	1.127453e-06	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	103	104	105	106	107	108
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	109	110	111	112	113	114
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	115	116	117	118	119	120
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	121	122	123	124	125	126
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	127	128	129	130	131	132
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	133	134	135	136	137	138
##	1.302473e-06	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.127453e-06
##	139	140	141	142	143	144
##	2.277678e-04	2.882932e-02	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	145	146	147	148	149	150
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	151	152	153	154	155	156
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	157	158	159	160	161	162
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	163	164	165	166	167	168
##	1.001680e-01	1.001680e-01	1.001680e-01	1.127453e-06	1.127453e-06	1.001680e-01
##	169	170	171	172	173	174

##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	175	176	177	178	179	180
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	181	182	183	184	185	186
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	187	188	189	190	191	192
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.127453e-06	2.277678e-04
##	193	194	195	196	197	198
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	199	200	201	202	203	204
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.127453e-06	5.505997e-04
##	205	206	207	208	209	210
##	5.505997e-04	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	211	212	213	214	215	216
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	217	218	219	220	221	222
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	223	224	225	226	227	228
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	229	230	231	232	233	234
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	235	236	237	238	239	240
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	241	242	243	244	245	246
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	247	248	249	250	251	252
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	253	254	255	256	257	258
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	259	260	261	262	263	264
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	265	266	267	268	269	270
##	1.001680e-01	1.001680e-01	2.277678e-04	1.001680e-01	1.001680e-01	1.001680e-01
##	271	272	273	274	275	276
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	277	278	279	280	281	282
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	283	284	285	286	287	288
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	5.505997e-04
##	289	290	291	292	293	294
##	1.001680e-01	1.127453e-06	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	295	296	297	298	299	300
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	301	302	303	304	305	306
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	307	308	309	310	311	312
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	313	314	315	316	317	318
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	319	320	321	322	323	324
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.127453e-06
##	325	326	327	328	329	330
##	1.127453e-06	1.127453e-06	1.127453e-06	1.127453e-06	7.909899e-05	1.001680e-01
##	331	332	333	334	335	336

##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	337	338	339	340	341	342
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	343	344	345	346	347	348
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	349	350	351	352	353	354
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	355	356	357	358	359	360
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	361	362	363	364	365	366
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	367	368	369	370	371	372
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	373	374	375	376	377	378
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	379	380	381	382	383	384
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	385	386	387	388	389	390
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	391	392	393	394	395	396
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	397	398	399	400	401	402
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	403	404	405	406	407	408
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	409	410	411	412	413	414
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	415	416	417	418	419	420
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	421	422	423	424	425	426
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	427	428	429	430	431	432
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	433	434	435	436	437	438
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	439	440	441	442	443	444
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	445	446	447	448	449	450
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	451	452	453	454	455	456
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.127453e-06	1.127453e-06
##	457	458	459	460	461	462
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.127453e-06
##	463	464	465	466	467	468
##	1.127453e-06	1.127453e-06	1.127453e-06	1.127453e-06	1.001680e-01	1.001680e-01
##	469	470	471	472	473	474
##	1.001680e-01	1.001680e-01	2.277678e-04	1.001680e-01	1.127453e-06	1.127453e-06
##	475	476	477	478	479	480
##	1.127453e-06	1.127453e-06	1.127453e-06	1.001680e-01	1.001680e-01	1.001680e-01
##	481	482	483	484	485	486
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	487	488	489	490	491	492
##	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01	1.001680e-01
##	493	494	495	496	497	498

```

## 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.127453e-06 1.127453e-06
##          499          500          501          502          503          504
## 1.127453e-06 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01
##          505          506          507          508          509          510
## 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01
##          511          512          513          514          515          516
## 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01
##          517          518          519          520          521          522
## 1.001680e-01 1.001680e-01 1.001680e-01 1.992968e-04 1.001680e-01 1.001680e-01
##          523          524          525          526          527          528
## 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01
##          529          530          531          532          533          534
## 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01
##          535          536          537          538          539          540
## 2.277678e-04 2.277678e-04 4.200999e-01 2.277671e-04 2.277678e-04 2.277678e-04
##          541          542          543          544          545          546
## 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01
##          547          548          549          550          551          552
## 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01 1.127453e-06
##          553          554          555          556          557          558
## 1.127453e-06 1.127453e-06 1.127453e-06 1.127453e-06 1.127453e-06 1.127453e-06
##          559          560          561          562          563          564
## 2.277678e-04 1.127453e-06 1.127453e-06 1.127453e-06 1.127453e-06 1.001680e-01
##          565          566          567          568
## 1.001680e-01 1.001680e-01 1.001680e-01 1.001680e-01

```

```
print(predictions_svm)
```

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```

[illegible]

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```

```
print(predictions_knn)
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## [306] 1.396336247 -0.104479848 -0.039256437 -0.039256437 -0.166484441
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## [551] -0.039256437 -1.097061572 -1.157541462 -0.885974897 -0.370117012
## [556] 0.012210764 -1.268539849 -0.926294824 -1.597265839 -0.814822085
## [561] -0.817342081 -1.597265839 -1.443931530 -0.039256437 -0.039256437
## [566] -0.039256437 -0.039256437 -0.039256437
```

```
print(predictions_lm)
```

```
##          1          2          3          4          5          6          7          8
## 55.40918 56.31064 60.03497 73.99586 74.35283 74.71673 77.72393 75.22680
##          9         10         11         12         13         14         15         16
## 48.79664 52.73567 57.00471 73.95571 74.32363 74.97225 76.07796 73.39254
##         17         18         19         20         21         22         23         24
## 74.78669 76.20015 72.23972 74.42583 74.63352 74.87404 80.08938 80.24114
##         25         26         27         28         29         30         31         32
## 80.60569 82.16615 82.29446 78.92121 80.09739 80.29647 80.89864 81.13880
##         33         34         35         36         37         38         39         40
## 68.24268 70.28269 71.25363 71.87053 72.07480 74.80094 67.03191 70.83462
##         41         42         43         44         45         46         47         48
## 71.51779 77.92698 79.35621 69.10740 70.56446 72.60692 79.63012 79.80981
##         49         50         51         52         53         54         55         56
## 80.39907 80.89328 70.71507 71.31691 72.19770 72.70980 55.72641 59.49899
##         57         58         59         60         61         62         63         64
## 59.59346 60.11646 65.90115 66.95902 67.79555 68.06544 69.55925 65.18543
##         65         66         67         68         69         70         71         72
## 68.96990 69.65094 74.53100 74.94559 75.30949 75.69307 76.34528 49.49701
##         73         74         75         76         77         78         79         80
## 54.06821 56.50355 60.97443 62.21107 65.13282 72.70140 73.27600 74.25319
##         81         82         83         84         85         86         87         88
## 74.44383 73.42595 73.62586 73.98415 74.74125 74.91340 75.05882 71.68756
##         89         90         91         92         93         94         95         96
## 72.22805 74.30036 51.55349 55.13151 58.40916 52.16555 54.60666 58.49772
##         97         98         99        100        101        102        103        104
## 72.50201 60.82985 62.62025 64.10803 66.32068 68.28105 50.67129 80.05811
##        105        106        107        108        109        110        111        112
```



##	80.14148	80.68148	45.72137	47.80694	50.84308	51.81429	52.11146	52.54387
##	113	114	115	116	117	118	119	120
##	52.91379	78.11971	73.96222	74.43964	74.77593	74.80572	75.57605	73.99585
##	121	122	123	124	125	126	127	128
##	58.89414	59.19493	60.41642	56.87422	58.24493	54.63985	55.73250	77.44600
##	129	130	131	132	133	134	135	136
##	77.79493	79.41959	75.35018	75.59353	77.31457	77.93608	78.66290	78.47020
##	137	138	139	140	141	142	143	144
##	79.72266	75.23509	77.33061	78.51781	78.18130	78.53972	62.52061	70.04137
##	145	146	147	148	149	150	151	152
##	70.23879	70.97476	73.03998	73.94536	75.97824	76.44059	68.67199	68.94546
##	153	154	155	156	157	158	159	160
##	69.68727	71.08216	71.35222	69.96890	52.95165	54.76646	55.69198	57.06678
##	161	162	163	164	165	166	167	168
##	60.82074	72.59613	72.81643	76.42747	76.79955	48.78392	51.31253	56.53176
##	169	170	171	172	173	174	175	176
##	60.44266	65.50666	78.74542	78.57406	79.65706	79.92995	79.72027	79.90517
##	177	178	179	180	181	182	183	184
##	80.43996	80.77325	80.90809	81.51458	82.36211	57.61682	58.02098	60.87089
##	185	186	187	188	189	190	191	192
##	62.08781	62.68850	63.18049	56.04860	58.55652	59.23000	70.32403	71.41392
##	193	194	195	196	197	198	199	200
##	72.64935	78.12639	78.52476	78.96694	79.78143	80.80031	56.92118	59.47648
##	201	202	203	204	205	206	207	208
##	79.12819	79.41158	71.49909	72.83582	73.53325	70.12273	72.24953	53.89884
##	209	210	211	212	213	214	215	216
##	54.50867	57.20647	57.67512	58.08701	50.63385	53.67637	55.72539	68.33099
##	217	218	219	220	221	222	223	224
##	57.46766	61.49873	73.33970	73.80510	72.15226	72.32723	79.98106	81.09932
##	225	226	227	228	229	230	231	232
##	81.59123	81.79374	64.96707	65.69759	67.08188	67.52993	68.36042	69.37459
##	233	234	235	236	237	238	239	240
##	69.61700	70.07759	71.19869	72.36627	67.92844	68.06672	69.93078	70.47370
##	241	242	243	244	245	246	247	248
##	78.28929	80.15688	80.40860	79.54976	80.57599	80.96498	72.60605	73.83971
##	249	250	251	252	253	254	255	256
##	74.28777	74.74834	82.28675	82.61383	83.50430	71.35791	72.73228	66.58834
##	257	258	259	260	261	262	263	264
##	52.10039	58.00985	59.21852	62.40423	63.55471	64.83871	64.95358	65.51061
##	265	266	267	268	269	270	271	272
##	65.74823	72.41744	72.55934	75.06138	67.97675	68.14104	66.51735	70.30585
##	273	274	275	276	277	278	279	280
##	71.06105	73.11100	73.94608	74.99799	75.17143	75.95485	76.96624	78.18233
##	281	282	283	284	285	286	287	288
##	78.39628	78.95437	42.54641	45.23615	51.69716	55.84573	60.26676	70.17415
##	289	290	291	292	293	294	295	296
##	71.42126	72.59631	71.79083	74.17623	74.91259	78.39674	79.05845	80.22296
##	297	298	299	300	301	302	303	304
##	80.90037	59.00949	61.24343	61.69646	62.51373	57.71009	61.00086	73.56149
##	305	306	307	308	309	310	311	312
##	75.48445	76.30818	77.02562	54.03338	54.76610	55.12032	79.95941	80.12214
##	313	314	315	316	317	318	319	320
##	80.20918	60.28348	61.86723	63.05269	73.96459	74.49284	75.29923	76.29537
##	321	322	323	324	325	326	327	328

##	65.16201	66.18872	66.53704	66.65285	67.05511	67.36704	68.06564	71.00893
##	329	330	331	332	333	334	335	336
##	71.18487	63.72287	64.25098	64.79379	65.17377	65.66799	67.03286	68.38503
##	337	338	339	340	341	342	343	344
##	69.09816	73.98832	76.00937	68.80706	69.83424	71.07377	72.92828	75.00653
##	345	346	347	348	349	350	351	352
##	75.26710	49.38925	50.07303	52.46584	53.46775	56.81955	61.47027	61.85030
##	353	354	355	356	357	358	359	360
##	64.86555	51.68578	52.29741	53.66389	57.68246	64.50332	68.15024	69.33450
##	361	362	363	364	365	366	367	368
##	78.70295	79.76085	80.09620	79.62863	80.28546	70.27427	73.48921	51.85387
##	369	370	371	372	373	374	375	376
##	54.64087	56.25834	57.29535	57.77769	46.77000	47.84473	48.30257	73.14315
##	377	378	379	380	381	382	383	384
##	73.23330	74.21088	74.45973	74.82130	75.17273	75.23144	79.38466	79.50257
##	385	386	387	388	389	390	391	392
##	80.19443	80.68853	81.10107	81.77801	75.93645	64.88894	65.61168	66.02723
##	393	394	395	396	397	398	399	400
##	75.89961	77.17605	59.02438	60.06961	61.85364	71.87775	72.27662	72.56047
##	401	402	403	404	405	406	407	408
##	71.99732	74.61202	68.91791	70.29846	73.90407	74.30295	74.56405	74.73926
##	409	410	411	412	413	414	415	416
##	75.15013	76.09094	76.58348	77.46177	78.69362	79.70992	79.41590	72.38908
##	417	418	419	420	421	422	423	424
##	72.68363	72.98696	74.88105	65.09469	64.98412	47.83134	61.02381	63.74801
##	425	426	427	428	429	430	431	432
##	65.48620	65.97265	69.93241	70.78673	71.76373	72.59705	62.79951	63.71081
##	433	434	435	436	437	438	439	440
##	66.20096	66.56773	71.93779	73.13174	73.34405	58.96451	60.59053	63.32641
##	441	442	443	444	445	446	447	448
##	72.16652	72.76940	73.02230	73.29814	73.55201	72.15230	73.01199	73.34024
##	449	450	451	452	453	454	455	456
##	73.61215	41.61896	44.95098	80.61053	80.78313	81.96907	75.45364	75.61310
##	457	458	459	460	461	462	463	464
##	77.46835	78.68718	67.53439	68.55167	70.15062	51.38037	52.11411	52.39360
##	465	466	467	468	469	470	471	472
##	53.97163	55.86667	53.99014	57.87613	80.44525	81.45473	73.79617	74.82435
##	473	474	475	476	477	478	479	480
##	74.52874	75.51222	70.29079	72.49952	72.92296	68.24370	69.88233	70.41611
##	481	482	483	484	485	486	487	488
##	70.64512	71.08796	71.54335	80.47001	80.72639	81.58336	81.83631	80.67757
##	489	490	491	492	493	494	495	496
##	82.15772	82.64914	82.96336	72.26326	73.12428	72.43690	70.32082	67.28814
##	497	498	499	500	501	502	503	504
##	49.78595	50.34160	54.31095	70.96438	71.76096	74.57592	75.29784	58.89555
##	505	506	507	508	509	510	511	512
##	67.49249	68.79583	53.43412	53.87908	54.80792	55.49882	68.54058	70.42578
##	513	514	515	516	517	518	519	520
##	70.80091	69.58295	70.94064	71.03459	72.81599	75.85366	76.08947	63.59914
##	521	522	523	524	525	526	527	528
##	66.99022	47.59474	53.22265	58.19239	59.29524	60.27334	60.72057	67.67114
##	529	530	531	532	533	534	535	536
##	68.15774	71.75913	75.66287	76.07582	76.18712	76.36048	79.30064	80.49359
##	537	538	539	540	541	542	543	544

```
## 80.88688 78.19955 78.51992 78.58995 76.47192 76.93647 77.68765 65.63752
##      545      546      547      548      549      550      551      552
## 66.77513 67.75324 71.70522 67.43017 68.03888 68.29864 69.93810 71.48385
##      553      554      555      556      557      558      559      560
## 72.16043 73.36807 73.85251 74.01501 74.93527 75.09249 75.41860 64.75627
##      561      562      563      564      565      566      567      568
## 65.06516 65.27787 65.89078 46.16585 47.77561 51.84918 60.28735 55.64159
## attr("non-estim")
##  1  4  5  6  7 11 12 13 14 15 19 20 21 22 23 24 25 33 34 38
##  1  4  5  6  7 11 12 13 14 15 19 20 21 22 23 24 25 33 34 38
## 39 42 43 47 50 51 52 56 58 60 62 64 65 66 75 76 77 82 83 84
## 39 42 43 47 50 51 52 56 58 60 62 64 65 66 75 76 77 82 83 84
## 85 86 87 88 96 97 98 100 101 106 113 120 124 130 131 132 133 134 135 136
## 85 86 87 88 96 97 98 100 101 106 113 120 124 130 131 132 133 134 135 136
## 138 139 140 147 159 160 163 165 166 167 185 191 192 193 201 203 204 205 206 212
## 138 139 140 147 159 160 163 165 166 167 185 191 192 193 201 203 204 205 206 212
## 214 216 218 221 223 224 244 245 248 249 250 251 252 253 254 256 261 262 263 264
## 214 216 218 221 223 224 244 245 248 249 250 251 252 253 254 256 261 262 263 264
## 265 266 267 268 272 275 283 284 287 288 289 290 293 295 305 306 307 310 311 312
## 265 266 267 268 272 275 283 284 287 288 289 290 293 295 305 306 307 310 311 312
## 314 317 324 325 326 327 328 329 334 336 338 339 346 347 350 354 355 356 361 364
## 314 317 324 325 326 327 328 329 334 336 338 339 346 347 350 354 355 356 361 364
## 365 389 415 422 424 427 428 429 430 431 432 433 434 435 436 437 446 447 448 449
## 365 389 415 422 424 427 428 429 430 431 432 433 434 435 436 437 446 447 448 449
## 452 453 454 455 456 457 458 461 462 463 464 465 466 471 472 473 474 475 476 477
## 452 453 454 455 456 457 458 461 462 463 464 465 466 471 472 473 474 475 476 477
## 480 482 483 485 487 495 497 498 499 504 511 512 513 515 516 520 521 531 532 533
## 480 482 483 485 487 495 497 498 499 504 511 512 513 515 516 520 521 531 532 533
## 534 535 536 537 538 539 540 544 546 547 548 549 550 551 552 553 554 555 556 557
## 534 535 536 537 538 539 540 544 546 547 548 549 550 551 552 553 554 555 556 557
## 558 559 560 561 562 563
## 558 559 560 561 562 563
```

```
print(predictions_rf)
```

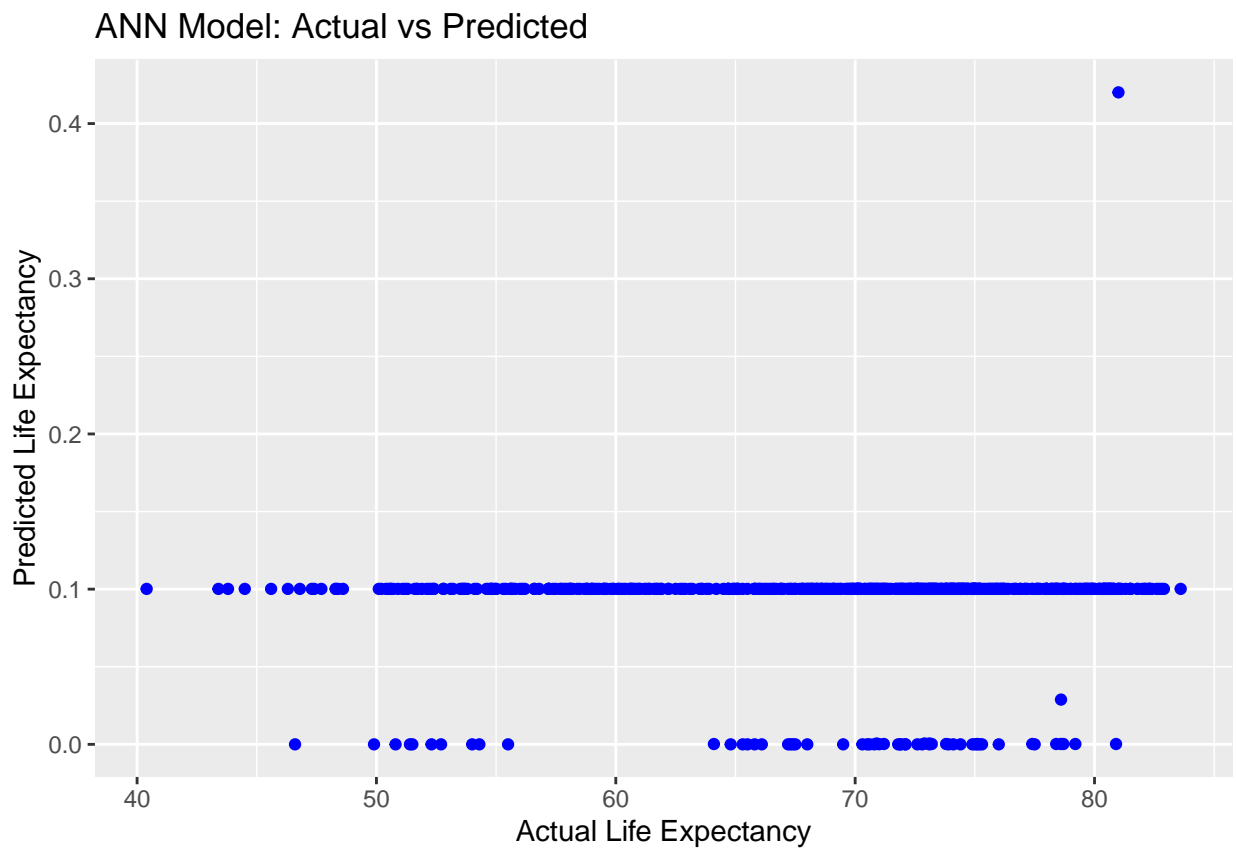
```
##      1      2      3      4      5      6      7      8
## 52.48446 53.86283 59.76634 74.64547 75.12923 75.20208 78.20086 75.65512
##      9     10     11     12     13     14     15     16
## 49.56717 52.72135 58.52441 73.63276 73.76531 74.29134 75.57645 73.94803
##     17     18     19     20     21     22     23     24
## 74.91428 75.97598 72.44929 74.26002 74.58218 74.77983 79.78341 79.96578
##     25     26     27     28     29     30     31     32
## 80.45739 82.20787 82.24361 78.46387 80.23862 80.34506 80.81841 81.12906
##     33     34     35     36     37     38     39     40
## 67.81465 70.09948 71.95597 72.07839 72.10022 75.64521 66.13299 70.81626
##     41     42     43     44     45     46     47     48
## 71.42043 77.56902 77.79284 69.30206 71.02757 72.85982 79.66904 79.85491
##     49     50     51     52     53     54     55     56
## 80.43372 80.88454 70.51292 71.33056 72.72461 73.34281 54.84321 59.56942
##     57     58     59     60     61     62     63     64
## 59.84228 60.26155 64.68346 65.79316 67.04147 68.03627 68.91466 65.65776
##     65     66     67     68     69     70     71     72
## 69.86419 70.40948 74.83956 75.20681 75.77288 76.28060 76.57708 49.97286
##     73     74     75     76     77     78     79     80
```

##	52.74533	55.17219	60.40751	62.17737	65.00427	72.61807	73.26259	74.01224
##	81	82	83	84	85	86	87	88
##	73.86455	74.06193	74.33018	74.74133	75.66655	75.77572	75.73746	72.08798
##	89	90	91	92	93	94	95	96
##	72.25514	74.33008	50.81570	55.16029	59.59961	51.59145	54.78238	58.83362
##	97	98	99	100	101	102	103	104
##	73.50497	60.32625	62.43508	64.00488	66.88261	69.75128	50.96668	79.80433
##	105	106	107	108	109	110	111	112
##	79.89028	80.45959	46.29035	47.59690	51.44985	52.88451	53.46062	53.92014
##	113	114	115	116	117	118	119	120
##	54.28825	78.10480	74.76572	75.72905	76.00424	76.27141	76.90624	73.75990
##	121	122	123	124	125	126	127	128
##	59.67268	59.68817	60.64753	57.59303	59.16526	54.75375	55.51725	77.41256
##	129	130	131	132	133	134	135	136
##	77.75703	78.63819	76.02731	76.37563	77.23502	77.93246	78.21104	78.68358
##	137	138	139	140	141	142	143	144
##	79.98582	75.17109	77.49240	78.89003	78.21997	78.81571	61.99477	69.79226
##	145	146	147	148	149	150	151	152
##	70.06795	70.85117	72.70594	73.88431	75.21707	75.82965	69.30615	69.50492
##	153	154	155	156	157	158	159	160
##	70.00145	71.22849	71.48561	70.20463	53.01263	53.76119	53.97666	56.21251
##	161	162	163	164	165	166	167	168
##	60.32799	72.55339	72.83782	76.99719	77.30231	48.09445	50.85824	54.72959
##	169	170	171	172	173	174	175	176
##	58.83113	66.97242	78.38206	78.64466	79.45133	80.01970	79.07855	79.11959
##	177	178	179	180	181	182	183	184
##	79.52665	80.06749	80.67065	81.69936	81.87261	57.65267	57.73986	60.24460
##	185	186	187	188	189	190	191	192
##	62.11472	62.90745	63.61888	57.03100	58.71031	59.44730	70.94025	71.45127
##	193	194	195	196	197	198	199	200
##	72.55644	78.02734	78.35969	78.83532	79.96312	81.14492	57.39698	59.74678
##	201	202	203	204	205	206	207	208
##	78.93618	79.25233	72.70350	73.04414	73.01274	69.67966	71.98455	53.03696
##	209	210	211	212	213	214	215	216
##	53.69069	57.18442	57.94733	58.94961	51.37113	54.64163	56.51652	68.95826
##	217	218	219	220	221	222	223	224
##	57.22768	60.97595	73.23712	73.75348	72.20597	72.40286	79.46913	81.01012
##	225	226	227	228	229	230	231	232
##	81.52708	81.71789	64.74049	65.65068	67.15139	67.92359	68.92003	70.25968
##	233	234	235	236	237	238	239	240
##	70.39564	70.58537	71.31492	72.90870	69.30285	68.51274	70.17954	70.22922
##	241	242	243	244	245	246	247	248
##	77.99593	80.82447	80.99486	79.58879	80.49225	80.86231	73.85769	73.67784
##	249	250	251	252	253	254	255	256
##	73.69468	73.95967	82.02967	82.26270	82.95503	71.89553	73.30844	67.12680
##	257	258	259	260	261	262	263	264
##	52.34926	57.51882	59.00843	61.79651	63.61683	65.11165	65.36663	66.01679
##	265	266	267	268	269	270	271	272
##	66.21346	74.05077	74.19198	75.86840	68.27296	68.16790	66.60198	70.30936
##	273	274	275	276	277	278	279	280
##	70.93240	73.03091	73.42803	74.08136	75.04634	75.78944	76.49083	78.56267
##	281	282	283	284	285	286	287	288
##	78.68571	78.81202	44.66337	44.74797	51.25910	53.96120	59.22726	71.39729
##	289	290	291	292	293	294	295	296

##	72.05108	72.10447	71.73628	73.81479	74.33801	78.00825	78.28055	80.58262
##	297	298	299	300	301	302	303	304
##	81.06126	58.01879	61.03406	61.29624	62.15889	56.28182	60.27200	73.29222
##	305	306	307	308	309	310	311	312
##	75.82769	77.06149	77.68666	55.08773	56.40224	56.78366	79.76851	79.89580
##	313	314	315	316	317	318	319	320
##	80.21725	61.25535	62.05441	62.90029	73.72773	75.09885	75.21363	75.57126
##	321	322	323	324	325	326	327	328
##	65.80516	67.12570	67.43321	67.63109	67.86292	67.96884	68.52674	70.98860
##	329	330	331	332	333	334	335	336
##	71.22221	63.91645	64.32191	65.32686	65.75892	66.15494	67.82818	69.25861
##	337	338	339	340	341	342	343	344
##	69.97316	74.15216	76.42960	68.32676	69.74405	71.24337	73.58741	75.44183
##	345	346	347	348	349	350	351	352
##	75.75997	49.70140	49.89259	51.83020	52.34938	56.52025	61.84469	62.30005
##	353	354	355	356	357	358	359	360
##	65.76124	51.22053	54.14025	53.98548	59.15414	64.60247	68.58088	69.74230
##	361	362	363	364	365	366	367	368
##	78.45884	79.96281	80.42172	79.47744	80.35199	70.59016	73.31234	50.93371
##	369	370	371	372	373	374	375	376
##	55.14818	57.74103	59.55045	60.08112	47.71419	48.96448	49.75528	74.25204
##	377	378	379	380	381	382	383	384
##	74.21306	74.75342	75.24933	75.89651	76.07504	76.14403	79.06969	79.21557
##	385	386	387	388	389	390	391	392
##	80.23459	80.68828	81.05600	82.06445	76.35722	64.65671	65.18307	65.95388
##	393	394	395	396	397	398	399	400
##	75.59971	76.87586	59.89394	60.73049	62.18671	71.91774	72.36683	72.61531
##	401	402	403	404	405	406	407	408
##	72.02050	74.61277	69.40342	70.28983	73.39366	74.08933	74.49988	74.58122
##	409	410	411	412	413	414	415	416
##	75.07438	75.84685	75.92372	77.12570	78.36641	80.25835	79.43332	72.30930
##	417	418	419	420	421	422	423	424
##	72.63643	72.81808	74.72574	66.03125	65.60504	48.37964	59.93788	63.96717
##	425	426	427	428	429	430	431	432
##	67.44000	67.67055	70.46844	71.39361	71.97251	73.29504	62.62208	63.46521
##	433	434	435	436	437	438	439	440
##	67.12721	67.26457	73.35419	74.04961	74.19670	59.04258	60.69948	64.55488
##	441	442	443	444	445	446	447	448
##	72.63385	73.00555	73.10669	73.48795	73.89204	72.04437	73.05497	73.02516
##	449	450	451	452	453	454	455	456
##	73.76292	42.73853	45.50441	80.73418	81.06336	82.39376	75.84438	75.97811
##	457	458	459	460	461	462	463	464
##	77.00983	78.37237	68.17043	68.91558	70.15604	51.71927	52.25709	52.75562
##	465	466	467	468	469	470	471	472
##	53.89869	55.14897	54.14043	59.82835	79.90594	81.31329	73.44909	74.89318
##	473	474	475	476	477	478	479	480
##	74.34756	75.09882	71.04837	72.33828	72.77061	68.69567	70.39704	70.88453
##	481	482	483	484	485	486	487	488
##	71.01538	71.34285	71.51966	80.56461	80.82926	81.85033	81.99164	80.32509
##	489	490	491	492	493	494	495	496
##	82.14152	82.72052	82.72048	73.19529	73.84013	72.90148	70.39158	67.73856
##	497	498	499	500	501	502	503	504
##	51.60517	51.78444	54.46737	70.46996	71.34287	74.60501	75.40021	57.94160
##	505	506	507	508	509	510	511	512

