Predicting Childhood Mortality Based on Health and Socio-Economic Indicators

Aicha Sidiya, Hanin Alzaher, Razan Almahdi

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#loading libraries  
library(tidyverse)

## ── Attaching packages ─────────────────────────────────────── tidyverse 1.3.2 ──  
## ✔ ggplot2 3.4.1 ✔ purrr 1.0.1  
## ✔ tibble 3.2.1 ✔ dplyr 1.1.0  
## ✔ tidyr 1.3.0 ✔ stringr 1.5.0  
## ✔ readr 2.1.3 ✔ forcats 1.0.0

## Warning: package 'tibble' was built under R version 4.2.3

## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## ✖ dplyr::filter() masks stats::filter()  
## ✖ dplyr::lag() masks stats::lag()

library(dplyr)  
library(readr)  
library(caret)

## Warning: package 'caret' was built under R version 4.2.3

## Loading required package: lattice  
##   
## Attaching package: 'caret'  
##   
## The following object is masked from 'package:purrr':  
##   
## lift

library(RANN)

## Warning: package 'RANN' was built under R version 4.2.3

library(skimr)

## Warning: package 'skimr' was built under R version 4.2.3

library(ggplot2)  
library(stringr)  
library(gbm)

## Warning: package 'gbm' was built under R version 4.2.3

## Loaded gbm 2.1.8.1

#loading the data set  
mortality\_rate <- read.csv('data/Mortality rate, under-5 (per 1,000 live births).csv')  
health\_expenditure <- read.csv('data/Current health expenditure per capita (current US$).csv')  
health\_expenditure\_per <- read.csv('data/Current health expenditure (% of GDP).csv')  
education\_expenditure <- read.csv('data/Current education expenditure, total (%).csv')  
literacy\_rate <- read.csv('data/literacy\_rate.csv')  
domestic\_health\_expenditure <- read.csv('data/Domestic private health expenditure (% of current health expenditure).csv')  
economic\_inequality <- read.csv('data/economic-inequality-gini-index.csv')  
water\_invest <- read.csv('data/Investment in water and sanitation (current US$).csv')  
vacinnation <- read.csv('data/vaccination-coverage-by-income-in.csv')  
water\_productivity <- read.csv('data/Water productivity\_per cubic meter of total freshwater withdrawal.csv')  
healthcare\_access <- read.csv('data/healthcare-access-and-quality-index.csv')

#selecting from year 2000 till 2020  
mortality\_rate <- select(mortality\_rate, country, 'X2000':'X2020')  
health\_expenditure <- select(health\_expenditure, country, 'X2000':'X2020')  
health\_expenditure\_per<- select(health\_expenditure\_per, country, 'X2000':'X2020')  
literacy\_rate <- select(literacy\_rate, country, 'X2000':'X2020')  
education\_expenditure <- select(education\_expenditure, country, 'X2000':'X2020')  
water\_invest <- select(water\_invest, country, 'X2000':'X2020')  
water\_productivity <- select(water\_productivity, country, 'X2000':'X2020')  
domestic\_health\_expenditure <- select(domestic\_health\_expenditure, country, 'X2000':'X2020')  
economic\_inequality <- filter(economic\_inequality, year >= 2000)  
vacinnation <- filter(vacinnation, year >= 2000)  
healthcare\_access <- filter(healthcare\_access, year >= 2000)

#renaming columns  
mortality\_rate\_years <- select (mortality\_rate, 'X2000':'X2020')  
names(mortality\_rate\_years) <- str\_sub(names(mortality\_rate\_years),2)  
mortality\_rate <- select(mortality\_rate, country)  
mortality\_rate <- bind\_cols(mortality\_rate,mortality\_rate\_years)  
  
health\_expenditure\_years <- select (health\_expenditure, 'X2000':'X2020')  
names(health\_expenditure\_years) <- str\_sub(names(health\_expenditure\_years),2)  
health\_expenditure <- select(health\_expenditure, country)  
health\_expenditure <- bind\_cols(health\_expenditure, health\_expenditure\_years)  
  
health\_expenditure\_per\_years <- select (health\_expenditure\_per, 'X2000':'X2020')  
names(health\_expenditure\_per\_years) <- str\_sub(names(health\_expenditure\_per\_years),2)  
health\_expenditure\_per <- select(health\_expenditure\_per, country)  
health\_expenditure\_per <- bind\_cols(health\_expenditure\_per, health\_expenditure\_per\_years)  
  
education\_expenditure\_years <- select (education\_expenditure, 'X2000':'X2020')  
names(education\_expenditure\_years) <- str\_sub(names(education\_expenditure\_years),2)  
education\_expenditure <- select(education\_expenditure, country)  
education\_expenditure <- bind\_cols(education\_expenditure, education\_expenditure\_years)  
  
domestic\_health\_expenditure\_years <- select (domestic\_health\_expenditure, 'X2000':'X2020')  
names(domestic\_health\_expenditure\_years) <- str\_sub(names(domestic\_health\_expenditure\_years),2)  
domestic\_health\_expenditure <- select(domestic\_health\_expenditure, country)  
domestic\_health\_expenditure <- bind\_cols(domestic\_health\_expenditure, domestic\_health\_expenditure\_years)  
  
literacy\_rate\_years <- select (literacy\_rate, 'X2000':'X2020')  
names(literacy\_rate\_years) <- str\_sub(names(literacy\_rate\_years),2)  
literacy\_rate <- select(literacy\_rate, country)  
literacy\_rate <- bind\_cols(literacy\_rate, literacy\_rate\_years)  
  
water\_invest\_years <- select (water\_invest, 'X2000':'X2020')  
names(water\_invest\_years) <- str\_sub(names(water\_invest\_years),2)  
water\_invest <- select(water\_invest, country)  
water\_invest <- bind\_cols(water\_invest, water\_invest\_years)  
  
water\_productivity\_years <- select (water\_productivity, 'X2000':'X2020')  
names(water\_productivity\_years) <- str\_sub(names(water\_productivity\_years),2)  
water\_productivity <- select(water\_productivity, country)  
water\_productivity <- bind\_cols(water\_productivity, water\_productivity\_years)

#pivoting tables  
mortality\_rate1 <- pivot\_longer(mortality\_rate, cols="2000":"2020",  
 names\_to = "year",  
 values\_to = "mortality\_rate")  
health\_expenditure1 <- pivot\_longer(health\_expenditure, cols="2000":"2020",  
 names\_to = "year",  
 values\_to = "health\_expenditure")  
health\_expenditure\_per1 <- pivot\_longer(health\_expenditure\_per, cols="2000":"2020",  
 names\_to = "year",  
 values\_to = "health\_expenditure\_per")  
education\_expenditure1 <- pivot\_longer(education\_expenditure, cols="2000":"2020",  
 names\_to = "year",  
 values\_to = "education\_expenditure")  
domestic\_health\_expenditure1 <- pivot\_longer(domestic\_health\_expenditure, cols="2000":"2020",  
 names\_to = "year",  
 values\_to = "domestic\_health\_expenditure")  
literacy\_rate1 <- pivot\_longer(literacy\_rate, cols="2000":"2020",  
 names\_to = "year",  
 values\_to = "literacy\_rate")  
water\_invest1 <- pivot\_longer(water\_invest, cols="2000":"2020",  
 names\_to = "year",  
 values\_to = "water\_invest")  
water\_productivity1 <- pivot\_longer(water\_productivity, cols="2000":"2020",  
 names\_to = "year",  
 values\_to = "water\_productivity")

#merging data  
merge\_data <- merge(mortality\_rate1, health\_expenditure1, by = c("country", "year"), all = TRUE)  
merge\_data <- merge(merge\_data, health\_expenditure\_per1, by = c("country", "year"), all = TRUE)  
merge\_data <- merge(merge\_data, education\_expenditure1, by = c("country", "year"), all = TRUE)  
merge\_data <- merge(merge\_data, domestic\_health\_expenditure1, by = c("country", "year"), all = TRUE)  
merge\_data <- merge(merge\_data, literacy\_rate1, by = c("country", "year"), all = TRUE)  
merge\_data <- merge(merge\_data, water\_invest1, by = c("country", "year"), all = TRUE)  
merge\_data <- merge(merge\_data, water\_productivity1, by = c("country", "year"), all = TRUE)  
merge\_data <- merge(merge\_data, vacinnation, by = c("country", "year"), all = TRUE)

glimpse(merge\_data)

## Rows: 7,403  
## Columns: 12  
## $ country <chr> "Abkhazia", "Afghanistan", "Afghanistan", …  
## $ year <chr> "2015", "2000", "2001", "2002", "2003", "2…  
## $ mortality\_rate <dbl> NA, 129.3, 125.3, 121.2, 117.0, 112.8, 108…  
## $ health\_expenditure <dbl> NA, NA, NA, 17.00759, 17.81492, 21.42946, …  
## $ health\_expenditure\_per <dbl> NA, NA, NA, 9.443391, 8.941258, 9.808474, …  
## $ education\_expenditure <dbl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA…  
## $ domestic\_health\_expenditure <dbl> NA, NA, NA, 85.37560, 86.06919, 84.52759, …  
## $ literacy\_rate <dbl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA…  
## $ water\_invest <dbl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA…  
## $ water\_productivity <dbl> NA, NA, NA, 0.3725069, 0.4054078, 0.411140…  
## $ immunazation <int> NA, 24, 33, 36, 41, 50, 58, 58, 63, 64, 63…  
## $ GDP\_per\_capita <dbl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA…

skimmed <- skim\_to\_wide(merge\_data)

## Warning: 'skim\_to\_wide' is deprecated.  
## Use 'skim()' instead.  
## See help("Deprecated")

skimmed

Data summary

|  |  |
| --- | --- |
| Name | Piped data |
| Number of rows | 7403 |
| Number of columns | 12 |
| \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |
| Column type frequency: |  |
| character | 2 |
| numeric | 10 |
| \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |
| Group variables | None |

**Variable type: character**

| skim\_variable | n\_missing | complete\_rate | min | max | empty | n\_unique | whitespace |
| --- | --- | --- | --- | --- | --- | --- | --- |
| country | 0 | 1 | 4 | 52 | 0 | 385 | 0 |
| year | 0 | 1 | 4 | 4 | 0 | 22 | 0 |

**Variable type: numeric**

| skim\_variable | n\_missing | complete\_rate | mean | sd | p0 | p25 | p50 | p75 | p100 | hist |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| mortality\_rate | 2279 | 0.69 | 40.90 | 4.085000e+01 | 1.80 | 9.80 | 2.42000e+01 | 6.252000e+01 | 2.285000e+02 | ▇▂▁▁▁ |
| health\_expenditure | 2477 | 0.67 | 876.37 | 1.567730e+03 | 4.45 | 62.73 | 2.40640e+02 | 7.461300e+02 | 1.170241e+04 | ▇▁▁▁▁ |
| health\_expenditure\_per | 2477 | 0.67 | 6.14 | 2.740000e+00 | 1.26 | 4.24 | 5.40000e+00 | 7.720000e+00 | 2.423000e+01 | ▇▅▁▁▁ |
| education\_expenditure | 5669 | 0.23 | 90.86 | 7.220000e+00 | 32.81 | 88.92 | 9.22500e+01 | 9.509000e+01 | 1.000000e+02 | ▁▁▁▁▇ |
| domestic\_health\_expenditure | 2477 | 0.67 | 42.30 | 1.852000e+01 | 0.52 | 28.05 | 4.22700e+01 | 5.585000e+01 | 8.794000e+01 | ▃▆▇▆▂ |
| literacy\_rate | 5742 | 0.22 | 80.21 | 1.719000e+01 | 14.38 | 66.54 | 8.54000e+01 | 9.450000e+01 | 1.000000e+02 | ▁▁▃▃▇ |
| water\_invest | 7117 | 0.04 | 953377952.62 | 1.280216e+09 | 0.00 | 96250000.00 | 3.67710e+08 | 1.338034e+09 | 6.272480e+09 | ▇▂▁▁▁ |
| water\_productivity | 2827 | 0.62 | 56.87 | 1.424400e+02 | 0.22 | 6.65 | 1.56500e+01 | 4.772000e+01 | 3.072790e+03 | ▇▁▁▁▁ |
| immunazation | 2978 | 0.60 | 86.79 | 1.470000e+01 | 19.00 | 82.00 | 9.30000e+01 | 9.700000e+01 | 9.900000e+01 | ▁▁▁▂▇ |
| GDP\_per\_capita | 3753 | 0.49 | 19489.65 | 2.203415e+04 | 251.09 | 4219.56 | 1.15329e+04 | 2.762972e+04 | 3.032066e+05 | ▇▁▁▁▁ |

