Supervised Learning with R - Naive Bayes

```
# Build a naive bayes model in order to classify whether a patient is
# either diabetic or normal given the following dataset.
# ---
# Dataset url = http://bit.ly/Diabetesdataset
#
#
```

Loading Packages

```
# We will now install and load the required packages
# ---
#
#install.packages('tidyverse')
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --

## v ggplot2 3.3.3     v purrr   0.3.4
## v tibble  3.1.0     v dplyr   1.0.5
## v tidyr   1.1.3     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.1

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
#install.packages('ggplot2')
library(ggplot2)
#install.packages('caret')
library(caret)
```

```
## Loading required package: lattice

##
## Attaching package: 'caret'

## The following object is masked from 'package:purrr':
##
##     lift
```

```
#install.packages('caretEnsemble')
library(caretEnsemble)
```

```
##
## Attaching package: 'caretEnsemble'
```

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

```
#install.packages('psych')
library(psych)
```

```
##
## Attaching package: 'psych'
```

```
## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha
```

```
#install.packages('Amelia')
library(Amelia)
```

```
## Loading required package: Rcpp
```

```
## ##
## ## Amelia II: Multiple Imputation
## ## (Version 1.7.6, built: 2019-11-24)
## ## Copyright (C) 2005-2021 James Honaker, Gary King and Matthew Blackwell
## ## Refer to http://gking.harvard.edu/amelia/ for more information
## ##
```

```
#install.packages('mice')
library(mice)
```

```
##
## Attaching package: 'mice'
```

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

```
## The following objects are masked from 'package:base':
##
##     cbind, rbind
```

```
#install.packages('GGally')
library(GGally)
```

```
## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2
```

```r
#install.packages('rpart')
library(rpart)
```

```r
# Loading our dataset
# ---
#
data<- read.csv("http://bit.ly/Diabetesdataset")
```

```r
# Looking at the structure of our data
# ---
#
str(data)