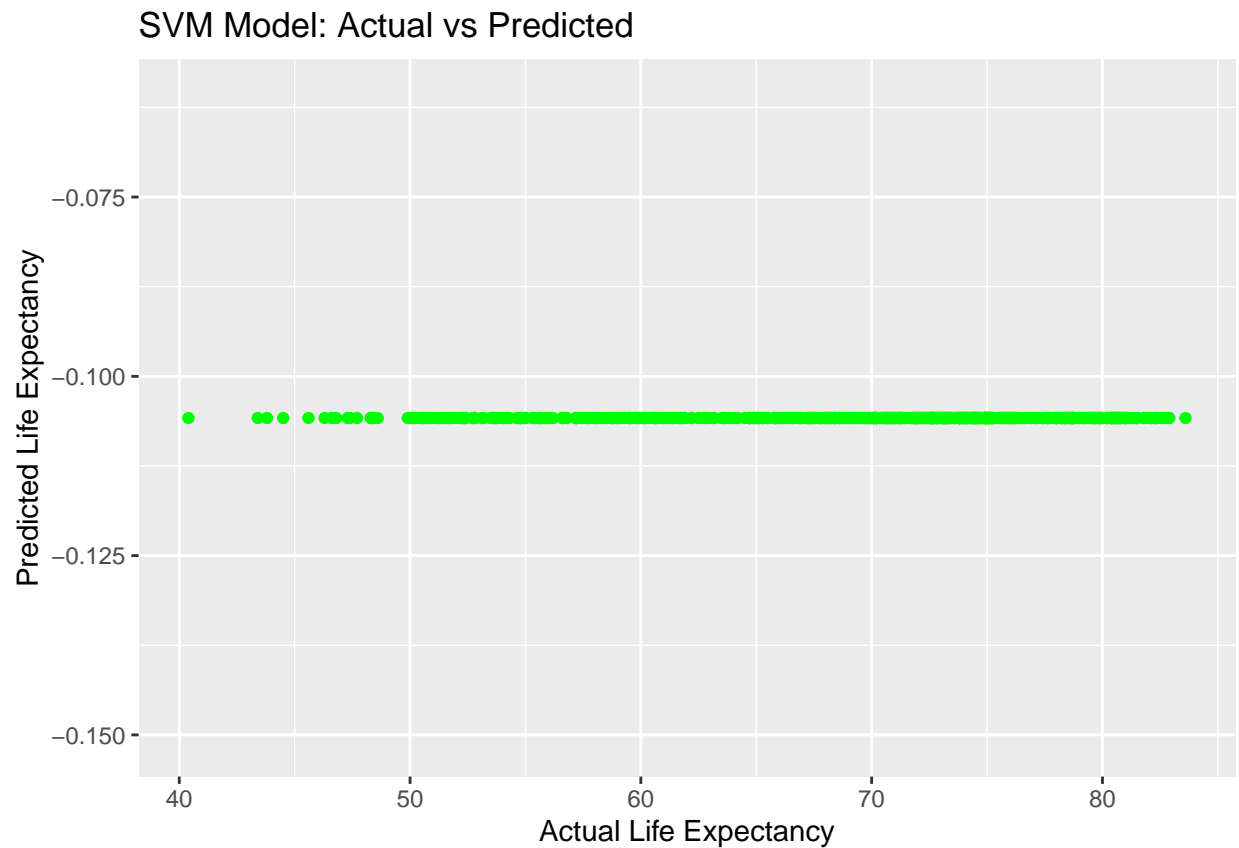
```
## 67.32746 68.17811 54.12113 54.16088 55.48140 56.15079 70.41429 70.62898
##      513      514      515      516      517      518      519      520
## 70.81120 69.71444 70.97109 71.16738 72.60399 75.83275 75.80372 64.14528
##      521      522      523      524      525      526      527      528
## 66.93273 48.37844 53.07050 57.38306 58.44565 59.79884 60.44150 67.95224
##      529      530      531      532      533      534      535      536
## 68.49412 71.19426 76.28686 76.63343 76.78892 76.94696 79.20902 80.90210
##      537      538      539      540      541      542      543      544
## 80.90654 78.30857 78.48376 78.60765 76.45012 76.89547 77.20627 65.44150
##      545      546      547      548      549      550      551      552
## 67.93725 68.12027 71.92560 68.27307 68.67763 68.81640 69.87572 72.68342
##      553      554      555      556      557      558      559      560
## 72.86838 73.20629 73.76497 73.88625 74.80611 74.89624 74.93353 64.48387
##      561      562      563      564      565      566      567      568
## 65.04976 65.34459 65.49062 46.06202 47.56214 52.41986 59.91560 55.26456
```

```
# ML Plots
## Plot for ANN model
ggplot() +
  geom_point(aes(x = actual_values, y = predictions_ann), colour = "blue") +
  geom_abline(intercept = 0, slope = 1, linetype = "dashed") +
  labs(title = "ANN Model: Actual vs Predicted", x = "Actual Life Expectancy", y = "Predicted Life Expectancy")
```



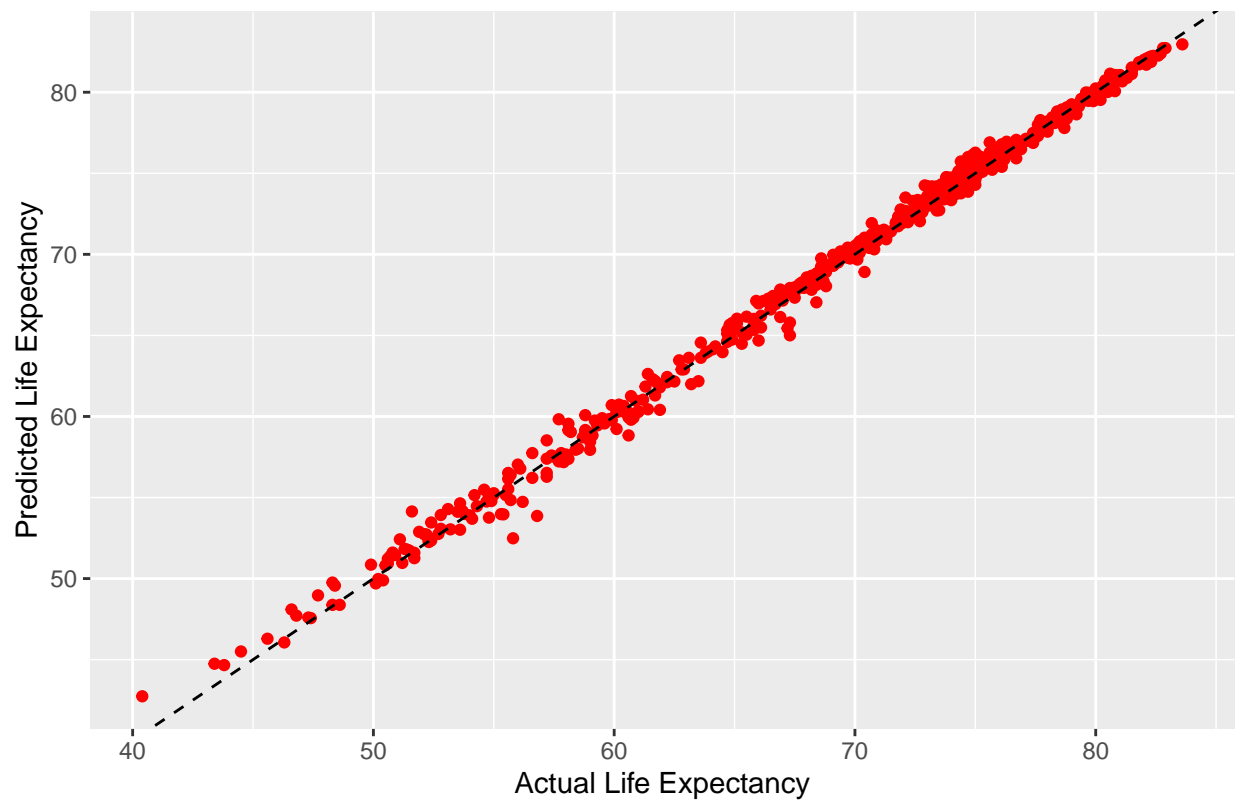
```
# Plot for SVM model
ggplot() +
```

```
geom_point(aes(x = actual_values, y = predictions_svm), colour = "green") +
geom_abline(intercept = 0, slope = 1, linetype = "dashed") +
labs(title = "SVM Model: Actual vs Predicted", x = "Actual Life Expectancy", y = "Predicted Life Expectancy")
```



```
# Plot for Random Forest Model
ggplot() +
  geom_point(aes(x = actual_values, y = predictions_rf), colour = "red") +
  geom_abline(intercept = 0, slope = 1, linetype = "dashed") +
  labs(title = "Random Forest Model: Actual vs Predicted", x = "Actual Life Expectancy", y = "Predicted Life Expectancy")
```

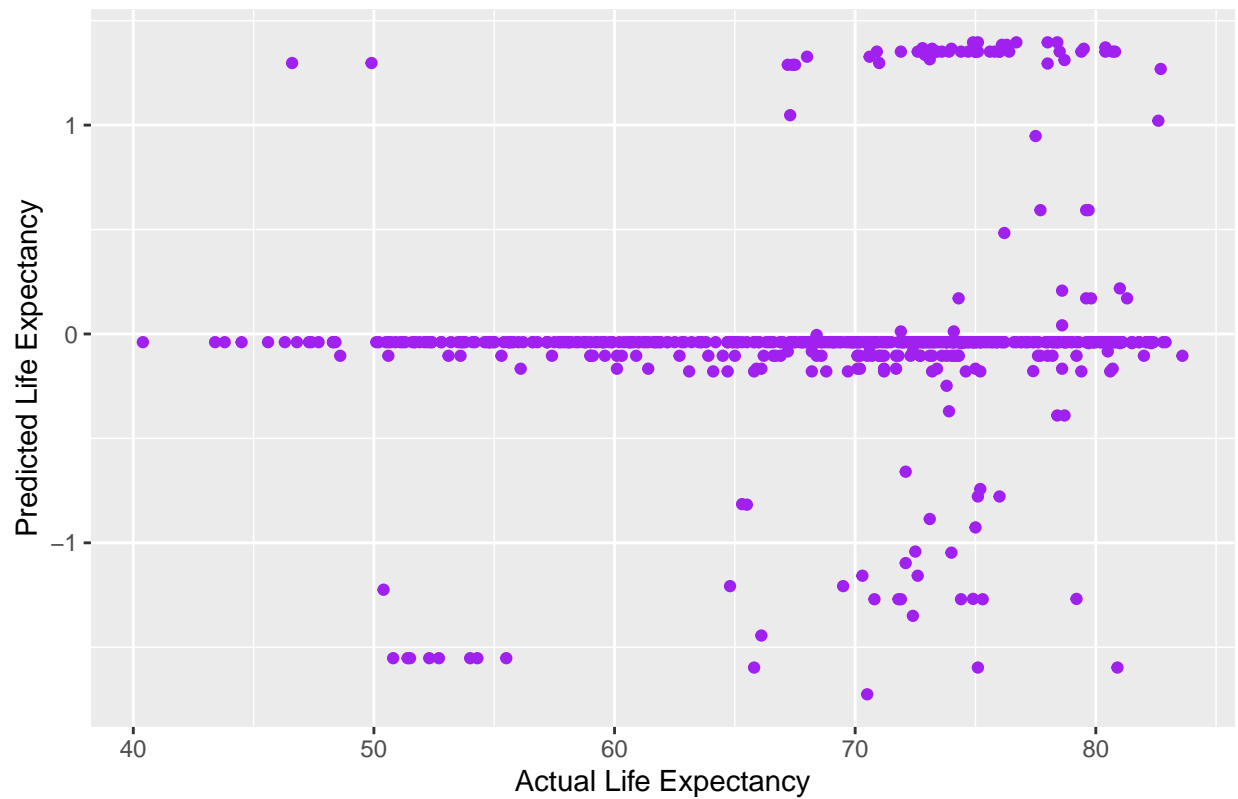
Random Forest Model: Actual vs Predicted



```
# Plot for KNN Model
ggplot() +
  geom_point(aes(x = actual_values, y = predictions_knn), colour = "purple") +
  geom_abline(intercept = 0, slope = 1, linetype = "dashed") +
  labs(title = "KNN Model: Actual vs Predicted", x = "Actual Life Expectancy", y = "Predicted Life Expectancy")
```

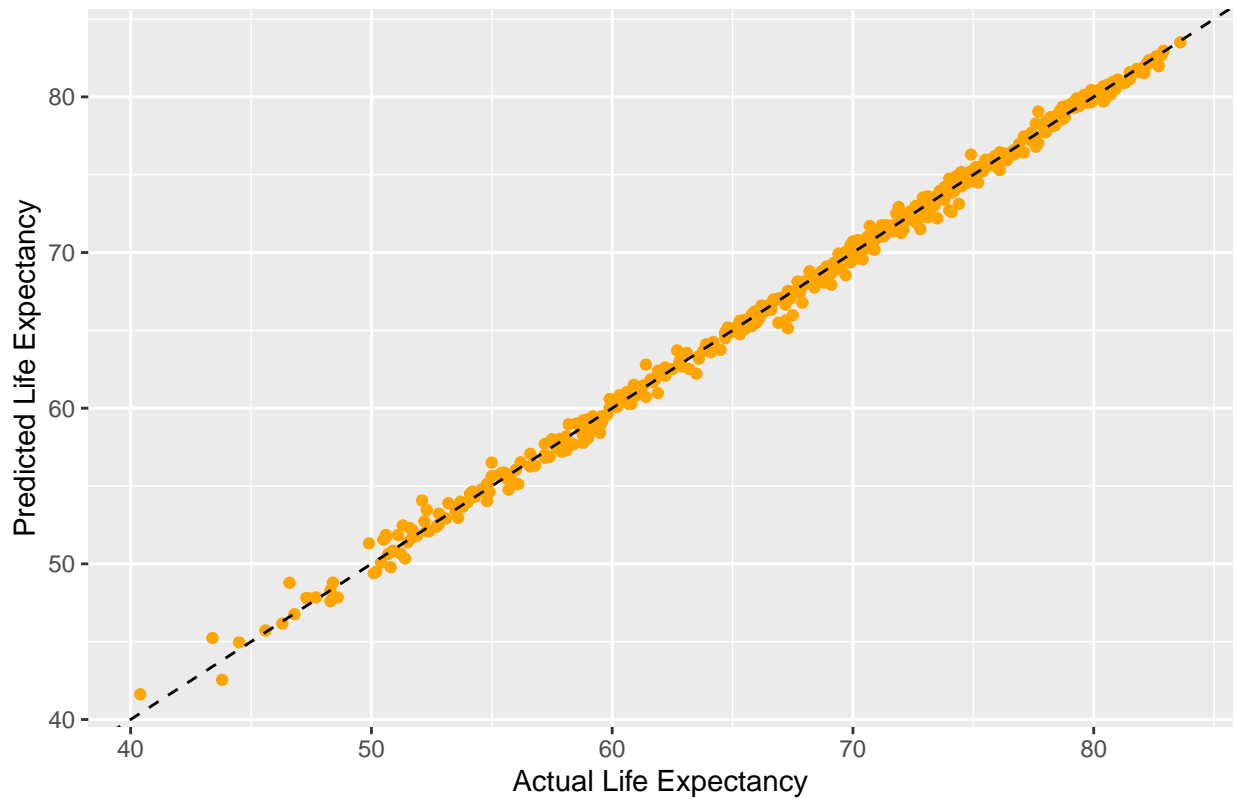


KNN Model: Actual vs Predicted



```
# Plot for LRM
ggplot() +
  geom_point(aes(x = actual_values, y = predictions_lm), colour = "orange") +
  geom_abline(intercept = 0, slope = 1, linetype = "dashed") +
  labs(title = "Linear Regression Model: Actual vs Predicted", x = "Actual Life Expectancy", y = "Predicted Life Expectancy")
```

## Linear Regression Model: Actual vs Predicted



```
# Plot together
# Combine all predictions into a single data frame
predictions_df <- data.frame(
  Actual = actual_values,
  ANN = predictions_ann,
  SVM = predictions_svm,
  RF = predictions_rf,
  KNN = predictions_knn,
  LM = predictions_lm
)
summary(predictions_df)
```

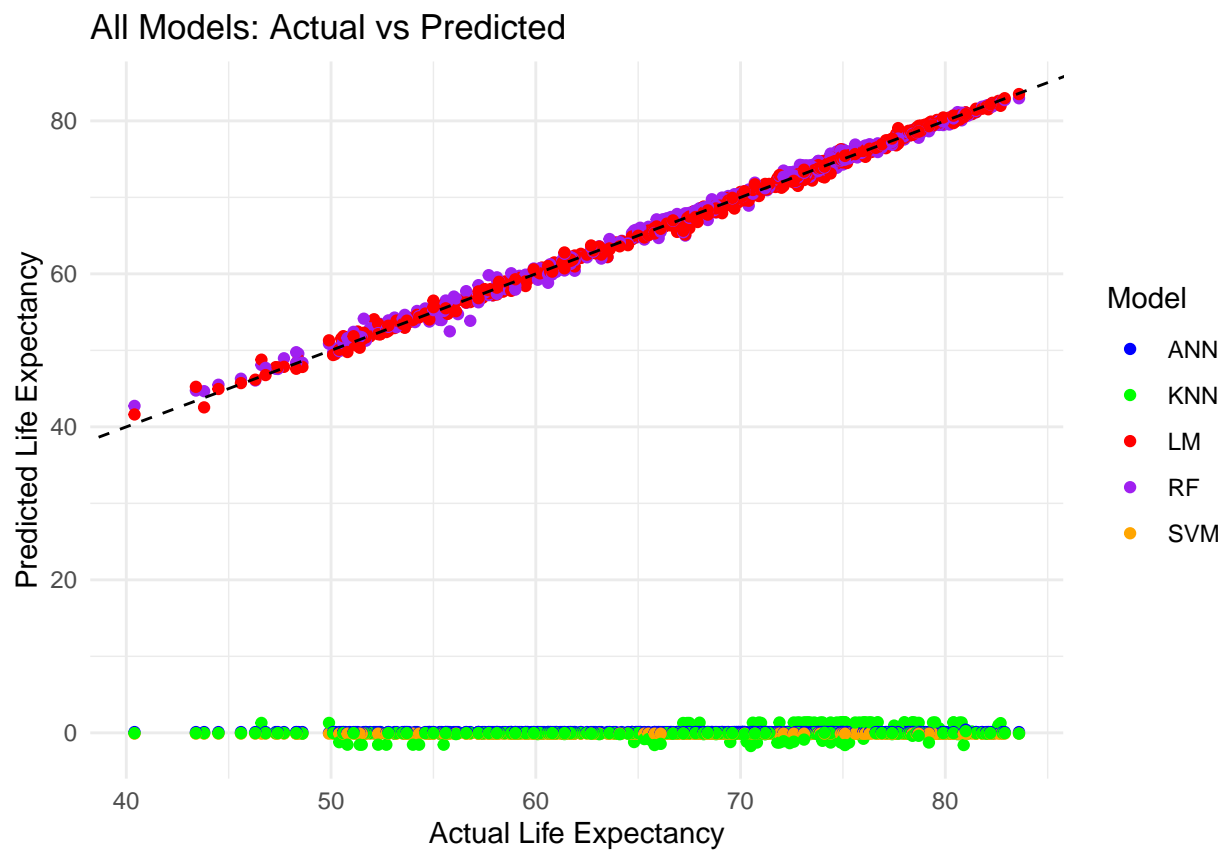
##	Actual	ANN	SVM	RF
##	Min. :40.40	Min. :0.0000011	Min. :-0.1058	Min. :42.74
##	1st Qu.:62.88	1st Qu.:0.1001680	1st Qu.: -0.1058	1st Qu.:62.83
##	Median :71.45	Median :0.1001680	Median : -0.1058	Median :71.63
##	Mean :69.07	Mean :0.0903847	Mean : -0.1058	Mean :69.20
##	3rd Qu.:75.33	3rd Qu.:0.1001680	3rd Qu.: -0.1058	3rd Qu.:75.83
##	Max. :83.60	Max. :0.4200999	Max. : -0.1058	Max. :82.96
##	KNN	LM		
##	Min. :-1.725341	Min. :41.62		
##	1st Qu.: -0.039256	1st Qu.:62.77		
##	Median : -0.039256	Median :71.49		
##	Mean : 0.001471	Mean :69.05		
##	3rd Qu.: -0.039256	3rd Qu.:75.49		
##	Max. : 1.396336	Max. :83.50		

```

# Convert to long format for plotting
predictions_long <- predictions_df %>%
  pivot_longer(cols = -Actual, names_to = "Model", values_to = "Predicted")

# Plot all models together
ggplot(predictions_long, aes(x = Actual, y = Predicted, colour = Model)) +
  geom_point() +
  geom_abline(intercept = 0, slope = 1, linetype = "dashed") +
  labs(title = "All Models: Actual vs Predicted", x = "Actual Life Expectancy", y = "Predicted Life Expectancy") +
  theme_minimal() +
  scale_colour_manual(values = c("blue", "green", "red", "purple", "orange"))

```



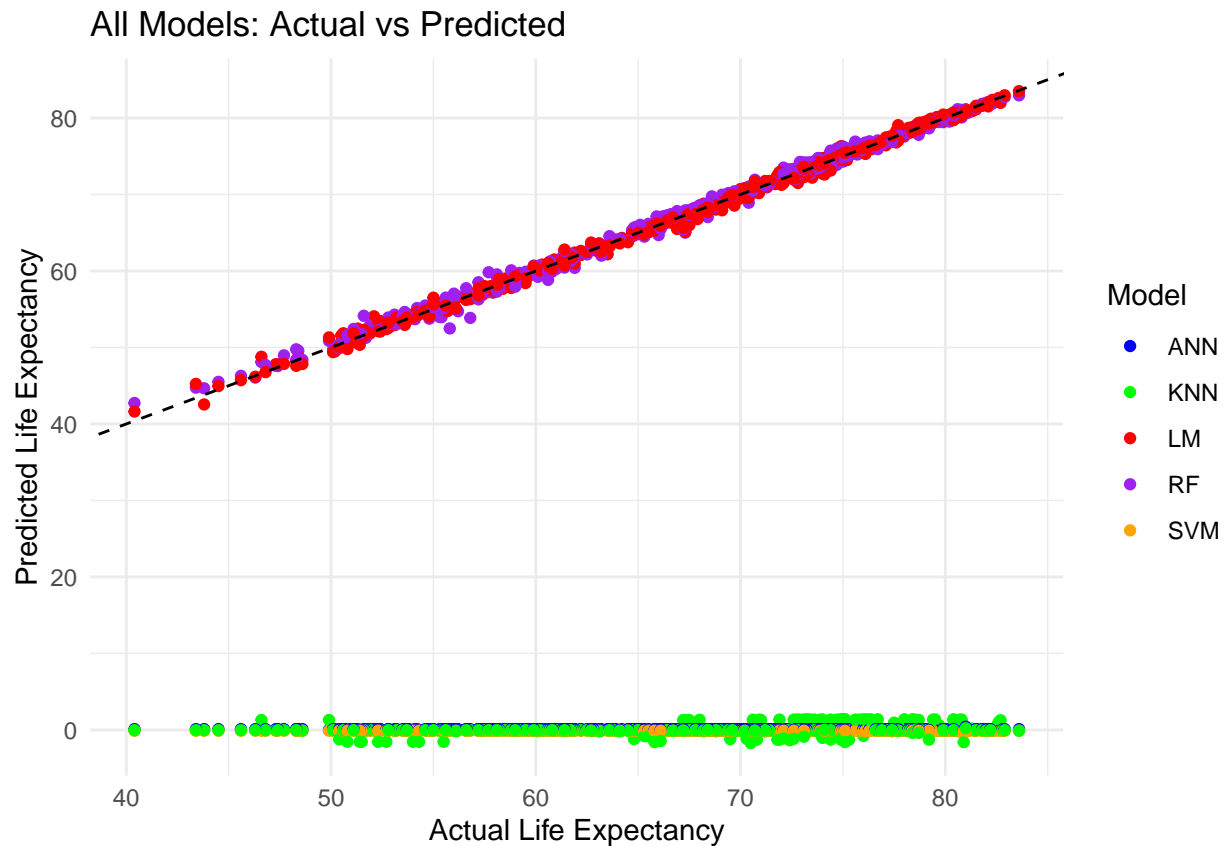
```

# Plot ML together
predictions_df <- data.frame(
  Actual = actual_values,
  ANN = predictions_ann,
  SVM = predictions_svm,
  RF = predictions_rf,
  KNN = predictions_knn,
  LM = predictions_lm
)

ggplot(predictions_long, aes(x = Actual, y = Predicted, colour = Model)) +
  geom_point() +
  geom_abline(intercept = 0, slope = 1, linetype = "dashed") +

```

```
labs(title = "All Models: Actual vs Predicted", x = "Actual Life Expectancy", y = "Predicted Life Exp")
theme_minimal() +
scale_colour_manual(values = c("blue", "green", "red", "purple", "orange"))
```



```
# Convert to long format for plotting
predictions_long <- predictions_df %>%
  pivot_longer(cols = c("ANN", "SVM", "RF", "KNN", "LM"), names_to = "Model", values_to = "Predicted")
```

#### #### Evaluation RMSE

```
calculateRMSE <- function(model, test_data) {
  predictions <- predict(model, test_data)
  mse <- mean((predictions - test_data$Life_expectancy)^2)
  return(sqrt(mse))
}
```

#### # Evaluate Models to get RMSE

```
rmse_ann <- calculateRMSE(ann_model, test_data)
rmse_knn <- calculateRMSE(knn_model, test_data) # Update this as per KNN's output format
rmse_svm <- calculateRMSE(svm_model, test_data)
rmse_rf <- calculateRMSE(rf_model, test_data)
rmse_lm <- calculateRMSE(lm_model, test_data) # Assuming lm_model is already fitted using train_data
```

```
## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
```

```
## attr(*, "non-estim") has doubtful cases
```

```
# Create a data frame with all RMSE values
rmse_data <- data.frame(
  Model = c("ANN", "KNN", "SVM", "RF", "LM"),
  RMSE = c(rmse_ann, rmse_knn, rmse_svm, rmse_rf, rmse_lm)
)
summary(rmse_data)
```

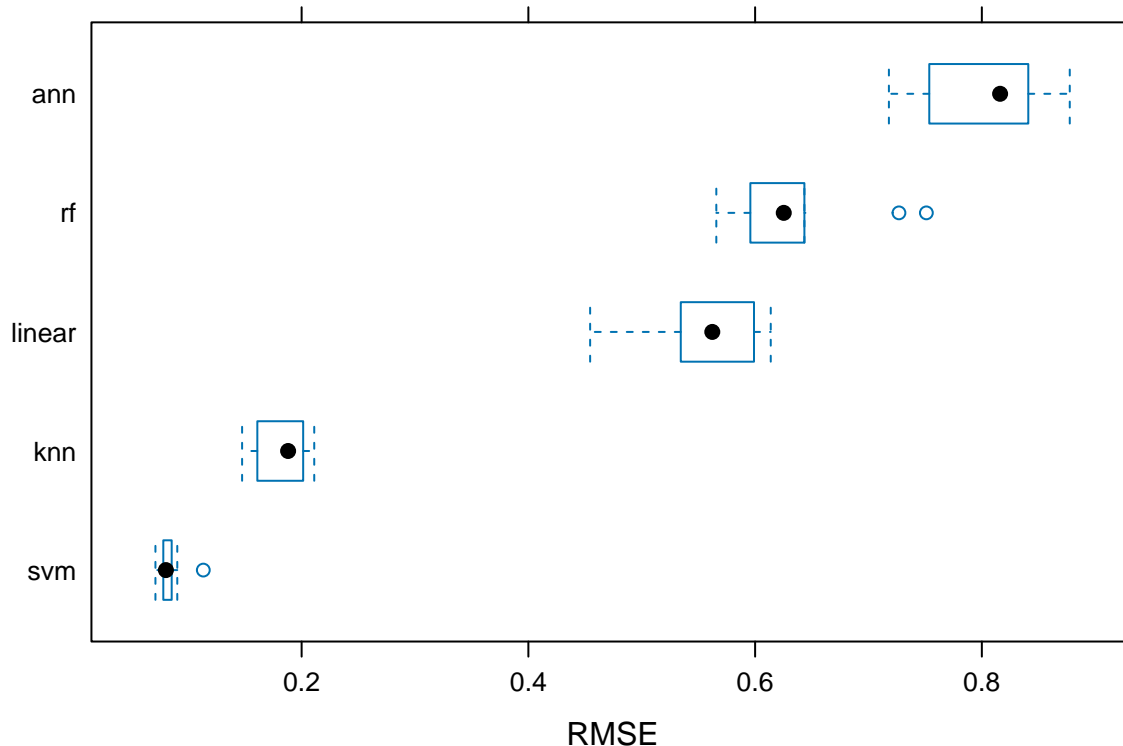
```
##      Model      RMSE
## Length:5      Min.   : 0.4712
## Class :character 1st Qu.: 0.6091
## Mode  :character Median :69.5914
##                      Mean  :42.0253
##                      3rd Qu.:69.6689
##                      Max.   :69.7860
```

```
#### Box and Whisker Plot
```

```
results <- resamples(list(linear = lm_model, knn = knn_model, ann = ann_model, svm = svm_model, rf = rf_model))
print(results)
```

```
##
## Call:
## resamples.default(x = list(linear = lm_model, knn = knn_model, ann =
##   ann_model, svm = svm_model, rf = rf_model))
##
## Models: linear, knn, ann, svm, rf
## Number of resamples: 10
## Performance metrics: MAE, RMSE, Rsquared
## Time estimates for: everything, final model fit
```

```
bwplot(results, metric = "RMSE")
```



## Part D: Splitting into Training & Validation

This part of the analysis focuses on preparing the dataset for predictive modeling by splitting it into training and validation sets. This is a crucial step in any data analysis project as it allows for the validation of model performance on unseen data.