#including counties of the world  
all\_countries <- c("Afghanistan", "Albania", "Algeria", "Andorra", "Angola", "Antigua and Barbuda",  
 "Argentina", "Armenia", "Australia", "Austria", "Azerbaijan", "Bahamas", "Bahrain",  
 "Bangladesh", "Barbados", "Belarus", "Belgium", "Belize", "Benin", "Bhutan",  
 "Bolivia", "Bosnia and Herzegovina", "Botswana", "Brazil", "Brunei", "Bulgaria",  
 "Burkina Faso", "Burundi", "Cabo Verde", "Cambodia", "Cameroon", "Canada",  
 "Central African Republic", "Chad", "Chile", "China", "Colombia", "Comoros",  
 "Congo", "Costa Rica", "Croatia", "Cuba", "Cyprus", "Czech Republic", "Denmark",  
 "Djibouti", "Dominica", "Dominican Republic", "East Timor", "Ecuador", "Egypt",  
 "El Salvador", "Equatorial Guinea", "Eritrea", "Estonia", "Eswatini", "Ethiopia",  
 "Fiji", "Finland", "France", "Gabon", "Gambia", "Georgia", "Germany", "Ghana",  
 "Greece", "Grenada", "Guatemala", "Guinea", "Guinea-Bissau", "Guyana", "Haiti",  
 "Honduras", "Hungary", "Iceland", "India", "Indonesia", "Iran", "Iraq", "Ireland",  
 "Israel", "Italy", "Jamaica", "Japan", "Jordan", "Kazakhstan", "Kenya", "Kiribati",  
 "Korea, North", "Korea, South", "Kosovo", "Kuwait", "Kyrgyzstan", "Laos", "Latvia",  
 "Lebanon", "Lesotho", "Liberia", "Libya", "Liechtenstein", "Lithuania", "Luxembourg",  
 "Madagascar", "Malawi", "Malaysia", "Maldives", "Mali", "Malta", "Marshall Islands",  
 "Mauritania", "Mauritius", "Mexico", "Micronesia", "Moldova", "Monaco", "Mongolia",  
 "Montenegro", "Morocco", "Mozambique", "Myanmar", "Namibia", "Nauru", "Nepal",  
 "Netherlands", "New Zealand", "Nicaragua", "Niger", "Nigeria", "North Macedonia",  
 "Norway", "Oman", "Pakistan", "Palau", "Panama", "Papua New Guinea", "Paraguay",  
 "Peru", "Philippines", "Poland", "Portugal", "Qatar", "Romania", "Russia", "Rwanda",  
 "Saint Kitts and Nevis", "Saint Lucia", "Saint Vincent and the Grenadines", "Samoa",  
 "San Marino", "Sao Tome and Principe", "Saudi Arabia", "Senegal", "Serbia", "Seychelles",  
 "Sierra Leone", "Singapore", "Slovakia", "Slovenia", "Solomon Islands", "Somalia",  
 "South Africa", "South Sudan", "Spain", "Sri Lanka", "Sudan", "Suriname", "Sweden",  
 "Switzerland", "Syria", "Taiwan", "Tajikistan", "Tanzania", "Thailand", "Togo",  
 "Tonga", "Trinidad and Tobago", "Tunisia", "Turkey", "Turkmenistan", "Tuvalu",  
 "Uganda", "Ukraine", "United Arab Emirates", "United Kingdom", "United States",  
 "Uruguay", "Uzbekistan", "Vanuatu", "Vatican City", "Venezuela", "Vietnam",  
 "Yemen", "Zambia", "Zimbabwe")  
  
merge\_data <- subset(merge\_data, country %in% all\_countries)

#saving the final data  
write.csv(merge\_data, "data/my\_data.csv")

#remove rows with all na  
filtered\_data <- merge\_data %>%  
 select(-country, -year) %>%  
 filter(rowSums(is.na(.)) != ncol(.))

# Create the knn imputation model on the training data  
preProcess\_missingdata\_model <- preProcess(filtered\_data, method='knnImpute')  
preProcess\_missingdata\_model

## Created from 39 samples and 10 variables  
##   
## Pre-processing:  
## - centered (10)  
## - ignored (0)  
## - 5 nearest neighbor imputation (10)  
## - scaled (10)

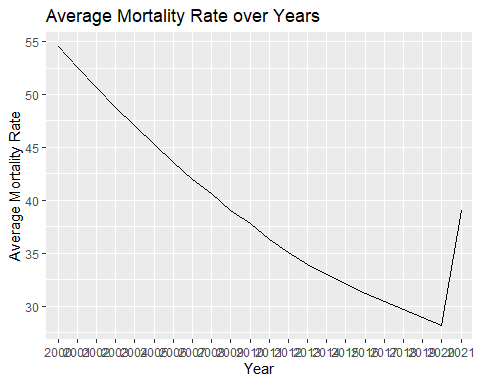
# Use the imputation model to predict the values of missing data points  
my\_data\_imputed <- predict(preProcess\_missingdata\_model, newdata = filtered\_data)  
anyNA(my\_data\_imputed)

## [1] FALSE

#saving the imputed data  
write.csv(my\_data\_imputed, "data/my\_data\_imputed.csv")

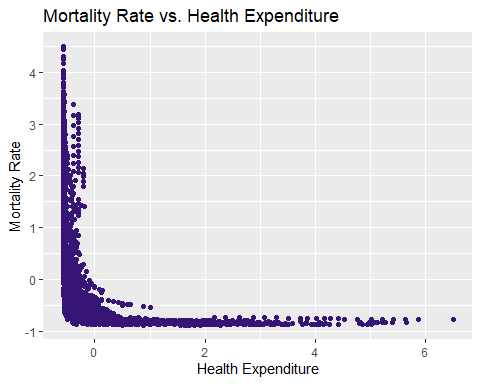
What is the trend and pattern of the average mortality rate over the years and are there any significant changes or fluctuations observed?

# Impute missing values in the mortality\_rate column using mean  
imputed\_data\_mean <- merge\_data %>%  
 mutate(mortality\_rate = replace\_na(mortality\_rate, mean(mortality\_rate, na.rm = TRUE)))  
  
write.csv(imputed\_data\_mean, "data/imputed\_data\_mean.csv")  
  
# Aggregate data by year and calculate the average mortality rate  
avg\_mortality <- aggregate(mortality\_rate ~ year, data = imputed\_data\_mean, FUN = mean)  
  
# Create the line plot  
ggplot(avg\_mortality, aes(x = year, y = mortality\_rate, group = 1)) +  
 geom\_line() +  
 xlab("Year") +  
 ylab("Average Mortality Rate") +  
 ggtitle("Average Mortality Rate over Years")

 The plot depicts the average mortality rate over a range of years. The x-axis represents the years, while the y-axis represents the average mortality rate. The plot reveals a trend of the average mortality rate over time. In the earlier years, the average mortality rate was relatively high, gradually declining in subsequent years. However, there was a slight increase in the average mortality rate in 2018. Also, the plot shows a significant and noticeable increase in the average mortality rate in 2020. The sudden surge in the average mortality rate suggests a critical event or influential factor that impacted the population’s health during this period.

What is the relationship between Mortality Rate and Health Expenditure?

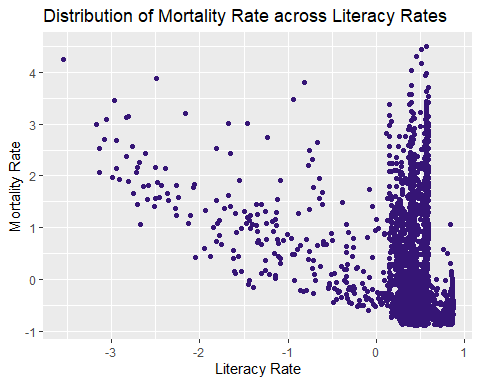
ggplot(data=my\_data\_imputed,mapping= aes(x = health\_expenditure, y = mortality\_rate)) +  
 geom\_point(color="#361576") +  
 xlab("Health Expenditure") +  
 ylab("Mortality Rate") +  
 ggtitle("Mortality Rate vs. Health Expenditure")

 The plot showcases the relationship between Mortality Rate and Health Expenditure. The x-axis represents Health Expenditure, while the y-axis represents Mortality Rate. The plot demonstrates the varying levels of Mortality Rate observed at different levels of Health Expenditure.

Upon closer examination, it becomes apparent that there is an inverse relationship between Mortality Rate and Health Expenditure. As Health Expenditure increases, Mortality Rate tends to decrease, suggesting a potential link between higher healthcare investment and improved health outcomes. However, it is worth noting that this relationship may not be entirely linear, as there are instances where the Mortality Rate remains relatively high despite higher Health Expenditure.

How does Literacy Rate affects Mortality Rate?

ggplot(data = my\_data\_imputed, mapping=aes(x = literacy\_rate, y = mortality\_rate)) +  
 geom\_point(color="#361576") +  
 xlab("Literacy Rate") +  
 ylab("Mortality Rate") +  
 ggtitle("Distribution of Mortality Rate across Literacy Rates")

 The plot illustrates the distribution of Mortality Rate across different levels of Literacy Rates. The x-axis represents the Literacy Rates, while the y-axis represents the Mortality Rate.

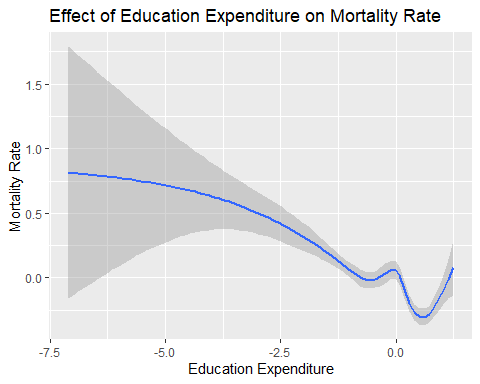
Examining the plot, it is evident that there is a discernible pattern in the distribution of Mortality Rate with respect to Literacy Rates. As Literacy Rates increase, there is a tendency for the Mortality Rate to decrease. This suggests a potential correlation between higher literacy levels and lower Mortality Rates, indicating that education and literacy may play a role in improving overall health outcomes.

However, it is important to note that the relationship between Mortality Rate and Literacy Rate may not be solely determined by literacy itself. Other confounding factors such as healthcare access, socioeconomic status, and healthcare utilization may also contribute to the observed distribution.

What is the effect of Education Expenditure on Mortality Rate?

ggplot(data=my\_data\_imputed,mapping= aes(x = education\_expenditure, y = mortality\_rate)) +  
 geom\_smooth() +  
 xlab("Education Expenditure") +  
 ylab("Mortality Rate") +  
 ggtitle("Effect of Education Expenditure on Mortality Rate")

## `geom\_smooth()` using method = 'gam' and formula = 'y ~ s(x, bs = "cs")'

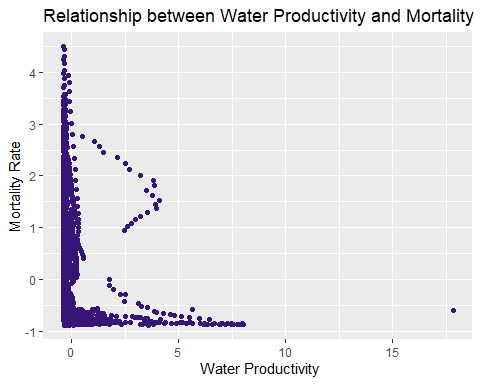
 The plot visually represents the relationship between Education Expenditure and Mortality Rate. The x-axis represents Education Expenditure, while the y-axis represents Mortality Rate.

Upon examination of the plot, it is evident that there is an observable pattern indicating the effect of Education Expenditure on Mortality Rate. As Education Expenditure increases, there is a corresponding decrease in Mortality Rate. This suggests a potentially significant and meaningful relationship between higher investments in education and improved health outcomes.

The plot demonstrates that allocating resources towards education expenditure may play a crucial role in reducing Mortality Rate. However, it is important to note that this relationship may not be solely determined by education expenditure itself. As we observe the significant increase of the mortality rate, other factors such as healthcare infrastructure, socioeconomic conditions, and healthcare accessibility might also influence the observed relationship.

What is the relationship between Water Productivity and Mortality Rate?

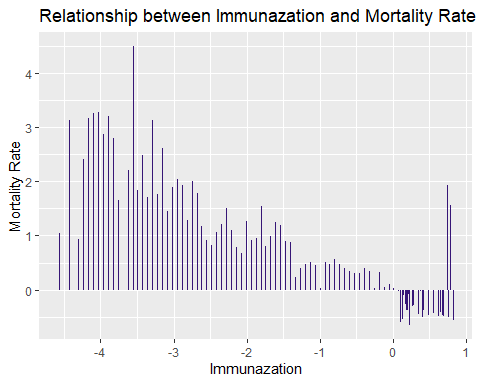
ggplot(data=my\_data\_imputed,mapping = aes(x = water\_productivity, y = mortality\_rate)) +  
 geom\_point(color = "#361576") +  
 xlab(" Water Productivity") +  
 ylab("Mortality Rate") +  
 ggtitle("Relationship between Water Productivity and Mortality Rate")

 The plot visually represents the relationship between Water Productivity and Mortality Rate. The x-axis represents Water Productivity, while the y-axis represents Mortality Rate.

Upon examining the plot, it becomes apparent that there is a discernible pattern suggesting a relationship between Water Productivity and Mortality Rate. As Water Productivity increases, there is a tendency for the Mortality Rate to decrease. This implies that higher efficiency and productivity in water usage may be associated with improved health outcomes and reduced Mortality Rates.

What is the relationship between Immunazation and Mortality Rate?

ggplot(data= my\_data\_imputed, mapping = aes(x = immunazation,y = mortality\_rate))+  
 geom\_bar(stat = "summary", fun = "mean",color="#361576")+  
 xlab("Immunazation") +  
 ylab("Mortality Rate") +  
 ggtitle("Relationship between Immunazation and Mortality Rate")

 The plot visually represents the relationship between Immunization and Mortality Rate. The x-axis represents the level of Immunization, while the y-axis represents the Mortality Rate.

Upon examining the plot, a clear pattern emerges, indicating a relationship between Immunization and Mortality Rate. As the level of Immunization increases, there is a corresponding decrease in the Mortality Rate. This suggests that higher rates of Immunization may be associated with lower Mortality Rates, highlighting the potential protective effect of immunization against preventable diseases.