```

```
## 'data.frame':    768 obs. of  9 variables:
##  $ Pregnancies             : int  6 1 8 1 0 5 3 10 2 8 ...
##  $ Glucose                 : int  148 85 183 89 137 116 78 115 197 125 ...
##  $ BloodPressure           : int  72 66 64 66 40 74 50 0 70 96 ...
##  $ SkinThickness           : int  35 29 0 23 35 0 32 0 45 0 ...
##  $ Insulin                 : int  0 0 0 94 168 0 88 0 543 0 ...
##  $ BMI                     : num  33.6 26.6 23.3 28.1 43.1 25.6 31 35.3 30.5 0 ...
##  $ DiabetesPedigreeFunction: num  0.627 0.351 0.672 0.167 2.288 ...
##  $ Age                     : int  50 31 32 21 33 30 26 29 53 54 ...
##  $ Outcome                 : int  1 0 1 0 1 0 1 0 1 1 ...
```

```r
# Previewing our data
# ---
#
head(data)
```

```
##   Pregnancies Glucose BloodPressure SkinThickness Insulin  BMI
## 1           6     148            72            35       0 33.6
## 2           1      85            66            29       0 26.6
## 3           8     183            64             0       0 23.3
## 4           1      89            66            23      94 28.1
## 5           0     137            40            35     168 43.1
## 6           5     116            74             0       0 25.6
##   DiabetesPedigreeFunction Age Outcome
## 1                    0.627  50       1
## 2                    0.351  31       0
## 3                    0.672  32       1
## 4                    0.167  21       0
## 5                    2.288  33       1
## 6                    0.201  30       0
```

```r
# Understanding our dataset
# ---
#
describe(data)
```

```
##                           vars   n   mean     sd median trimmed   mad   min
## Pregnancies                  1 768   3.85   3.37   3.00    3.46  2.97  0.00
```

```