### Data Splitting Process

- **Objective:** To divide the dataset into two parts; one for training the model and the other for validating its performance.
- **Method Used:** The data is split using the `createDataPartition` function from the `caret` package in R, ensuring a balanced distribution of the target variable, `Life_expectancy`, in both sets.
- **Seed Setting:** `set.seed(123)` is used for reproducibility, ensuring that the same random split can be generated again if needed.

### Training Data

- **Description:** The training data is used to build and train the predictive models. It consists of a larger portion of the dataset to provide the models with ample data to learn from.
- **Size of Training Data:** From the original dataset, 70% is allocated to the training set.
- **Training Data Snapshot:**
  - A tibble with 1,996 rows and 23 columns.

- Includes a diverse range of variables such as Country, Region, Year, Economy\_status\_Developed, Adult\_mortality, and others.

## Validation Data

- **Purpose:** This subset is used to validate the performance of the trained models. It acts as new, unseen data for the models to make predictions.
- **Size of Validation Data:** The remaining 30% of the dataset is used as validation data.
- **Validation Data Snapshot:**
  - A tibble with 852 rows and 23 columns.
  - Mirrors the structure of the training data, ensuring consistency in variable types and ranges.

## Summary

The dataset has been successfully split into training and validation sets, maintaining a balance in the distribution of the target variable. This split is essential for developing robust predictive models and evaluating their performance accurately.

```
# 1. Splitting the Data: Split data into training and validation sets.
set.seed(123) # For reproducibility
index <- createDataPartition(data$Life_expectancy, p = 0.7, list = FALSE)
train_data <- data[index, ]
validation_data <- data[-index, ]
print(validation_data)
```

```
## # A tibble: 852 x 23
##   Country   Region Year Economy_status_Devel~1 Life_expectancy Adult_mortality
##   <chr>     <chr> <dbl> <fct>                                <dbl>         <dbl>
## 1 Afghanis~ Asia   2000 0                                55.8         311.
## 2 Afghanis~ Asia   2001 0                                56.3         305.
## 3 Afghanis~ Asia   2002 0                                56.8         299.
## 4 Afghanis~ Asia   2003 0                                57.3         292.
## 5 Afghanis~ Asia   2006 0                                58.8         271.
## 6 Afghanis~ Asia   2008 0                                59.9         260.
## 7 Afghanis~ Asia   2014 0                                63           232.
## 8 Albania  Rest ~ 2001 0                                74.3         90.9
## 9 Albania  Rest ~ 2002 0                                74.6         87.2
## 10 Albania Rest ~ 2005 0                                75.2         84.5
## # i 842 more rows
## # i abbreviated name: 1: Economy_status_Developed
## # i 17 more variables: Infant_deaths <dbl>, Alcohol_consumption <dbl>,
## #   `percentage expenditure` <dbl>, Hepatitis_B <dbl>, Measles <dbl>,
## #   BMI <dbl>, Under_five_deaths <dbl>, Polio <dbl>, `Total expenditure` <dbl>,
## #   Diphtheria <dbl>, Incidents_HIV <dbl>, GDP_per_capita <dbl>,
## #   Population_millions <dbl>, Thinness_ten_nineteen_years <dbl>, ...
```

```
print(train_data)
```

```
## # A tibble: 1,996 x 23
##   Country   Region Year Economy_status_Devel~1 Life_expectancy Adult_mortality
```

```
##      <chr>      <chr> <dbl> <fct>                <dbl>                <dbl>
## 1 Afghanis~ Asia    2004 0                    57.8                285.
## 2 Afghanis~ Asia    2005 0                    58.3                278.
## 3 Afghanis~ Asia    2007 0                    59.4                265.
## 4 Afghanis~ Asia    2009 0                    60.5                255.
## 5 Afghanis~ Asia    2010 0                     61                250.
## 6 Afghanis~ Asia    2011 0                    61.6                245.
## 7 Afghanis~ Asia    2012 0                    62.1                240.
## 8 Afghanis~ Asia    2013 0                    62.5                236.
## 9 Afghanis~ Asia    2015 0                    63.4                228.
## 10 Albania  Rest ~ 2000 0                     74                 94.7
## # i 1,986 more rows
## # i abbreviated name: 1: Economy_status_Developed
## # i 17 more variables: Infant_deaths <dbl>, Alcohol_consumption <dbl>,
## #   `percentage expenditure` <dbl>, Hepatitis_B <dbl>, Measles <dbl>,
## #   BMI <dbl>, Under_five_deaths <dbl>, Polio <dbl>, `Total expenditure` <dbl>,
## #   Diphtheria <dbl>, Incidents_HIV <dbl>, GDP_per_capita <dbl>, ...
## #   Population_millions <dbl>, Thinness_ten_nineteen_years <dbl>, ...
```

## Part E: Recursive Feature Elimination (RFE) and Model Building

This section focuses on using Recursive Feature Elimination (RFE) with a random forest model to select important features and build predictive models.

### Comprehensive Analysis on Part E:

#### 1. Data Loading and Overview:

- The data (`trainData`) is loaded from a CSV file, containing 1,996 rows and 24 columns.
- The columns include a mix of character (`chr`) and double (`dbl`) types, covering various demographic and health-related metrics.

#### 2. Recursive Feature Elimination (RFE) Process:

- RFE is used to identify the most significant features that influence life expectancy. This method iteratively removes the least important features to find the best subset for prediction.
- Random forest is chosen as the feature selection method within RFE. This is a robust method considering it's good at handling both linear and non-linear relationships and can deal with high-dimensional data.
- The `rfeControl` function with cross-validation (`cv`) and 10 folds is set for the RFE process. Cross-validation helps in assessing the model's generalizability.

#### 3. Selected Features:

- The RFE process results in the selection of 21 features out of the original set. These include factors like `Adult_mortality`, `Infant_deaths`, `Alcohol_consumption`, country-specific indicators, and others.
- Notably, both direct health indicators (like `Adult_mortality`, `BMI`, `Diphtheria`) and socio-economic factors (`GDP_per_capita`, `Schooling`) are included, reflecting the multidimensional nature of life expectancy determinants.

#### 4. Linear Regression Model:

- A linear regression model (`simple_model`) is then built using the selected features.
- The model summary provides coefficients for each feature, which represent the estimated change in life expectancy for a one-unit change in the feature, holding all other features constant.



- The coefficients show a mix of positive and negative relationships. For example, increases in `Adult_mortality` and `Infant_deaths` are associated with decreases in life expectancy.
- `Year` has a positive coefficient, suggesting an overall improvement in life expectancy over time.
- The p-values indicate the statistical significance of each feature's relationship with life expectancy. Features with p-values below a typical alpha level (e.g., 0.05) are considered statistically significant.

#### 5. Interpretation of Coefficients:

- The large number of country-specific coefficients (dummy variables) suggests that geographical factors significantly influence life expectancy, likely due to differences in healthcare, lifestyle, and socio-economic conditions.
- Some coefficients are not defined due to singularities, possibly indicating multicollinearity issues where some variables are highly correlated with each other.

#### 6. Model Evaluation:

- The residuals of the model (difference between observed and predicted life expectancy) indicate the model's fit. A median close to zero suggests a good central tendency in predictions.
- However, the presence of significant residuals (Min, Max) suggests that there might be instances where the model does not predict accurately, indicating potential for model improvement.

#### 7. Considerations for Improvement:

- Addressing multicollinearity by removing or combining highly correlated variables could improve the model.
- Testing interaction effects or non-linear relationships could provide a more nuanced understanding.
- Validating the model on a separate test set would be crucial to assess its predictive accuracy.

#### 8. Model Summary and Performance:

- The initial simple linear regression model (`simple_model`) has a very high Multiple R-squared value (0.9971), indicating that the model explains almost all the variability in the response data around its mean. However, such a high value might also hint at overfitting.
- Three enhanced models were built for comparison: a model with polynomial terms (`model_1`), a reduced model with fewer predictors (`model_2`), and a generalized linear model with a logarithmic link (`model_3`).

#### 9. Enhanced Models Analysis:

- `Model_1` incorporates a quadratic term for `Alcohol_consumption`. It has a similar performance to the `simple_model`, suggesting that adding the quadratic term doesn't significantly change the model's explanatory power.
- `Model_2` focuses on key variables (`Year`, `Adult_mortality`, `Alcohol_consumption`, `BMI`). It understandably has a lower R-squared value (0.927) compared to the full model, indicating a reduction in explanatory power but potentially better generalizability.
- `Model_3` (GLM with log link) also shows a strong fit, but it's important to check if the assumptions of GLM are met in this case.

#### 10. Model Diagnostics and Residual Analysis:

- The influence plot and residuals plots are crucial for understanding model diagnostics. High Cook's Distance values in the influence plot indicate influential observations that might unduly affect the model's predictions.
- The residuals vs. fitted values plot should ideally show no discernible pattern. Patterns might suggest non-linearity, heteroscedasticity, or outliers.
- The histogram and Q-Q plot of residuals are used to check the normality assumption. In the ideal scenario, residuals should be normally distributed (bell-shaped histogram and points following the line in the Q-Q plot).

## 11. Model Comparison and Selection:

- ANOVA results are used to compare models statistically. A significant difference in the residual sum of squares between models suggests one model may be better than the other.
- Cross-validation results (RMSE, R-squared) can also be used to compare models. Lower RMSE and higher R-squared values on cross-validation suggest a model that generalizes better.

**12 Multicollinearity Check:** - High VIF (Variance Inflation Factor) values indicate multicollinearity, which can make coefficients unstable and difficult to interpret. It's important to address this by possibly removing or combining correlated predictors.

## 13. Visualization and Interpretation:

- Plots comparing actual vs. predicted life expectancy help visually assess model performance. Closer alignment of predicted values with actual ones indicates better model performance.
- The scatter plots, histograms, and Q-Q plots provide a visual means to assess model assumptions and fit, enhancing the statistical interpretation.

In conclusion, while the models demonstrate strong predictive power, careful consideration of overfitting, influence of outliers, and the fulfillment of model assumptions is necessary. The choice of model should balance complexity and generalizability, and diagnostics plots play a crucial role in this decision-making process.

In summary, the RFE process successfully identified key variables influencing life expectancy, and the linear regression model built with these variables provides insights into the nature of these relationships. However, there are opportunities for further refining and validating the model to enhance its predictive power.

```
# Load the data
trainData <- read_csv("train_data.csv")

## Rows: 1996 Columns: 24
## -- Column specification -----
## Delimiter: ","
## chr  (2): Country, Region
## dbl (22): Column1, Year, Economy_status_Developed, Life_expectancy, Adult_mo...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.

# Define control for RFE using a random forest selection function
control <- rfeControl(functions=rfFuncs, method="cv", number=10)

# Run RFE with Random Forest Model
# Perform the RFE to identify the most significant features for predicting life expectancy
# Specifying the outcome and predictors
results <- rfe(x=train_data[, -which(names(train_data) == "Life_expectancy")],
               y=train_data$Life_expectancy,
               sizes=c(1:5),
               rfeControl=control)

# Extract the best subset of variables
selected_features <- results$optVariables
print(selected_features)
```

```
## [1] "Adult_mortality"           "Infant_deaths"
## [3] "Alcohol_consumption"       "Country"
## [5] "Under_five_deaths"         "Year"
## [7] "Incidents_HIV"             "Income composition of resources"
## [9] "Total_expenditure"         "Thinness_ten_nineteen_years"
## [11] "Thinness_five_nine_years"  "Region"
## [13] "Measles"                   "Polio"
## [15] "BMI"                        "Diphtheria"
## [17] "GDP_per_capita"            "percentage expenditure"
## [19] "Schooling"                 "Hepatitis_B"
## [21] "Population_millions"       "Economy_status_Developed"
```

```
# Use only these selected features for model training
train_data_selected <- trainData[, c(selected_features, "Life_expectancy")]

# Simple Linear Regression Model
simple_model <- lm(Life_expectancy ~ ., data = train_data_selected)
summary(simple_model)
```

```
##
## Call:
## lm(formula = Life_expectancy ~ ., data = train_data_selected)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.1432 -0.2178 -0.0087  0.2001  3.2582
##
## Coefficients: (9 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -1.444e+02  1.247e+01 -11.585 < 2e-16
## Adult_mortality -4.070e-02  8.744e-04 -46.543 < 2e-16
## Infant_deaths  -8.724e-02  2.970e-03 -29.374 < 2e-16
## Alcohol_consumption -3.304e-02  1.573e-02 -2.100 0.035832
## CountryAlbania    4.483e+00  4.119e-01  10.882 < 2e-16
## CountryAlgeria    4.325e+00  3.387e-01  12.769 < 2e-16
## CountryAngola    -3.686e+00  2.875e-01 -12.821 < 2e-16
## CountryAntigua and Barbuda 5.789e+00  4.153e-01  13.941 < 2e-16
## CountryArgentina  5.171e+00  4.196e-01  12.323 < 2e-16
## CountryArmenia    4.184e+00  4.493e-01  9.313 < 2e-16
## CountryAustria    8.410e+00  5.166e-01  16.280 < 2e-16
## CountryAustria    7.605e+00  5.048e-01  15.066 < 2e-16
## CountryAzerbaijan  2.912e+00  4.317e-01  6.746 2.05e-11
## CountryBahamas, The 4.576e+00  4.691e-01  9.756 < 2e-16
## CountryBahrain    3.131e+00  3.895e-01  8.037 1.65e-15
## CountryBangladesh  2.157e+00  2.676e-01  8.062 1.35e-15
## CountryBarbados   7.937e+00  4.219e-01  18.811 < 2e-16
## CountryBelarus    4.068e+00  4.810e-01  8.457 < 2e-16
## CountryBelgium    7.493e+00  4.911e-01  15.259 < 2e-16
## CountryBelize     4.106e+00  4.327e-01  9.490 < 2e-16
## CountryBenin      -1.378e+00  2.601e-01 -5.298 1.31e-07
## CountryBhutan     2.846e+00  2.645e-01  10.762 < 2e-16
## CountryBolivia    2.183e+00  3.431e-01  6.362 2.52e-10
## CountryBosnia and Herzegovina 4.277e+00  3.768e-01  11.349 < 2e-16
## CountryBotswana   1.734e+00  3.943e-01  4.398 1.16e-05
```

## CountryBrazil	4.694e+00	3.570e-01	13.147	< 2e-16
## CountryBrunei Darussalam	2.498e+00	3.956e-01	6.313	3.44e-10
## CountryBulgaria	4.124e+00	4.555e-01	9.054	< 2e-16
## CountryBurkina Faso	-3.015e+00	3.020e-01	-9.983	< 2e-16
## CountryBurundi	-2.121e+00	2.705e-01	-7.841	7.57e-15
## CountryCabo Verde	1.627e+00	3.186e-01	5.106	3.64e-07
## CountryCambodia	3.921e-01	2.839e-01	1.381	0.167402
## CountryCameroon	-6.909e-01	2.825e-01	-2.446	0.014560
## CountryCanada	8.249e+00	5.088e-01	16.212	< 2e-16
## CountryCentral African Republic	-1.277e+00	3.426e-01	-3.728	0.000199
## CountryChad	-3.304e+00	2.928e-01	-11.286	< 2e-16
## CountryChile	6.895e+00	4.214e-01	16.362	< 2e-16
## CountryChina	2.755e+00	3.772e-01	7.303	4.21e-13
## CountryColombia	6.350e+00	3.719e-01	17.077	< 2e-16
## CountryComoros	2.386e-01	2.796e-01	0.853	0.393554
## CountryCongo, Dem. Rep.	-1.601e+00	2.739e-01	-5.845	5.99e-09
## CountryCongo, Rep.	-2.011e-01	2.921e-01	-0.688	0.491259
## CountryCosta Rica	6.824e+00	3.868e-01	17.642	< 2e-16
## CountryCroatia	4.793e+00	4.730e-01	10.133	< 2e-16
## CountryCuba	6.291e+00	4.407e-01	14.274	< 2e-16
## CountryCyprus	5.977e+00	4.940e-01	12.100	< 2e-16
## CountryCzechia	5.342e+00	5.156e-01	10.359	< 2e-16
## CountryDenmark	6.643e+00	5.465e-01	12.155	< 2e-16
## CountryDjibouti	2.983e-01	2.638e-01	1.131	0.258315
## CountryDominican Republic	4.787e+00	3.401e-01	14.076	< 2e-16
## CountryEcuador	5.508e+00	3.660e-01	15.050	< 2e-16
## CountryEgypt, Arab Rep.	2.293e+00	3.319e-01	6.908	6.79e-12
## CountryEl Salvador	4.038e+00	3.294e-01	12.258	< 2e-16
## CountryEquatorial Guinea	-3.056e-03	3.246e-01	-0.009	0.992490
## CountryEritrea	2.898e-02	2.695e-01	0.108	0.914382
## CountryEstonia	5.387e+00	5.367e-01	10.038	< 2e-16
## CountryEswatini	-2.606e+00	3.574e-01	-7.293	4.52e-13
## CountryEthiopia	-4.381e-02	2.734e-01	-0.160	0.872736
## CountryFiji	3.497e-01	4.126e-01	0.848	0.396739
## CountryFinland	7.462e+00	4.974e-01	15.000	< 2e-16
## CountryFrance	9.023e+00	4.919e-01	18.342	< 2e-16
## CountryGabon	-4.392e-02	3.532e-01	-0.124	0.901043
## CountryGambia	-2.311e+00	2.614e-01	-8.843	< 2e-16
## CountryGeorgia	3.649e+00	4.784e-01	7.626	3.90e-14
## CountryGermany	7.488e+00	5.551e-01	13.490	< 2e-16
## CountryGhana	-1.094e+00	3.005e-01	-3.639	0.000282
## CountryGreece	7.346e+00	4.509e-01	16.292	< 2e-16
## CountryGrenada	4.166e+00	3.766e-01	11.062	< 2e-16
## CountryGuatemala	4.272e+00	3.018e-01	14.156	< 2e-16
## CountryGuinea	-2.348e+00	2.732e-01	-8.594	< 2e-16
## CountryGuinea-Bissau	-4.219e+00	2.697e-01	-15.642	< 2e-16
## CountryGuyana	2.860e+00	3.594e-01	7.959	3.05e-15
## CountryHaiti	4.762e-02	2.763e-01	0.172	0.863145
## CountryHonduras	4.442e+00	3.080e-01	14.421	< 2e-16
## CountryHungary	5.164e+00	4.977e-01	10.374	< 2e-16
## CountryIceland	8.192e+00	4.758e-01	17.218	< 2e-16
## CountryIndia	2.246e+00	6.111e-01	3.675	0.000245
## CountryIndonesia	2.062e+00	3.486e-01	5.914	3.99e-09
## CountryIran	3.118e+00	3.669e-01	8.498	< 2e-16

## CountryIraq	1.965e+00	3.098e-01	6.343	2.84e-10
## CountryIreland	7.224e+00	5.262e-01	13.728	< 2e-16
## CountryIsrael	7.808e+00	5.158e-01	15.139	< 2e-16
## CountryItaly	8.065e+00	4.459e-01	18.089	< 2e-16
## CountryJamaica	5.235e+00	3.883e-01	13.480	< 2e-16
## CountryJapan	9.508e+00	4.991e-01	19.051	< 2e-16
## CountryJordan	3.205e+00	4.044e-01	7.926	3.94e-15
## CountryKazakhstan	4.048e+00	4.657e-01	8.693	< 2e-16
## CountryKenya	-5.323e-01	3.039e-01	-1.752	0.079960
## CountryKiribati	1.419e+00	3.410e-01	4.162	3.31e-05
## CountryKuwait	1.172e+00	3.650e-01	3.211	0.001347
## CountryKyrgyz Republic	4.175e+00	4.209e-01	9.918	< 2e-16
## CountryLao PDR	9.224e-01	2.720e-01	3.391	0.000711
## CountryLatvia	5.314e+00	5.002e-01	10.624	< 2e-16
## CountryLebanon	5.057e+00	3.772e-01	13.408	< 2e-16
## CountryLesotho	-1.428e+00	3.351e-01	-4.260	2.15e-05
## CountryLiberia	9.269e-02	2.744e-01	0.338	0.735512
## CountryLibya	2.348e+00	3.381e-01	6.946	5.22e-12
## CountryLithuania	5.546e+00	5.088e-01	10.901	< 2e-16
## CountryLuxembourg	7.481e+00	5.102e-01	14.663	< 2e-16
## CountryMadagascar	6.305e-01	2.879e-01	2.190	0.028662
## CountryMalawi	-5.144e-01	2.918e-01	-1.763	0.078127
## CountryMalaysia	3.634e+00	3.920e-01	9.268	< 2e-16
## CountryMaldives	3.258e+00	3.094e-01	10.530	< 2e-16
## CountryMali	-4.365e+00	2.703e-01	-16.151	< 2e-16
## CountryMalta	6.856e+00	4.446e-01	15.418	< 2e-16
## CountryMauritania	-2.627e-01	2.632e-01	-0.998	0.318367
## CountryMauritius	4.083e+00	3.570e-01	11.438	< 2e-16
## CountryMexico	5.330e+00	3.766e-01	14.154	< 2e-16
## CountryMicronesia, Fed. Sts.	-1.049e+00	3.337e-01	-3.143	0.001698
## CountryMoldova	2.811e+00	4.511e-01	6.230	5.79e-10
## CountryMongolia	2.347e+00	3.933e-01	5.967	2.90e-09
## CountryMontenegro	4.468e+00	4.667e-01	9.574	< 2e-16
## CountryMorocco	2.921e+00	3.061e-01	9.540	< 2e-16
## CountryMozambique	-1.696e+00	2.912e-01	-5.824	6.79e-09
## CountryMyanmar	-3.364e-01	2.578e-01	-1.305	0.191993
## CountryNamibia	-3.068e-01	3.268e-01	-0.939	0.348035
## CountryNepal	1.166e+00	2.608e-01	4.472	8.25e-06
## CountryNetherlands	7.346e+00	5.097e-01	14.412	< 2e-16
## CountryNew Zealand	7.837e+00	5.069e-01	15.460	< 2e-16
## CountryNicaragua	4.158e+00	3.186e-01	13.050	< 2e-16
## CountryNiger	-4.093e+00	2.610e-01	-15.681	< 2e-16
## CountryNigeria	-2.700e+00	4.076e-01	-6.624	4.59e-11
## CountryNorth Macedonia	3.522e+00	4.089e-01	8.613	< 2e-16
## CountryNorway	7.814e+00	5.145e-01	15.186	< 2e-16
## CountryOman	3.589e+00	3.559e-01	10.083	< 2e-16
## CountryPakistan	1.694e+00	2.901e-01	5.841	6.14e-09
## CountryPanama	6.779e+00	4.067e-01	16.668	< 2e-16
## CountryPapua New Guinea	-1.443e+00	2.850e-01	-5.064	4.54e-07
## CountryParaguay	4.283e+00	3.582e-01	11.958	< 2e-16
## CountryPeru	4.587e+00	3.985e-01	11.511	< 2e-16
## CountryPhilippines	3.999e+00	3.840e-01	10.415	< 2e-16
## CountryPoland	5.713e+00	5.057e-01	11.296	< 2e-16
## CountryPortugal	6.660e+00	4.210e-01	15.819	< 2e-16

## CountryQatar	5.516e+00	4.257e-01	12.958	< 2e-16
## CountryRomania	4.313e+00	4.510e-01	9.563	< 2e-16
## CountryRussian Federation	3.956e+00	5.118e-01	7.729	1.79e-14
## CountryRwanda	-1.542e-01	2.927e-01	-0.527	0.598448
## CountrySamoa	2.027e+00	4.185e-01	4.843	1.39e-06
## CountrySao Tome and Principe	8.803e-01	3.200e-01	2.751	0.006001
## CountrySaudi Arabia	2.359e+00	3.687e-01	6.397	2.01e-10
## CountrySenegal	-1.066e+00	2.628e-01	-4.058	5.15e-05
## CountrySerbia	3.804e+00	4.621e-01	8.232	3.50e-16
## CountrySeychelles	4.223e+00	3.882e-01	10.878	< 2e-16
## CountrySierra Leone	-1.345e+00	3.076e-01	-4.372	1.30e-05
## CountrySingapore	7.227e+00	4.614e-01	15.662	< 2e-16
## CountrySlovak Republic	4.809e+00	4.926e-01	9.762	< 2e-16
## CountrySlovenia	7.023e+00	5.086e-01	13.808	< 2e-16
## CountrySolomon Islands	2.697e+00	3.142e-01	8.582	< 2e-16
## CountrySomalia	-1.505e+00	3.183e-01	-4.727	2.45e-06
## CountrySouth Africa	2.959e+00	4.071e-01	7.269	5.38e-13
## CountrySpain	8.244e+00	4.385e-01	18.800	< 2e-16
## CountrySri Lanka	4.997e+00	4.218e-01	11.848	< 2e-16
## CountrySt. Lucia	6.133e+00	4.253e-01	14.421	< 2e-16
## CountrySt. Vincent and the Grenadines	3.995e+00	4.003e-01	9.980	< 2e-16
## CountrySuriname	2.942e+00	3.647e-01	8.066	1.32e-15
## CountrySweden	7.865e+00	5.185e-01	15.170	< 2e-16
## CountrySwitzerland	8.810e+00	5.376e-01	16.389	< 2e-16
## CountrySyrian Arab Republic	3.145e+00	3.214e-01	9.783	< 2e-16
## CountryTajikistan	9.304e-01	4.081e-01	2.280	0.022724
## CountryTanzania	-6.966e-01	3.372e-01	-2.066	0.039011
## CountryThailand	5.117e+00	3.408e-01	15.014	< 2e-16
## CountryTimor-Leste	1.401e+00	2.606e-01	5.375	8.64e-08
## CountryTogo	-2.190e+00	2.770e-01	-7.905	4.64e-15
## CountryTonga	6.899e-01	4.393e-01	1.570	0.116492
## CountryTrinidad and Tobago	4.556e+00	4.152e-01	10.973	< 2e-16
## CountryTunisia	3.784e+00	3.425e-01	11.049	< 2e-16
## CountryTurkiye	3.668e+00	3.283e-01	11.174	< 2e-16
## CountryTurkmenistan	1.694e+00	3.970e-01	4.268	2.08e-05
## CountryUganda	-3.604e-01	3.580e-01	-1.007	0.314180
## CountryUkraine	4.122e+00	4.705e-01	8.762	< 2e-16
## CountryUnited Arab Emirates	3.545e+00	4.136e-01	8.572	< 2e-16
## CountryUnited Kingdom	7.254e+00	5.238e-01	13.849	< 2e-16
## CountryUnited States	6.984e+00	5.275e-01	13.242	< 2e-16
## CountryUruguay	5.565e+00	3.925e-01	14.176	< 2e-16
## CountryUzbekistan	2.307e+00	4.156e-01	5.551	3.26e-08
## CountryVanuatu	5.053e-01	3.358e-01	1.505	0.132595
## CountryVenezuela, RB	4.202e+00	4.107e-01	10.230	< 2e-16
## CountryVietnam	5.166e+00	3.181e-01	16.239	< 2e-16
## CountryYemen, Rep.	1.582e+00	2.670e-01	5.923	3.77e-09
## CountryZambia	-1.639e-01	3.285e-01	-0.499	0.617992
## CountryZimbabwe	1.227e-01	3.919e-01	0.313	0.754261
## Under_five_deaths	-1.894e-04	3.155e-04	-0.600	0.548396
## Year	1.103e-01	6.206e-03	17.777	< 2e-16
## Incidents_HIV	-1.435e-03	8.160e-03	-0.176	0.860402
## `Income composition of resources`	-2.886e-01	1.431e-01	-2.017	0.043844
## `Total expenditure`	-3.285e-03	6.120e-03	-0.537	0.591500
## Thinness_ten_nineteen_years	-1.631e-02	9.602e-03	-1.699	0.089475