# Store X and Y for later use.  
X = my\_data\_imputed[, 2:10]  
y = my\_data\_imputed$mortality\_rate

# Set the seed for reproducibility  
set.seed(123)  
  
#train test split   
train\_indices <- createDataPartition(y, p = 0.8, list = FALSE)  
X\_train <- X[train\_indices,]  
y\_train <- y[train\_indices]  
X\_test <- X[-train\_indices,]  
y\_test <- y[-train\_indices]

# Create and fit the linear regression model  
model\_LR <- train(X\_train, y\_train, method = "lm")  
  
# Make predictions on the test set  
y\_pred\_LR <- predict(model\_LR, X\_test)  
  
# Evaluate the model using mean squared error  
mse\_LR <- mean((y\_test - y\_pred\_LR)^2)  
  
# Calculate R-squared  
r2\_LR <- cor(y\_pred\_LR, y\_test)^2

# Create and fit the decison tree model  
model\_tree <- train(X\_train, y\_train, method = "rpart")

## Warning in nominalTrainWorkflow(x = x, y = y, wts = weights, info = trainInfo,  
## : There were missing values in resampled performance measures.

# Make predictions on the test set  
y\_pred\_tree <- predict(model\_tree, X\_test)  
  
# Evaluate the model using mean squared error  
mse\_tree <- mean((y\_test - y\_pred\_tree)^2)  
  
# Calculate R-squared  
r2\_tree <- cor(y\_pred\_tree, y\_test)^2

# Create and fit the gradiant boost model  
model\_gbm <- train(X\_train, y\_train, method = "gbm")

## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7803 nan 0.1000 0.0713  
## 2 0.7223 nan 0.1000 0.0571  
## 3 0.6753 nan 0.1000 0.0489  
## 4 0.6342 nan 0.1000 0.0367  
## 5 0.5963 nan 0.1000 0.0402  
## 6 0.5628 nan 0.1000 0.0340  
## 7 0.5328 nan 0.1000 0.0286  
## 8 0.5055 nan 0.1000 0.0279  
## 9 0.4828 nan 0.1000 0.0201  
## 10 0.4612 nan 0.1000 0.0202  
## 20 0.3258 nan 0.1000 0.0086  
## 40 0.2398 nan 0.1000 0.0019  
## 60 0.2196 nan 0.1000 0.0003  
## 80 0.2099 nan 0.1000 0.0004  
## 100 0.2035 nan 0.1000 0.0001  
## 120 0.1992 nan 0.1000 -0.0000  
## 140 0.1956 nan 0.1000 0.0002  
## 150 0.1941 nan 0.1000 -0.0002  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7659 nan 0.1000 0.0844  
## 2 0.6942 nan 0.1000 0.0733  
## 3 0.6277 nan 0.1000 0.0634  
## 4 0.5732 nan 0.1000 0.0531  
## 5 0.5260 nan 0.1000 0.0451  
## 6 0.4898 nan 0.1000 0.0369  
## 7 0.4558 nan 0.1000 0.0335  
## 8 0.4228 nan 0.1000 0.0290  
## 9 0.3974 nan 0.1000 0.0235  
## 10 0.3747 nan 0.1000 0.0217  
## 20 0.2544 nan 0.1000 0.0061  
## 40 0.1958 nan 0.1000 0.0004  
## 60 0.1705 nan 0.1000 0.0007  
## 80 0.1583 nan 0.1000 0.0001  
## 100 0.1470 nan 0.1000 0.0000  
## 120 0.1379 nan 0.1000 0.0008  
## 140 0.1274 nan 0.1000 -0.0000  
## 150 0.1240 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7514 nan 0.1000 0.0978  
## 2 0.6712 nan 0.1000 0.0785  
## 3 0.6010 nan 0.1000 0.0615  
## 4 0.5439 nan 0.1000 0.0535  
## 5 0.4922 nan 0.1000 0.0522  
## 6 0.4527 nan 0.1000 0.0410  
## 7 0.4181 nan 0.1000 0.0311  
## 8 0.3893 nan 0.1000 0.0265  
## 9 0.3625 nan 0.1000 0.0229  
## 10 0.3366 nan 0.1000 0.0229  
## 20 0.2219 nan 0.1000 0.0055  
## 40 0.1654 nan 0.1000 0.0005  
## 60 0.1419 nan 0.1000 0.0003  
## 80 0.1262 nan 0.1000 0.0018  
## 100 0.1153 nan 0.1000 0.0001  
## 120 0.1068 nan 0.1000 -0.0000  
## 140 0.0987 nan 0.1000 -0.0001  
## 150 0.0959 nan 0.1000 0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7879 nan 0.1000 0.0692  
## 2 0.7283 nan 0.1000 0.0568  
## 3 0.6765 nan 0.1000 0.0453  
## 4 0.6375 nan 0.1000 0.0363  
## 5 0.5964 nan 0.1000 0.0398  
## 6 0.5620 nan 0.1000 0.0337  
## 7 0.5319 nan 0.1000 0.0299  
## 8 0.5020 nan 0.1000 0.0291  
## 9 0.4770 nan 0.1000 0.0225  
## 10 0.4564 nan 0.1000 0.0197  
## 20 0.3237 nan 0.1000 0.0075  
## 40 0.2473 nan 0.1000 0.0002  
## 60 0.2268 nan 0.1000 0.0001  
## 80 0.2162 nan 0.1000 -0.0000  
## 100 0.2099 nan 0.1000 0.0001  
## 120 0.2056 nan 0.1000 -0.0008  
## 140 0.2026 nan 0.1000 0.0002  
## 150 0.2013 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7723 nan 0.1000 0.0902  
## 2 0.7048 nan 0.1000 0.0693  
## 3 0.6430 nan 0.1000 0.0657  
## 4 0.5874 nan 0.1000 0.0529  
## 5 0.5408 nan 0.1000 0.0448  
## 6 0.4978 nan 0.1000 0.0437  
## 7 0.4626 nan 0.1000 0.0362  
## 8 0.4321 nan 0.1000 0.0304  
## 9 0.4060 nan 0.1000 0.0264  
## 10 0.3834 nan 0.1000 0.0243  
## 20 0.2570 nan 0.1000 0.0067  
## 40 0.1898 nan 0.1000 0.0014  
## 60 0.1656 nan 0.1000 0.0005  
## 80 0.1539 nan 0.1000 0.0002  
## 100 0.1411 nan 0.1000 -0.0000  
## 120 0.1342 nan 0.1000 -0.0001  
## 140 0.1284 nan 0.1000 0.0000  
## 150 0.1260 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7656 nan 0.1000 0.0981  
## 2 0.6878 nan 0.1000 0.0801  
## 3 0.6229 nan 0.1000 0.0616  
## 4 0.5637 nan 0.1000 0.0568  
## 5 0.5147 nan 0.1000 0.0497  
## 6 0.4739 nan 0.1000 0.0389  
## 7 0.4345 nan 0.1000 0.0392  
## 8 0.4020 nan 0.1000 0.0318  
## 9 0.3755 nan 0.1000 0.0261  
## 10 0.3505 nan 0.1000 0.0240  
## 20 0.2310 nan 0.1000 0.0059  
## 40 0.1668 nan 0.1000 0.0012  
## 60 0.1452 nan 0.1000 0.0007  
## 80 0.1303 nan 0.1000 -0.0001  
## 100 0.1176 nan 0.1000 0.0002  
## 120 0.1085 nan 0.1000 -0.0002  
## 140 0.1007 nan 0.1000 0.0001  
## 150 0.0975 nan 0.1000 0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8103 nan 0.1000 0.0763  
## 2 0.7459 nan 0.1000 0.0633  
## 3 0.6922 nan 0.1000 0.0554  
## 4 0.6460 nan 0.1000 0.0479  
## 5 0.6048 nan 0.1000 0.0389  
## 6 0.5689 nan 0.1000 0.0363  
## 7 0.5402 nan 0.1000 0.0295  
## 8 0.5118 nan 0.1000 0.0289  
## 9 0.4865 nan 0.1000 0.0241  
## 10 0.4658 nan 0.1000 0.0198  
## 20 0.3237 nan 0.1000 0.0082  
## 40 0.2375 nan 0.1000 0.0012  
## 60 0.2178 nan 0.1000 0.0005  
## 80 0.2084 nan 0.1000 0.0005  
## 100 0.2018 nan 0.1000 -0.0001  
## 120 0.1964 nan 0.1000 -0.0001  
## 140 0.1920 nan 0.1000 0.0001  
## 150 0.1903 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7928 nan 0.1000 0.0942  
## 2 0.7166 nan 0.1000 0.0753  
## 3 0.6473 nan 0.1000 0.0690  
## 4 0.5929 nan 0.1000 0.0488  
## 5 0.5435 nan 0.1000 0.0488  
## 6 0.5044 nan 0.1000 0.0375  
## 7 0.4669 nan 0.1000 0.0365  
## 8 0.4370 nan 0.1000 0.0282  
## 9 0.4152 nan 0.1000 0.0217  
## 10 0.3902 nan 0.1000 0.0229  
## 20 0.2580 nan 0.1000 0.0069  
## 40 0.1925 nan 0.1000 0.0015  
## 60 0.1727 nan 0.1000 0.0007  
## 80 0.1587 nan 0.1000 -0.0000  
## 100 0.1505 nan 0.1000 0.0000  
## 120 0.1416 nan 0.1000 0.0001  
## 140 0.1339 nan 0.1000 0.0001  
## 150 0.1309 nan 0.1000 0.0004  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7853 nan 0.1000 0.1012  
## 2 0.6985 nan 0.1000 0.0837  
## 3 0.6276 nan 0.1000 0.0715  
## 4 0.5673 nan 0.1000 0.0558  
## 5 0.5164 nan 0.1000 0.0513  
## 6 0.4724 nan 0.1000 0.0410  
## 7 0.4343 nan 0.1000 0.0372  
## 8 0.4030 nan 0.1000 0.0312  
## 9 0.3761 nan 0.1000 0.0262  
## 10 0.3524 nan 0.1000 0.0250  
## 20 0.2270 nan 0.1000 0.0054  
## 40 0.1635 nan 0.1000 0.0009  
## 60 0.1441 nan 0.1000 0.0006  
## 80 0.1320 nan 0.1000 -0.0001  
## 100 0.1198 nan 0.1000 0.0002  
## 120 0.1099 nan 0.1000 0.0001  
## 140 0.1012 nan 0.1000 0.0001  
## 150 0.0975 nan 0.1000 0.0004  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8401 nan 0.1000 0.0744  
## 2 0.7762 nan 0.1000 0.0634  
## 3 0.7194 nan 0.1000 0.0573  
## 4 0.6723 nan 0.1000 0.0476  
## 5 0.6318 nan 0.1000 0.0395  
## 6 0.5909 nan 0.1000 0.0393  
## 7 0.5588 nan 0.1000 0.0327  
## 8 0.5288 nan 0.1000 0.0284  
## 9 0.5024 nan 0.1000 0.0260  
## 10 0.4808 nan 0.1000 0.0214  
## 20 0.3381 nan 0.1000 0.0090  
## 40 0.2509 nan 0.1000 0.0015  
## 60 0.2285 nan 0.1000 0.0004  
## 80 0.2183 nan 0.1000 0.0001  
## 100 0.2106 nan 0.1000 0.0001  
## 120 0.2056 nan 0.1000 -0.0001  
## 140 0.2014 nan 0.1000 0.0002  
## 150 0.1995 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8227 nan 0.1000 0.0898  
## 2 0.7461 nan 0.1000 0.0779  
## 3 0.6778 nan 0.1000 0.0687  
## 4 0.6206 nan 0.1000 0.0563  
## 5 0.5716 nan 0.1000 0.0489  
## 6 0.5314 nan 0.1000 0.0407  
## 7 0.4914 nan 0.1000 0.0384  
## 8 0.4568 nan 0.1000 0.0323  
## 9 0.4283 nan 0.1000 0.0279  
## 10 0.4040 nan 0.1000 0.0235  
## 20 0.2698 nan 0.1000 0.0053  
## 40 0.1993 nan 0.1000 0.0012  
## 60 0.1779 nan 0.1000 0.0003  
## 80 0.1637 nan 0.1000 0.0002  
## 100 0.1541 nan 0.1000 -0.0000  
## 120 0.1437 nan 0.1000 -0.0001  
## 140 0.1359 nan 0.1000 -0.0001  
## 150 0.1334 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8128 nan 0.1000 0.0996  
## 2 0.7252 nan 0.1000 0.0860  
## 3 0.6536 nan 0.1000 0.0768  
## 4 0.5911 nan 0.1000 0.0564  
## 5 0.5383 nan 0.1000 0.0558  
## 6 0.4923 nan 0.1000 0.0404  
## 7 0.4551 nan 0.1000 0.0348  
## 8 0.4223 nan 0.1000 0.0340  
## 9 0.3920 nan 0.1000 0.0277  
## 10 0.3671 nan 0.1000 0.0236  
## 20 0.2328 nan 0.1000 0.0060  
## 40 0.1652 nan 0.1000 0.0010  
## 60 0.1418 nan 0.1000 0.0004  
## 80 0.1296 nan 0.1000 -0.0002  
## 100 0.1215 nan 0.1000 0.0003  
## 120 0.1130 nan 0.1000 0.0004  
## 140 0.1038 nan 0.1000 -0.0003  
## 150 0.1005 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8846 nan 0.1000 0.0846  
## 2 0.8121 nan 0.1000 0.0708  
## 3 0.7518 nan 0.1000 0.0614  
## 4 0.6984 nan 0.1000 0.0518  
## 5 0.6557 nan 0.1000 0.0446  
## 6 0.6129 nan 0.1000 0.0425  
## 7 0.5732 nan 0.1000 0.0373  
## 8 0.5413 nan 0.1000 0.0328  
## 9 0.5120 nan 0.1000 0.0303  
## 10 0.4864 nan 0.1000 0.0253  
## 20 0.3230 nan 0.1000 0.0095  
## 40 0.2259 nan 0.1000 0.0009  
## 60 0.2036 nan 0.1000 0.0002  
## 80 0.1951 nan 0.1000 0.0003  
## 100 0.1899 nan 0.1000 -0.0000  
## 120 0.1857 nan 0.1000 0.0002  
## 140 0.1828 nan 0.1000 -0.0000  
## 150 0.1813 nan 0.1000 -0.0002  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8645 nan 0.1000 0.0949  
## 2 0.7758 nan 0.1000 0.0920  
## 3 0.7040 nan 0.1000 0.0691  
## 4 0.6412 nan 0.1000 0.0609  
## 5 0.5878 nan 0.1000 0.0553  
## 6 0.5364 nan 0.1000 0.0462  
## 7 0.4928 nan 0.1000 0.0416  
## 8 0.4550 nan 0.1000 0.0351  
## 9 0.4245 nan 0.1000 0.0288  