## Glucose                     2 768 120.89  31.97 117.00  119.38 29.65  0.00
## BloodPressure               3 768  69.11  19.36  72.00   71.36 11.86  0.00
## SkinThickness               4 768  20.54  15.95  23.00   19.94 17.79  0.00
## Insulin                     5 768  79.80 115.24  30.50   56.75 45.22  0.00
## BMI                         6 768  31.99   7.88  32.00   31.96  6.82  0.00
## DiabetesPedigreeFunction    7 768   0.47   0.33   0.37    0.42  0.25  0.08
## Age                         8 768  33.24  11.76  29.00   31.54 10.38 21.00
## Outcome                     9 768   0.35   0.48   0.00    0.31  0.00  0.00
##                              max  range  skew kurtosis   se
## Pregnancies                17.00  17.00  0.90     0.14 0.12
## Glucose                   199.00 199.00  0.17     0.62 1.15
## BloodPressure             122.00 122.00 -1.84     5.12 0.70
## SkinThickness              99.00  99.00  0.11    -0.53 0.58
## Insulin                   846.00 846.00  2.26     7.13 4.16
## BMI                        67.10  67.10 -0.43     3.24 0.28
## DiabetesPedigreeFunction   2.42   2.34  1.91     5.53 0.01
## Age                       81.00  60.00  1.13     0.62 0.42
## Outcome                    1.00   1.00  0.63    -1.60 0.02
```

```
# We convert the output variable into a categorical variable
# ---
#
data$Outcome <- factor(data$Outcome, levels = c(0,1), labels =
c("False", "True"))
```

```
# We then clean our dataset by setting zero values to NA's
# ---
#
data[, 2:7][data[, 2:7] == 0] <- NA
```

```
# We visualize our dataset by checking how many missing values
# ---
#
missmap(data)
```


```
# We can learn from the above dataset that there are many missing values
# thus removing them wouldn't be better options since we'd be leftith a smaller dataset.
# Thus we resort to performing imputations by using the mice package in R.
# ---
#
# We use mice package to predict missing values
mice_mod <- mice(data[,
c("Glucose","BloodPressure","SkinThickness","Insulin","BMI")],
method='rf')
```

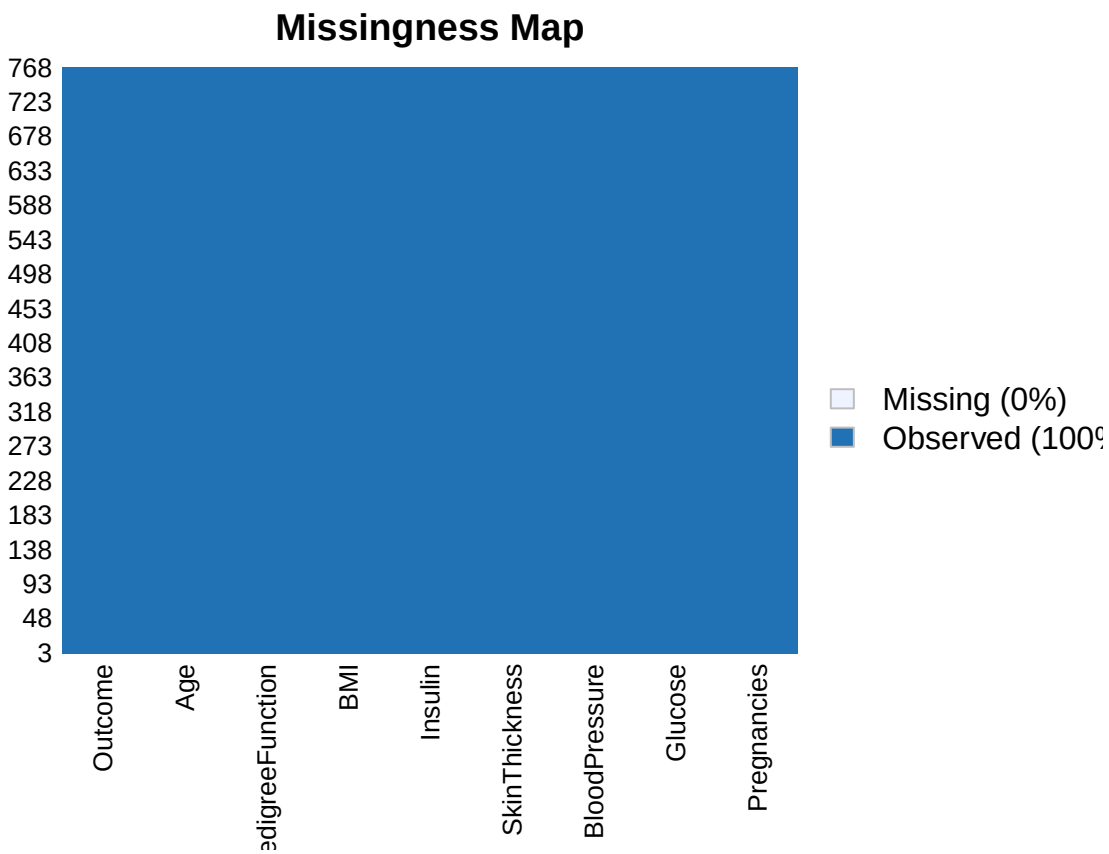
```