## Thinness_five_nine_years	3.936e-03	9.473e-03	0.415	0.677840
## RegionAsia	NA	NA	NA	NA
## RegionCentral America and Caribbean	NA	NA	NA	NA
## RegionEuropean Union	NA	NA	NA	NA
## RegionMiddle East	NA	NA	NA	NA
## RegionNorth America	NA	NA	NA	NA
## RegionOceania	NA	NA	NA	NA
## RegionRest of Europe	NA	NA	NA	NA
## RegionSouth America	NA	NA	NA	NA
## Measles	-1.464e-06	1.610e-06	-0.910	0.363115
## Polio	9.009e-04	7.935e-04	1.135	0.256373
## BMI	7.429e-04	1.014e-03	0.733	0.463870
## Diphtheria	1.349e-03	9.127e-04	1.478	0.139682
## GDP_per_capita	1.824e-06	2.637e-06	0.692	0.489321
## `percentage expenditure`	-1.900e-06	1.647e-05	-0.115	0.908163
## Schooling	-7.888e-02	3.863e-02	-2.042	0.041340
## Hepatitis_B	7.493e-04	5.853e-04	1.280	0.200613
## Population_millions	6.917e-11	2.712e-10	0.255	0.798742
## Economy_status_Developed	NA	NA	NA	NA
##				
## (Intercept)	***			
## Adult_mortality	***			
## Infant_deaths	***			
## Alcohol_consumption	*			
## CountryAlbania	***			
## CountryAlgeria	***			
## CountryAngola	***			
## CountryAntigua and Barbuda	***			
## CountryArgentina	***			
## CountryArmenia	***			
## CountryAustralia	***			
## CountryAustria	***			
## CountryAzerbaijan	***			
## CountryBahamas, The	***			
## CountryBahrain	***			
## CountryBangladesh	***			
## CountryBarbados	***			
## CountryBelarus	***			
## CountryBelgium	***			
## CountryBelize	***			
## CountryBenin	***			
## CountryBhutan	***			
## CountryBolivia	***			
## CountryBosnia and Herzegovina	***			
## CountryBotswana	***			
## CountryBrazil	***			
## CountryBrunei Darussalam	***			
## CountryBulgaria	***			
## CountryBurkina Faso	***			
## CountryBurundi	***			
## CountryCabo Verde	***			
## CountryCambodia				
## CountryCameroon	*			
## CountryCanada	***			

## CountryCentral African Republic	***
## CountryChad	***
## CountryChile	***
## CountryChina	***
## CountryColombia	***
## CountryComoros	
## CountryCongo, Dem. Rep.	***
## CountryCongo, Rep.	
## CountryCosta Rica	***
## CountryCroatia	***
## CountryCuba	***
## CountryCyprus	***
## CountryCzechia	***
## CountryDenmark	***
## CountryDjibouti	
## CountryDominican Republic	***
## CountryEcuador	***
## CountryEgypt, Arab Rep.	***
## CountryEl Salvador	***
## CountryEquatorial Guinea	
## CountryEritrea	
## CountryEstonia	***
## CountryEswatini	***
## CountryEthiopia	
## CountryFiji	
## CountryFinland	***
## CountryFrance	***
## CountryGabon	
## CountryGambia	***
## CountryGeorgia	***
## CountryGermany	***
## CountryGhana	***
## CountryGreece	***
## CountryGrenada	***
## CountryGuatemala	***
## CountryGuinea	***
## CountryGuinea-Bissau	***
## CountryGuyana	***
## CountryHaiti	
## CountryHonduras	***
## CountryHungary	***
## CountryIceland	***
## CountryIndia	***
## CountryIndonesia	***
## CountryIran	***
## CountryIraq	***
## CountryIreland	***
## CountryIsrael	***
## CountryItaly	***
## CountryJamaica	***
## CountryJapan	***
## CountryJordan	***
## CountryKazakhstan	***
## CountryKenya	.



## CountryKiribati	***
## CountryKuwait	**
## CountryKyrgyz Republic	***
## CountryLao PDR	***
## CountryLatvia	***
## CountryLebanon	***
## CountryLesotho	***
## CountryLiberia	
## CountryLibya	***
## CountryLithuania	***
## CountryLuxembourg	***
## CountryMadagascar	*
## CountryMalawi	.
## CountryMalaysia	***
## CountryMaldives	***
## CountryMali	***
## CountryMalta	***
## CountryMauritania	
## CountryMauritius	***
## CountryMexico	***
## CountryMicronesia, Fed. Sts.	**
## CountryMoldova	***
## CountryMongolia	***
## CountryMontenegro	***
## CountryMorocco	***
## CountryMozambique	***
## CountryMyanmar	
## CountryNamibia	
## CountryNepal	***
## CountryNetherlands	***
## CountryNew Zealand	***
## CountryNicaragua	***
## CountryNiger	***
## CountryNigeria	***
## CountryNorth Macedonia	***
## CountryNorway	***
## CountryOman	***
## CountryPakistan	***
## CountryPanama	***
## CountryPapua New Guinea	***
## CountryParaguay	***
## CountryPeru	***
## CountryPhilippines	***
## CountryPoland	***
## CountryPortugal	***
## CountryQatar	***
## CountryRomania	***
## CountryRussian Federation	***
## CountryRwanda	
## CountrySamoa	***
## CountrySao Tome and Principe	**
## CountrySaudi Arabia	***
## CountrySenegal	***
## CountrySerbia	***

```

## CountrySeychelles          ***
## CountrySierra Leone       ***
## CountrySingapore           ***
## CountrySlovak Republic     ***
## CountrySlovenia            ***
## CountrySolomon Islands     ***
## CountrySomalia             ***
## CountrySouth Africa        ***
## CountrySpain               ***
## CountrySri Lanka           ***
## CountrySt. Lucia           ***
## CountrySt. Vincent and the Grenadines ***
## CountrySuriname            ***
## CountrySweden              ***
## CountrySwitzerland         ***
## CountrySyrian Arab Republic ***
## CountryTajikistan          *
## CountryTanzania            *
## CountryThailand             ***
## CountryTimor-Leste         ***
## CountryTogo                 ***
## CountryTonga                *
## CountryTrinidad and Tobago ***
## CountryTunisia             ***
## CountryTurkiye             ***
## CountryTurkmenistan        ***
## CountryUganda              *
## CountryUkraine             ***
## CountryUnited Arab Emirates ***
## CountryUnited Kingdom      ***
## CountryUnited States       ***
## CountryUruguay             ***
## CountryUzbekistan          ***
## CountryVanuatu              *
## CountryVenezuela, RB       ***
## CountryVietnam             ***
## CountryYemen, Rep.         ***
## CountryZambia              *
## CountryZimbabwe            *
## Under_five_deaths          ***
## Year                       ***
## Incidents_HIV              ***
## `Income composition of resources` *
## `Total expenditure`        *
## Thinness_ten_nineteen_years .
## Thinness_five_nine_years  .
## RegionAsia                 .
## RegionCentral America and Caribbean
## RegionEuropean Union       .
## RegionMiddle East          .
## RegionNorth America         .
## RegionOceania               .
## RegionRest of Europe        .
## RegionSouth America         .

```

```

## Measles
## Polio
## BMI
## Diphtheria
## GDP_per_capita
## `percentage expenditure`
## Schooling
## Hepatitis_B
## Population_millions
## Economy_status_Developed
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5291 on 1799 degrees of freedom
## Multiple R-squared:  0.9971, Adjusted R-squared:  0.9968
## F-statistic: 3183 on 196 and 1799 DF, p-value: < 2.2e-16

# Influence PLOT
influencePlot(simple_model, id.method="identify", main="Influence Plot",
              sub="Circle size is proportional to Cook's Distance")

## Warning in plot.window(...): "id.method" is not a graphical parameter

## Warning in plot.xy(xy, type, ...): "id.method" is not a graphical parameter

## Warning in axis(side = side, at = at, labels = labels, ...): "id.method" is not
## a graphical parameter

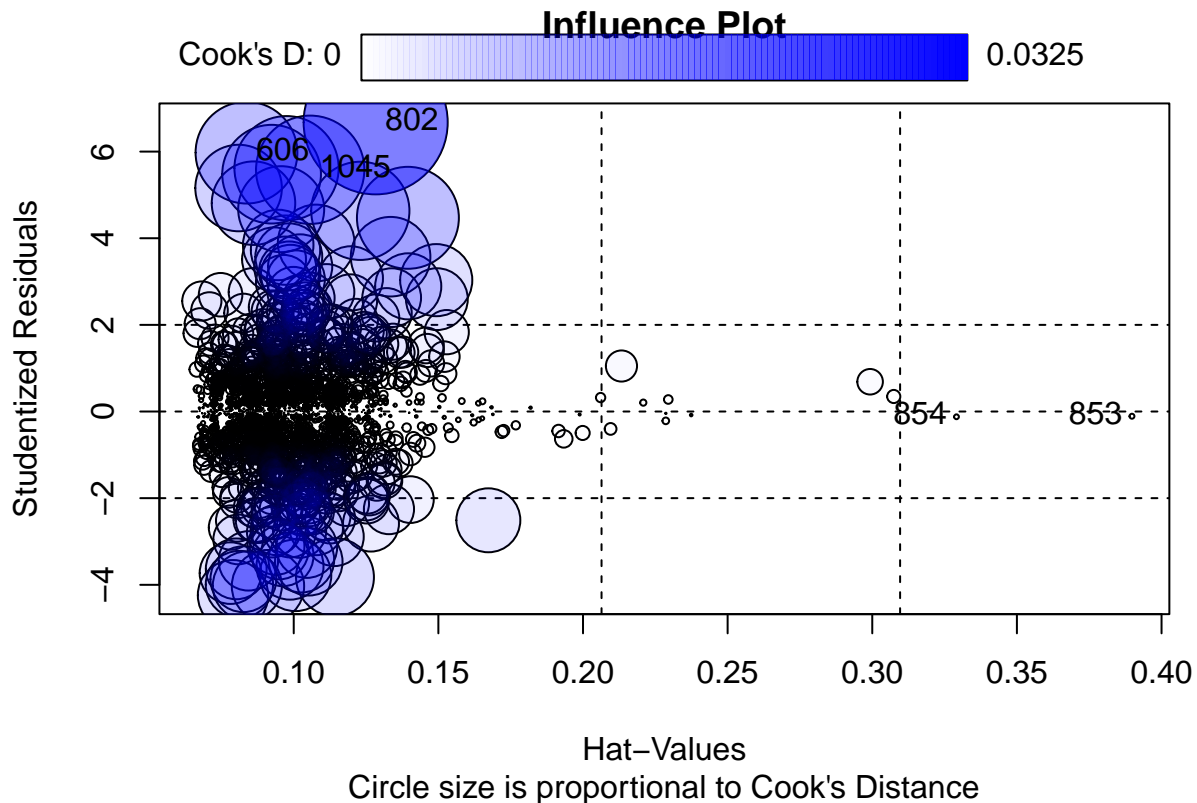
## Warning in axis(side = side, at = at, labels = labels, ...): "id.method" is not
## a graphical parameter

## Warning in box(...): "id.method" is not a graphical parameter

## Warning in title(...): "id.method" is not a graphical parameter

## Warning in plot.xy(xy.coords(x, y), type = type, ...): "id.method" is not a
## graphical parameter

```



```
##           StudRes      Hat      CookD
## 606      5.9761888 0.08366793 1.624007e-02
## 802      6.6750860 0.12832118 3.250870e-02
## 853     -0.1088356 0.38976986 3.842636e-05
## 854     -0.1213443 0.32910775 3.668558e-05
## 1045     5.5808644 0.10568911 1.837643e-02
```

```
# Enhanced Model Plots : Model 1, Model 2, Model 3
# Model 1 Enhanced Model with Polynomial Terms
enhanced_model <- lm(Life_expectancy ~ . + I(Alcohol_consumption^2), data = train_data_selected)
model_1 <- (enhanced_model)
summary(model_1)
```

```
##
## Call:
## lm(formula = Life_expectancy ~ . + I(Alcohol_consumption^2),
##     data = train_data_selected)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.1344 -0.2167 -0.0041  0.1986  3.2858
##
## Coefficients: (9 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -1.440e+02  1.247e+01 -11.554  < 2e-16
```

## Adult_mortality	-4.065e-02	8.745e-04	-46.489	< 2e-16
## Infant_deaths	-8.707e-02	2.971e-03	-29.307	< 2e-16
## Alcohol_consumption	2.641e-02	4.070e-02	0.649	0.516527
## CountryAlbania	4.294e+00	4.287e-01	10.016	< 2e-16
## CountryAlgeria	4.308e+00	3.387e-01	12.718	< 2e-16
## CountryAngola	-3.896e+00	3.164e-01	-12.312	< 2e-16
## CountryAntigua and Barbuda	5.554e+00	4.407e-01	12.603	< 2e-16
## CountryArgentina	4.932e+00	4.458e-01	11.065	< 2e-16
## CountryArmenia	4.017e+00	4.613e-01	8.708	< 2e-16
## CountryAustralia	8.188e+00	5.350e-01	15.305	< 2e-16
## CountryAustria	7.432e+00	5.162e-01	14.398	< 2e-16
## CountryAzerbaijan	2.876e+00	4.321e-01	6.655	3.75e-11
## CountryBahamas, The	4.350e+00	4.901e-01	8.876	< 2e-16
## CountryBahrain	3.050e+00	3.927e-01	7.765	1.36e-14
## CountryBangladesh	2.160e+00	2.675e-01	8.076	1.21e-15
## CountryBarbados	7.702e+00	4.469e-01	17.234	< 2e-16
## CountryBelarus	3.903e+00	4.920e-01	7.933	3.73e-15
## CountryBelgium	7.283e+00	5.084e-01	14.324	< 2e-16
## CountryBelize	3.886e+00	4.543e-01	8.555	< 2e-16
## CountryBenin	-1.461e+00	2.652e-01	-5.509	4.14e-08
## CountryBhutan	2.818e+00	2.649e-01	10.638	< 2e-16
## CountryBolivia	2.034e+00	3.555e-01	5.721	1.24e-08
## CountryBosnia and Herzegovina	4.088e+00	3.951e-01	10.348	< 2e-16
## CountryBotswana	1.504e+00	4.199e-01	3.583	0.000349
## CountryBrazil	4.453e+00	3.880e-01	11.477	< 2e-16
## CountryBrunei Darussalam	2.485e+00	3.956e-01	6.282	4.19e-10
## CountryBulgaria	3.905e+00	4.759e-01	8.206	4.31e-16
## CountryBurkina Faso	-3.249e+00	3.361e-01	-9.666	< 2e-16
## CountryBurundi	-2.340e+00	3.037e-01	-7.706	2.13e-14
## CountryCabo Verde	1.434e+00	3.408e-01	4.208	2.70e-05
## CountryCambodia	2.994e-01	2.898e-01	1.033	0.301537
## CountryCameroon	-9.085e-01	3.141e-01	-2.893	0.003864
## CountryCanada	8.012e+00	5.302e-01	15.111	< 2e-16
## CountryCentral African Republic	-1.390e+00	3.498e-01	-3.974	7.35e-05
## CountryChad	-3.352e+00	2.942e-01	-11.394	< 2e-16
## CountryChile	6.660e+00	4.465e-01	14.918	< 2e-16
## CountryChina	2.585e+00	3.921e-01	6.591	5.71e-11
## CountryColombia	6.150e+00	3.926e-01	15.664	< 2e-16
## CountryComoros	2.196e-01	2.797e-01	0.785	0.432597
## CountryCongo, Dem. Rep.	-1.759e+00	2.914e-01	-6.037	1.91e-09
## CountryCongo, Rep.	-2.828e-01	2.965e-01	-0.954	0.340288
## CountryCosta Rica	6.658e+00	4.006e-01	16.621	< 2e-16
## CountryCroatia	4.608e+00	4.872e-01	9.459	< 2e-16
## CountryCuba	6.113e+00	4.546e-01	13.446	< 2e-16
## CountryCyprus	5.770e+00	5.108e-01	11.295	< 2e-16
## CountryCzechia	5.196e+00	5.235e-01	9.926	< 2e-16
## CountryDenmark	6.434e+00	5.620e-01	11.447	< 2e-16
## CountryDjibouti	2.513e-01	2.654e-01	0.947	0.343733
## CountryDominican Republic	4.566e+00	3.674e-01	12.427	< 2e-16
## CountryEcuador	5.332e+00	3.824e-01	13.945	< 2e-16
## CountryEgypt, Arab Rep.	2.281e+00	3.318e-01	6.875	8.52e-12
## CountryEl Salvador	3.909e+00	3.392e-01	11.526	< 2e-16
## CountryEquatorial Guinea	-2.587e-01	3.624e-01	-0.714	0.475456
## CountryEritrea	-3.178e-02	2.721e-01	-0.117	0.907040

## CountryEstonia	5.336e+00	5.374e-01	9.930	< 2e-16
## CountryEswatini	-2.863e+00	3.923e-01	-7.298	4.35e-13
## CountryEthiopia	-9.338e-02	2.751e-01	-0.339	0.734331
## CountryFiji	2.360e-01	4.186e-01	0.564	0.573030
## CountryFinland	7.234e+00	5.176e-01	13.977	< 2e-16
## CountryFrance	8.868e+00	5.014e-01	17.685	< 2e-16
## CountryGabon	-2.902e-01	3.858e-01	-0.752	0.451977
## CountryGambia	-2.461e+00	2.777e-01	-8.859	< 2e-16
## CountryGeorgia	3.437e+00	4.966e-01	6.920	6.25e-12
## CountryGermany	7.297e+00	5.678e-01	12.852	< 2e-16
## CountryGhana	-1.181e+00	3.055e-01	-3.867	0.000114
## CountryGreece	7.114e+00	4.740e-01	15.009	< 2e-16
## CountryGrenada	3.929e+00	4.050e-01	9.702	< 2e-16
## CountryGuatemala	4.159e+00	3.100e-01	13.418	< 2e-16
## CountryGuinea	-2.376e+00	2.737e-01	-8.681	< 2e-16
## CountryGuinea-Bissau	-4.379e+00	2.878e-01	-15.214	< 2e-16
## CountryGuyana	2.633e+00	3.867e-01	6.810	1.32e-11
## CountryHaiti	-1.150e-01	2.946e-01	-0.390	0.696270
## CountryHonduras	4.309e+00	3.193e-01	13.496	< 2e-16
## CountryHungary	4.992e+00	5.092e-01	9.804	< 2e-16
## CountryIceland	7.967e+00	4.964e-01	16.050	< 2e-16
## CountryIndia	2.048e+00	6.235e-01	3.285	0.001041
## CountryIndonesia	2.046e+00	3.486e-01	5.868	5.23e-09
## CountryIran	3.128e+00	3.668e-01	8.527	< 2e-16
## CountryIraq	1.956e+00	3.097e-01	6.314	3.42e-10
## CountryIreland	7.053e+00	5.370e-01	13.135	< 2e-16
## CountryIsrael	7.687e+00	5.212e-01	14.749	< 2e-16
## CountryItaly	7.834e+00	4.691e-01	16.700	< 2e-16
## CountryJamaica	5.081e+00	4.001e-01	12.698	< 2e-16
## CountryJapan	9.278e+00	5.197e-01	17.854	< 2e-16
## CountryJordan	3.185e+00	4.045e-01	7.875	5.87e-15
## CountryKazakhstan	3.849e+00	4.822e-01	7.984	2.51e-15
## CountryKenya	-6.161e-01	3.083e-01	-1.998	0.045822
## CountryKiribati	1.378e+00	3.419e-01	4.030	5.81e-05
## CountryKuwait	1.182e+00	3.649e-01	3.240	0.001217
## CountryKyrgyz Republic	3.949e+00	4.443e-01	8.888	< 2e-16
## CountryLao PDR	7.161e-01	3.015e-01	2.375	0.017642
## CountryLatvia	5.092e+00	5.193e-01	9.806	< 2e-16
## CountryLebanon	4.978e+00	3.803e-01	13.089	< 2e-16
## CountryLesotho	-1.579e+00	3.484e-01	-4.533	6.21e-06
## CountryLiberia	-9.414e-02	2.985e-01	-0.315	0.752545
## CountryLibya	2.357e+00	3.380e-01	6.974	4.30e-12
## CountryLithuania	5.394e+00	5.175e-01	10.423	< 2e-16
## CountryLuxembourg	7.303e+00	5.221e-01	13.988	< 2e-16
## CountryMadagascar	5.793e-01	2.896e-01	2.000	0.045602
## CountryMalawi	-6.208e-01	2.993e-01	-2.074	0.038228
## CountryMalaysia	3.618e+00	3.920e-01	9.230	< 2e-16
## CountryMaldives	3.198e+00	3.116e-01	10.264	< 2e-16
## CountryMali	-4.417e+00	2.721e-01	-16.231	< 2e-16
## CountryMalta	6.629e+00	4.669e-01	14.196	< 2e-16
## CountryMauritania	-2.678e-01	2.631e-01	-1.018	0.308964
## CountryMauritius	3.930e+00	3.698e-01	10.628	< 2e-16
## CountryMexico	5.138e+00	3.956e-01	12.985	< 2e-16
## CountryMicronesia, Fed. Sts.	-1.160e+00	3.409e-01	-3.404	0.000679

## CountryMoldova	2.570e+00	4.759e-01	5.399	7.59e-08
## CountryMongolia	2.160e+00	4.105e-01	5.263	1.59e-07
## CountryMontenegro	4.240e+00	4.881e-01	8.687	< 2e-16
## CountryMorocco	2.900e+00	3.063e-01	9.466	< 2e-16
## CountryMozambique	-1.766e+00	2.945e-01	-5.999	2.40e-09
## CountryMyanmar	-3.776e-01	2.590e-01	-1.458	0.145031
## CountryNamibia	-4.216e-01	3.346e-01	-1.260	0.207913
## CountryNepal	1.166e+00	2.606e-01	4.473	8.18e-06
## CountryNetherlands	7.118e+00	5.294e-01	13.446	< 2e-16
## CountryNew Zealand	7.603e+00	5.277e-01	14.407	< 2e-16
## CountryNicaragua	3.993e+00	3.349e-01	11.922	< 2e-16
## CountryNiger	-4.110e+00	2.611e-01	-15.740	< 2e-16
## CountryNigeria	-2.975e+00	4.428e-01	-6.718	2.47e-11
## CountryNorth Macedonia	3.347e+00	4.234e-01	7.905	4.62e-15
## CountryNorway	7.594e+00	5.327e-01	14.255	< 2e-16
## CountryOman	3.573e+00	3.559e-01	10.039	< 2e-16
## CountryPakistan	1.668e+00	2.904e-01	5.742	1.10e-08
## CountryPanama	6.567e+00	4.281e-01	15.338	< 2e-16
## CountryPapua New Guinea	-1.499e+00	2.871e-01	-5.220	1.99e-07
## CountryParaguay	4.070e+00	3.825e-01	10.641	< 2e-16
## CountryPeru	4.386e+00	4.181e-01	10.492	< 2e-16
## CountryPhilippines	3.804e+00	4.031e-01	9.436	< 2e-16
## CountryPoland	5.484e+00	5.257e-01	10.432	< 2e-16
## CountryPortugal	6.465e+00	4.385e-01	14.742	< 2e-16
## CountryQatar	5.472e+00	4.265e-01	12.831	< 2e-16
## CountryRomania	4.104e+00	4.698e-01	8.735	< 2e-16
## CountryRussian Federation	3.742e+00	5.291e-01	7.074	2.15e-12
## CountryRwanda	-4.011e-01	3.315e-01	-1.210	0.226541
## CountrySamoa	1.877e+00	4.289e-01	4.375	1.28e-05
## CountrySao Tome and Principe	6.740e-01	3.453e-01	1.952	0.051120
## CountrySaudi Arabia	2.370e+00	3.686e-01	6.428	1.65e-10
## CountrySenegal	-1.082e+00	2.628e-01	-4.115	4.05e-05
## CountrySerbia	3.571e+00	4.847e-01	7.367	2.65e-13
## CountrySeychelles	3.995e+00	4.139e-01	9.651	< 2e-16
## CountrySierra Leone	-1.534e+00	3.300e-01	-4.650	3.56e-06
## CountrySingapore	7.145e+00	4.641e-01	15.396	< 2e-16
## CountrySlovak Republic	4.596e+00	5.104e-01	9.006	< 2e-16
## CountrySlovenia	6.818e+00	5.246e-01	12.996	< 2e-16
## CountrySolomon Islands	2.640e+00	3.161e-01	8.352	< 2e-16
## CountrySomalia	-1.533e+00	3.187e-01	-4.811	1.63e-06
## CountrySouth Africa	2.706e+00	4.374e-01	6.186	7.61e-10
## CountrySpain	8.030e+00	4.589e-01	17.499	< 2e-16
## CountrySri Lanka	4.906e+00	4.255e-01	11.530	< 2e-16
## CountrySt. Lucia	5.921e+00	4.457e-01	13.286	< 2e-16
## CountrySt. Vincent and the Grenadines	3.760e+00	4.268e-01	8.808	< 2e-16
## CountrySuriname	2.740e+00	3.863e-01	7.092	1.89e-12
## CountrySweden	7.639e+00	5.376e-01	14.209	< 2e-16
## CountrySwitzerland	8.592e+00	5.547e-01	15.488	< 2e-16
## CountrySyrian Arab Republic	3.122e+00	3.216e-01	9.706	< 2e-16
## CountryTajikistan	8.899e-01	4.087e-01	2.177	0.029587
## CountryTanzania	-9.413e-01	3.708e-01	-2.538	0.011221
## CountryThailand	4.896e+00	3.681e-01	13.302	< 2e-16
## CountryTimor-Leste	1.383e+00	2.608e-01	5.304	1.27e-07
## CountryTogo	-2.265e+00	2.809e-01	-8.062	1.36e-15

## CountryTonga	6.265e-01	4.409e-01	1.421	0.155549
## CountryTrinidad and Tobago	4.343e+00	4.362e-01	9.955	< 2e-16
## CountryTunisia	3.725e+00	3.443e-01	10.817	< 2e-16
## CountryTurkiye	3.595e+00	3.314e-01	10.847	< 2e-16
## CountryTurkmenistan	1.558e+00	4.061e-01	3.837	0.000129
## CountryUganda	-6.019e-01	3.889e-01	-1.547	0.121927
## CountryUkraine	3.883e+00	4.940e-01	7.860	6.57e-15
## CountryUnited Arab Emirates	3.460e+00	4.169e-01	8.299	< 2e-16
## CountryUnited Kingdom	7.035e+00	5.415e-01	12.993	< 2e-16
## CountryUnited States	6.738e+00	5.497e-01	12.259	< 2e-16
## CountryUruguay	5.341e+00	4.169e-01	12.813	< 2e-16
## CountryUzbekistan	2.195e+00	4.214e-01	5.210	2.11e-07
## CountryVanuatu	4.390e-01	3.383e-01	1.298	0.194588
## CountryVenezuela, RB	3.963e+00	4.374e-01	9.060	< 2e-16
## CountryVietnam	5.095e+00	3.211e-01	15.868	< 2e-16
## CountryYemen, Rep.	1.581e+00	2.669e-01	5.922	3.79e-09
## CountryZambia	-3.200e-01	3.429e-01	-0.933	0.350789
## CountryZimbabwe	-3.542e-02	4.043e-01	-0.088	0.930204
## Under_five_deaths	-1.228e-04	3.182e-04	-0.386	0.699646
## Year	1.101e-01	6.205e-03	17.746	< 2e-16
## Incidents_HIV	-1.362e-03	8.156e-03	-0.167	0.867435
## `Income composition of resources`	-2.969e-01	1.431e-01	-2.074	0.038186
## `Total expenditure`	-3.232e-03	6.118e-03	-0.528	0.597402
## Thinness_ten_nineteen_years	-1.705e-02	9.609e-03	-1.774	0.076162
## Thinness_five_nine_years	3.484e-03	9.473e-03	0.368	0.713062
## RegionAsia	NA	NA	NA	NA
## RegionCentral America and Caribbean	NA	NA	NA	NA
## RegionEuropean Union	NA	NA	NA	NA
## RegionMiddle East	NA	NA	NA	NA
## RegionNorth America	NA	NA	NA	NA
## RegionOceania	NA	NA	NA	NA
## RegionRest of Europe	NA	NA	NA	NA
## RegionSouth America	NA	NA	NA	NA
## Measles	-1.529e-06	1.609e-06	-0.950	0.342262
## Polio	8.772e-04	7.933e-04	1.106	0.268953
## BMI	7.434e-04	1.014e-03	0.733	0.463389
## Diphtheria	1.308e-03	9.127e-04	1.433	0.152026
## GDP_per_capita	1.812e-06	2.636e-06	0.687	0.492024
## `percentage expenditure`	-1.648e-06	1.646e-05	-0.100	0.920254
## Schooling	-7.866e-02	3.862e-02	-2.037	0.041801
## Hepatitis_B	7.707e-04	5.852e-04	1.317	0.187984
## Population_millions	7.915e-11	2.712e-10	0.292	0.770431
## Economy_status_Developed	NA	NA	NA	NA
## I(Alcohol_consumption^2)	-3.629e-03	2.291e-03	-1.584	0.113452
##				
## (Intercept)	***			
## Adult_mortality	***			
## Infant_deaths	***			
## Alcohol_consumption				
## CountryAlbania	***			
## CountryAlgeria	***			
## CountryAngola	***			
## CountryAntigua and Barbuda	***			
## CountryArgentina	***			