## 10 0.3969 nan 0.1000 0.0276  
## 20 0.2464 nan 0.1000 0.0069  
## 40 0.1819 nan 0.1000 -0.0002  
## 60 0.1616 nan 0.1000 0.0000  
## 80 0.1509 nan 0.1000 0.0001  
## 100 0.1403 nan 0.1000 0.0000  
## 120 0.1316 nan 0.1000 0.0002  
## 140 0.1254 nan 0.1000 0.0002  
## 150 0.1220 nan 0.1000 0.0002  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8532 nan 0.1000 0.1111  
## 2 0.7586 nan 0.1000 0.0897  
## 3 0.6794 nan 0.1000 0.0788  
## 4 0.6092 nan 0.1000 0.0730  
## 5 0.5489 nan 0.1000 0.0573  
## 6 0.5008 nan 0.1000 0.0449  
## 7 0.4582 nan 0.1000 0.0432  
## 8 0.4194 nan 0.1000 0.0348  
## 9 0.3885 nan 0.1000 0.0315  
## 10 0.3583 nan 0.1000 0.0293  
## 20 0.2220 nan 0.1000 0.0054  
## 40 0.1538 nan 0.1000 0.0032  
## 60 0.1335 nan 0.1000 0.0004  
## 80 0.1202 nan 0.1000 0.0001  
## 100 0.1099 nan 0.1000 0.0004  
## 120 0.1005 nan 0.1000 0.0003  
## 140 0.0934 nan 0.1000 0.0002  
## 150 0.0905 nan 0.1000 -0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8346 nan 0.1000 0.0747  
## 2 0.7723 nan 0.1000 0.0601  
## 3 0.7200 nan 0.1000 0.0518  
## 4 0.6751 nan 0.1000 0.0406  
## 5 0.6331 nan 0.1000 0.0421  
## 6 0.5962 nan 0.1000 0.0346  
## 7 0.5661 nan 0.1000 0.0289  
## 8 0.5374 nan 0.1000 0.0286  
## 9 0.5133 nan 0.1000 0.0243  
## 10 0.4909 nan 0.1000 0.0213  
## 20 0.3437 nan 0.1000 0.0074  
## 40 0.2543 nan 0.1000 0.0023  
## 60 0.2303 nan 0.1000 0.0008  
## 80 0.2201 nan 0.1000 0.0003  
## 100 0.2142 nan 0.1000 -0.0002  
## 120 0.2102 nan 0.1000 0.0000  
## 140 0.2069 nan 0.1000 0.0000  
## 150 0.2054 nan 0.1000 -0.0007  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8174 nan 0.1000 0.0805  
## 2 0.7358 nan 0.1000 0.0834  
## 3 0.6704 nan 0.1000 0.0633  
## 4 0.6152 nan 0.1000 0.0540  
## 5 0.5659 nan 0.1000 0.0505  
## 6 0.5190 nan 0.1000 0.0443  
## 7 0.4845 nan 0.1000 0.0320  
## 8 0.4556 nan 0.1000 0.0281  
## 9 0.4299 nan 0.1000 0.0255  
## 10 0.4054 nan 0.1000 0.0232  
## 20 0.2689 nan 0.1000 0.0059  
## 40 0.1991 nan 0.1000 0.0015  
## 60 0.1761 nan 0.1000 0.0007  
## 80 0.1609 nan 0.1000 0.0004  
## 100 0.1498 nan 0.1000 0.0002  
## 120 0.1418 nan 0.1000 -0.0000  
## 140 0.1335 nan 0.1000 0.0001  
## 150 0.1302 nan 0.1000 -0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8042 nan 0.1000 0.0984  
## 2 0.7173 nan 0.1000 0.0884  
## 3 0.6465 nan 0.1000 0.0726  
## 4 0.5812 nan 0.1000 0.0608  
## 5 0.5271 nan 0.1000 0.0490  
## 6 0.4845 nan 0.1000 0.0430  
## 7 0.4479 nan 0.1000 0.0331  
## 8 0.4164 nan 0.1000 0.0314  
## 9 0.3889 nan 0.1000 0.0253  
## 10 0.3652 nan 0.1000 0.0233  
## 20 0.2350 nan 0.1000 0.0064  
## 40 0.1736 nan 0.1000 0.0005  
## 60 0.1498 nan 0.1000 0.0005  
## 80 0.1345 nan 0.1000 0.0009  
## 100 0.1212 nan 0.1000 0.0002  
## 120 0.1108 nan 0.1000 0.0001  
## 140 0.1034 nan 0.1000 0.0001  
## 150 0.1002 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7692 nan 0.1000 0.0696  
## 2 0.7068 nan 0.1000 0.0592  
## 3 0.6562 nan 0.1000 0.0511  
## 4 0.6141 nan 0.1000 0.0398  
## 5 0.5783 nan 0.1000 0.0318  
## 6 0.5453 nan 0.1000 0.0342  
## 7 0.5145 nan 0.1000 0.0307  
## 8 0.4894 nan 0.1000 0.0248  
## 9 0.4679 nan 0.1000 0.0211  
## 10 0.4463 nan 0.1000 0.0199  
## 20 0.3169 nan 0.1000 0.0077  
## 40 0.2357 nan 0.1000 0.0016  
## 60 0.2134 nan 0.1000 0.0002  
## 80 0.2041 nan 0.1000 0.0002  
## 100 0.1985 nan 0.1000 -0.0001  
## 120 0.1945 nan 0.1000 -0.0001  
## 140 0.1913 nan 0.1000 -0.0001  
## 150 0.1897 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7553 nan 0.1000 0.0838  
## 2 0.6858 nan 0.1000 0.0688  
## 3 0.6292 nan 0.1000 0.0561  
## 4 0.5766 nan 0.1000 0.0548  
## 5 0.5316 nan 0.1000 0.0432  
## 6 0.4930 nan 0.1000 0.0409  
## 7 0.4583 nan 0.1000 0.0340  
## 8 0.4312 nan 0.1000 0.0246  
## 9 0.4050 nan 0.1000 0.0261  
## 10 0.3827 nan 0.1000 0.0210  
## 20 0.2544 nan 0.1000 0.0070  
## 40 0.1932 nan 0.1000 0.0013  
## 60 0.1701 nan 0.1000 0.0006  
## 80 0.1568 nan 0.1000 0.0007  
## 100 0.1471 nan 0.1000 -0.0003  
## 120 0.1377 nan 0.1000 0.0000  
## 140 0.1298 nan 0.1000 0.0006  
## 150 0.1271 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7451 nan 0.1000 0.0929  
## 2 0.6656 nan 0.1000 0.0804  
## 3 0.5999 nan 0.1000 0.0639  
## 4 0.5437 nan 0.1000 0.0545  
## 5 0.4942 nan 0.1000 0.0472  
## 6 0.4511 nan 0.1000 0.0434  
## 7 0.4154 nan 0.1000 0.0368  
## 8 0.3847 nan 0.1000 0.0291  
## 9 0.3585 nan 0.1000 0.0249  
## 10 0.3351 nan 0.1000 0.0200  
## 20 0.2206 nan 0.1000 0.0062  
## 40 0.1591 nan 0.1000 0.0016  
## 60 0.1384 nan 0.1000 0.0007  
## 80 0.1234 nan 0.1000 0.0006  
## 100 0.1123 nan 0.1000 -0.0002  
## 120 0.1047 nan 0.1000 0.0001  
## 140 0.0965 nan 0.1000 -0.0000  
## 150 0.0928 nan 0.1000 0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8071 nan 0.1000 0.0722  
## 2 0.7437 nan 0.1000 0.0595  
## 3 0.6902 nan 0.1000 0.0537  
## 4 0.6420 nan 0.1000 0.0460  
## 5 0.6051 nan 0.1000 0.0369  
## 6 0.5732 nan 0.1000 0.0319  
## 7 0.5438 nan 0.1000 0.0288  
## 8 0.5126 nan 0.1000 0.0300  
## 9 0.4890 nan 0.1000 0.0213  
## 10 0.4666 nan 0.1000 0.0200  
## 20 0.3253 nan 0.1000 0.0099  
## 40 0.2347 nan 0.1000 0.0011  
## 60 0.2119 nan 0.1000 0.0002  
## 80 0.2026 nan 0.1000 0.0003  
## 100 0.1956 nan 0.1000 0.0004  
## 120 0.1915 nan 0.1000 -0.0000  
## 140 0.1878 nan 0.1000 -0.0002  
## 150 0.1865 nan 0.1000 -0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7880 nan 0.1000 0.0917  
## 2 0.7121 nan 0.1000 0.0701  
## 3 0.6471 nan 0.1000 0.0632  
## 4 0.5895 nan 0.1000 0.0563  
## 5 0.5433 nan 0.1000 0.0438  
## 6 0.4995 nan 0.1000 0.0405  
## 7 0.4636 nan 0.1000 0.0365  
## 8 0.4318 nan 0.1000 0.0287  
## 9 0.4042 nan 0.1000 0.0266  
## 10 0.3811 nan 0.1000 0.0206  
## 20 0.2511 nan 0.1000 0.0058  
## 40 0.1891 nan 0.1000 0.0012  
## 60 0.1684 nan 0.1000 0.0008  
## 80 0.1543 nan 0.1000 -0.0002  
## 100 0.1447 nan 0.1000 -0.0002  
## 120 0.1374 nan 0.1000 -0.0003  
## 140 0.1294 nan 0.1000 0.0000  
## 150 0.1258 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7794 nan 0.1000 0.1019  
## 2 0.6958 nan 0.1000 0.0801  
## 3 0.6194 nan 0.1000 0.0733  
## 4 0.5589 nan 0.1000 0.0596  
## 5 0.5072 nan 0.1000 0.0492  
## 6 0.4626 nan 0.1000 0.0430  
## 7 0.4258 nan 0.1000 0.0357  
## 8 0.3950 nan 0.1000 0.0293  
## 9 0.3686 nan 0.1000 0.0240  
## 10 0.3442 nan 0.1000 0.0211  
## 20 0.2192 nan 0.1000 0.0041  
## 40 0.1586 nan 0.1000 0.0011  
## 60 0.1394 nan 0.1000 0.0008  
## 80 0.1270 nan 0.1000 0.0003  
## 100 0.1165 nan 0.1000 -0.0003  
## 120 0.1071 nan 0.1000 0.0004  
## 140 0.0998 nan 0.1000 -0.0003  
## 150 0.0965 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8015 nan 0.1000 0.0742  
## 2 0.7359 nan 0.1000 0.0625  
## 3 0.6831 nan 0.1000 0.0510  
## 4 0.6355 nan 0.1000 0.0489  
## 5 0.5971 nan 0.1000 0.0378  
## 6 0.5630 nan 0.1000 0.0344  
## 7 0.5310 nan 0.1000 0.0305  
## 8 0.5012 nan 0.1000 0.0276  
## 9 0.4771 nan 0.1000 0.0245  
## 10 0.4515 nan 0.1000 0.0241  
## 20 0.3150 nan 0.1000 0.0093  
## 40 0.2336 nan 0.1000 0.0013  
## 60 0.2135 nan 0.1000 -0.0002  
## 80 0.2045 nan 0.1000 0.0002  
## 100 0.1987 nan 0.1000 0.0002  
## 120 0.1948 nan 0.1000 0.0001  
## 140 0.1921 nan 0.1000 -0.0000  
## 150 0.1908 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7880 nan 0.1000 0.0868  
## 2 0.7079 nan 0.1000 0.0795  
## 3 0.6415 nan 0.1000 0.0695  
## 4 0.5906 nan 0.1000 0.0517  
## 5 0.5432 nan 0.1000 0.0467  
## 6 0.5001 nan 0.1000 0.0455  
## 7 0.4610 nan 0.1000 0.0379  
## 8 0.4277 nan 0.1000 0.0325  
## 9 0.3990 nan 0.1000 0.0305  
## 10 0.3764 nan 0.1000 0.0208  
## 20 0.2480 nan 0.1000 0.0065  
## 40 0.1912 nan 0.1000 0.0005  
## 60 0.1712 nan 0.1000 0.0004  
## 80 0.1605 nan 0.1000 -0.0007  
## 100 0.1497 nan 0.1000 0.0001  
## 120 0.1435 nan 0.1000 0.0000  
## 140 0.1366 nan 0.1000 0.0003  
## 150 0.1334 nan 0.1000 0.0003  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7766 nan 0.1000 0.0955  
## 2 0.6932 nan 0.1000 0.0868  
## 3 0.6191 nan 0.1000 0.0740  
## 4 0.5578 nan 0.1000 0.0597  
## 5 0.5060 nan 0.1000 0.0463  
## 6 0.4615 nan 0.1000 0.0409  
## 7 0.4229 nan 0.1000 0.0372  
## 8 0.3900 nan 0.1000 0.0328  
## 9 0.3627 nan 0.1000 0.0241  
## 10 0.3398 nan 0.1000 0.0227  
## 20 0.2210 nan 0.1000 0.0056  
## 40 0.1672 nan 0.1000 0.0010  
## 60 0.1490 nan 0.1000 -0.0000  
## 80 0.1348 nan 0.1000 0.0000  
## 100 0.1233 nan 0.1000 0.0002  
## 120 0.1123 nan 0.1000 0.0001  
## 140 0.1032 nan 0.1000 0.0002  
## 150 0.1000 nan 0.1000 0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8288 nan 0.1000 0.0834  
## 2 0.7649 nan 0.1000 0.0643  
## 3 0.7037 nan 0.1000 0.0589  
## 4 0.6531 nan 0.1000 0.0493  
## 5 0.6129 nan 0.1000 0.0404  
## 6 0.5783 nan 0.1000 0.0349  
## 7 0.5451 nan 0.1000 0.0325  
## 8 0.5152 nan 0.1000 0.0274  
## 9 0.4890 nan 0.1000 0.0249  
## 10 0.4658 nan 0.1000 0.0222  
## 20 0.3183 nan 0.1000 0.0094  
## 40 0.2276 nan 0.1000 0.0012  
## 60 0.2066 nan 0.1000 0.0002  
## 80 0.1985 nan 0.1000 0.0003  
## 100 0.1931 nan 0.1000 0.0001  
## 120 0.1893 nan 0.1000 -0.0000  
## 140 0.1857 nan 0.1000 0.0001  
## 150 0.1844 nan 0.1000 -0.0004  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8140 nan 0.1000 0.0980  
## 2 0.7317 nan 0.1000 0.0812  
## 3 0.6602 nan 0.1000 0.0716  
## 4 0.6001 nan 0.1000 0.0584  
## 5 0.5514 nan 0.1000 0.0493  
## 6 0.5091 nan 0.1000 0.0425  
## 7 0.4697 nan 0.1000 0.0397  
## 8 0.4394 nan 0.1000 0.0298  
## 9 0.4081 nan 0.1000 0.0291  
## 10 0.3838 nan 0.1000 0.0231  
## 20 0.2462 nan 0.1000 0.0055  
## 40 0.1811 nan 0.1000 0.0008  
## 60 0.1594 nan 0.1000 0.0002  
## 80 0.1486 nan 0.1000 0.0001  
## 100 0.1394 nan 0.1000 0.0007  
## 120 0.1302 nan 0.1000 0.0005  
## 140 0.1232 nan 0.1000 -0.0001  
## 150 0.1200 nan 0.1000 0.0004  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7987 nan 0.1000 0.1083  
## 2 0.7066 nan 