## CountryArmenia	***
## CountryAustralia	***
## CountryAustria	***
## CountryAzerbaijan	***
## CountryBahamas, The	***
## CountryBahrain	***
## CountryBangladesh	***
## CountryBarbados	***
## CountryBelarus	***
## CountryBelgium	***
## CountryBelize	***
## CountryBenin	***
## CountryBhutan	***
## CountryBolivia	***
## CountryBosnia and Herzegovina	***
## CountryBotswana	***
## CountryBrazil	***
## CountryBrunei Darussalam	***
## CountryBulgaria	***
## CountryBurkina Faso	***
## CountryBurundi	***
## CountryCabo Verde	***
## CountryCambodia	
## CountryCameroon	**
## CountryCanada	***
## CountryCentral African Republic	***
## CountryChad	***
## CountryChile	***
## CountryChina	***
## CountryColombia	***
## CountryComoros	
## CountryCongo, Dem. Rep.	***
## CountryCongo, Rep.	
## CountryCosta Rica	***
## CountryCroatia	***
## CountryCuba	***
## CountryCyprus	***
## CountryCzechia	***
## CountryDenmark	***
## CountryDjibouti	
## CountryDominican Republic	***
## CountryEcuador	***
## CountryEgypt, Arab Rep.	***
## CountryEl Salvador	***
## CountryEquatorial Guinea	
## CountryEritrea	
## CountryEstonia	***
## CountryEswatini	***
## CountryEthiopia	
## CountryFiji	
## CountryFinland	***
## CountryFrance	***
## CountryGabon	
## CountryGambia	***

## CountryGeorgia	***
## CountryGermany	***
## CountryGhana	***
## CountryGreece	***
## CountryGrenada	***
## CountryGuatemala	***
## CountryGuinea	***
## CountryGuinea-Bissau	***
## CountryGuyana	***
## CountryHaiti	
## CountryHonduras	***
## CountryHungary	***
## CountryIceland	***
## CountryIndia	**
## CountryIndonesia	***
## CountryIran	***
## CountryIraq	***
## CountryIreland	***
## CountryIsrael	***
## CountryItaly	***
## CountryJamaica	***
## CountryJapan	***
## CountryJordan	***
## CountryKazakhstan	***
## CountryKenya	*
## CountryKiribati	***
## CountryKuwait	**
## CountryKyrgyz Republic	***
## CountryLao PDR	*
## CountryLatvia	***
## CountryLebanon	***
## CountryLesotho	***
## CountryLiberia	
## CountryLibya	***
## CountryLithuania	***
## CountryLuxembourg	***
## CountryMadagascar	*
## CountryMalawi	*
## CountryMalaysia	***
## CountryMaldives	***
## CountryMali	***
## CountryMalta	***
## CountryMauritania	
## CountryMauritius	***
## CountryMexico	***
## CountryMicronesia, Fed. Sts.	***
## CountryMoldova	***
## CountryMongolia	***
## CountryMontenegro	***
## CountryMorocco	***
## CountryMozambique	***
## CountryMyanmar	
## CountryNamibia	
## CountryNepal	***

## CountryNetherlands	***
## CountryNew Zealand	***
## CountryNicaragua	***
## CountryNiger	***
## CountryNigeria	***
## CountryNorth Macedonia	***
## CountryNorway	***
## CountryOman	***
## CountryPakistan	***
## CountryPanama	***
## CountryPapua New Guinea	***
## CountryParaguay	***
## CountryPeru	***
## CountryPhilippines	***
## CountryPoland	***
## CountryPortugal	***
## CountryQatar	***
## CountryRomania	***
## CountryRussian Federation	***
## CountryRwanda	
## CountrySamoa	***
## CountrySao Tome and Principe	.
## CountrySaudi Arabia	***
## CountrySenegal	***
## CountrySerbia	***
## CountrySeychelles	***
## CountrySierra Leone	***
## CountrySingapore	***
## CountrySlovak Republic	***
## CountrySlovenia	***
## CountrySolomon Islands	***
## CountrySomalia	***
## CountrySouth Africa	***
## CountrySpain	***
## CountrySri Lanka	***
## CountrySt. Lucia	***
## CountrySt. Vincent and the Grenadines	***
## CountrySuriname	***
## CountrySweden	***
## CountrySwitzerland	***
## CountrySyrian Arab Republic	***
## CountryTajikistan	*
## CountryTanzania	*
## CountryThailand	***
## CountryTimor-Leste	***
## CountryTogo	***
## CountryTonga	
## CountryTrinidad and Tobago	***
## CountryTunisia	***
## CountryTurkiye	***
## CountryTurkmenistan	***
## CountryUganda	
## CountryUkraine	***
## CountryUnited Arab Emirates	***

```

## CountryUnited Kingdom          ***
## CountryUnited States           ***
## CountryUruguay                 ***
## CountryUzbekistan              ***
## CountryVanuatu
## CountryVenezuela, RB           ***
## CountryVietnam                 ***
## CountryYemen, Rep.             ***
## CountryZambia
## CountryZimbabwe
## Under_five_deaths
## Year                           ***
## Incidents_HIV
## `Income composition of resources` *
## `Total expenditure`
## Thinness_ten_nineteen_years    .
## Thinness_five_nine_years
## RegionAsia
## RegionCentral America and Caribbean
## RegionEuropean Union
## RegionMiddle East
## RegionNorth America
## RegionOceania
## RegionRest of Europe
## RegionSouth America
## Measles
## Polio
## BMI
## Diphtheria
## GDP_per_capita
## `percentage expenditure`
## Schooling                      *
## Hepatitis_B
## Population_millions
## Economy_status_Developed
## I(Alcohol_consumption^2)
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5289 on 1798 degrees of freedom
## Multiple R-squared:  0.9971, Adjusted R-squared:  0.9968
## F-statistic: 3169 on 197 and 1798 DF, p-value: < 2.2e-16

```

```
# Model 2 Enhanced LRM with Predictors (Model 2)
```

```

model_2 <- lm(Life_expectancy ~ Year + Adult_mortality + Alcohol_consumption + BMI, data = train_data_selected)
summary(model_2)

```

```

##
## Call:
## lm(formula = Life_expectancy ~ Year + Adult_mortality + Alcohol_consumption +
##     BMI, data = train_data_selected)
##
## Residuals:
##      Min       1Q   Median       3Q      Max

```

```
## -9.1307 -1.4582 0.1005 1.5635 13.5022
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.472e+01 2.513e+01 -0.983 0.326
## Year         5.187e-02 1.251e-02  4.146 3.53e-05 ***
## Adult_mortality -7.072e-02 5.626e-04 -125.705 < 2e-16 ***
## Alcohol_consumption 4.054e-01 1.497e-02 27.082 < 2e-16 ***
## BMI           2.984e-02 3.133e-03  9.525 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.534 on 1991 degrees of freedom
## Multiple R-squared:  0.927, Adjusted R-squared:  0.9269
## F-statistic: 6323 on 4 and 1991 DF, p-value: < 2.2e-16
```

### *# Model 3 Generalized Linear Model with Log Link*

```
glm_model <- glm(Life_expectancy ~ ., family = gaussian(link = "log"), data = train_data_selected)
model_3 <- (glm_model)
summary(model_3)
```

```
##
## Call:
## glm(formula = Life_expectancy ~ ., family = gaussian(link = "log"),
##      data = train_data_selected)
##
## Coefficients: (9 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.532e+00  1.813e-01  13.963 < 2e-16
## Adult_mortality -7.219e-04  1.523e-05 -47.410 < 2e-16
## Infant_deaths   -1.728e-03  4.927e-05 -35.070 < 2e-16
## Alcohol_consumption -5.879e-04  2.344e-04 -2.508 0.012235
## CountryAlbania      2.396e-02  6.356e-03  3.770 0.000169
## CountryAlgeria      3.244e-02  5.285e-03  6.137 1.03e-09
## CountryAngola      -5.930e-02  4.958e-03 -11.959 < 2e-16
## CountryAntigua and Barbuda 4.925e-02  6.319e-03  7.793 1.09e-14
## CountryArgentina    4.162e-02  6.436e-03  6.466 1.29e-10
## CountryArmenia      3.226e-02  6.820e-03  4.731 2.41e-06
## CountryAustralia    6.632e-02  7.794e-03  8.510 < 2e-16
## CountryAustria      5.832e-02  7.565e-03  7.709 2.08e-14
## CountryAzerbaijan    2.485e-02  6.586e-03  3.773 0.000167
## CountryBahamas, The 4.125e-02  7.076e-03  5.829 6.60e-09
## CountryBahrain      3.058e-05  6.027e-03  0.005 0.995952
## CountryBangladesh    1.370e-02  4.267e-03  3.211 0.001346
## CountryBarbados      7.450e-02  6.411e-03 11.621 < 2e-16
## CountryBelarus      3.758e-02  7.285e-03  5.158 2.77e-07
## CountryBelgium      5.851e-02  7.417e-03  7.888 5.29e-15
## CountryBelize      3.793e-02  6.565e-03  5.777 8.92e-09
## CountryBenin        -1.924e-02  4.433e-03 -4.340 1.50e-05
## CountryBhutan        3.486e-02  4.258e-03  8.186 5.05e-16
## CountryBolivia      2.222e-02  5.412e-03  4.106 4.21e-05
## CountryBosnia and Herzegovina 2.102e-02  5.863e-03  3.585 0.000346
## CountryBotswana      4.032e-02  6.323e-03  6.377 2.29e-10
## CountryBrazil        4.386e-02  5.540e-03  7.916 4.24e-15
```

## CountryBrunei Darussalam	-5.095e-03	6.092e-03	-0.836	0.403032
## CountryBulgaria	2.934e-02	6.914e-03	4.243	2.32e-05
## CountryBurkina Faso	-4.641e-02	5.119e-03	-9.066	< 2e-16
## CountryBurundi	-3.147e-02	4.612e-03	-6.824	1.21e-11
## CountryCabo Verde	5.722e-04	5.120e-03	0.112	0.911028
## CountryCambodia	-3.473e-03	4.622e-03	-0.752	0.452447
## CountryCameroon	-8.495e-03	4.774e-03	-1.780	0.075325
## CountryCanada	7.003e-02	7.699e-03	9.097	< 2e-16
## CountryCentral African Republic	-3.012e-02	6.128e-03	-4.915	9.66e-07
## CountryChad	-5.267e-02	5.379e-03	-9.792	< 2e-16
## CountryChile	5.845e-02	6.479e-03	9.022	< 2e-16
## CountryChina	4.538e-03	5.901e-03	0.769	0.442000
## CountryColombia	6.381e-02	5.831e-03	10.943	< 2e-16
## CountryComoros	4.946e-03	4.664e-03	1.061	0.289057
## CountryCongo, Dem. Rep.	-2.182e-02	4.715e-03	-4.628	3.96e-06
## CountryCongo, Rep.	-1.629e-03	4.825e-03	-0.338	0.735753
## CountryCosta Rica	5.322e-02	5.990e-03	8.885	< 2e-16
## CountryCroatia	2.893e-02	7.172e-03	4.033	5.73e-05
## CountryCuba	4.532e-02	6.708e-03	6.756	1.91e-11
## CountryCyprus	3.361e-02	7.509e-03	4.476	8.07e-06
## CountryCzechia	3.364e-02	7.793e-03	4.316	1.67e-05
## CountryDenmark	4.955e-02	8.179e-03	6.058	1.68e-09
## CountryDjibouti	1.011e-02	4.467e-03	2.264	0.023711
## CountryDominican Republic	5.275e-02	5.312e-03	9.929	< 2e-16
## CountryEcuador	4.958e-02	5.694e-03	8.707	< 2e-16
## CountryEgypt, Arab Rep.	1.208e-02	5.245e-03	2.304	0.021351
## CountryEl Salvador	3.950e-02	5.215e-03	7.574	5.75e-14
## CountryEquatorial Guinea	1.088e-02	5.433e-03	2.003	0.045329
## CountryEritrea	-2.111e-03	4.476e-03	-0.472	0.637315
## CountryEstonia	4.811e-02	8.036e-03	5.987	2.58e-09
## CountryEswatini	-4.989e-02	6.286e-03	-7.936	3.64e-15
## CountryEthiopia	5.384e-05	4.622e-03	0.012	0.990708
## CountryFiji	-1.440e-02	6.347e-03	-2.268	0.023421
## CountryFinland	5.847e-02	7.518e-03	7.777	1.24e-14
## CountryFrance	7.843e-02	7.440e-03	10.542	< 2e-16
## CountryGabon	2.973e-03	5.636e-03	0.527	0.597941
## CountryGambia	-3.914e-02	4.392e-03	-8.912	< 2e-16
## CountryGeorgia	2.925e-02	7.208e-03	4.058	5.16e-05
## CountryGermany	5.818e-02	8.321e-03	6.993	3.79e-12
## CountryGhana	-1.974e-02	4.893e-03	-4.035	5.70e-05
## CountryGreece	5.457e-02	6.877e-03	7.936	3.65e-15
## CountryGrenada	3.170e-02	5.818e-03	5.448	5.78e-08
## CountryGuatemala	4.646e-02	4.842e-03	9.594	< 2e-16
## CountryGuinea	-3.449e-02	4.755e-03	-7.252	6.08e-13
## CountryGuinea-Bissau	-6.562e-02	4.691e-03	-13.988	< 2e-16
## CountryGuyana	3.164e-02	5.562e-03	5.689	1.49e-08
## CountryHaiti	4.600e-03	4.612e-03	0.997	0.318749
## CountryHonduras	4.048e-02	4.920e-03	8.228	3.61e-16
## CountryHungary	4.481e-02	7.497e-03	5.977	2.73e-09
## CountryIceland	6.041e-02	7.234e-03	8.352	< 2e-16
## CountryIndia	1.664e-02	9.434e-03	1.764	0.077911
## CountryIndonesia	1.366e-02	5.464e-03	2.500	0.012490
## CountryIran	1.156e-02	5.671e-03	2.039	0.041572
## CountryIraq	1.047e-02	4.914e-03	2.130	0.033299

## CountryIreland	5.389e-02	7.912e-03	6.811	1.32e-11
## CountryIsrael	5.713e-02	7.761e-03	7.361	2.75e-13
## CountryItaly	5.963e-02	6.838e-03	8.721	< 2e-16
## CountryJamaica	4.722e-02	6.001e-03	7.870	6.08e-15
## CountryJapan	7.859e-02	7.519e-03	10.451	< 2e-16
## CountryJordan	1.473e-02	6.214e-03	2.370	0.017876
## CountryKazakhstan	4.781e-02	7.051e-03	6.780	1.63e-11
## CountryKenya	-8.273e-03	5.031e-03	-1.644	0.100281
## CountryKiribati	1.501e-02	5.445e-03	2.757	0.005896
## CountryKuwait	-2.627e-02	5.739e-03	-4.578	5.01e-06
## CountryKyrgyz Republic	4.742e-02	6.405e-03	7.405	2.01e-13
## CountryLao PDR	1.116e-02	4.415e-03	2.528	0.011556
## CountryLatvia	5.257e-02	7.516e-03	6.995	3.72e-12
## CountryLebanon	2.692e-02	5.850e-03	4.601	4.49e-06
## CountryLesotho	-2.361e-02	6.062e-03	-3.894	0.000102
## CountryLiberia	8.817e-03	4.655e-03	1.894	0.058359
## CountryLibya	4.042e-03	5.301e-03	0.762	0.445928
## CountryLithuania	5.565e-02	7.627e-03	7.296	4.42e-13
## CountryLuxembourg	5.633e-02	7.686e-03	7.329	3.48e-13
## CountryMadagascar	6.841e-03	4.671e-03	1.465	0.143207
## CountryMalawi	-1.768e-03	5.115e-03	-0.346	0.729690
## CountryMalaysia	1.557e-02	5.999e-03	2.596	0.009509
## CountryMaldives	7.206e-03	4.834e-03	1.491	0.136241
## CountryMali	-7.130e-02	4.749e-03	-15.015	< 2e-16
## CountryMalta	4.526e-02	6.835e-03	6.622	4.68e-11
## CountryMauritania	-5.329e-03	4.382e-03	-1.216	0.224087
## CountryMauritius	2.981e-02	5.499e-03	5.420	6.76e-08
## CountryMexico	4.352e-02	5.841e-03	7.451	1.43e-13
## CountryMicronesia, Fed. Sts.	-3.445e-02	5.359e-03	-6.429	1.64e-10
## CountryMoldova	2.202e-02	6.863e-03	3.209	0.001354
## CountryMongolia	2.442e-02	6.100e-03	4.003	6.51e-05
## CountryMontenegro	2.779e-02	7.076e-03	3.927	8.92e-05
## CountryMorocco	1.456e-02	4.875e-03	2.987	0.002856
## CountryMozambique	-1.949e-02	5.204e-03	-3.745	0.000186
## CountryMyanmar	-1.190e-02	4.241e-03	-2.806	0.005066
## CountryNamibia	2.128e-03	5.460e-03	0.390	0.696848
## CountryNepal	4.011e-03	4.203e-03	0.954	0.340113
## CountryNetherlands	5.390e-02	7.686e-03	7.013	3.30e-12
## CountryNew Zealand	6.189e-02	7.666e-03	8.073	1.24e-15
## CountryNicaragua	3.827e-02	5.058e-03	7.566	6.09e-14
## CountryNiger	-6.693e-02	4.509e-03	-14.842	< 2e-16
## CountryNigeria	-4.592e-02	6.846e-03	-6.709	2.62e-11
## CountryNorth Macedonia	1.538e-02	6.315e-03	2.435	0.014981
## CountryNorway	5.869e-02	7.762e-03	7.561	6.34e-14
## CountryOman	1.274e-02	5.538e-03	2.300	0.021544
## CountryPakistan	2.098e-02	4.694e-03	4.469	8.34e-06
## CountryPanama	6.401e-02	6.225e-03	10.284	< 2e-16
## CountryPapua New Guinea	-2.687e-02	4.753e-03	-5.653	1.83e-08
## CountryParaguay	3.870e-02	5.578e-03	6.937	5.56e-12
## CountryPeru	3.789e-02	6.134e-03	6.178	8.03e-10
## CountryPhilippines	4.237e-02	5.906e-03	7.174	1.06e-12
## CountryPoland	4.589e-02	7.581e-03	6.053	1.72e-09
## CountryPortugal	4.834e-02	6.481e-03	7.460	1.34e-13
## CountryQatar	2.874e-02	6.464e-03	4.446	9.26e-06

## CountryRomania	3.402e-02	6.829e-03	4.981	6.92e-07
## CountryRussian Federation	4.532e-02	7.727e-03	5.865	5.32e-09
## CountryRwanda	-1.658e-03	4.807e-03	-0.345	0.730240
## CountrySamoa	1.666e-03	6.458e-03	0.258	0.796447
## CountrySao Tome and Principe	-4.015e-04	5.087e-03	-0.079	0.937100
## CountrySaudi Arabia	-4.495e-03	5.727e-03	-0.785	0.432582
## CountrySenegal	-2.377e-02	4.360e-03	-5.452	5.68e-08
## CountrySerbia	2.092e-02	6.991e-03	2.992	0.002806
## CountrySeychelles	3.217e-02	5.928e-03	5.426	6.53e-08
## CountrySierra Leone	-2.514e-02	5.597e-03	-4.492	7.51e-06
## CountrySingapore	4.758e-02	7.011e-03	6.786	1.56e-11
## CountrySlovak Republic	3.371e-02	7.432e-03	4.536	6.13e-06
## CountrySlovenia	5.475e-02	7.657e-03	7.150	1.26e-12
## CountrySolomon Islands	1.911e-02	5.034e-03	3.796	0.000152
## CountrySomalia	-1.703e-02	5.530e-03	-3.080	0.002104
## CountrySouth Africa	6.429e-02	6.511e-03	9.875	< 2e-16
## CountrySpain	6.370e-02	6.742e-03	9.448	< 2e-16
## CountrySri Lanka	3.563e-02	6.333e-03	5.626	2.14e-08
## CountrySt. Lucia	6.129e-02	6.516e-03	9.407	< 2e-16
## CountrySt. Vincent and the Grenadines	3.396e-02	6.211e-03	5.468	5.18e-08
## CountrySuriname	2.438e-02	5.665e-03	4.303	1.77e-05
## CountrySweden	5.748e-02	7.802e-03	7.368	2.62e-13
## CountrySwitzerland	7.097e-02	8.089e-03	8.773	< 2e-16
## CountrySyrian Arab Republic	2.303e-02	5.042e-03	4.569	5.24e-06
## CountryTajikistan	-1.231e-03	6.273e-03	-0.196	0.844484
## CountryTanzania	-1.197e-02	5.559e-03	-2.152	0.031505
## CountryThailand	4.681e-02	5.262e-03	8.896	< 2e-16
## CountryTimor-Leste	1.413e-02	4.259e-03	3.318	0.000926
## CountryTogo	-3.275e-02	4.768e-03	-6.868	8.91e-12
## CountryTonga	-1.858e-02	6.765e-03	-2.747	0.006071
## CountryTrinidad and Tobago	4.614e-02	6.288e-03	7.337	3.28e-13
## CountryTunisia	1.836e-02	5.332e-03	3.444	0.000587
## CountryTurkiye	2.167e-02	5.174e-03	4.189	2.94e-05
## CountryTurkmenistan	1.571e-02	6.125e-03	2.565	0.010403
## CountryUganda	-3.517e-03	6.035e-03	-0.583	0.560115
## CountryUkraine	4.415e-02	7.126e-03	6.196	7.17e-10
## CountryUnited Arab Emirates	6.505e-03	6.357e-03	1.023	0.306348
## CountryUnited Kingdom	5.413e-02	7.927e-03	6.829	1.17e-11
## CountryUnited States	5.750e-02	7.935e-03	7.247	6.31e-13
## CountryUruguay	4.221e-02	6.054e-03	6.972	4.37e-12
## CountryUzbekistan	1.476e-02	6.370e-03	2.317	0.020589
## CountryVanuatu	-1.569e-02	5.348e-03	-2.934	0.003384
## CountryVenezuela, RB	3.324e-02	6.287e-03	5.287	1.40e-07
## CountryVietnam	4.277e-02	4.911e-03	8.709	< 2e-16
## CountryYemen, Rep.	1.977e-02	4.355e-03	4.540	6.00e-06
## CountryZambia	1.049e-04	5.535e-03	0.019	0.984876
## CountryZimbabwe	7.067e-03	6.679e-03	1.058	0.290133
## Under_five_deaths	1.976e-06	4.894e-06	0.404	0.686388
## Year	9.332e-04	9.006e-05	10.362	< 2e-16
## Incidents_HIV	-9.150e-04	1.506e-04	-6.076	1.50e-09
## `Income composition of resources`	-5.036e-03	2.095e-03	-2.404	0.016300
## `Total expenditure`	-8.882e-05	8.722e-05	-1.018	0.308661
## Thinness_ten_nineteen_years	-2.116e-04	1.564e-04	-1.353	0.176141
## Thinness_five_nine_years	1.601e-04	1.533e-04	1.045	0.296345



## RegionAsia	NA	NA	NA	NA
## RegionCentral America and Caribbean	NA	NA	NA	NA
## RegionEuropean Union	NA	NA	NA	NA
## RegionMiddle East	NA	NA	NA	NA
## RegionNorth America	NA	NA	NA	NA
## RegionOceania	NA	NA	NA	NA
## RegionRest of Europe	NA	NA	NA	NA
## RegionSouth America	NA	NA	NA	NA
## Measles	-7.014e-08	2.835e-08	-2.474	0.013449
## Polio	6.579e-07	1.212e-05	0.054	0.956719
## BMI	1.703e-05	1.415e-05	1.203	0.229130
## Diphtheria	3.433e-05	1.397e-05	2.457	0.014086
## GDP_per_capita	3.031e-08	3.432e-08	0.883	0.377290
## `percentage expenditure`	-7.456e-08	2.134e-07	-0.349	0.726812
## Schooling	-1.222e-03	5.539e-04	-2.207	0.027465
## Hepatitis_B	1.672e-05	8.712e-06	1.919	0.055199
## Population_millions	2.110e-12	4.177e-12	0.505	0.613478
## Economy_status_Developed	NA	NA	NA	NA
##				
## (Intercept)	***			
## Adult_mortality	***			
## Infant_deaths	***			
## Alcohol_consumption	*			
## CountryAlbania	***			
## CountryAlgeria	***			
## CountryAngola	***			
## CountryAntigua and Barbuda	***			
## CountryArgentina	***			
## CountryArmenia	***			
## CountryAustralia	***			
## CountryAustria	***			
## CountryAzerbaijan	***			
## CountryBahamas, The	***			
## CountryBahrain				
## CountryBangladesh	**			
## CountryBarbados	***			
## CountryBelarus	***			
## CountryBelgium	***			
## CountryBelize	***			
## CountryBenin	***			
## CountryBhutan	***			
## CountryBolivia	***			
## CountryBosnia and Herzegovina	***			
## CountryBotswana	***			
## CountryBrazil	***			
## CountryBrunei Darussalam				
## CountryBulgaria	***			
## CountryBurkina Faso	***			
## CountryBurundi	***			
## CountryCabo Verde				
## CountryCambodia				
## CountryCameroon	.			
## CountryCanada	***			
## CountryCentral African Republic	***			

## CountryChad	***
## CountryChile	***
## CountryChina	
## CountryColombia	***
## CountryComoros	
## CountryCongo, Dem. Rep.	***
## CountryCongo, Rep.	
## CountryCosta Rica	***
## CountryCroatia	***
## CountryCuba	***
## CountryCyprus	***
## CountryCzechia	***
## CountryDenmark	***
## CountryDjibouti	*
## CountryDominican Republic	***
## CountryEcuador	***
## CountryEgypt, Arab Rep.	*
## CountryEl Salvador	***
## CountryEquatorial Guinea	*
## CountryEritrea	
## CountryEstonia	***
## CountryEswatini	***
## CountryEthiopia	
## CountryFiji	*
## CountryFinland	***
## CountryFrance	***
## CountryGabon	
## CountryGambia	***
## CountryGeorgia	***
## CountryGermany	***
## CountryGhana	***
## CountryGreece	***
## CountryGrenada	***
## CountryGuatemala	***
## CountryGuinea	***
## CountryGuinea-Bissau	***
## CountryGuyana	***
## CountryHaiti	
## CountryHonduras	***
## CountryHungary	***
## CountryIceland	***
## CountryIndia	.
## CountryIndonesia	*
## CountryIran	*
## CountryIraq	*
## CountryIreland	***
## CountryIsrael	***
## CountryItaly	***
## CountryJamaica	***
## CountryJapan	***
## CountryJordan	*
## CountryKazakhstan	***
## CountryKenya	
## CountryKiribati	**

## CountryKuwait	***
## CountryKyrgyz Republic	***
## CountryLao PDR	*
## CountryLatvia	***
## CountryLebanon	***
## CountryLesotho	***
## CountryLiberia	.
## CountryLibya	
## CountryLithuania	***
## CountryLuxembourg	***
## CountryMadagascar	
## CountryMalawi	
## CountryMalaysia	**
## CountryMaldives	
## CountryMali	***
## CountryMalta	***
## CountryMauritania	
## CountryMauritius	***
## CountryMexico	***
## CountryMicronesia, Fed. Sts.	***
## CountryMoldova	**
## CountryMongolia	***
## CountryMontenegro	***
## CountryMorocco	**
## CountryMozambique	***
## CountryMyanmar	**
## CountryNamibia	
## CountryNepal	
## CountryNetherlands	***
## CountryNew Zealand	***
## CountryNicaragua	***
## CountryNiger	***
## CountryNigeria	***
## CountryNorth Macedonia	*
## CountryNorway	***
## CountryOman	*
## CountryPakistan	***
## CountryPanama	***
## CountryPapua New Guinea	***
## CountryParaguay	***
## CountryPeru	***
## CountryPhilippines	***
## CountryPoland	***
## CountryPortugal	***
## CountryQatar	***
## CountryRomania	***
## CountryRussian Federation	***
## CountryRwanda	
## CountrySamoa	
## CountrySao Tome and Principe	
## CountrySaudi Arabia	
## CountrySenegal	***
## CountrySerbia	**
## CountrySeychelles	***

## CountrySierra Leone	***
## CountrySingapore	***
## CountrySlovak Republic	***
## CountrySlovenia	***
## CountrySolomon Islands	***
## CountrySomalia	**
## CountrySouth Africa	***
## CountrySpain	***
## CountrySri Lanka	***
## CountrySt. Lucia	***
## CountrySt. Vincent and the Grenadines	***
## CountrySuriname	***
## CountrySweden	***
## CountrySwitzerland	***
## CountrySyrian Arab Republic	***
## CountryTajikistan	
## CountryTanzania	*
## CountryThailand	***
## CountryTimor-Leste	***
## CountryTogo	***
## CountryTonga	**
## CountryTrinidad and Tobago	***
## CountryTunisia	***
## CountryTurkiye	***
## CountryTurkmenistan	*
## CountryUganda	
## CountryUkraine	***
## CountryUnited Arab Emirates	
## CountryUnited Kingdom	***
## CountryUnited States	***
## CountryUruguay	***
## CountryUzbekistan	*
## CountryVanuatu	**
## CountryVenezuela, RB	***
## CountryVietnam	***
## CountryYemen, Rep.	***
## CountryZambia	
## CountryZimbabwe	
## Under_five_deaths	
## Year	***
## Incidents_HIV	***
## `Income composition of resources`	*
## `Total expenditure`	
## Thinness_ten_nineteen_years	
## Thinness_five_nine_years	
## RegionAsia	
## RegionCentral America and Caribbean	
## RegionEuropean Union	
## RegionMiddle East	
## RegionNorth America	
## RegionOceania	
## RegionRest of Europe	
## RegionSouth America	
## Measles	*

```

## Polio
## BMI
## Diphtheria *
## GDP_per_capita
## `percentage expenditure`
## Schooling *
## Hepatitis_B .
## Population_millions
## Economy_status_Developed
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.2905737)
##
## Null deviance: 175136.33 on 1995 degrees of freedom
## Residual deviance: 522.74 on 1799 degrees of freedom
## AIC: 3386.1
##
## Number of Fisher Scoring iterations: 4

# Convert to long format for plotting
comparison_long <- comparison_df %>%
  pivot_longer(cols = starts_with("Predicted"), names_to = "Model", values_to = "Predicted")

# Load the training data
trainData <- read_csv("train_data.csv")

## Rows: 1996 Columns: 24
## -- Column specification -----
## Delimiter: ","
## chr (2): Country, Region
## dbl (22): Column1, Year, Economy_status_Developed, Life_expectancy, Adult_mo...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.

# Generate predicted values
predicted_values_1 <- predict(model_1, trainData)

## Warning in predict.lm(model_1, trainData): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases

predicted_values_2 <- predict(model_2, trainData)
predicted_values_3 <- predict(model_3, trainData)

# Combine actual and predicted values into a data frame
comparison_df <- data.frame(
  Actual = trainData$Life_expectancy,
  Predicted_Model_1 = predicted_values_1,
  Predicted_Model_2 = predicted_values_2,
  Predicted_Model_3 = predicted_values_3
)

```

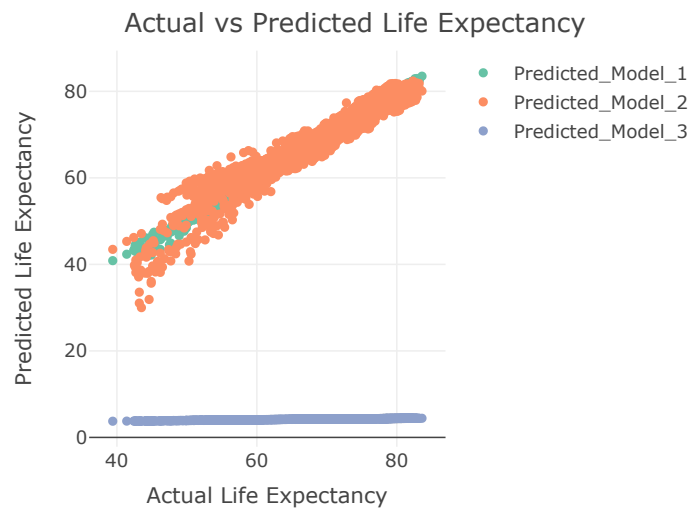
```

# Convert to long format for plotting
comparison_long <- comparison_df %>%
  pivot_longer(cols = starts_with("Predicted"), names_to = "Model", values_to = "Predicted")

# Create the plot
p123 <- comparison_long %>%
  plot_ly(x = ~Actual, y = ~Predicted, color = ~Model, type = 'scatter', mode = 'markers') %>%
  layout(title = "Actual vs Predicted Life Expectancy",
         xaxis = list(title = "Actual Life Expectancy"),
         yaxis = list(title = "Predicted Life Expectancy"),
         hovermode = "compare")

# Display the plot
p123

```



```
# Model Evaluation and Comparison  
# ANOVA for Model Comparison
```

```
anova_result_1 <- anova(simple_model, enhanced_model)
print(anova_result_1)
```

```
## Analysis of Variance Table
##
## Model 1: Life_expectancy ~ Adult_mortality + Infant_deaths + Alcohol_consumption +
##   Country + Under_five_deaths + Year + Incidents_HIV + `Income composition of resources` +
##   `Total expenditure` + Thinness_ten_nineteen_years + Thinness_five_nine_years +
##   Region + Measles + Polio + BMI + Diphtheria + GDP_per_capita +
##   `percentage expenditure` + Schooling + Hepatitis_B + Population_millions +
##   Economy_status_Developed
## Model 2: Life_expectancy ~ Adult_mortality + Infant_deaths + Alcohol_consumption +
##   Country + Under_five_deaths + Year + Incidents_HIV + `Income composition of resources` +
##   `Total expenditure` + Thinness_ten_nineteen_years + Thinness_five_nine_years +
##   Region + Measles + Polio + BMI + Diphtheria + GDP_per_capita +
##   `percentage expenditure` + Schooling + Hepatitis_B + Population_millions +
##   Economy_status_Developed + I(Alcohol_consumption^2)
##   Res.Df    RSS Df Sum of Sq    F Pr(>F)
## 1    1799 503.62
## 2    1798 502.92  1   0.70149 2.5079 0.1135
```

```
anova_result_2 <- anova(simple_model, model_2)
print(anova_result_2)
```

```
## Analysis of Variance Table
##
## Model 1: Life_expectancy ~ Adult_mortality + Infant_deaths + Alcohol_consumption +
##   Country + Under_five_deaths + Year + Incidents_HIV + `Income composition of resources` +
##   `Total expenditure` + Thinness_ten_nineteen_years + Thinness_five_nine_years +
##   Region + Measles + Polio + BMI + Diphtheria + GDP_per_capita +
##   `percentage expenditure` + Schooling + Hepatitis_B + Population_millions +
##   Economy_status_Developed
## Model 2: Life_expectancy ~ Year + Adult_mortality + Alcohol_consumption +
##   BMI
##   Res.Df    RSS    Df Sum of Sq    F    Pr(>F)
## 1    1799    503.6
## 2    1991 12779.8 -192    -12276 228.4 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Cross-Validation for Model Selection
```

```
control_cv <- trainControl(method = "cv", number = 10) # 10-fold CV
cv_model <- train(Life_expectancy ~ ., data = train_data_selected, method = "lm", trControl = control_cv)
```

```
## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases
```

```
## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases
```

```
## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
```



```
## attr(*, "non-estim") has doubtful cases

## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases

## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases

## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases

## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases

## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases

## Warning in predict.lm(modelFit, newdata): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases
```

```
print(cv_model)
```

```
## Linear Regression
##
## 1996 samples
## 22 predictor
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 1795, 1798, 1796, 1798, 1797, 1795, ...
## Resampling results:
##
## RMSE      Rsquared   MAE
## 0.5605027  0.9964575  0.3710295
##
## Tuning parameter 'intercept' was held constant at a value of TRUE
```

```
# Ensure only numeric data is used for correlation
numeric_data <- train_data_selected %>% dplyr::select_if(is.numeric)

# Define control for cross-validation
control_cv <- trainControl(method = "cv", number = 10)

# Train the model using cross-validation
cv_model <- train(Life_expectancy ~ ., data = numeric_data, method = "lm", trControl = control_cv)
print(cv_model)
```

```
## Linear Regression
##
## 1996 samples
```

```
## 20 predictor
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 1798, 1796, 1797, 1796, 1796, 1796, ...
## Resampling results:
##
## RMSE      Rsquared    MAE
## 1.42829    0.9767583    1.141538
##
## Tuning parameter 'intercept' was held constant at a value of TRUE
```

```
# Checking Multicollinearity with VIF
# Select only numeric predictors including Life_expectancy
numeric_predictors <- train_data_selected %>%
  dplyr::select_if(is.numeric)

# Build the model
simple_model <- lm(Life_expectancy ~ ., data = numeric_predictors)

# Calculate VIF
vif_values <- vif(simple_model)

# Save VIF values to a variable for later use
saved_vif_values <- vif_values

# Analyze VIF values
print(saved_vif_values)
```

```
##                Adult_mortality                Infant_deaths
##                7.247209                6.823786
##                Alcohol_consumption          Under_five_deaths
##                2.661002                2.315195
##                Year                Incidents_HIV
##                1.205640                2.767337
## `Income composition of resources`          `Total expenditure`
##                1.819810                1.278385
##                Thinness_ten_nineteen_years    Thinness_five_nine_years
##                8.802770                8.755260
##                Measles                Polio
##                1.414925                2.434013
##                BMI                Diphtheria
##                1.821269                2.709575
##                GDP_per_capita          `percentage expenditure`
##                5.918139                5.806101
##                Schooling                Hepatitis_B
##                3.967074                1.770356
##                Population_millions          Economy_status_Developed
##                1.504514                2.705831
```

```
# Enhanced Model Plots : Model 1, Model 2, Model 3
# Model 1 Enhanced Model with Polynomial Terms
enhanced_model <- lm(Life_expectancy ~ . + I(Alcohol_consumption^2), data = train_data_selected)
```

```
model_1 <- (enhanced_model)
summary(model_1)
```

```
##
## Call:
## lm(formula = Life_expectancy ~ . + I(Alcohol_consumption^2),
##     data = train_data_selected)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.1344 -0.2167 -0.0041  0.1986  3.2858
##
## Coefficients: (9 not defined because of singularities)
##
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -1.440e+02  1.247e+01 -11.554 < 2e-16
## Adult_mortality -4.065e-02  8.745e-04 -46.489 < 2e-16
## Infant_deaths   -8.707e-02  2.971e-03 -29.307 < 2e-16
## Alcohol_consumption 2.641e-02  4.070e-02  0.649 0.516527
## CountryAlbania    4.294e+00  4.287e-01  10.016 < 2e-16
## CountryAlgeria    4.308e+00  3.387e-01  12.718 < 2e-16
## CountryAngola     -3.896e+00  3.164e-01 -12.312 < 2e-16
## CountryAntigua and Barbuda 5.554e+00  4.407e-01  12.603 < 2e-16
## CountryArgentina  4.932e+00  4.458e-01  11.065 < 2e-16
## CountryArmenia    4.017e+00  4.613e-01  8.708 < 2e-16
## CountryAustralia  8.188e+00  5.350e-01  15.305 < 2e-16
## CountryAustria    7.432e+00  5.162e-01  14.398 < 2e-16
## CountryAzerbaijan 2.876e+00  4.321e-01  6.655 3.75e-11
## CountryBahamas, The 4.350e+00  4.901e-01  8.876 < 2e-16
## CountryBahrain    3.050e+00  3.927e-01  7.765 1.36e-14
## CountryBangladesh 2.160e+00  2.675e-01  8.076 1.21e-15
## CountryBarbados   7.702e+00  4.469e-01  17.234 < 2e-16
## CountryBelarus    3.903e+00  4.920e-01  7.933 3.73e-15
## CountryBelgium    7.283e+00  5.084e-01  14.324 < 2e-16
## CountryBelize     3.886e+00  4.543e-01  8.555 < 2e-16
## CountryBenin      -1.461e+00  2.652e-01 -5.509 4.14e-08
## CountryBhutan     2.818e+00  2.649e-01  10.638 < 2e-16
## CountryBolivia    2.034e+00  3.555e-01  5.721 1.24e-08
## CountryBosnia and Herzegovina 4.088e+00  3.951e-01  10.348 < 2e-16
## CountryBotswana   1.504e+00  4.199e-01  3.583 0.000349
## CountryBrazil     4.453e+00  3.880e-01  11.477 < 2e-16
## CountryBrunei Darussalam 2.485e+00  3.956e-01  6.282 4.19e-10
## CountryBulgaria   3.905e+00  4.759e-01  8.206 4.31e-16
## CountryBurkina Faso -3.249e+00  3.361e-01 -9.666 < 2e-16
## CountryBurundi    -2.340e+00  3.037e-01 -7.706 2.13e-14
## CountryCabo Verde 1.434e+00  3.408e-01  4.208 2.70e-05
## CountryCambodia   2.994e-01  2.898e-01  1.033 0.301537
## CountryCameroon   -9.085e-01  3.141e-01 -2.893 0.003864
## CountryCanada     8.012e+00  5.302e-01  15.111 < 2e-16
## CountryCentral African Republic -1.390e+00  3.498e-01 -3.974 7.35e-05
## CountryChad       -3.352e+00  2.942e-01 -11.394 < 2e-16
## CountryChile      6.660e+00  4.465e-01  14.918 < 2e-16
## CountryChina      2.585e+00  3.921e-01  6.591 5.71e-11
## CountryColombia   6.150e+00  3.926e-01  15.664 < 2e-16
```

## CountryComoros	2.196e-01	2.797e-01	0.785	0.432597
## CountryCongo, Dem. Rep.	-1.759e+00	2.914e-01	-6.037	1.91e-09
## CountryCongo, Rep.	-2.828e-01	2.965e-01	-0.954	0.340288
## CountryCosta Rica	6.658e+00	4.006e-01	16.621	< 2e-16
## CountryCroatia	4.608e+00	4.872e-01	9.459	< 2e-16
## CountryCuba	6.113e+00	4.546e-01	13.446	< 2e-16
## CountryCyprus	5.770e+00	5.108e-01	11.295	< 2e-16
## CountryCzechia	5.196e+00	5.235e-01	9.926	< 2e-16
## CountryDenmark	6.434e+00	5.620e-01	11.447	< 2e-16
## CountryDjibouti	2.513e-01	2.654e-01	0.947	0.343733
## CountryDominican Republic	4.566e+00	3.674e-01	12.427	< 2e-16
## CountryEcuador	5.332e+00	3.824e-01	13.945	< 2e-16
## CountryEgypt, Arab Rep.	2.281e+00	3.318e-01	6.875	8.52e-12
## CountryEl Salvador	3.909e+00	3.392e-01	11.526	< 2e-16
## CountryEquatorial Guinea	-2.587e-01	3.624e-01	-0.714	0.475456
## CountryEritrea	-3.178e-02	2.721e-01	-0.117	0.907040
## CountryEstonia	5.336e+00	5.374e-01	9.930	< 2e-16
## CountryEswatini	-2.863e+00	3.923e-01	-7.298	4.35e-13
## CountryEthiopia	-9.338e-02	2.751e-01	-0.339	0.734331
## CountryFiji	2.360e-01	4.186e-01	0.564	0.573030
## CountryFinland	7.234e+00	5.176e-01	13.977	< 2e-16
## CountryFrance	8.868e+00	5.014e-01	17.685	< 2e-16
## CountryGabon	-2.902e-01	3.858e-01	-0.752	0.451977
## CountryGambia	-2.461e+00	2.777e-01	-8.859	< 2e-16
## CountryGeorgia	3.437e+00	4.966e-01	6.920	6.25e-12
## CountryGermany	7.297e+00	5.678e-01	12.852	< 2e-16
## CountryGhana	-1.181e+00	3.055e-01	-3.867	0.000114
## CountryGreece	7.114e+00	4.740e-01	15.009	< 2e-16
## CountryGrenada	3.929e+00	4.050e-01	9.702	< 2e-16
## CountryGuatemala	4.159e+00	3.100e-01	13.418	< 2e-16
## CountryGuinea	-2.376e+00	2.737e-01	-8.681	< 2e-16
## CountryGuinea-Bissau	-4.379e+00	2.878e-01	-15.214	< 2e-16
## CountryGuyana	2.633e+00	3.867e-01	6.810	1.32e-11
## CountryHaiti	-1.150e-01	2.946e-01	-0.390	0.696270
## CountryHonduras	4.309e+00	3.193e-01	13.496	< 2e-16
## CountryHungary	4.992e+00	5.092e-01	9.804	< 2e-16
## CountryIceland	7.967e+00	4.964e-01	16.050	< 2e-16
## CountryIndia	2.048e+00	6.235e-01	3.285	0.001041
## CountryIndonesia	2.046e+00	3.486e-01	5.868	5.23e-09
## CountryIran	3.128e+00	3.668e-01	8.527	< 2e-16
## CountryIraq	1.956e+00	3.097e-01	6.314	3.42e-10
## CountryIreland	7.053e+00	5.370e-01	13.135	< 2e-16
## CountryIsrael	7.687e+00	5.212e-01	14.749	< 2e-16
## CountryItaly	7.834e+00	4.691e-01	16.700	< 2e-16
## CountryJamaica	5.081e+00	4.001e-01	12.698	< 2e-16
## CountryJapan	9.278e+00	5.197e-01	17.854	< 2e-16
## CountryJordan	3.185e+00	4.045e-01	7.875	5.87e-15
## CountryKazakhstan	3.849e+00	4.822e-01	7.984	2.51e-15
## CountryKenya	-6.161e-01	3.083e-01	-1.998	0.045822
## CountryKiribati	1.378e+00	3.419e-01	4.030	5.81e-05
## CountryKuwait	1.182e+00	3.649e-01	3.240	0.001217
## CountryKyrgyz Republic	3.949e+00	4.443e-01	8.888	< 2e-16
## CountryLao PDR	7.161e-01	3.015e-01	2.375	0.017642
## CountryLatvia	5.092e+00	5.193e-01	9.806	< 2e-16

## CountryLebanon	4.978e+00	3.803e-01	13.089	< 2e-16
## CountryLesotho	-1.579e+00	3.484e-01	-4.533	6.21e-06
## CountryLiberia	-9.414e-02	2.985e-01	-0.315	0.752545
## CountryLibya	2.357e+00	3.380e-01	6.974	4.30e-12
## CountryLithuania	5.394e+00	5.175e-01	10.423	< 2e-16
## CountryLuxembourg	7.303e+00	5.221e-01	13.988	< 2e-16
## CountryMadagascar	5.793e-01	2.896e-01	2.000	0.045602
## CountryMalawi	-6.208e-01	2.993e-01	-2.074	0.038228
## CountryMalaysia	3.618e+00	3.920e-01	9.230	< 2e-16
## CountryMaldives	3.198e+00	3.116e-01	10.264	< 2e-16
## CountryMali	-4.417e+00	2.721e-01	-16.231	< 2e-16
## CountryMalta	6.629e+00	4.669e-01	14.196	< 2e-16
## CountryMauritania	-2.678e-01	2.631e-01	-1.018	0.308964
## CountryMauritius	3.930e+00	3.698e-01	10.628	< 2e-16
## CountryMexico	5.138e+00	3.956e-01	12.985	< 2e-16
## CountryMicronesia, Fed. Sts.	-1.160e+00	3.409e-01	-3.404	0.000679
## CountryMoldova	2.570e+00	4.759e-01	5.399	7.59e-08
## CountryMongolia	2.160e+00	4.105e-01	5.263	1.59e-07
## CountryMontenegro	4.240e+00	4.881e-01	8.687	< 2e-16
## CountryMorocco	2.900e+00	3.063e-01	9.466	< 2e-16
## CountryMozambique	-1.766e+00	2.945e-01	-5.999	2.40e-09
## CountryMyanmar	-3.776e-01	2.590e-01	-1.458	0.145031
## CountryNamibia	-4.216e-01	3.346e-01	-1.260	0.207913
## CountryNepal	1.166e+00	2.606e-01	4.473	8.18e-06
## CountryNetherlands	7.118e+00	5.294e-01	13.446	< 2e-16
## CountryNew Zealand	7.603e+00	5.277e-01	14.407	< 2e-16
## CountryNicaragua	3.993e+00	3.349e-01	11.922	< 2e-16
## CountryNiger	-4.110e+00	2.611e-01	-15.740	< 2e-16
## CountryNigeria	-2.975e+00	4.428e-01	-6.718	2.47e-11
## CountryNorth Macedonia	3.347e+00	4.234e-01	7.905	4.62e-15
## CountryNorway	7.594e+00	5.327e-01	14.255	< 2e-16
## CountryOman	3.573e+00	3.559e-01	10.039	< 2e-16
## CountryPakistan	1.668e+00	2.904e-01	5.742	1.10e-08
## CountryPanama	6.567e+00	4.281e-01	15.338	< 2e-16
## CountryPapua New Guinea	-1.499e+00	2.871e-01	-5.220	1.99e-07
## CountryParaguay	4.070e+00	3.825e-01	10.641	< 2e-16
## CountryPeru	4.386e+00	4.181e-01	10.492	< 2e-16
## CountryPhilippines	3.804e+00	4.031e-01	9.436	< 2e-16
## CountryPoland	5.484e+00	5.257e-01	10.432	< 2e-16
## CountryPortugal	6.465e+00	4.385e-01	14.742	< 2e-16
## CountryQatar	5.472e+00	4.265e-01	12.831	< 2e-16
## CountryRomania	4.104e+00	4.698e-01	8.735	< 2e-16
## CountryRussian Federation	3.742e+00	5.291e-01	7.074	2.15e-12
## CountryRwanda	-4.011e-01	3.315e-01	-1.210	0.226541
## CountrySamoa	1.877e+00	4.289e-01	4.375	1.28e-05
## CountrySao Tome and Principe	6.740e-01	3.453e-01	1.952	0.051120
## CountrySaudi Arabia	2.370e+00	3.686e-01	6.428	1.65e-10
## CountrySenegal	-1.082e+00	2.628e-01	-4.115	4.05e-05
## CountrySerbia	3.571e+00	4.847e-01	7.367	2.65e-13
## CountrySeychelles	3.995e+00	4.139e-01	9.651	< 2e-16
## CountrySierra Leone	-1.534e+00	3.300e-01	-4.650	3.56e-06
## CountrySingapore	7.145e+00	4.641e-01	15.396	< 2e-16
## CountrySlovak Republic	4.596e+00	5.104e-01	9.006	< 2e-16
## CountrySlovenia	6.818e+00	5.246e-01	12.996	< 2e-16

## CountrySolomon Islands	2.640e+00	3.161e-01	8.352	< 2e-16
## CountrySomalia	-1.533e+00	3.187e-01	-4.811	1.63e-06
## CountrySouth Africa	2.706e+00	4.374e-01	6.186	7.61e-10
## CountrySpain	8.030e+00	4.589e-01	17.499	< 2e-16
## CountrySri Lanka	4.906e+00	4.255e-01	11.530	< 2e-16
## CountrySt. Lucia	5.921e+00	4.457e-01	13.286	< 2e-16
## CountrySt. Vincent and the Grenadines	3.760e+00	4.268e-01	8.808	< 2e-16
## CountrySuriname	2.740e+00	3.863e-01	7.092	1.89e-12
## CountrySweden	7.639e+00	5.376e-01	14.209	< 2e-16
## CountrySwitzerland	8.592e+00	5.547e-01	15.488	< 2e-16
## CountrySyrian Arab Republic	3.122e+00	3.216e-01	9.706	< 2e-16
## CountryTajikistan	8.899e-01	4.087e-01	2.177	0.029587
## CountryTanzania	-9.413e-01	3.708e-01	-2.538	0.011221
## CountryThailand	4.896e+00	3.681e-01	13.302	< 2e-16
## CountryTimor-Leste	1.383e+00	2.608e-01	5.304	1.27e-07
## CountryTogo	-2.265e+00	2.809e-01	-8.062	1.36e-15
## CountryTonga	6.265e-01	4.409e-01	1.421	0.155549
## CountryTrinidad and Tobago	4.343e+00	4.362e-01	9.955	< 2e-16
## CountryTunisia	3.725e+00	3.443e-01	10.817	< 2e-16
## CountryTurkiye	3.595e+00	3.314e-01	10.847	< 2e-16
## CountryTurkmenistan	1.558e+00	4.061e-01	3.837	0.000129
## CountryUganda	-6.019e-01	3.889e-01	-1.547	0.121927
## CountryUkraine	3.883e+00	4.940e-01	7.860	6.57e-15
## CountryUnited Arab Emirates	3.460e+00	4.169e-01	8.299	< 2e-16
## CountryUnited Kingdom	7.035e+00	5.415e-01	12.993	< 2e-16
## CountryUnited States	6.738e+00	5.497e-01	12.259	< 2e-16
## CountryUruguay	5.341e+00	4.169e-01	12.813	< 2e-16
## CountryUzbekistan	2.195e+00	4.214e-01	5.210	2.11e-07
## CountryVanuatu	4.390e-01	3.383e-01	1.298	0.194588
## CountryVenezuela, RB	3.963e+00	4.374e-01	9.060	< 2e-16
## CountryVietnam	5.095e+00	3.211e-01	15.868	< 2e-16
## CountryYemen, Rep.	1.581e+00	2.669e-01	5.922	3.79e-09
## CountryZambia	-3.200e-01	3.429e-01	-0.933	0.350789
## CountryZimbabwe	-3.542e-02	4.043e-01	-0.088	0.930204
## Under_five_deaths	-1.228e-04	3.182e-04	-0.386	0.699646
## Year	1.101e-01	6.205e-03	17.746	< 2e-16
## Incidents_HIV	-1.362e-03	8.156e-03	-0.167	0.867435
## `Income composition of resources`	-2.969e-01	1.431e-01	-2.074	0.038186
## `Total expenditure`	-3.232e-03	6.118e-03	-0.528	0.597402
## Thinness_ten_nineteen_years	-1.705e-02	9.609e-03	-1.774	0.076162
## Thinness_five_nine_years	3.484e-03	9.473e-03	0.368	0.713062
## RegionAsia	NA	NA	NA	NA
## RegionCentral America and Caribbean	NA	NA	NA	NA
## RegionEuropean Union	NA	NA	NA	NA
## RegionMiddle East	NA	NA	NA	NA
## RegionNorth America	NA	NA	NA	NA
## RegionOceania	NA	NA	NA	NA
## RegionRest of Europe	NA	NA	NA	NA
## RegionSouth America	NA	NA	NA	NA
## Measles	-1.529e-06	1.609e-06	-0.950	0.342262
## Polio	8.772e-04	7.933e-04	1.106	0.268953
## BMI	7.434e-04	1.014e-03	0.733	0.463389
## Diphtheria	1.308e-03	9.127e-04	1.433	0.152026
## GDP_per_capita	1.812e-06	2.636e-06	0.687	0.492024

## `percentage expenditure`	-1.648e-06	1.646e-05	-0.100	0.920254
## Schooling	-7.866e-02	3.862e-02	-2.037	0.041801
## Hepatitis_B	7.707e-04	5.852e-04	1.317	0.187984
## Population_millions	7.915e-11	2.712e-10	0.292	0.770431
## Economy_status_Developed	NA	NA	NA	NA
## I(Alcohol_consumption^2)	-3.629e-03	2.291e-03	-1.584	0.113452
##				
## (Intercept)	***			
## Adult_mortality	***			
## Infant_deaths	***			
## Alcohol_consumption				
## CountryAlbania	***			
## CountryAlgeria	***			
## CountryAngola	***			
## CountryAntigua and Barbuda	***			
## CountryArgentina	***			
## CountryArmenia	***			
## CountryAustralia	***			
## CountryAustria	***			
## CountryAzerbaijan	***			
## CountryBahamas, The	***			
## CountryBahrain	***			
## CountryBangladesh	***			
## CountryBarbados	***			
## CountryBelarus	***			
## CountryBelgium	***			
## CountryBelize	***			
## CountryBenin	***			
## CountryBhutan	***			
## CountryBolivia	***			
## CountryBosnia and Herzegovina	***			
## CountryBotswana	***			
## CountryBrazil	***			
## CountryBrunei Darussalam	***			
## CountryBulgaria	***			
## CountryBurkina Faso	***			
## CountryBurundi	***			
## CountryCabo Verde	***			
## CountryCambodia				
## CountryCameroon	**			
## CountryCanada	***			
## CountryCentral African Republic	***			
## CountryChad	***			
## CountryChile	***			
## CountryChina	***			
## CountryColombia	***			
## CountryComoros				
## CountryCongo, Dem. Rep.	***			
## CountryCongo, Rep.				
## CountryCosta Rica	***			
## CountryCroatia	***			
## CountryCuba	***			
## CountryCyprus	***			
## CountryCzechia	***			