0.1000 0.0914  
## 3 0.6323 nan 0.1000 0.0747  
## 4 0.5668 nan 0.1000 0.0639  
## 5 0.5145 nan 0.1000 0.0473  
## 6 0.4691 nan 0.1000 0.0480  
## 7 0.4312 nan 0.1000 0.0371  
## 8 0.3961 nan 0.1000 0.0337  
## 9 0.3669 nan 0.1000 0.0289  
## 10 0.3403 nan 0.1000 0.0243  
## 20 0.2157 nan 0.1000 0.0066  
## 40 0.1536 nan 0.1000 0.0013  
## 60 0.1360 nan 0.1000 0.0002  
## 80 0.1194 nan 0.1000 0.0003  
## 100 0.1084 nan 0.1000 0.0000  
## 120 0.1015 nan 0.1000 -0.0001  
## 140 0.0943 nan 0.1000 0.0000  
## 150 0.0915 nan 0.1000 0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7820 nan 0.1000 0.0726  
## 2 0.7205 nan 0.1000 0.0597  
## 3 0.6693 nan 0.1000 0.0488  
## 4 0.6265 nan 0.1000 0.0425  
## 5 0.5875 nan 0.1000 0.0396  
## 6 0.5520 nan 0.1000 0.0339  
## 7 0.5184 nan 0.1000 0.0316  
## 8 0.4893 nan 0.1000 0.0259  
## 9 0.4645 nan 0.1000 0.0226  
## 10 0.4429 nan 0.1000 0.0215  
## 20 0.3050 nan 0.1000 0.0078  
## 40 0.2232 nan 0.1000 0.0008  
## 60 0.2027 nan 0.1000 0.0004  
## 80 0.1946 nan 0.1000 0.0002  
## 100 0.1895 nan 0.1000 0.0001  
## 120 0.1860 nan 0.1000 0.0000  
## 140 0.1831 nan 0.1000 -0.0002  
## 150 0.1820 nan 0.1000 -0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7731 nan 0.1000 0.0838  
## 2 0.6984 nan 0.1000 0.0764  
## 3 0.6331 nan 0.1000 0.0637  
## 4 0.5807 nan 0.1000 0.0517  
## 5 0.5323 nan 0.1000 0.0477  
## 6 0.4914 nan 0.1000 0.0382  
## 7 0.4518 nan 0.1000 0.0366  
## 8 0.4201 nan 0.1000 0.0320  
## 9 0.3941 nan 0.1000 0.0265  
## 10 0.3717 nan 0.1000 0.0221  
## 20 0.2385 nan 0.1000 0.0059  
## 40 0.1787 nan 0.1000 0.0014  
## 60 0.1591 nan 0.1000 0.0004  
## 80 0.1481 nan 0.1000 0.0005  
## 100 0.1390 nan 0.1000 -0.0001  
## 120 0.1307 nan 0.1000 0.0001  
## 140 0.1230 nan 0.1000 -0.0000  
## 150 0.1196 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7596 nan 0.1000 0.1008  
## 2 0.6755 nan 0.1000 0.0750  
## 3 0.6071 nan 0.1000 0.0676  
## 4 0.5487 nan 0.1000 0.0566  
## 5 0.4972 nan 0.1000 0.0457  
## 6 0.4527 nan 0.1000 0.0413  
## 7 0.4135 nan 0.1000 0.0366  
## 8 0.3819 nan 0.1000 0.0331  
## 9 0.3557 nan 0.1000 0.0253  
## 10 0.3329 nan 0.1000 0.0238  
## 20 0.2091 nan 0.1000 0.0066  
## 40 0.1543 nan 0.1000 0.0006  
## 60 0.1328 nan 0.1000 0.0008  
## 80 0.1208 nan 0.1000 0.0004  
## 100 0.1102 nan 0.1000 0.0002  
## 120 0.1018 nan 0.1000 0.0000  
## 140 0.0949 nan 0.1000 0.0002  
## 150 0.0915 nan 0.1000 0.0004  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8646 nan 0.1000 0.0898  
## 2 0.7884 nan 0.1000 0.0692  
## 3 0.7239 nan 0.1000 0.0615  
## 4 0.6724 nan 0.1000 0.0518  
## 5 0.6265 nan 0.1000 0.0466  
## 6 0.5890 nan 0.1000 0.0351  
## 7 0.5569 nan 0.1000 0.0325  
## 8 0.5294 nan 0.1000 0.0284  
## 9 0.5009 nan 0.1000 0.0285  
## 10 0.4769 nan 0.1000 0.0237  
## 20 0.3280 nan 0.1000 0.0080  
## 40 0.2437 nan 0.1000 0.0010  
## 60 0.2225 nan 0.1000 0.0007  
## 80 0.2105 nan 0.1000 0.0005  
## 100 0.2025 nan 0.1000 0.0001  
## 120 0.1976 nan 0.1000 0.0003  
## 140 0.1939 nan 0.1000 0.0000  
## 150 0.1923 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8533 nan 0.1000 0.0990  
## 2 0.7691 nan 0.1000 0.0774  
## 3 0.6922 nan 0.1000 0.0716  
## 4 0.6275 nan 0.1000 0.0644  
## 5 0.5752 nan 0.1000 0.0544  
## 6 0.5311 nan 0.1000 0.0422  
## 7 0.4914 nan 0.1000 0.0375  
## 8 0.4563 nan 0.1000 0.0319  
## 9 0.4272 nan 0.1000 0.0294  
## 10 0.3988 nan 0.1000 0.0276  
## 20 0.2691 nan 0.1000 0.0067  
## 40 0.1982 nan 0.1000 0.0020  
## 60 0.1778 nan 0.1000 0.0007  
## 80 0.1671 nan 0.1000 0.0005  
## 100 0.1556 nan 0.1000 0.0004  
## 120 0.1459 nan 0.1000 0.0004  
## 140 0.1375 nan 0.1000 0.0001  
## 150 0.1340 nan 0.1000 -0.0002  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8377 nan 0.1000 0.1085  
## 2 0.7396 nan 0.1000 0.0934  
## 3 0.6654 nan 0.1000 0.0717  
## 4 0.6006 nan 0.1000 0.0627  
## 5 0.5406 nan 0.1000 0.0603  
## 6 0.4898 nan 0.1000 0.0451  
## 7 0.4500 nan 0.1000 0.0406  
## 8 0.4163 nan 0.1000 0.0329  
## 9 0.3892 nan 0.1000 0.0253  
## 10 0.3640 nan 0.1000 0.0256  
## 20 0.2353 nan 0.1000 0.0061  
## 40 0.1687 nan 0.1000 0.0018  
## 60 0.1449 nan 0.1000 0.0004  
## 80 0.1320 nan 0.1000 0.0001  
## 100 0.1215 nan 0.1000 0.0003  
## 120 0.1122 nan 0.1000 0.0001  
## 140 0.1031 nan 0.1000 0.0005  
## 150 0.0998 nan 0.1000 0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7816 nan 0.1000 0.0766  
## 2 0.7190 nan 0.1000 0.0602  
## 3 0.6672 nan 0.1000 0.0519  
## 4 0.6229 nan 0.1000 0.0413  
## 5 0.5858 nan 0.1000 0.0366  
## 6 0.5502 nan 0.1000 0.0320  
## 7 0.5176 nan 0.1000 0.0324  
## 8 0.4913 nan 0.1000 0.0247  
## 9 0.4689 nan 0.1000 0.0218  
## 10 0.4501 nan 0.1000 0.0199  
## 20 0.3199 nan 0.1000 0.0092  
## 40 0.2402 nan 0.1000 0.0015  
## 60 0.2202 nan 0.1000 0.0004  
## 80 0.2096 nan 0.1000 0.0005  
## 100 0.2029 nan 0.1000 0.0003  
## 120 0.1976 nan 0.1000 0.0003  
## 140 0.1940 nan 0.1000 -0.0002  
## 150 0.1925 nan 0.1000 -0.0003  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7678 nan 0.1000 0.0893  
## 2 0.6969 nan 0.1000 0.0660  
## 3 0.6340 nan 0.1000 0.0558  
## 4 0.5824 nan 0.1000 0.0495  
## 5 0.5368 nan 0.1000 0.0461  
## 6 0.4948 nan 0.1000 0.0419  
## 7 0.4598 nan 0.1000 0.0369  
## 8 0.4281 nan 0.1000 0.0307  
## 9 0.4027 nan 0.1000 0.0228  
## 10 0.3757 nan 0.1000 0.0261  
## 20 0.2520 nan 0.1000 0.0074  
## 40 0.1913 nan 0.1000 0.0013  
## 60 0.1719 nan 0.1000 0.0003  
## 80 0.1616 nan 0.1000 0.0003  
## 100 0.1535 nan 0.1000 -0.0002  
## 120 0.1435 nan 0.1000 -0.0004  
## 140 0.1360 nan 0.1000 -0.0001  
## 150 0.1324 nan 0.1000 0.0003  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7581 nan 0.1000 0.1013  
## 2 0.6792 nan 0.1000 0.0744  
## 3 0.6100 nan 0.1000 0.0631  
## 4 0.5516 nan 0.1000 0.0564  
## 5 0.4984 nan 0.1000 0.0490  
## 6 0.4542 nan 0.1000 0.0428  
## 7 0.4204 nan 0.1000 0.0345  
## 8 0.3897 nan 0.1000 0.0261  
## 9 0.3645 nan 0.1000 0.0261  
## 10 0.3418 nan 0.1000 0.0228  
## 20 0.2285 nan 0.1000 0.0047  
## 40 0.1700 nan 0.1000 0.0007  
## 60 0.1468 nan 0.1000 0.0002  
## 80 0.1351 nan 0.1000 0.0003  
## 100 0.1232 nan 0.1000 0.0005  
## 120 0.1126 nan 0.1000 0.0001  
## 140 0.1019 nan 0.1000 0.0000  
## 150 0.0984 nan 0.1000 -0.0002  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8183 nan 0.1000 0.0702  
## 2 0.7563 nan 0.1000 0.0630  
## 3 0.7034 nan 0.1000 0.0526  
## 4 0.6547 nan 0.1000 0.0473  
## 5 0.6160 nan 0.1000 0.0354  
## 6 0.5789 nan 0.1000 0.0364  
## 7 0.5455 nan 0.1000 0.0308  
## 8 0.5177 nan 0.1000 0.0273  
## 9 0.4893 nan 0.1000 0.0263  
## 10 0.4662 nan 0.1000 0.0231  
## 20 0.3247 nan 0.1000 0.0091  
## 40 0.2375 nan 0.1000 0.0007  
## 60 0.2171 nan 0.1000 0.0005  
## 80 0.2069 nan 0.1000 0.0003  
## 100 0.2007 nan 0.1000 0.0004  
## 120 0.1957 nan 0.1000 0.0001  
## 140 0.1920 nan 0.1000 0.0001  
## 150 0.1904 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8027 nan 0.1000 0.0876  
## 2 0.7297 nan 0.1000 0.0680  
## 3 0.6587 nan 0.1000 0.0706  
## 4 0.6000 nan 0.1000 0.0557  
## 5 0.5511 nan 0.1000 0.0455  
## 6 0.5070 nan 0.1000 0.0442  
## 7 0.4695 nan 0.1000 0.0400  
## 8 0.4345 nan 0.1000 0.0299  
## 9 0.4064 nan 0.1000 0.0269  
## 10 0.3855 nan 0.1000 0.0204  
## 20 0.2558 nan 0.1000 0.0070  
## 40 0.1894 nan 0.1000 0.0011  
## 60 0.1695 nan 0.1000 0.0004  
## 80 0.1564 nan 0.1000 0.0001  
## 100 0.1467 nan 0.1000 -0.0000  
## 120 0.1373 nan 0.1000 -0.0001  
## 140 0.1303 nan 0.1000 -0.0001  
## 150 0.1263 nan 0.1000 0.0003  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7965 nan 0.1000 0.0955  
## 2 0.7121 nan 0.1000 0.0885  
## 3 0.6366 nan 0.1000 0.0749  
## 4 0.5724 nan 0.1000 0.0603  
## 5 0.5183 nan 0.1000 0.0562  
## 6 0.4746 nan 0.1000 0.0425  
## 7 0.4316 nan 0.1000 0.0406  
## 8 0.4008 nan 0.1000 0.0298  
## 9 0.3722 nan 0.1000 0.0276  
## 10 0.3465 nan 0.1000 0.0224  
## 20 0.2176 nan 0.1000 0.0070  
## 40 0.1587 nan 0.1000 0.0015  
## 60 0.1357 nan 0.1000 0.0004  
## 80 0.1218 nan 0.1000 0.0006  
## 100 0.1120 nan 0.1000 0.0004  
## 120 0.1042 nan 0.1000 -0.0001  
## 140 0.0977 nan 0.1000 0.0001  
## 150 0.0948 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8103 nan 0.1000 0.0762  
## 2 0.7410 nan 0.1000 0.0703  
## 3 0.6850 nan 0.1000 0.0570  
## 4 0.6377 nan 0.1000 0.0479  
## 5 0.5959 nan 0.1000 0.0404  
## 6 0.5628 nan 0.1000 0.0292  
## 7 0.5300 nan 0.1000 0.0323  
## 8 0.5041 nan 0.1000 0.0245  
## 9 0.4740 nan 0.1000 0.0290  
## 10 0.4512 nan 0.1000 0.0231  
## 20 0.3142 nan 0.1000 0.0087  
## 40 0.2318 nan 0.1000 0.0015  
## 60 0.2128 nan 0.1000 0.0002  
## 80 0.2029 nan 0.1000 0.0002  
## 100 0.1969 nan 0.1000 -0.0005  
## 120 0.1927 nan 0.1000 -0.0002  
## 140 0.1897 nan 0.1000 0.0001  
## 150 0.1886 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7929 nan 0.1000 0.1002  
## 2 0.7155 nan 0.1000 0.0753  
## 3 0.6428 nan 0.1000 0.0665  
## 4 0.5853 nan 0.1000 0.0540  
## 5 0.5372 nan 0.1000 0.0470  
## 6 0.4943 nan 0.1000 0.0402  
## 7 0.4602 nan 0.1000 0.0312  
## 8 0.4286 nan 0.1000 0.0284  
## 9 0.4035 nan 0.1000 0.0252  
## 10 0.3793 nan 0.1000 0.0233  
## 20 0.2475 nan 0.1000 0.0062  
## 40 0.1865 nan 0.1000 0.0015  
## 60 0.1671 nan 0.1000 0.0009  
## 80 0.1546 nan 0.1000 0.0002  
## 100 0.1481 nan 0.1000 -0.0005  
## 120 0.1400 nan 0.1000 0.0001  
## 140 0.1316 nan 0.1000 0.0001  
## 150 0.1291 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7823 nan 0.1000 0.1039  
## 2 0.6944 nan 0.1000 0.0831  
## 3 0.6179 nan 0.1000 0.0708  
## 4 0.5572 nan 0.1000 0.0571  
## 5 0.5076 nan 0.1000 0.0471  
## 6 0.4635 nan 0.1000 0.0409  
## 7 0.4237 nan 0.1000 0.0389  
## 8 0.3925 nan 0.1000 0.0312  
## 9 0.3635 nan 0.1000 0.0297  
## 10 0.3379 nan 0.1000 0.0237  
## 20 0.2143 nan 0.1000 0.0062  
## 40 0.1577 nan 0.1000 0.0011  
## 60 0.1373 nan 0.1000 0.0004  
## 80 0.1220 nan 0.1000 