## CountryDenmark	***
## CountryDjibouti	
## CountryDominican Republic	***
## CountryEcuador	***
## CountryEgypt, Arab Rep.	***
## CountryEl Salvador	***
## CountryEquatorial Guinea	
## CountryEritrea	
## CountryEstonia	***
## CountryEswatini	***
## CountryEthiopia	
## CountryFiji	
## CountryFinland	***
## CountryFrance	***
## CountryGabon	
## CountryGambia	***
## CountryGeorgia	***
## CountryGermany	***
## CountryGhana	***
## CountryGreece	***
## CountryGrenada	***
## CountryGuatemala	***
## CountryGuinea	***
## CountryGuinea-Bissau	***
## CountryGuyana	***
## CountryHaiti	
## CountryHonduras	***
## CountryHungary	***
## CountryIceland	***
## CountryIndia	**
## CountryIndonesia	***
## CountryIran	***
## CountryIraq	***
## CountryIreland	***
## CountryIsrael	***
## CountryItaly	***
## CountryJamaica	***
## CountryJapan	***
## CountryJordan	***
## CountryKazakhstan	***
## CountryKenya	*
## CountryKiribati	***
## CountryKuwait	**
## CountryKyrgyz Republic	***
## CountryLao PDR	*
## CountryLatvia	***
## CountryLebanon	***
## CountryLesotho	***
## CountryLiberia	
## CountryLibya	***
## CountryLithuania	***
## CountryLuxembourg	***
## CountryMadagascar	*
## CountryMalawi	*



## CountryMalaysia	***
## CountryMaldives	***
## CountryMali	***
## CountryMalta	***
## CountryMauritania	
## CountryMauritius	***
## CountryMexico	***
## CountryMicronesia, Fed. Sts.	***
## CountryMoldova	***
## CountryMongolia	***
## CountryMontenegro	***
## CountryMorocco	***
## CountryMozambique	***
## CountryMyanmar	
## CountryNamibia	
## CountryNepal	***
## CountryNetherlands	***
## CountryNew Zealand	***
## CountryNicaragua	***
## CountryNiger	***
## CountryNigeria	***
## CountryNorth Macedonia	***
## CountryNorway	***
## CountryOman	***
## CountryPakistan	***
## CountryPanama	***
## CountryPapua New Guinea	***
## CountryParaguay	***
## CountryPeru	***
## CountryPhilippines	***
## CountryPoland	***
## CountryPortugal	***
## CountryQatar	***
## CountryRomania	***
## CountryRussian Federation	***
## CountryRwanda	
## CountrySamoa	***
## CountrySao Tome and Principe	.
## CountrySaudi Arabia	***
## CountrySenegal	***
## CountrySerbia	***
## CountrySeychelles	***
## CountrySierra Leone	***
## CountrySingapore	***
## CountrySlovak Republic	***
## CountrySlovenia	***
## CountrySolomon Islands	***
## CountrySomalia	***
## CountrySouth Africa	***
## CountrySpain	***
## CountrySri Lanka	***
## CountrySt. Lucia	***
## CountrySt. Vincent and the Grenadines	***
## CountrySuriname	***

```

## CountrySweden          ***
## CountrySwitzerland      ***
## CountrySyrian Arab Republic ***
## CountryTajikistan       *
## CountryTanzania         *
## CountryThailand         ***
## CountryTimor-Leste      ***
## CountryTogo             ***
## CountryTonga
## CountryTrinidad and Tobago ***
## CountryTunisia          ***
## CountryTurkiye           ***
## CountryTurkmenistan     ***
## CountryUganda
## CountryUkraine          ***
## CountryUnited Arab Emirates ***
## CountryUnited Kingdom   ***
## CountryUnited States    ***
## CountryUruguay          ***
## CountryUzbekistan       ***
## CountryVanuatu
## CountryVenezuela, RB    ***
## CountryVietnam          ***
## CountryYemen, Rep.      ***
## CountryZambia
## CountryZimbabwe
## Under_five_deaths
## Year                    ***
## Incidents_HIV
## `Income composition of resources` *
## `Total expenditure`
## Thinness_ten_nineteen_years .
## Thinness_five_nine_years
## RegionAsia
## RegionCentral America and Caribbean
## RegionEuropean Union
## RegionMiddle East
## RegionNorth America
## RegionOceania
## RegionRest of Europe
## RegionSouth America
## Measles
## Polio
## BMI
## Diphtheria
## GDP_per_capita
## `percentage expenditure`
## Schooling               *
## Hepatitis_B
## Population_millions
## Economy_status_Developed
## I(Alcohol_consumption^2)
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```
##
## Residual standard error: 0.5289 on 1798 degrees of freedom
## Multiple R-squared:  0.9971, Adjusted R-squared:  0.9968
## F-statistic: 3169 on 197 and 1798 DF,  p-value: < 2.2e-16

# Model 2 Enhanced LRM with Predictors (Model 2)
model_2 <- lm(Life_expectancy ~ Year + Adult_mortality + Alcohol_consumption + BMI, data = train_data_selected)
summary(model_2)

##
## Call:
## lm(formula = Life_expectancy ~ Year + Adult_mortality + Alcohol_consumption +
##     BMI, data = train_data_selected)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -9.1307 -1.4582  0.1005  1.5635 13.5022
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -2.472e+01  2.513e+01  -0.983   0.326
## Year           5.187e-02  1.251e-02   4.146 3.53e-05 ***
## Adult_mortality -7.072e-02  5.626e-04 -125.705 < 2e-16 ***
## Alcohol_consumption 4.054e-01  1.497e-02  27.082 < 2e-16 ***
## BMI            2.984e-02  3.133e-03   9.525 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.534 on 1991 degrees of freedom
## Multiple R-squared:  0.927, Adjusted R-squared:  0.9269
## F-statistic: 6323 on 4 and 1991 DF,  p-value: < 2.2e-16

# Model 3 Generalized Linear Model with Log Link
glm_model <- glm(Life_expectancy ~ ., family = gaussian(link = "log"), data = train_data_selected)
model_3 <- (glm_model)
summary(model_3)

##
## Call:
## glm(formula = Life_expectancy ~ ., family = gaussian(link = "log"),
##     data = train_data_selected)
##
## Coefficients: (9 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2.532e+00  1.813e-01  13.963 < 2e-16
## Adult_mortality -7.219e-04  1.523e-05 -47.410 < 2e-16
## Infant_deaths   -1.728e-03  4.927e-05 -35.070 < 2e-16
## Alcohol_consumption -5.879e-04  2.344e-04  -2.508 0.012235
## CountryAlbania     2.396e-02  6.356e-03   3.770 0.000169
## CountryAlgeria     3.244e-02  5.285e-03   6.137 1.03e-09
## CountryAngola     -5.930e-02  4.958e-03 -11.959 < 2e-16
## CountryAntigua and Barbuda 4.925e-02  6.319e-03   7.793 1.09e-14
## CountryArgentina    4.162e-02  6.436e-03   6.466 1.29e-10
```

## CountryArmenia	3.226e-02	6.820e-03	4.731	2.41e-06
## CountryAustralia	6.632e-02	7.794e-03	8.510	< 2e-16
## CountryAustria	5.832e-02	7.565e-03	7.709	2.08e-14
## CountryAzerbaijan	2.485e-02	6.586e-03	3.773	0.000167
## CountryBahamas, The	4.125e-02	7.076e-03	5.829	6.60e-09
## CountryBahrain	3.058e-05	6.027e-03	0.005	0.995952
## CountryBangladesh	1.370e-02	4.267e-03	3.211	0.001346
## CountryBarbados	7.450e-02	6.411e-03	11.621	< 2e-16
## CountryBelarus	3.758e-02	7.285e-03	5.158	2.77e-07
## CountryBelgium	5.851e-02	7.417e-03	7.888	5.29e-15
## CountryBelize	3.793e-02	6.565e-03	5.777	8.92e-09
## CountryBenin	-1.924e-02	4.433e-03	-4.340	1.50e-05
## CountryBhutan	3.486e-02	4.258e-03	8.186	5.05e-16
## CountryBolivia	2.222e-02	5.412e-03	4.106	4.21e-05
## CountryBosnia and Herzegovina	2.102e-02	5.863e-03	3.585	0.000346
## CountryBotswana	4.032e-02	6.323e-03	6.377	2.29e-10
## CountryBrazil	4.386e-02	5.540e-03	7.916	4.24e-15
## CountryBrunei Darussalam	-5.095e-03	6.092e-03	-0.836	0.403032
## CountryBulgaria	2.934e-02	6.914e-03	4.243	2.32e-05
## CountryBurkina Faso	-4.641e-02	5.119e-03	-9.066	< 2e-16
## CountryBurundi	-3.147e-02	4.612e-03	-6.824	1.21e-11
## CountryCabo Verde	5.722e-04	5.120e-03	0.112	0.911028
## CountryCambodia	-3.473e-03	4.622e-03	-0.752	0.452447
## CountryCameroon	-8.495e-03	4.774e-03	-1.780	0.075325
## CountryCanada	7.003e-02	7.699e-03	9.097	< 2e-16
## CountryCentral African Republic	-3.012e-02	6.128e-03	-4.915	9.66e-07
## CountryChad	-5.267e-02	5.379e-03	-9.792	< 2e-16
## CountryChile	5.845e-02	6.479e-03	9.022	< 2e-16
## CountryChina	4.538e-03	5.901e-03	0.769	0.442000
## CountryColombia	6.381e-02	5.831e-03	10.943	< 2e-16
## CountryComoros	4.946e-03	4.664e-03	1.061	0.289057
## CountryCongo, Dem. Rep.	-2.182e-02	4.715e-03	-4.628	3.96e-06
## CountryCongo, Rep.	-1.629e-03	4.825e-03	-0.338	0.735753
## CountryCosta Rica	5.322e-02	5.990e-03	8.885	< 2e-16
## CountryCroatia	2.893e-02	7.172e-03	4.033	5.73e-05
## CountryCuba	4.532e-02	6.708e-03	6.756	1.91e-11
## CountryCyprus	3.361e-02	7.509e-03	4.476	8.07e-06
## CountryCzechia	3.364e-02	7.793e-03	4.316	1.67e-05
## CountryDenmark	4.955e-02	8.179e-03	6.058	1.68e-09
## CountryDjibouti	1.011e-02	4.467e-03	2.264	0.023711
## CountryDominican Republic	5.275e-02	5.312e-03	9.929	< 2e-16
## CountryEcuador	4.958e-02	5.694e-03	8.707	< 2e-16
## CountryEgypt, Arab Rep.	1.208e-02	5.245e-03	2.304	0.021351
## CountryEl Salvador	3.950e-02	5.215e-03	7.574	5.75e-14
## CountryEquatorial Guinea	1.088e-02	5.433e-03	2.003	0.045329
## CountryEritrea	-2.111e-03	4.476e-03	-0.472	0.637315
## CountryEstonia	4.811e-02	8.036e-03	5.987	2.58e-09
## CountryEswatini	-4.989e-02	6.286e-03	-7.936	3.64e-15
## CountryEthiopia	5.384e-05	4.622e-03	0.012	0.990708
## CountryFiji	-1.440e-02	6.347e-03	-2.268	0.023421
## CountryFinland	5.847e-02	7.518e-03	7.777	1.24e-14
## CountryFrance	7.843e-02	7.440e-03	10.542	< 2e-16
## CountryGabon	2.973e-03	5.636e-03	0.527	0.597941
## CountryGambia	-3.914e-02	4.392e-03	-8.912	< 2e-16

## CountryGeorgia	2.925e-02	7.208e-03	4.058	5.16e-05
## CountryGermany	5.818e-02	8.321e-03	6.993	3.79e-12
## CountryGhana	-1.974e-02	4.893e-03	-4.035	5.70e-05
## CountryGreece	5.457e-02	6.877e-03	7.936	3.65e-15
## CountryGrenada	3.170e-02	5.818e-03	5.448	5.78e-08
## CountryGuatemala	4.646e-02	4.842e-03	9.594	< 2e-16
## CountryGuinea	-3.449e-02	4.755e-03	-7.252	6.08e-13
## CountryGuinea-Bissau	-6.562e-02	4.691e-03	-13.988	< 2e-16
## CountryGuyana	3.164e-02	5.562e-03	5.689	1.49e-08
## CountryHaiti	4.600e-03	4.612e-03	0.997	0.318749
## CountryHonduras	4.048e-02	4.920e-03	8.228	3.61e-16
## CountryHungary	4.481e-02	7.497e-03	5.977	2.73e-09
## CountryIceland	6.041e-02	7.234e-03	8.352	< 2e-16
## CountryIndia	1.664e-02	9.434e-03	1.764	0.077911
## CountryIndonesia	1.366e-02	5.464e-03	2.500	0.012490
## CountryIran	1.156e-02	5.671e-03	2.039	0.041572
## CountryIraq	1.047e-02	4.914e-03	2.130	0.033299
## CountryIreland	5.389e-02	7.912e-03	6.811	1.32e-11
## CountryIsrael	5.713e-02	7.761e-03	7.361	2.75e-13
## CountryItaly	5.963e-02	6.838e-03	8.721	< 2e-16
## CountryJamaica	4.722e-02	6.001e-03	7.870	6.08e-15
## CountryJapan	7.859e-02	7.519e-03	10.451	< 2e-16
## CountryJordan	1.473e-02	6.214e-03	2.370	0.017876
## CountryKazakhstan	4.781e-02	7.051e-03	6.780	1.63e-11
## CountryKenya	-8.273e-03	5.031e-03	-1.644	0.100281
## CountryKiribati	1.501e-02	5.445e-03	2.757	0.005896
## CountryKuwait	-2.627e-02	5.739e-03	-4.578	5.01e-06
## CountryKyrgyz Republic	4.742e-02	6.405e-03	7.405	2.01e-13
## CountryLao PDR	1.116e-02	4.415e-03	2.528	0.011556
## CountryLatvia	5.257e-02	7.516e-03	6.995	3.72e-12
## CountryLebanon	2.692e-02	5.850e-03	4.601	4.49e-06
## CountryLesotho	-2.361e-02	6.062e-03	-3.894	0.000102
## CountryLiberia	8.817e-03	4.655e-03	1.894	0.058359
## CountryLibya	4.042e-03	5.301e-03	0.762	0.445928
## CountryLithuania	5.565e-02	7.627e-03	7.296	4.42e-13
## CountryLuxembourg	5.633e-02	7.686e-03	7.329	3.48e-13
## CountryMadagascar	6.841e-03	4.671e-03	1.465	0.143207
## CountryMalawi	-1.768e-03	5.115e-03	-0.346	0.729690
## CountryMalaysia	1.557e-02	5.999e-03	2.596	0.009509
## CountryMaldives	7.206e-03	4.834e-03	1.491	0.136241
## CountryMali	-7.130e-02	4.749e-03	-15.015	< 2e-16
## CountryMalta	4.526e-02	6.835e-03	6.622	4.68e-11
## CountryMauritania	-5.329e-03	4.382e-03	-1.216	0.224087
## CountryMauritius	2.981e-02	5.499e-03	5.420	6.76e-08
## CountryMexico	4.352e-02	5.841e-03	7.451	1.43e-13
## CountryMicronesia, Fed. Sts.	-3.445e-02	5.359e-03	-6.429	1.64e-10
## CountryMoldova	2.202e-02	6.863e-03	3.209	0.001354
## CountryMongolia	2.442e-02	6.100e-03	4.003	6.51e-05
## CountryMontenegro	2.779e-02	7.076e-03	3.927	8.92e-05
## CountryMorocco	1.456e-02	4.875e-03	2.987	0.002856
## CountryMozambique	-1.949e-02	5.204e-03	-3.745	0.000186
## CountryMyanmar	-1.190e-02	4.241e-03	-2.806	0.005066
## CountryNamibia	2.128e-03	5.460e-03	0.390	0.696848
## CountryNepal	4.011e-03	4.203e-03	0.954	0.340113

## CountryNetherlands	5.390e-02	7.686e-03	7.013	3.30e-12
## CountryNew Zealand	6.189e-02	7.666e-03	8.073	1.24e-15
## CountryNicaragua	3.827e-02	5.058e-03	7.566	6.09e-14
## CountryNiger	-6.693e-02	4.509e-03	-14.842	< 2e-16
## CountryNigeria	-4.592e-02	6.846e-03	-6.709	2.62e-11
## CountryNorth Macedonia	1.538e-02	6.315e-03	2.435	0.014981
## CountryNorway	5.869e-02	7.762e-03	7.561	6.34e-14
## CountryOman	1.274e-02	5.538e-03	2.300	0.021544
## CountryPakistan	2.098e-02	4.694e-03	4.469	8.34e-06
## CountryPanama	6.401e-02	6.225e-03	10.284	< 2e-16
## CountryPapua New Guinea	-2.687e-02	4.753e-03	-5.653	1.83e-08
## CountryParaguay	3.870e-02	5.578e-03	6.937	5.56e-12
## CountryPeru	3.789e-02	6.134e-03	6.178	8.03e-10
## CountryPhilippines	4.237e-02	5.906e-03	7.174	1.06e-12
## CountryPoland	4.589e-02	7.581e-03	6.053	1.72e-09
## CountryPortugal	4.834e-02	6.481e-03	7.460	1.34e-13
## CountryQatar	2.874e-02	6.464e-03	4.446	9.26e-06
## CountryRomania	3.402e-02	6.829e-03	4.981	6.92e-07
## CountryRussian Federation	4.532e-02	7.727e-03	5.865	5.32e-09
## CountryRwanda	-1.658e-03	4.807e-03	-0.345	0.730240
## CountrySamoa	1.666e-03	6.458e-03	0.258	0.796447
## CountrySao Tome and Principe	-4.015e-04	5.087e-03	-0.079	0.937100
## CountrySaudi Arabia	-4.495e-03	5.727e-03	-0.785	0.432582
## CountrySenegal	-2.377e-02	4.360e-03	-5.452	5.68e-08
## CountrySerbia	2.092e-02	6.991e-03	2.992	0.002806
## CountrySeychelles	3.217e-02	5.928e-03	5.426	6.53e-08
## CountrySierra Leone	-2.514e-02	5.597e-03	-4.492	7.51e-06
## CountrySingapore	4.758e-02	7.011e-03	6.786	1.56e-11
## CountrySlovak Republic	3.371e-02	7.432e-03	4.536	6.13e-06
## CountrySlovenia	5.475e-02	7.657e-03	7.150	1.26e-12
## CountrySolomon Islands	1.911e-02	5.034e-03	3.796	0.000152
## CountrySomalia	-1.703e-02	5.530e-03	-3.080	0.002104
## CountrySouth Africa	6.429e-02	6.511e-03	9.875	< 2e-16
## CountrySpain	6.370e-02	6.742e-03	9.448	< 2e-16
## CountrySri Lanka	3.563e-02	6.333e-03	5.626	2.14e-08
## CountrySt. Lucia	6.129e-02	6.516e-03	9.407	< 2e-16
## CountrySt. Vincent and the Grenadines	3.396e-02	6.211e-03	5.468	5.18e-08
## CountrySuriname	2.438e-02	5.665e-03	4.303	1.77e-05
## CountrySweden	5.748e-02	7.802e-03	7.368	2.62e-13
## CountrySwitzerland	7.097e-02	8.089e-03	8.773	< 2e-16
## CountrySyrian Arab Republic	2.303e-02	5.042e-03	4.569	5.24e-06
## CountryTajikistan	-1.231e-03	6.273e-03	-0.196	0.844484
## CountryTanzania	-1.197e-02	5.559e-03	-2.152	0.031505
## CountryThailand	4.681e-02	5.262e-03	8.896	< 2e-16
## CountryTimor-Leste	1.413e-02	4.259e-03	3.318	0.000926
## CountryTogo	-3.275e-02	4.768e-03	-6.868	8.91e-12
## CountryTonga	-1.858e-02	6.765e-03	-2.747	0.006071
## CountryTrinidad and Tobago	4.614e-02	6.288e-03	7.337	3.28e-13
## CountryTunisia	1.836e-02	5.332e-03	3.444	0.000587
## CountryTurkiye	2.167e-02	5.174e-03	4.189	2.94e-05
## CountryTurkmenistan	1.571e-02	6.125e-03	2.565	0.010403
## CountryUganda	-3.517e-03	6.035e-03	-0.583	0.560115
## CountryUkraine	4.415e-02	7.126e-03	6.196	7.17e-10
## CountryUnited Arab Emirates	6.505e-03	6.357e-03	1.023	0.306348

## CountryUnited Kingdom	5.413e-02	7.927e-03	6.829	1.17e-11
## CountryUnited States	5.750e-02	7.935e-03	7.247	6.31e-13
## CountryUruguay	4.221e-02	6.054e-03	6.972	4.37e-12
## CountryUzbekistan	1.476e-02	6.370e-03	2.317	0.020589
## CountryVanuatu	-1.569e-02	5.348e-03	-2.934	0.003384
## CountryVenezuela, RB	3.324e-02	6.287e-03	5.287	1.40e-07
## CountryVietnam	4.277e-02	4.911e-03	8.709	< 2e-16
## CountryYemen, Rep.	1.977e-02	4.355e-03	4.540	6.00e-06
## CountryZambia	1.049e-04	5.535e-03	0.019	0.984876
## CountryZimbabwe	7.067e-03	6.679e-03	1.058	0.290133
## Under_five_deaths	1.976e-06	4.894e-06	0.404	0.686388
## Year	9.332e-04	9.006e-05	10.362	< 2e-16
## Incidents_HIV	-9.150e-04	1.506e-04	-6.076	1.50e-09
## `Income composition of resources`	-5.036e-03	2.095e-03	-2.404	0.016300
## `Total expenditure`	-8.882e-05	8.722e-05	-1.018	0.308661
## Thinness_ten_nineteen_years	-2.116e-04	1.564e-04	-1.353	0.176141
## Thinness_five_nine_years	1.601e-04	1.533e-04	1.045	0.296345
## RegionAsia	NA	NA	NA	NA
## RegionCentral America and Caribbean	NA	NA	NA	NA
## RegionEuropean Union	NA	NA	NA	NA
## RegionMiddle East	NA	NA	NA	NA
## RegionNorth America	NA	NA	NA	NA
## RegionOceania	NA	NA	NA	NA
## RegionRest of Europe	NA	NA	NA	NA
## RegionSouth America	NA	NA	NA	NA
## Measles	-7.014e-08	2.835e-08	-2.474	0.013449
## Polio	6.579e-07	1.212e-05	0.054	0.956719
## BMI	1.703e-05	1.415e-05	1.203	0.229130
## Diphtheria	3.433e-05	1.397e-05	2.457	0.014086
## GDP_per_capita	3.031e-08	3.432e-08	0.883	0.377290
## `percentage expenditure`	-7.456e-08	2.134e-07	-0.349	0.726812
## Schooling	-1.222e-03	5.539e-04	-2.207	0.027465
## Hepatitis_B	1.672e-05	8.712e-06	1.919	0.055199
## Population_millions	2.110e-12	4.177e-12	0.505	0.613478
## Economy_status_Developed	NA	NA	NA	NA
##				
## (Intercept)	***			
## Adult_mortality	***			
## Infant_deaths	***			
## Alcohol_consumption	*			
## CountryAlbania	***			
## CountryAlgeria	***			
## CountryAngola	***			
## CountryAntigua and Barbuda	***			
## CountryArgentina	***			
## CountryArmenia	***			
## CountryAustralia	***			
## CountryAustria	***			
## CountryAzerbaijan	***			
## CountryBahamas, The	***			
## CountryBahrain				
## CountryBangladesh	**			
## CountryBarbados	***			
## CountryBelarus	***			

## CountryBelgium	***
## CountryBelize	***
## CountryBenin	***
## CountryBhutan	***
## CountryBolivia	***
## CountryBosnia and Herzegovina	***
## CountryBotswana	***
## CountryBrazil	***
## CountryBrunei Darussalam	
## CountryBulgaria	***
## CountryBurkina Faso	***
## CountryBurundi	***
## CountryCabo Verde	
## CountryCambodia	
## CountryCameroon	.
## CountryCanada	***
## CountryCentral African Republic	***
## CountryChad	***
## CountryChile	***
## CountryChina	
## CountryColombia	***
## CountryComoros	
## CountryCongo, Dem. Rep.	***
## CountryCongo, Rep.	
## CountryCosta Rica	***
## CountryCroatia	***
## CountryCuba	***
## CountryCyprus	***
## CountryCzechia	***
## CountryDenmark	***
## CountryDjibouti	*
## CountryDominican Republic	***
## CountryEcuador	***
## CountryEgypt, Arab Rep.	*
## CountryEl Salvador	***
## CountryEquatorial Guinea	*
## CountryEritrea	
## CountryEstonia	***
## CountryEswatini	***
## CountryEthiopia	
## CountryFiji	*
## CountryFinland	***
## CountryFrance	***
## CountryGabon	
## CountryGambia	***
## CountryGeorgia	***
## CountryGermany	***
## CountryGhana	***
## CountryGreece	***
## CountryGrenada	***
## CountryGuatemala	***
## CountryGuinea	***
## CountryGuinea-Bissau	***
## CountryGuyana	***



## CountryHaiti	
## CountryHonduras	***
## CountryHungary	***
## CountryIceland	***
## CountryIndia	.
## CountryIndonesia	*
## CountryIran	*
## CountryIraq	*
## CountryIreland	***
## CountryIsrael	***
## CountryItaly	***
## CountryJamaica	***
## CountryJapan	***
## CountryJordan	*
## CountryKazakhstan	***
## CountryKenya	
## CountryKiribati	**
## CountryKuwait	***
## CountryKyrgyz Republic	***
## CountryLao PDR	*
## CountryLatvia	***
## CountryLebanon	***
## CountryLesotho	***
## CountryLiberia	.
## CountryLibya	
## CountryLithuania	***
## CountryLuxembourg	***
## CountryMadagascar	
## CountryMalawi	
## CountryMalaysia	**
## CountryMaldives	
## CountryMali	***
## CountryMalta	***
## CountryMauritania	
## CountryMauritius	***
## CountryMexico	***
## CountryMicronesia, Fed. Sts.	***
## CountryMoldova	**
## CountryMongolia	***
## CountryMontenegro	***
## CountryMorocco	**
## CountryMozambique	***
## CountryMyanmar	**
## CountryNamibia	
## CountryNepal	
## CountryNetherlands	***
## CountryNew Zealand	***
## CountryNicaragua	***
## CountryNiger	***
## CountryNigeria	***
## CountryNorth Macedonia	*
## CountryNorway	***
## CountryOman	*
## CountryPakistan	***

## CountryPanama	***
## CountryPapua New Guinea	***
## CountryParaguay	***
## CountryPeru	***
## CountryPhilippines	***
## CountryPoland	***
## CountryPortugal	***
## CountryQatar	***
## CountryRomania	***
## CountryRussian Federation	***
## CountryRwanda	
## CountrySamoa	
## CountrySao Tome and Principe	
## CountrySaudi Arabia	
## CountrySenegal	***
## CountrySerbia	**
## CountrySeychelles	***
## CountrySierra Leone	***
## CountrySingapore	***
## CountrySlovak Republic	***
## CountrySlovenia	***
## CountrySolomon Islands	***
## CountrySomalia	**
## CountrySouth Africa	***
## CountrySpain	***
## CountrySri Lanka	***
## CountrySt. Lucia	***
## CountrySt. Vincent and the Grenadines	***
## CountrySuriname	***
## CountrySweden	***
## CountrySwitzerland	***
## CountrySyrian Arab Republic	***
## CountryTajikistan	
## CountryTanzania	*
## CountryThailand	***
## CountryTimor-Leste	***
## CountryTogo	***
## CountryTonga	**
## CountryTrinidad and Tobago	***
## CountryTunisia	***
## CountryTurkiye	***
## CountryTurkmenistan	*
## CountryUganda	
## CountryUkraine	***
## CountryUnited Arab Emirates	
## CountryUnited Kingdom	***
## CountryUnited States	***
## CountryUruguay	***
## CountryUzbekistan	*
## CountryVanuatu	**
## CountryVenezuela, RB	***
## CountryVietnam	***
## CountryYemen, Rep.	***
## CountryZambia	

```

## CountryZimbabwe
## Under_five_deaths
## Year ***
## Incidents_HIV ***
## `Income composition of resources` *
## `Total expenditure`
## Thinness_ten_nineteen_years
## Thinness_five_nine_years
## RegionAsia
## RegionCentral America and Caribbean
## RegionEuropean Union
## RegionMiddle East
## RegionNorth America
## RegionOceania
## RegionRest of Europe
## RegionSouth America
## Measles *
## Polio
## BMI
## Diphtheria *
## GDP_per_capita
## `percentage expenditure`
## Schooling *
## Hepatitis_B .
## Population_millions
## Economy_status_Developed
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.2905737)
##
## Null deviance: 175136.33 on 1995 degrees of freedom
## Residual deviance: 522.74 on 1799 degrees of freedom
## AIC: 3386.1
##
## Number of Fisher Scoring iterations: 4

# Plot Models 1,2,3

# Convert to long format for plotting
comparison_long <- comparison_df %>%
  pivot_longer(cols = starts_with("Predicted"), names_to = "Model", values_to = "Predicted")
# Load the training data
trainData <- read_csv("train_data.csv")

## Rows: 1996 Columns: 24
## -- Column specification -----
## Delimiter: ","
## chr (2): Country, Region
## dbl (22): Column1, Year, Economy_status_Developed, Life_expectancy, Adult_mo...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.

```

```

# Generate predicted values
predicted_values_1 <- predict(model_1, trainData)

## Warning in predict.lm(model_1, trainData): prediction from rank-deficient fit;
## attr(*, "non-estim") has doubtful cases

predicted_values_2 <- predict(model_2, trainData)
predicted_values_3 <- predict(model_3, trainData)

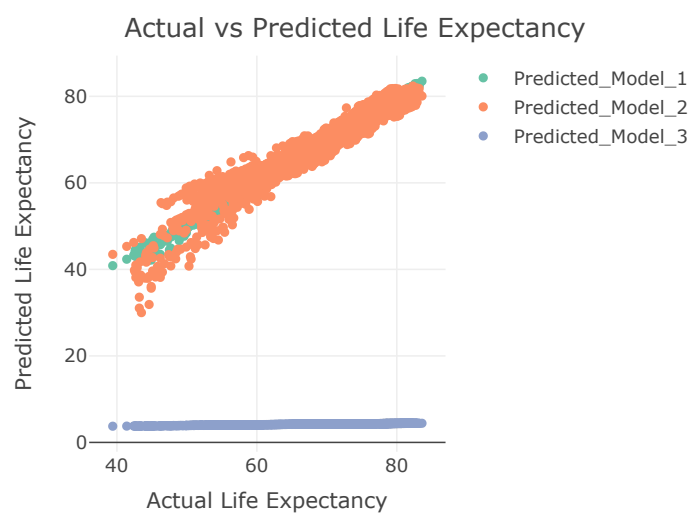
# Combine actual and predicted values into a data frame
comparison_df <- data.frame(
  Actual = trainData$Life_expectancy,
  Predicted_Model_1 = predicted_values_1,
  Predicted_Model_2 = predicted_values_2,
  Predicted_Model_3 = predicted_values_3
)

# Convert to long format for plotting
comparison_long <- comparison_df %>%
  pivot_longer(cols = starts_with("Predicted"), names_to = "Model", values_to = "Predicted")

# Create the plot
p123 <- comparison_long %>%
  plot_ly(x = ~Actual, y = ~Predicted, color = ~Model, type = 'scatter', mode = 'markers') %>%
  layout(title = "Actual vs Predicted Life Expectancy",
    xaxis = list(title = "Actual Life Expectancy"),
    yaxis = list(title = "Predicted Life Expectancy"),
    hovermode = "compare")

# Display the plot
p123

```



```
saveRDS(p123, file = "plot123.rds")  
save(p123, file = "plot123.RData")
```

```
# Residual Analysis and Diagnostics Plots
```

```
# Residuals vs Fitted Values
```

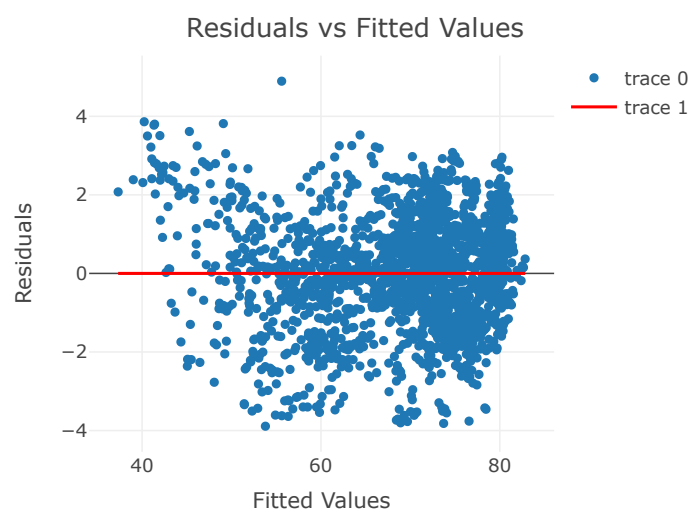
```
predicted_values <- predict(simple_model, train_data_selected)  
residuals <- residuals(simple_model)
```

```
# Interactive Residuals vs Fitted Values Plot
```

```
p_residuals_fitted <- plot_ly(x = predicted_values, y = residuals, type = 'scatter', mode = 'markers')  
  layout(title = 'Residuals vs Fitted Values',  
    xaxis = list(title = 'Fitted Values'),  
    yaxis = list(title = 'Residuals')) %>%  
  add_lines(x = predicted_values, y = rep(0, length(residuals)), line = list(color = 'red'))
```

```
# Display the interactive plot
```

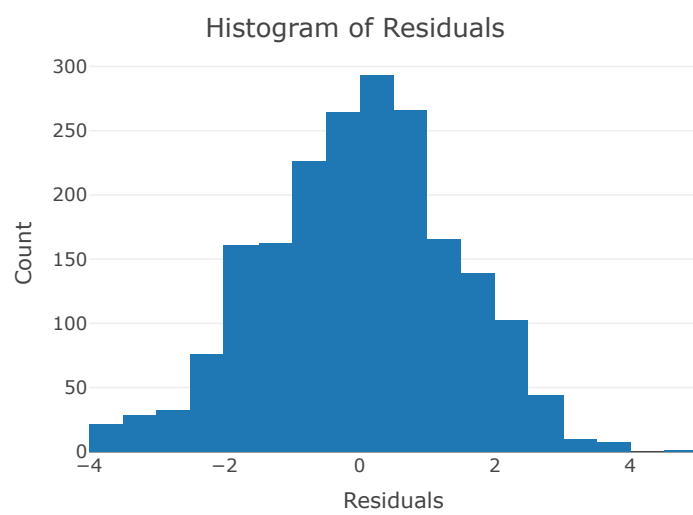
```
p_residuals_fitted
```



*# Normality of Residuals: Histogram*

```
p_hist_residuals <- plot_ly(x = residuals, type = 'histogram', nbinsx = 30) %>%  
  layout(title = 'Histogram of Residuals',  
    xaxis = list(title = 'Residuals'),  
    yaxis = list(title = 'Count'))  
  
# Display the histogram  
p_hist_residuals
```





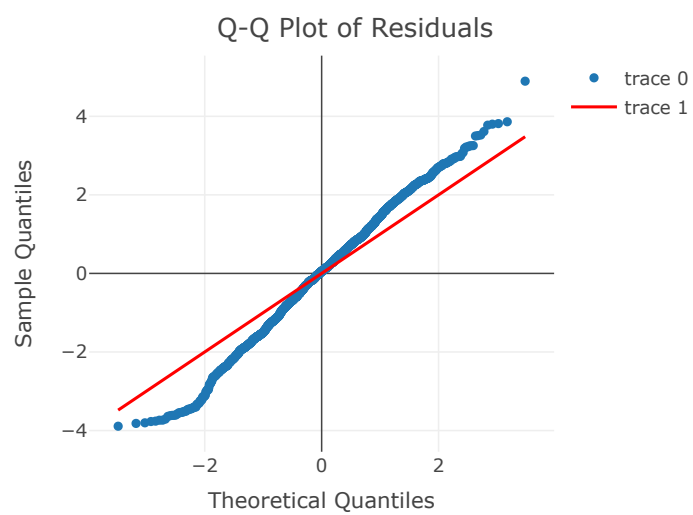
*# Normality of Residuals: Q-Q Plot*

```

qq <- qqnorm(residuals, plot.it = FALSE)
p_qq_residuals <- plot_ly(x = qq$x, y = qq$y, type = 'scatter', mode = 'markers') %>%
  layout(title = 'Q-Q Plot of Residuals',
    xaxis = list(title = 'Theoretical Quantiles'),
    yaxis = list(title = 'Sample Quantiles')) %>%
  add_lines(x = qq$x, y = qq$x, line = list(color = 'red'))

# Display the Q-Q plot
p_qq_residuals

```



## Part F: AIC

The Akaike Information Criterion (AIC) is a tool used to assess the quality of statistical models for a given dataset. It balances the complexity of the model against how well the model fits the data. A lower AIC value generally indicates a better model, as it suggests a model that explains a high degree of variability in the data without unnecessary complexity.

Let's analyze the AIC values for each of the models:

### 1. Simple Linear Regression Model (`simple_model`):

- AIC: 7096.756
- This is a baseline model with a relatively high AIC, suggesting it might be more complex or fit the data less effectively compared to others.

### 2. Enhanced Linear Regression Model (`enhanced_model`):

- AIC: 3310.982
- This model has a significantly lower AIC compared to the simple model, indicating a better balance of model fit and complexity. It might be the preferred model based on AIC.

### 3. Reduced Linear Regression Model (`model_2`):

- AIC: 9382.416
- The high AIC value suggests that while this model is simpler (fewer predictors), it may not fit the data as well as other models.

### 4. Generalized Linear Model with Log Link (`glm_model`):

- AIC: 3386.137
- This AIC is slightly higher than that of the enhanced model but still lower than the simple model, indicating reasonable model performance.

### 5. Robust Linear Regression Model (`robust_model`):

- AIC: 10195.21
- This model has the highest AIC value among the ones compared, suggesting it might be the least preferable in terms of the balance between data fit and complexity.

In summary, based on AIC values, the `enhanced_model` appears to be the most effective in balancing data fit and model simplicity. It's important to remember that while AIC is a useful criterion for model comparison, it should be considered alongside other diagnostic measures and domain-specific considerations to choose the most appropriate model for your analysis.

```
#reduced model
reduced_model <- lm(Life_expectancy ~ Adult_mortality + Year + BMI, data = train_data_selected)
summary(reduced_model)
```

```
##
## Call:
## lm(formula = Life_expectancy ~ Adult_mortality + Year + BMI,
##     data = train_data_selected)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.4124  -2.0922   0.2876   1.9695  13.7407
##
## Coefficients:
```

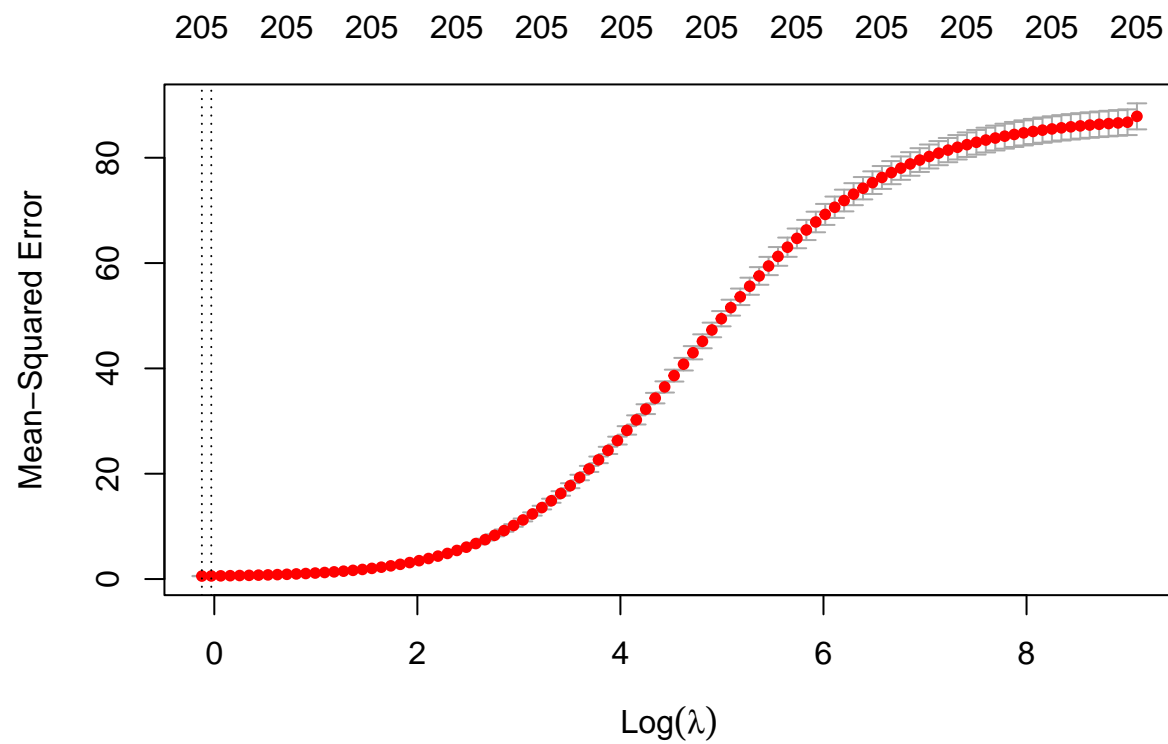
```
##               Estimate Std. Error  t value Pr(>|t|)
## (Intercept)    23.9753240  29.3179603    0.818   0.414
## Adult_mortality -0.0729695  0.0006508 -112.123 <2e-16 ***
## Year           0.0285014  0.0145968    1.953   0.051 .
## BMI            0.0462211  0.0035956   12.855 <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.963 on 1992 degrees of freedom
## Multiple R-squared:  0.9001, Adjusted R-squared:  0.9
## F-statistic: 5986 on 3 and 1992 DF,  p-value: < 2.2e-16
```

```
library(car)
vif_results <- vif(reduced_model)
print(vif_results)
```

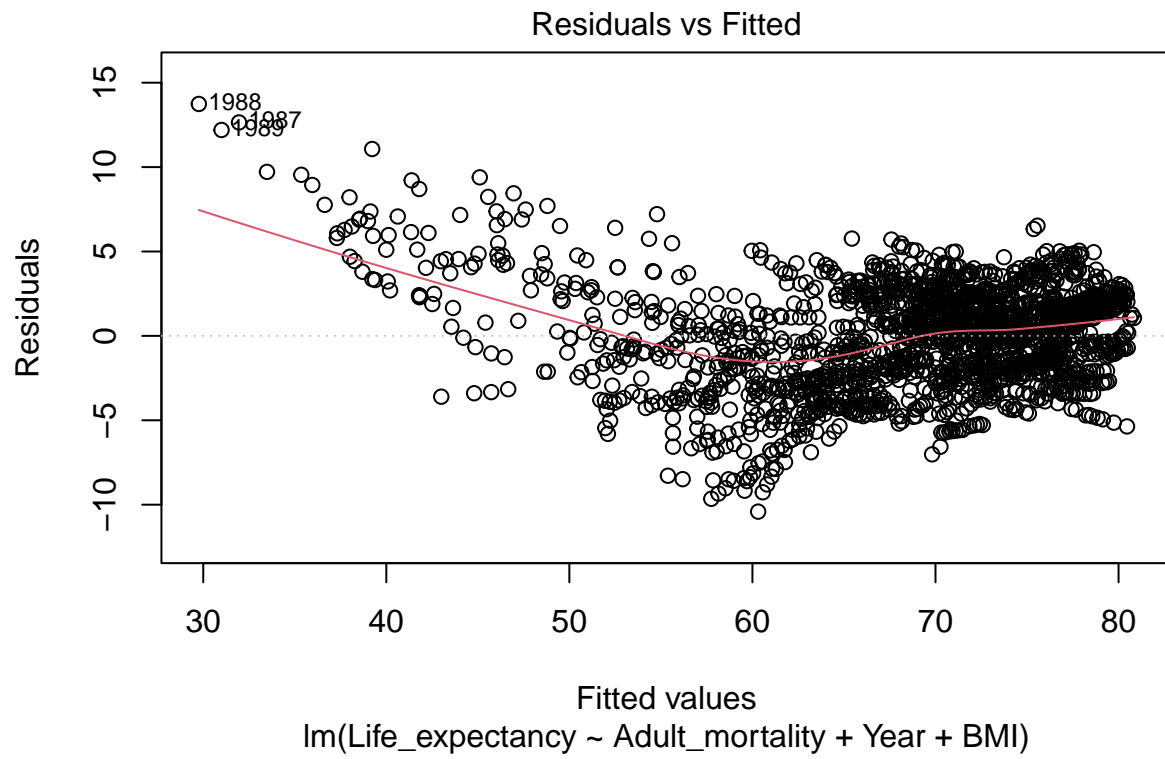
```
## Adult_mortality      Year      BMI
##      1.275126      1.032341      1.249543
```

```
library(glmnet)
# Standardize variables for regularization
x <- model.matrix(Life_expectancy ~ ., data = train_data_selected)[-1]
y <- train_data_selected$Life_expectancy

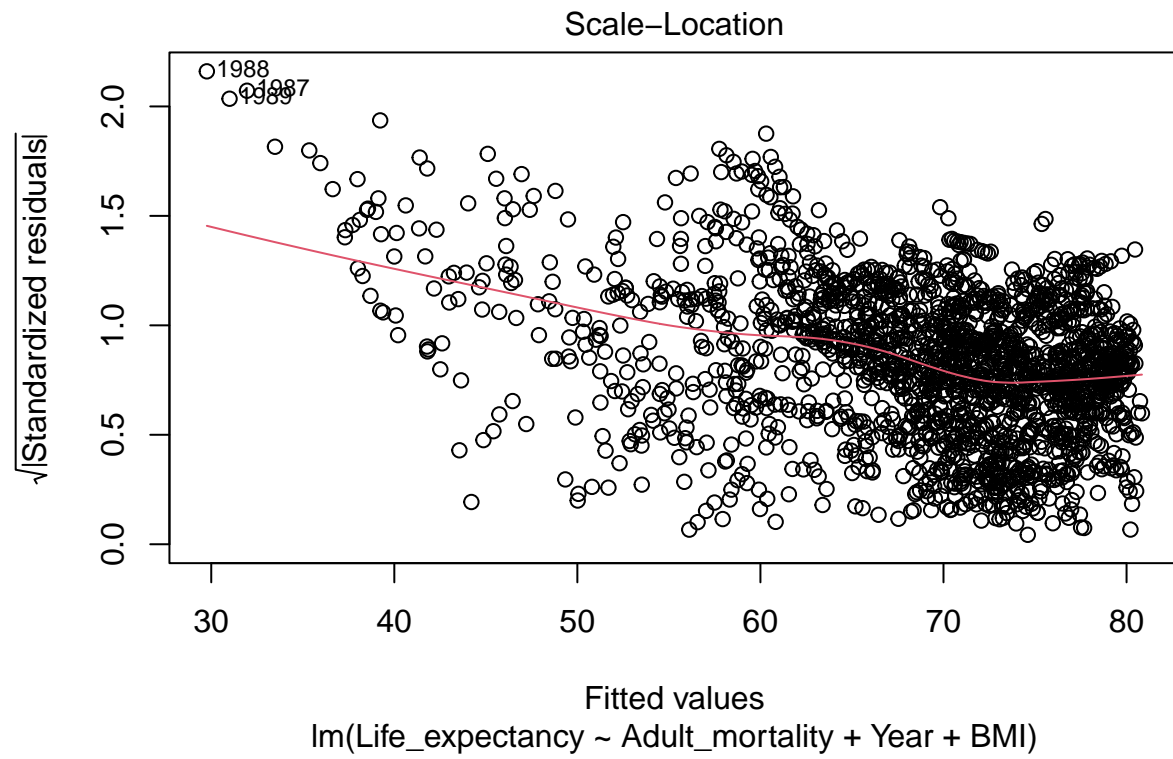
# Fit Ridge Regression Model
ridge_model <- cv.glmnet(x, y, alpha = 0)
plot(ridge_model)
```



```
# Residuals vs Fitted  
plot(reduced_model, which = 1)
```

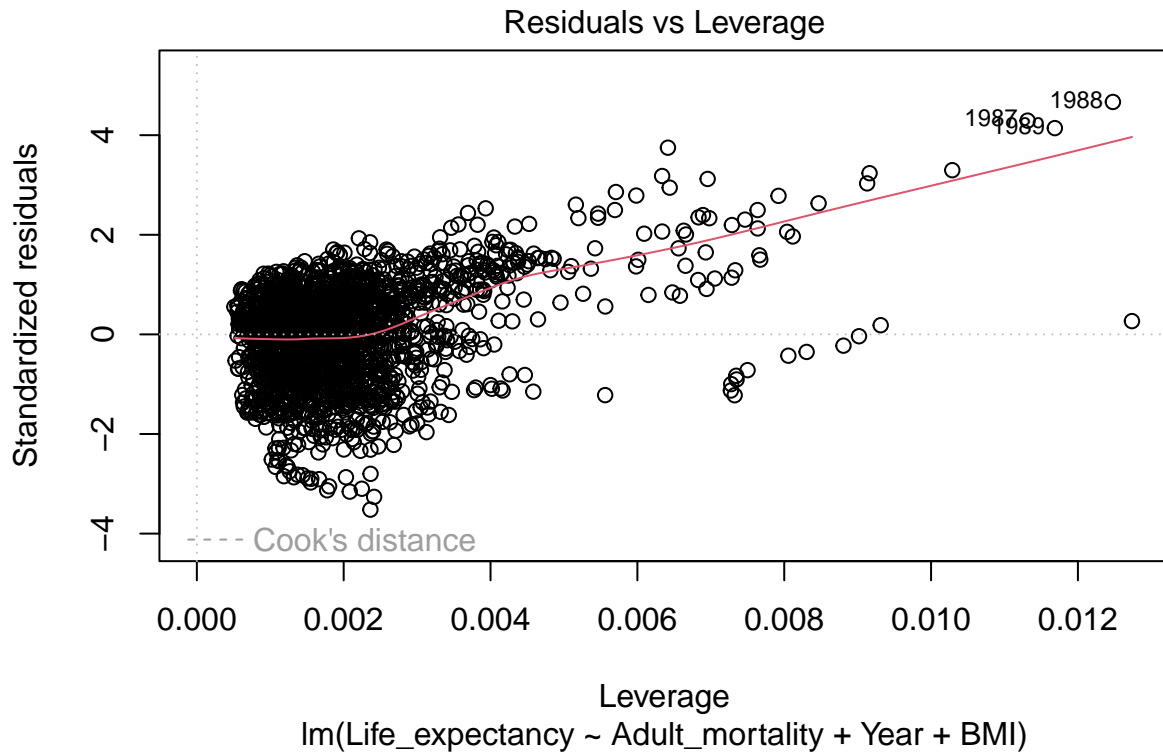


```
# Scale-Location (Spread-Location)  
plot(reduced_model, which = 3)
```



```
# Residuals vs Leverage  
plot(reduced_model, which = 5)
```





```
library(boot)
```

```
##
## Attaching package: 'boot'
```

```
## The following object is masked from 'package:car':
##
##   logit
```

```
## The following object is masked from 'package:lattice':
##
##   melanoma
```

```
set.seed(123) # for reproducibility
cv_results <- cv.glm(data = train_data_selected, glmfit = reduced_model, K = 10) # 10-fold CV
print(cv_results$delta) # delta contains cross-validated results
```

```
## [1] NaN NaN
```

```
{r} mancova_results <- manova(cbind(Life_expectancy, Adult_mortality, Alcohol_consumption)
~ Economy_status_Developed + Year, data = train_data) summary(mancova_results, test =
"Pillai")
```

## Summarizing Finding:

Based on the validation set metrics, here's a concise summary and interpretation of the performance of the three models:

### 1. Model 1:

- **RMSE:** 0.6048335
- **MAE:** 0.393135
- **Interpretation:** Exhibits the best performance with the lowest RMSE and MAE, indicating high accuracy and fewer average errors in predicting life expectancy.

### 2. Model 2:

- **RMSE:** 2.488072
- **MAE:** 1.873971
- **Interpretation:** Shows significantly poorer performance with much higher RMSE and MAE, suggesting it is less effective in accurately predicting life expectancy.

### 3. Model 3:

- **RMSE:** 0.6331086
- **MAE:** 0.4011408
- **Interpretation:** Performs slightly less accurately than Model 1 but still demonstrates reasonable effectiveness.

**Model Selection Considerations:** - **Model 1** is the most accurate. However, balance this accuracy with considerations of model complexity and interpretability. - If **Model 1** is much more complex or less interpretable than **Model 3**, and the performance difference is marginal, **Model 3** could be a viable alternative, depending on specific project needs. - **Model 2** may require revision or a different approach due to its lower accuracy.

**Final Steps for Model Selection:** - Select the best model based on a combination of accuracy, complexity, and interpretability. - Conduct a final review of model diagnostics, ensuring all assumptions (like normality of residuals, homoscedasticity, etc.) are met. - Address any specific issues such as multicollinearity, especially in Model 1, as indicated by its warning message about a “rank-deficient fit.” - Once a model is chosen and confirmed to meet all criteria and assumptions, it can be finalized for deployment or further application in the project. **Decision Making:** - Given these metrics, **Model 1** appears to be the best model among the three in terms of prediction accuracy on the validation set. - However, we need to balance model accuracy with complexity and interpretability. If Model 1 is considerably more complex or harder to interpret than Model 3, and the difference in RMSE/MAE is marginal, Model 3 could still be a viable option.

**Final Steps:** - Select Best Model - Based on everything, Model\_1 is the best model for this analysis.

The influence plot demonstrates standardized residuals versus leverage for each data point, with circle size indicating Cook's distance. This tool identifies influential points in model fitting.

### Key Aspects of the Influence Plot:

1. **Leverage:** Data points far right on the x-axis have high leverage, potentially impacting the regression line. These points typically possess extreme predictor values.
2. **Standardized Residuals:** Points distant from 0 on the y-axis indicate large residuals, signifying prediction inaccuracy. These are outliers.
3. **Cook's Distance:** Larger circles symbolize greater influence. Points with Cook's distance over 1 might excessively affect model predictions.

### Notable Observations:

- **High Leverage Points:** Positioned far right, potentially disproportionately influencing regression coefficients.
- **Outliers:** Exhibiting high residuals, indicating poor model fit.
- **Influential Points:** Identified by large circles, such as points 602, 801, 1045.

### Strategies for Analysis:

- Investigate outliers and high leverage points for errors or rare but valid conditions.
- Assess whether to remove influential points that may skew the model.
- Refit the model if necessary, ensuring it still meets key assumptions.

### Cross-Validation Plot for Ridge Regression:

This plot, generated by `cv.glmnet` in R, uses k-fold cross-validation for selecting lambda in ridge regression.

#### Plot Components:

1. **X-axis (Log( )):** Displays the log of lambda values tested. Lambda controls shrinkage of coefficients.
2. **Y-axis (Mean Squared Error):** Shows the MSE for each lambda, with lower MSE indicating better performance.
3. **Error Bars:** Represent the standard error range for each lambda's cross-validation error.
4. **Red Dots:** Average cross-validation error for each lambda.
5. **Solid Line:** Traces the error trajectory as lambda changes.
6. **Vertical Dashed Lines:** Indicate optimal lambda (`lambda.min`) and a more conservative choice (`lambda.1se`).

#### Interpretation:

- Choose `lambda.min` for lowest prediction error.
- `lambda.1se` offers a simpler model at a slightly higher error.

In the given plot, `lambda.min` is at the curve's lowest point, extractable from the `cv.glmnet` object.

#### Model Evaluation for Predicting Life Expectancy:

1. **Model 1:** Best predictive accuracy with lowest RMSE and MAE.
2. **Model 2:** Least accurate, suggested by higher RMSE and MAE.
3. **Model 3:** Slightly less accurate than Model 1 but still effective.

In summary, Model 1 appears most effective for this task, with a need to address its potential multicollinearity issues. # Summarizing Findings

Based on the validation set metrics for all three models, we can now compare their performance. Here are the results summarized:

## Model 1

- **RMSE:** 0.6048335
- **MAE:** 0.393135

## Model 2

- **RMSE:** 2.488072
- **MAE:** 1.873971

## Model 3

- **RMSE:** 0.6331086
- **MAE:** 0.4011408

## Model Comparison and Selection

- **Model 1** has the lowest RMSE and MAE, suggesting it predicts life expectancy more accurately and with fewer errors on average compared to the other two models.
- **Model 2** shows significantly higher RMSE and MAE, indicating it might not be as effective in predicting life expectancy as the other models.
- **Model 3** has slightly higher RMSE and MAE than Model 1, but these are still reasonably low.

## Decision Making

- Given these metrics, **Model 1** appears to be the best model among the three in terms of prediction accuracy on the validation set.
- However, remember to balance model accuracy with complexity and interpretability. If Model 1 is considerably more complex or harder to interpret than Model 3, and the difference in RMSE/MAE is marginal, Model 3 could still be a viable option depending on your project's needs.
- Ensure that the chosen model aligns well with the specific objectives and constraints of your analysis.

## Final Steps

- After selecting model\_1 we performed a final review of model diagnostics to ensure it meets all assumptions (like normality of residuals, homoscedasticity, etc.).
- There is no “perfect mode;” but from all the testing, it seems model 1 is the best.