0.0004  
## 100 0.1111 nan 0.1000 0.0001  
## 120 0.1038 nan 0.1000 0.0002  
## 140 0.0975 nan 0.1000 -0.0001  
## 150 0.0943 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8068 nan 0.1000 0.0701  
## 2 0.7487 nan 0.1000 0.0601  
## 3 0.6975 nan 0.1000 0.0531  
## 4 0.6524 nan 0.1000 0.0413  
## 5 0.6146 nan 0.1000 0.0373  
## 6 0.5818 nan 0.1000 0.0328  
## 7 0.5520 nan 0.1000 0.0272  
## 8 0.5250 nan 0.1000 0.0279  
## 9 0.5016 nan 0.1000 0.0253  
## 10 0.4794 nan 0.1000 0.0212  
## 20 0.3394 nan 0.1000 0.0072  
## 40 0.2515 nan 0.1000 0.0013  
## 60 0.2313 nan 0.1000 0.0007  
## 80 0.2214 nan 0.1000 -0.0001  
## 100 0.2146 nan 0.1000 0.0000  
## 120 0.2102 nan 0.1000 0.0002  
## 140 0.2066 nan 0.1000 -0.0002  
## 150 0.2049 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7934 nan 0.1000 0.0828  
## 2 0.7205 nan 0.1000 0.0727  
## 3 0.6542 nan 0.1000 0.0636  
## 4 0.5982 nan 0.1000 0.0525  
## 5 0.5500 nan 0.1000 0.0439  
## 6 0.5070 nan 0.1000 0.0393  
## 7 0.4774 nan 0.1000 0.0252  
## 8 0.4472 nan 0.1000 0.0306  
## 9 0.4213 nan 0.1000 0.0248  
## 10 0.3966 nan 0.1000 0.0239  
## 20 0.2699 nan 0.1000 0.0056  
## 40 0.1977 nan 0.1000 0.0011  
## 60 0.1771 nan 0.1000 0.0007  
## 80 0.1610 nan 0.1000 0.0004  
## 100 0.1529 nan 0.1000 0.0003  
## 120 0.1437 nan 0.1000 -0.0002  
## 140 0.1356 nan 0.1000 -0.0001  
## 150 0.1325 nan 0.1000 0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7836 nan 0.1000 0.1004  
## 2 0.7021 nan 0.1000 0.0808  
## 3 0.6334 nan 0.1000 0.0671  
## 4 0.5738 nan 0.1000 0.0592  
## 5 0.5238 nan 0.1000 0.0505  
## 6 0.4823 nan 0.1000 0.0443  
## 7 0.4456 nan 0.1000 0.0364  
## 8 0.4123 nan 0.1000 0.0301  
## 9 0.3835 nan 0.1000 0.0269  
## 10 0.3582 nan 0.1000 0.0234  
## 20 0.2373 nan 0.1000 0.0054  
## 40 0.1693 nan 0.1000 0.0015  
## 60 0.1473 nan 0.1000 0.0002  
## 80 0.1323 nan 0.1000 0.0003  
## 100 0.1217 nan 0.1000 0.0004  
## 120 0.1126 nan 0.1000 0.0002  
## 140 0.1051 nan 0.1000 0.0001  
## 150 0.1011 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7661 nan 0.1000 0.0642  
## 2 0.7050 nan 0.1000 0.0581  
## 3 0.6562 nan 0.1000 0.0491  
## 4 0.6103 nan 0.1000 0.0426  
## 5 0.5722 nan 0.1000 0.0365  
## 6 0.5417 nan 0.1000 0.0315  
## 7 0.5123 nan 0.1000 0.0275  
## 8 0.4868 nan 0.1000 0.0252  
## 9 0.4628 nan 0.1000 0.0220  
## 10 0.4422 nan 0.1000 0.0200  
## 20 0.3118 nan 0.1000 0.0086  
## 40 0.2307 nan 0.1000 0.0019  
## 60 0.2106 nan 0.1000 0.0007  
## 80 0.2010 nan 0.1000 0.0003  
## 100 0.1945 nan 0.1000 0.0004  
## 120 0.1909 nan 0.1000 0.0000  
## 140 0.1882 nan 0.1000 0.0001  
## 150 0.1868 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7544 nan 0.1000 0.0832  
## 2 0.6783 nan 0.1000 0.0728  
## 3 0.6203 nan 0.1000 0.0588  
## 4 0.5643 nan 0.1000 0.0536  
## 5 0.5190 nan 0.1000 0.0452  
## 6 0.4835 nan 0.1000 0.0357  
## 7 0.4485 nan 0.1000 0.0340  
## 8 0.4196 nan 0.1000 0.0302  
## 9 0.3964 nan 0.1000 0.0238  
## 10 0.3702 nan 0.1000 0.0230  
## 20 0.2415 nan 0.1000 0.0062  
## 40 0.1852 nan 0.1000 0.0007  
## 60 0.1630 nan 0.1000 0.0005  
## 80 0.1536 nan 0.1000 -0.0001  
## 100 0.1445 nan 0.1000 0.0005  
## 120 0.1343 nan 0.1000 -0.0001  
## 140 0.1270 nan 0.1000 -0.0001  
## 150 0.1245 nan 0.1000 -0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7401 nan 0.1000 0.0961  
## 2 0.6620 nan 0.1000 0.0822  
## 3 0.5952 nan 0.1000 0.0635  
## 4 0.5386 nan 0.1000 0.0545  
## 5 0.4887 nan 0.1000 0.0454  
## 6 0.4483 nan 0.1000 0.0390  
## 7 0.4158 nan 0.1000 0.0326  
## 8 0.3854 nan 0.1000 0.0286  
## 9 0.3583 nan 0.1000 0.0225  
## 10 0.3320 nan 0.1000 0.0240  
## 20 0.2167 nan 0.1000 0.0053  
## 40 0.1571 nan 0.1000 0.0014  
## 60 0.1399 nan 0.1000 0.0003  
## 80 0.1248 nan 0.1000 0.0008  
## 100 0.1131 nan 0.1000 0.0005  
## 120 0.1050 nan 0.1000 0.0001  
## 140 0.0970 nan 0.1000 0.0001  
## 150 0.0936 nan 0.1000 0.0006  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8512 nan 0.1000 0.0834  
## 2 0.7818 nan 0.1000 0.0669  
## 3 0.7238 nan 0.1000 0.0582  
## 4 0.6729 nan 0.1000 0.0464  
## 5 0.6292 nan 0.1000 0.0417  
## 6 0.5909 nan 0.1000 0.0338  
## 7 0.5572 nan 0.1000 0.0335  
## 8 0.5283 nan 0.1000 0.0311  
## 9 0.5020 nan 0.1000 0.0252  
## 10 0.4748 nan 0.1000 0.0271  
## 20 0.3285 nan 0.1000 0.0083  
## 40 0.2399 nan 0.1000 0.0012  
## 60 0.2195 nan 0.1000 0.0003  
## 80 0.2091 nan 0.1000 0.0003  
## 100 0.2025 nan 0.1000 0.0001  
## 120 0.1978 nan 0.1000 -0.0003  
## 140 0.1939 nan 0.1000 -0.0003  
## 150 0.1925 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8387 nan 0.1000 0.0908  
## 2 0.7580 nan 0.1000 0.0766  
## 3 0.6856 nan 0.1000 0.0683  
## 4 0.6247 nan 0.1000 0.0659  
## 5 0.5721 nan 0.1000 0.0512  
## 6 0.5256 nan 0.1000 0.0450  
## 7 0.4848 nan 0.1000 0.0391  
## 8 0.4479 nan 0.1000 0.0362  
## 9 0.4165 nan 0.1000 0.0320  
## 10 0.3906 nan 0.1000 0.0252  
## 20 0.2560 nan 0.1000 0.0060  
## 40 0.1869 nan 0.1000 0.0013  
## 60 0.1637 nan 0.1000 0.0004  
## 80 0.1494 nan 0.1000 0.0000  
## 100 0.1402 nan 0.1000 0.0004  
## 120 0.1323 nan 0.1000 -0.0001  
## 140 0.1230 nan 0.1000 0.0001  
## 150 0.1208 nan 0.1000 0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8204 nan 0.1000 0.1065  
## 2 0.7304 nan 0.1000 0.0853  
## 3 0.6509 nan 0.1000 0.0802  
## 4 0.5864 nan 0.1000 0.0619  
## 5 0.5314 nan 0.1000 0.0538  
## 6 0.4843 nan 0.1000 0.0464  
## 7 0.4450 nan 0.1000 0.0392  
## 8 0.4094 nan 0.1000 0.0347  
## 9 0.3791 nan 0.1000 0.0295  
## 10 0.3524 nan 0.1000 0.0225  
## 20 0.2244 nan 0.1000 0.0062  
## 40 0.1600 nan 0.1000 0.0011  
## 60 0.1376 nan 0.1000 0.0012  
## 80 0.1234 nan 0.1000 -0.0001  
## 100 0.1131 nan 0.1000 0.0007  
## 120 0.1052 nan 0.1000 -0.0001  
## 140 0.0972 nan 0.1000 0.0000  
## 150 0.0946 nan 0.1000 0.0002  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7952 nan 0.1000 0.0726  
## 2 0.7346 nan 0.1000 0.0617  
## 3 0.6833 nan 0.1000 0.0502  
## 4 0.6366 nan 0.1000 0.0476  
## 5 0.5962 nan 0.1000 0.0376  
## 6 0.5637 nan 0.1000 0.0327  
## 7 0.5322 nan 0.1000 0.0303  
## 8 0.5046 nan 0.1000 0.0263  
## 9 0.4814 nan 0.1000 0.0228  
## 10 0.4569 nan 0.1000 0.0230  
## 20 0.3225 nan 0.1000 0.0093  
## 40 0.2426 nan 0.1000 0.0012  
## 60 0.2220 nan 0.1000 0.0006  
## 80 0.2121 nan 0.1000 0.0002  
## 100 0.2054 nan 0.1000 0.0001  
## 120 0.2007 nan 0.1000 0.0002  
## 140 0.1975 nan 0.1000 -0.0000  
## 150 0.1959 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7767 nan 0.1000 0.0954  
## 2 0.7009 nan 0.1000 0.0741  
## 3 0.6357 nan 0.1000 0.0619  
## 4 0.5825 nan 0.1000 0.0507  
## 5 0.5376 nan 0.1000 0.0386  
## 6 0.4996 nan 0.1000 0.0370  
## 7 0.4645 nan 0.1000 0.0310  
## 8 0.4341 nan 0.1000 0.0276  
## 9 0.4084 nan 0.1000 0.0256  
## 10 0.3860 nan 0.1000 0.0215  
## 20 0.2597 nan 0.1000 0.0066  
## 40 0.1967 nan 0.1000 0.0007  
## 60 0.1755 nan 0.1000 0.0000  
## 80 0.1615 nan 0.1000 -0.0003  
## 100 0.1546 nan 0.1000 -0.0003  
## 120 0.1481 nan 0.1000 -0.0001  
## 140 0.1406 nan 0.1000 -0.0001  
## 150 0.1365 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7723 nan 0.1000 0.0929  
## 2 0.6887 nan 0.1000 0.0844  
## 3 0.6177 nan 0.1000 0.0691  
## 4 0.5598 nan 0.1000 0.0589  
## 5 0.5104 nan 0.1000 0.0489  
## 6 0.4651 nan 0.1000 0.0424  
## 7 0.4298 nan 0.1000 0.0334  
## 8 0.3979 nan 0.1000 0.0292  
## 9 0.3724 nan 0.1000 0.0232  
## 10 0.3484 nan 0.1000 0.0247  
## 20 0.2265 nan 0.1000 0.0068  
## 40 0.1655 nan 0.1000 0.0014  
## 60 0.1470 nan 0.1000 -0.0000  
## 80 0.1346 nan 0.1000 0.0002  
## 100 0.1224 nan 0.1000 0.0000  
## 120 0.1132 nan 0.1000 -0.0003  
## 140 0.1045 nan 0.1000 0.0000  
## 150 0.1021 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8017 nan 0.1000 0.0781  
## 2 0.7384 nan 0.1000 0.0610  
## 3 0.6872 nan 0.1000 0.0513  
## 4 0.6429 nan 0.1000 0.0430  
## 5 0.6047 nan 0.1000 0.0354  
## 6 0.5697 nan 0.1000 0.0329  
## 7 0.5408 nan 0.1000 0.0254  
## 8 0.5129 nan 0.1000 0.0276  
## 9 0.4885 nan 0.1000 0.0230  
## 10 0.4667 nan 0.1000 0.0224  
## 20 0.3324 nan 0.1000 0.0069  
## 40 0.2453 nan 0.1000 0.0019  
## 60 0.2240 nan 0.1000 0.0002  
## 80 0.2154 nan 0.1000 0.0000  
## 100 0.2104 nan 0.1000 -0.0000  
## 120 0.2066 nan 0.1000 -0.0005  
## 140 0.2032 nan 0.1000 0.0002  
## 150 0.2019 nan 0.1000 -0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7867 nan 0.1000 0.0854  
## 2 0.7117 nan 0.1000 0.0699  
## 3 0.6491 nan 0.1000 0.0605  
## 4 0.5956 nan 0.1000 0.0515  
## 5 0.5472 nan 0.1000 0.0498  
## 6 0.5068 nan 0.1000 0.0380  
## 7 0.4709 nan 0.1000 0.0352  
## 8 0.4411 nan 0.1000 0.0265  
## 9 0.4127 nan 0.1000 0.0247  
## 10 0.3881 nan 0.1000 0.0239  
## 20 0.2565 nan 0.1000 0.0071  
## 40 0.1990 nan 0.1000 0.0014  
## 60 0.1758 nan 0.1000 0.0007  
## 80 0.1601 nan 0.1000 0.0009  
## 100 0.1506 nan 0.1000 0.0001  
## 120 0.1439 nan 0.1000 0.0010  
## 140 0.1382 nan 0.1000 0.0002  
## 150 0.1348 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7771 nan 0.1000 0.1034  
## 2 0.6912 nan 0.1000 0.0875  
## 3 0.6225 nan 0.1000 0.0667  
## 4 0.5614 nan 0.1000 0.0608  
## 5 0.5104 nan 0.1000 0.0484  
## 6 0.4667 nan 0.1000 0.0407  
## 7 0.4306 nan 0.1000 0.0360  
## 8 0.3989 nan 0.1000 0.0297  
## 9 0.3728 nan 0.1000 0.0238  
## 10 0.3510 nan 0.1000 0.0207  
## 20 0.2299 nan 0.1000 0.0058  
## 40 0.1689 nan 0.1000 0.0004  
## 60 0.1468 nan 0.1000 0.0006  
## 80 0.1341 nan 0.1000 -0.0000  
## 100 0.1204 nan 0.1000 -0.0000  
## 120 0.1125 nan 0.1000 0.0003  
## 140 0.1058 nan 0.1000 -0.0001  
## 150 0.1023 nan 0.1000 0.0003  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8211 nan 0.1000 0.0821  
## 2 0.7533 nan 0.1000 0.0679  
## 3 0.6951 nan 0.1000 0.0564  
## 4 0.6462 nan 0.1000 0.0478  
## 5 0.6079 nan 0.1000 0.0347  
## 6 0.5665 nan 0.1000 0.0372  
## 7 0.5297 nan 0.1000 0.0348  
## 8 0.5007 nan 0.1000 0.0262  
## 9 0.4766 nan 0.1000 0.0241  
## 10 0.4544 nan 0.1000 0.0198  
## 20 0.3096 nan 0.1000 0.0081  
## 40 0.2254 nan 0.1000 0.0019  
## 60 0.2071 nan 0.1000 0.0000  
## 80 0.1984 nan 0.1000 0.0004  
## 100 0.1931 nan 0.1000 -0.0006  
## 120 0.1888 nan 0.1000 0.0001  
## 140 0.1860 nan 0.1000 0.0000  
## 150 0.1845 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8030 nan 0.1000 0.1002  
## 2 0.7238 nan 0.1000 0.0793  
## 3 0.6495 nan 0.1000 0.0714  
## 4 0.5889 nan 0.1000 0.0619  
## 5 0.5414 nan 0.1000 0.0454  
## 6 0.4982 nan 0.1000 0.0422  
## 7 0.4590 nan 0.1000 0.0356  
## 8 0.4262 nan 0.1000 0.0319  
## 9 0.4013 nan 0.1000 0.0240  
## 10 0.3760 nan 0.1000 0.0246  
## 20 0.2432 nan 0.1000 0.0057  
## 40 0.1806 nan 0.1000 0.0009  
## 60 0.1606 nan 0.1000 -0.0003  
## 80 0.1467 nan 0.1000 -0.0000  
## 100 0.1370 nan 0.1000 -0.0003  
## 120 0.1286 nan 0.1000 0.0001  
## 140 0.1220 nan 0.1000 -0.0001  
## 150 0.1202 nan 0.1000 -0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7926 nan 0.1000 0.1046  
## 2 0.7042 nan 0.1000 0.0883  
## 3 0.6283 nan 0.1000 0.0768  
## 4 0.5635 nan 0.1000 0.0652  
## 5 0.5122 nan 0.1000 0.0489  
## 6 0.4672 nan 0.1000 0.0454  
## 7 0.4290 nan 0.1000 0.0376  
## 8 0.3960 nan 0.1000 0.0329  
## 9 0.3672 nan 0.1000 0.0281  
## 10 0.3426 nan 0.1000 0.0254  
## 20 0.2183 nan 0.1000 0.0059  
## 40 0.1546 nan 0.1000 0.0015  
## 60 0.1341 nan 0.1000 -0.0001  
## 80 0.1189 nan 0.1000 -0.0000  
## 100 0.1097 nan 0.1000 -0.0001  
## 120 0.1018 nan 0.1000 -0.0001  
## 140 0.0952 nan 0.1000 0.0001  
## 150 0.0927 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7966 nan 0.1000 0.0708  
## 2 0.7333 nan 0.1000 0.0596  
## 3 0.6801 nan 0.1000 0.0485  
## 4 0.6363 nan 0.1000 0.0475  
## 5 0.5969 nan 0.1000 0.0383  
## 6 0.5639 nan 0.1000 0.0305  
## 7 0.5340 nan 0.1000 0.0289  
## 8 0.5080 nan 0.1000 0.0239  
## 9 0.4833 nan 0.1000 0.0226  
## 10 0.4574 nan 0.1000 0.0249  
## 20 0.3235 nan 0.1000 0.0087  
## 40 0.2391 nan 0.1000 0.0016  
## 60 0.2190 nan 0.1000 0.0002  
## 80 0.2087 nan 0.1000 0.0001  
## 100 0.2012 nan 0.1000 -0.0000  
## 120 0.1973 nan 0.1000 -0.0003  
## 140 0.1938 nan 0.1000 -0.0001  
## 150 0.1923 nan 0.1000 -0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7818 nan 0.1000 0.0865  
## 2 0.7098 nan 0.1000 0.0716  
## 3 0.6409 nan 0.1000 0.0656  
## 4 0.5886 nan 0.1000 0.0496  
## 5 0.5407 nan 0.1000 0.0475  
## 6 0.4984 nan 0.1000 0.0396  
## 7 0.4639 nan 0.1000 0.0336  
## 8 0.4345 nan 0.1000 0.0301  
## 9 0.4072 nan 0.1000 0.0246  
## 10 0.3829 nan 0.1000 0.0241  
## 20 0.2551 nan 0.1000 0.0057  
## 40 0.1924 nan 0.1000 0.0009  
## 60 0.1718 nan 0.1000 0.0009  
## 80 0.1601 nan 0.1000 -0.0001  
## 100 0.1513 nan 0.1000 0.0002  
## 120 0.1424 nan 0.1000 0.0003  
## 140 0.1361 nan 0.1000 -0.0003  
## 150 0.1318 nan 0.1000 0.0005  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7724 nan 0.1000 0.0960  
## 2 0.6885 nan 0.1000 0.0820  
## 3 0.6238 nan 0.1000 0.0630  
## 4 0.5615 nan 0.1000 0.0623  
## 5 0.5095 nan 0.1000 0.0525  
## 6 0.4652 nan 0.1000 0.0419  
## 7 0.4274 nan 0.1000 0.0363  
## 8 0.3931 nan 0.1000 0.0302  
## 9 0.3652 nan 0.1000 0.0254  
## 10 0.3436 nan 0.1000 0.0208  
## 20 0.2252 nan 0.1000 0.0064  
## 40 0.1615 nan 0.1000 0.0005  
## 60 0.1436 nan 0.1000 -0.0005  
## 80 0.1292 nan 0.1000 0.0001  
## 100 0.1183 nan 0.1000 0.0004  
## 120 0.1097 nan 0.1000 0.0001  
## 140 0.1036 nan 0.1000 0.0000  
## 150 0.1002 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7298 nan 0.1000 0.0691  
## 2 0.6726 nan 0.1000 0.0581  
## 3 0.6268 nan 0.1000 0.0496  
## 4 0.5855 nan 0.1000 0.0414  
## 5 0.5504 nan 0.1000 0.0348  
## 6 0.5209 nan 0.1000 0.0299  
## 7 0.4918 nan 0.1000 0.0292  
## 8 0.4632 nan 0.1000 0.0245  
## 9 0.4426 nan 0.1000 0.0200  
## 10 0.4234 nan 0.1000 0.0190  
## 20 0.2934 nan 0.1000 0.0088  
## 40 0.2106 nan 0.1000 0.0012  
## 60 0.1914 nan 0.1000 0.0005  
## 80 0.1836 nan 0.1000 -0.0001  
## 100 0.1781 nan 0.1000 -0.0002  
## 120 0.1749 nan 0.1000 -0.0005  
## 140 0.1711 nan 0.1000 0.0000  
## 150 0.1695 nan 0.1000 0.0002  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7220 nan 0.1000 0.0799  
## 2 0.6511 nan 0.1000 0.0730  
## 3 0.5930 nan 0.1000 0.0532  
## 4 0.5393 nan 0.1000 0.0514  
## 5 0.4959 nan 0.1000 0.0431  
## 6 0.4582 nan 0.1000 0.0359  
## 7 0.4272 nan 0.1000 0.0290  
## 8 0.3998 nan 0.1000 0.0264  
## 9 0.3754 nan 0.1000 0.0230  
## 10 0.3515 nan 0.1000 0.0227  
## 20 0.2251 nan 0.1000 0.0065  
## 40 0.1687 nan 0.1000 0.0013  
## 60 0.1516 nan 0.1000 -0.0001  
## 80 0.1421 nan 0.1000 0.0003  
## 100 0.1343 nan 0.1000 0.0001  
## 120 0.1261 nan 0.1000 0.0004  
## 140 0.1190 nan 0.1000 0.0002  
## 150 0.1161 nan 0.1000 0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7077 nan 0.1000 0.0945  
## 2 0.6317 nan 0.1000 0.0788  
## 3 0.5659 nan 0.1000 0.0598  
## 4 0.5135 nan 0.1000 0.0532  
## 5 0.4651 nan 0.1000 0.0450  
## 6 0.4261 nan 0.1000 0.0361  
## 7 0.3898 nan 0.1000 0.0347  
## 8 0.3586 nan 0.1000 0.0313  
## 9 0.3327 nan 0.1000 0.0251  
## 10 0.3080 nan 0.1000 0.0236  
## 20 0.1996 nan 0.1000 0.0038  
## 40 0.1419 nan 0.1000 0.0006  
## 60 0.1232 nan 0.1000 0.0003  
## 80 0.1123 nan 0.1000 0.0007  
## 100 0.1050 nan 0.1000 -0.0002  
## 120 0.0978 nan 0.1000 -0.0003  
## 140 0.0916 nan 0.1000 -0.0002  
## 150 0.0890 nan 0.1000 -0.0000  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8283 nan 0.1000 0.0804  
## 2 0.7598 nan 0.1000 0.0702  
## 3 0.7036 nan 0.1000 0.0547  
## 4 0.6527 nan 0.1000 0.0476  
## 5 0.6121 nan 0.1000 0.0408  
## 6 0.5741 nan 0.1000 0.0368  
## 7 0.5439 nan 0.1000 0.0306  
## 8 0.5156 nan 0.1000 0.0279  
## 9 0.4895 nan 0.1000 0.0240  
## 10 0.4674 nan 0.1000 0.0183  
## 20 0.3260 nan 0.1000 0.0079  
## 40 0.2420 nan 0.1000 0.0014  
## 60 0.2204 nan 0.1000 0.0003  
## 80 0.2098 nan 0.1000 0.0005  
## 100 0.2023 nan 0.1000 0.0001  
## 120 0.1979 nan 0.1000 0.0001  
## 140 0.1938 nan 0.1000 -0.0003  
## 150 0.1927 nan 0.1000 -0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8186 nan 0.1000 0.0969  
## 2 0.7351 nan 0.1000 0.0800  
## 3 0.6672 nan 0.1000 0.0644  
## 4 0.6102 nan 0.1000 0.0549  
## 5 0.5588 nan 0.1000 0.0539  
## 6 0.5148 nan 0.1000 0.0435  
## 7 0.4762 nan 0.1000 0.0399  
## 8 0.4464 nan 0.1000 0.0293  
## 9 0.4190 nan 0.1000 0.0248  
## 10 0.3944 nan 0.1000 0.0248  
## 20 0.2626 nan 0.1000 0.0060  
## 40 0.1947 nan 0.1000 0.0010  
## 60 0.1693 nan 0.1000 0.0008  
## 80 0.1555 nan 0.1000 0.0001  
## 100 0.1456 nan 0.1000 0.0001  
## 120 0.1366 nan 0.1000 0.0001  
## 140 0.1301 nan 0.1000 -0.0002  
## 150 0.1274 nan 0.1000 0.0002  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.8062 nan 0.1000 0.1036  
## 2 0.7141 nan 0.1000 0.0917  
## 3 0.6397 nan 0.1000 0.0741  
## 4 0.5790 nan 0.1000 0.0599  
## 5 0.5239 nan 0.1000 0.0492  
## 6 0.4784 nan 0.1000 0.0425  
## 7 0.4391 nan 0.1000 0.0386  
## 8 0.4059 nan 0.1000 0.0316  
## 9 0.3799 nan 0.1000 0.0270  
## 10 0.3543 nan 0.1000 0.0234  
## 20 0.2268 nan 0.1000 0.0052  
## 40 0.1655 nan 0.1000 0.0012  
## 60 0.1446 nan 0.1000 0.0006  
## 80 0.1290 nan 0.1000 -0.0003  
## 100 0.1165 nan 0.1000 -0.0002  
## 120 0.1078 nan 0.1000 -0.0001  
## 140 0.0993 nan 0.1000 -0.0001  
## 150 0.0956 nan 0.1000 0.0002  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7649 nan 0.1000 0.0749  
## 2 0.7055 nan 0.1000 0.0586  
## 3 0.6533 nan 0.1000 0.0493  
## 4 0.6095 nan 0.1000 0.0421  
## 5 0.5724 nan 0.1000 0.0343  
## 6 0.5419 nan 0.1000 0.0314  
## 7 0.5152 nan 0.1000 0.0268  
## 8 0.4880 nan 0.1000 0.0253  
## 9 0.4628 nan 0.1000 0.0246  
## 10 0.4427 nan 0.1000 0.0197  
## 20 0.3094 nan 0.1000 0.0063  
## 40 0.2315 nan 0.1000 -0.0008  
## 60 0.2126 nan 0.1000 0.0003  
## 80 0.2035 nan 0.1000 0.0005  
## 100 0.1976 nan 0.1000 0.0002  
## 120 0.1936 nan 0.1000 0.0001  
## 140 0.1906 nan 0.1000 -0.0001  
## 150 0.1894 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7510 nan 0.1000 0.0846  
## 2 0.6778 nan 0.1000 0.0741  
## 3 0.6171 nan 0.1000 0.0601  
## 4 0.5629 nan 0.1000 0.0541  
## 5 0.5166 nan 0.1000 0.0456  
## 6 0.4778 nan 0.1000 0.0372  
## 7 0.4427 nan 0.1000 0.0352  
## 8 0.4143 nan 0.1000 0.0239  
## 9 0.3879 nan 0.1000 0.0231  
## 10 0.3667 nan 0.1000 0.0197  
## 20 0.2422 nan 0.1000 0.0062  
## 40 0.1840 nan 0.1000 0.0016  
## 60 0.1637 nan 0.1000 0.0006  
## 80 0.1495 nan 0.1000 0.0000  
## 100 0.1413 nan 0.1000 0.0002  
## 120 0.1346 nan 0.1000 -0.0001  
## 140 0.1291 nan 0.1000 -0.0000  
## 150 0.1257 nan 0.1000 0.0001  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7422 nan 0.1000 0.0940  
## 2 0.6588 nan 0.1000 0.0815  
## 3 0.5927 nan 0.1000 0.0622  
## 4 0.5330 nan 0.1000 0.0592  
## 5 0.4844 nan 0.1000 0.0487  
## 6 0.4449 nan 0.1000 0.0377  
## 7 0.4100 nan 0.1000 0.0314  
## 8 0.3799 nan 0.1000 0.0277  
## 9 0.3524 nan 0.1000 0.0243  
## 10 0.3313 nan 0.1000 0.0210  
## 20 0.2209 nan 0.1000 0.0033  
## 40 0.1626 nan 0.1000 0.0018  
## 60 0.1402 nan 0.1000 0.0000  
## 80 0.1258 nan 0.1000 0.0004  
## 100 0.1133 nan 0.1000 0.0000  
## 120 0.1046 nan 0.1000 0.0001  
## 140 0.0992 nan 0.1000 -0.0000  
## 150 0.0945 nan 0.1000 0.0004  
##   
## Iter TrainDeviance ValidDeviance StepSize Improve  
## 1 0.7851 nan 0.1000 0.1010  
## 2 0.7025 nan 0.1000 0.0738  
## 3 0.6308 nan 0.1000 0.0717  
## 4 0.5688 nan 0.1000 0.0579  
## 5 0.5146 nan 0.1000 0.0520  
## 6 0.4658 nan 0.1000 0.0499  
## 7 0.4279 nan 0.1000 0.0372  
## 8 0.3947 nan 0.1000 0.0293  
## 9 0.3688 nan 0.1000 0.0272  
## 10 0.3441 nan 0.1000 0.0226  
## 20 0.2257 nan 0.1000 0.0051  
## 40 0.1726 nan 0.1000 0.0003  
## 60 0.1518 nan 0.1000 0.0001  
## 80 0.1396 nan 0.1000 0.0001  
## 100 0.1294 nan 0.1000 0.0002  
## 120 0.1200 nan 0.1000 0.0002  
## 140 0.1126 nan 0.1000 0.0000  
## 150 0.1089 nan 0.1000 0.0002

# Make predictions on the test set  
y\_pred\_gbm <- predict(model\_gbm, X\_test)  
  
# Evaluate the model using mean squared error  
mse\_gbm <- mean((y\_test - y\_pred\_gbm)^2)  
  
# Calculate R-squared  
r2\_gbm <- cor(y\_pred\_gbm, y\_test)^2

# Create and fit the XGBoost model  
model\_xgb <- train(X\_train, y\_train, method = "xgbTree")

## [19:32:06] WARNING: src/c\_api/c\_api.cc:935: `ntree\_limit` is deprecated, use `iteration\_range` instead.  
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# Make predictions on the test set  
y\_pred\_xgb <- predict(model\_xgb, X\_test)  
  
# Evaluate the model using mean squared error  
mse\_xgb <- mean((y\_test - y\_pred\_xgb)^2)  
  
# Calculate R-squared  
r2\_xgb <- cor(y\_pred\_xgb, y\_test)^2

# Create and fit the SVM model  
model\_svm <- train(X\_train, y\_train, method = "svmRadial")  
  
# Make predictions on the test set  
y\_pred\_svm <- predict(model\_svm, X\_test)  
  
# Evaluate the model using mean squared error  
mse\_svm <- mean((y\_test - y\_pred\_svm)^2)  
  
# Calculate R-squared  
r2\_svm <- cor(y\_pred\_xgb, y\_test)^2

#create table to compare models  
metrics\_df <- data.frame(Model = c("Linear Regression", "Decision Tree", "GBM", "XGBoost", "SVM"),  
 RMSE = c(mse\_LR, mse\_tree, mse\_gbm, mse\_xgb, mse\_svm),  
 R\_squared = c(r2\_LR, r2\_tree, r2\_gbm, r2\_xgb, r2\_svm))  
  
# Print the table  
print(metrics\_df)

## Model RMSE R\_squared  
## 1 Linear Regression 0.4262095 0.5214246  
## 2 Decision Tree 0.4370168 0.5092996  
## 3 GBM 0.1665639 0.8139392  
## 4 XGBoost 0.1159076 0.8703444  
## 5 SVM 0.2509491 0.8703444

#printing feature table for linear regression model  
feature\_importance\_LR <- varImp(model\_LR)  
print(feature\_importance\_LR)

## lm variable importance  
##   
## Overall  
## immunazation 100.000  
## literacy\_rate 28.309  
## domestic\_health\_expenditure 17.010  
## GDP\_per\_capita 14.246  
## education\_expenditure 11.466  
## water\_invest 7.259  
## health\_expenditure 4.347  
## water\_productivity 3.676  
## health\_expenditure\_per 0.000

#printing feature table for decision tree model  
feature\_importance\_tree <- varImp(model\_tree)  
print(feature\_importance\_tree)

## rpart variable importance  
##   
## Overall  
## GDP\_per\_capita 100.000  
## health\_expenditure 85.066  
## immunazation 74.809  
## domestic\_health\_expenditure 17.300  
## health\_expenditure\_per 15.521  
## water\_invest 10.045  
## literacy\_rate 9.464  
## water\_productivity 0.000  
## education\_expenditure 0.000

#printing feature table for gradient boost model  
feature\_importance\_gbm <- varImp(model\_gbm)  
print(feature\_importance\_gbm)

## gbm variable importance  
##   
## Overall  
## health\_expenditure 100.000  
## GDP\_per\_capita 50.399  
## immunazation 47.966  
## domestic\_health\_expenditure 6.493  
## water\_productivity 5.509  
## health\_expenditure\_per 3.604  
## water\_invest 2.270  
## literacy\_rate 2.095  
## education\_expenditure 0.000

#printing feature table for XGBoost model  
feature\_importance\_xgb <- varImp(model\_xgb)  
print(feature\_importance\_xgb)

## xgbTree variable importance  
##   
## Overall  
## GDP\_per\_capita 100.000  
## health\_expenditure 59.749  
## immunazation 53.809  
## water\_productivity 11.570  
## domestic\_health\_expenditure 10.071  
## health\_expenditure\_per 8.821  
## water\_invest 6.242  
## literacy\_rate 4.555  
## education\_expenditure 0.000

#printing feature table for SVM model  
feature\_importance\_svm <- varImp(model\_svm)  
print(feature\_importance\_svm)

## loess r-squared variable importance  
##   
## Overall  
## health\_expenditure 100.000  
## GDP\_per\_capita 97.337  
## immunazation 74.854  
## domestic\_health\_expenditure 23.158  
## water\_invest 16.408  
## health\_expenditure\_per 15.249  
## literacy\_rate 13.271  
## water\_productivity 3.007  
## education\_expenditure 0.000