##
##  iter imp variable
##    1   1  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    1   2  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    1   3  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    1   4  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    1   5  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    2   1  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    2   2  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    2   3  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    2   4  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    2   5  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    3   1  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    3   2  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    3   3  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##    3   4  Glucose  BloodPressure  SkinThickness  Insulin  BMI
```

```
##   3   5  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   4   1  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   4   2  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   4   3  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   4   4  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   4   5  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   5   1  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   5   2  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   5   3  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   5   4  Glucose  BloodPressure  SkinThickness  Insulin  BMI
##   5   5  Glucose  BloodPressure  SkinThickness  Insulin  BMI
```

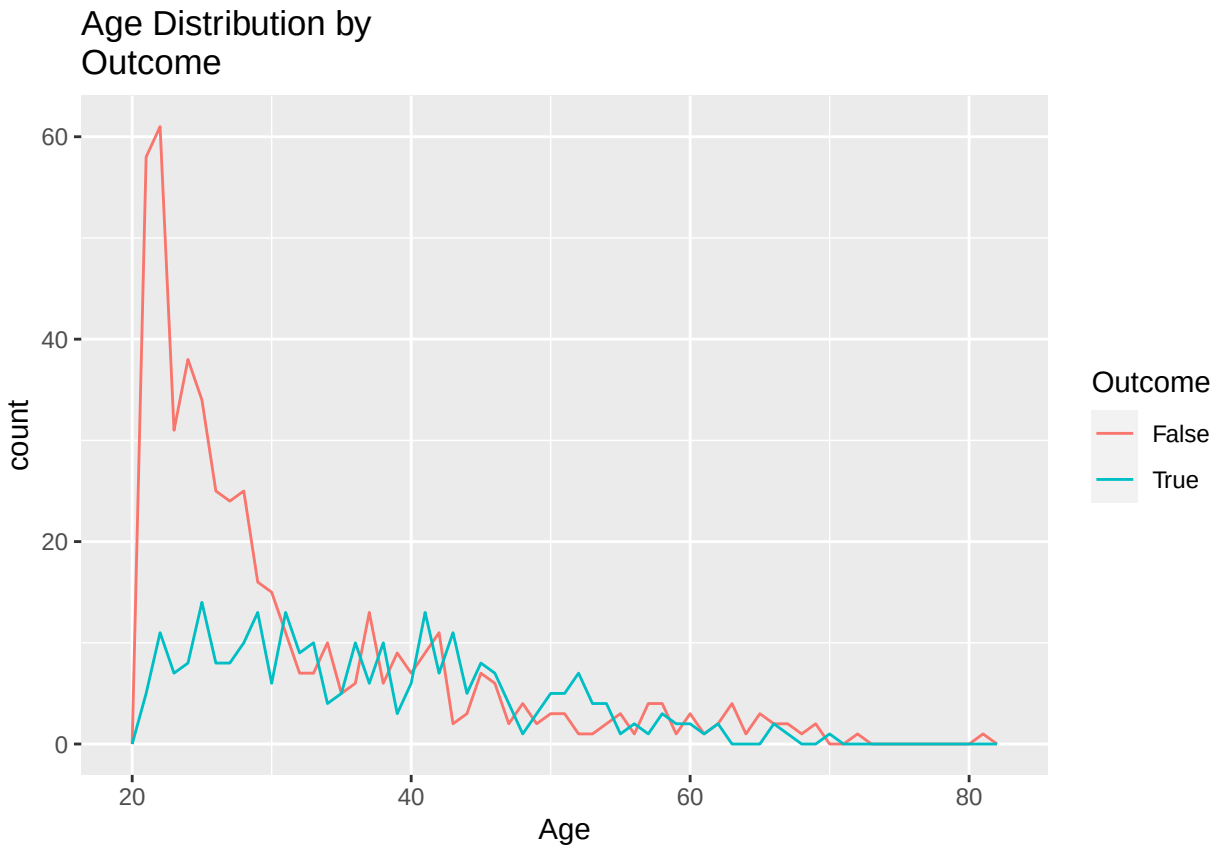
```
mice_complete <- complete(mice_mod)
```

```
# We ransfer the predicted missing values into the main data set
# ---
#
data$Glucose <- mice_complete$Glucose
data$BloodPressure <- mice_complete$BloodPressure
data$SkinThickness <- mice_complete$SkinThickness
data$Insulin<- mice_complete$Insulin
data$BMI <- mice_complete$BMI
```

```
# Now checking whether there are still many missing values
# ---
#
missmap(data)
```

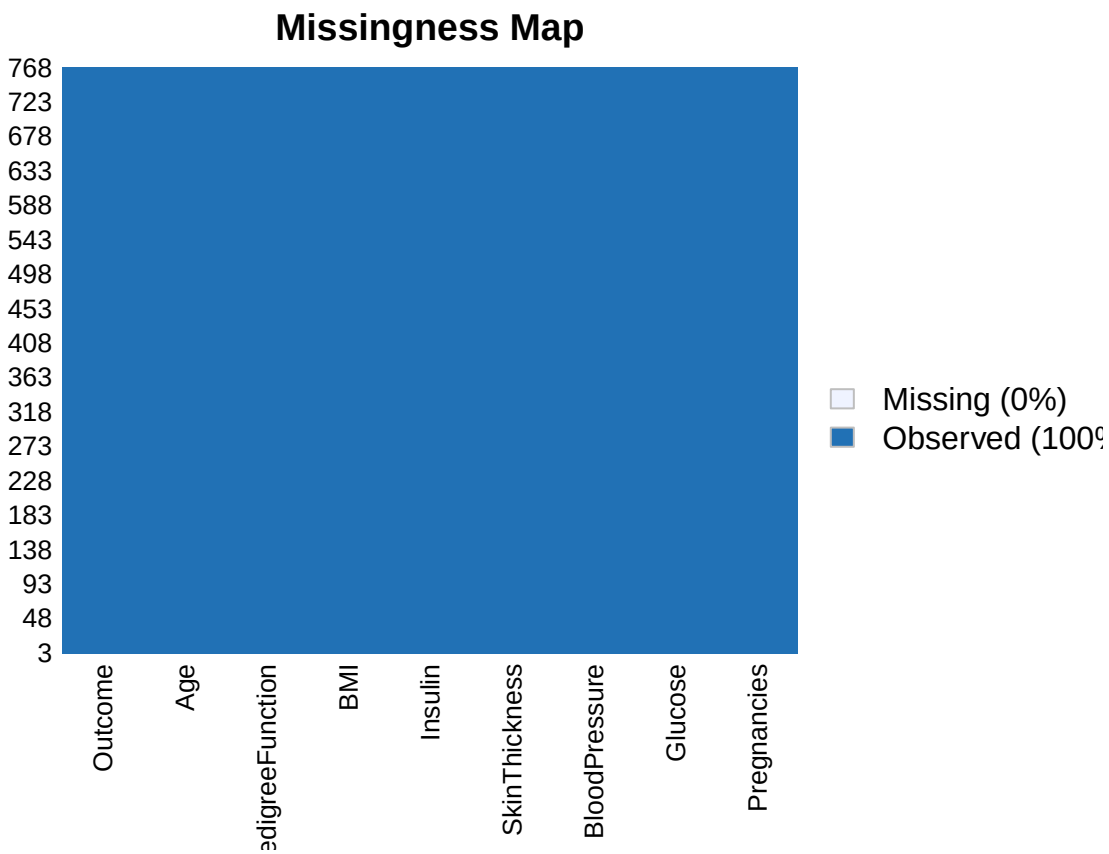



```
# Creating some visualisations to take a look at each variable
# ---
# Visualisation 1
#
ggplot(data, aes(Age, colour = Outcome)) +
geom_freqpoly(binwidth = 1) + labs(title="Age Distribution by
Outcome")
```

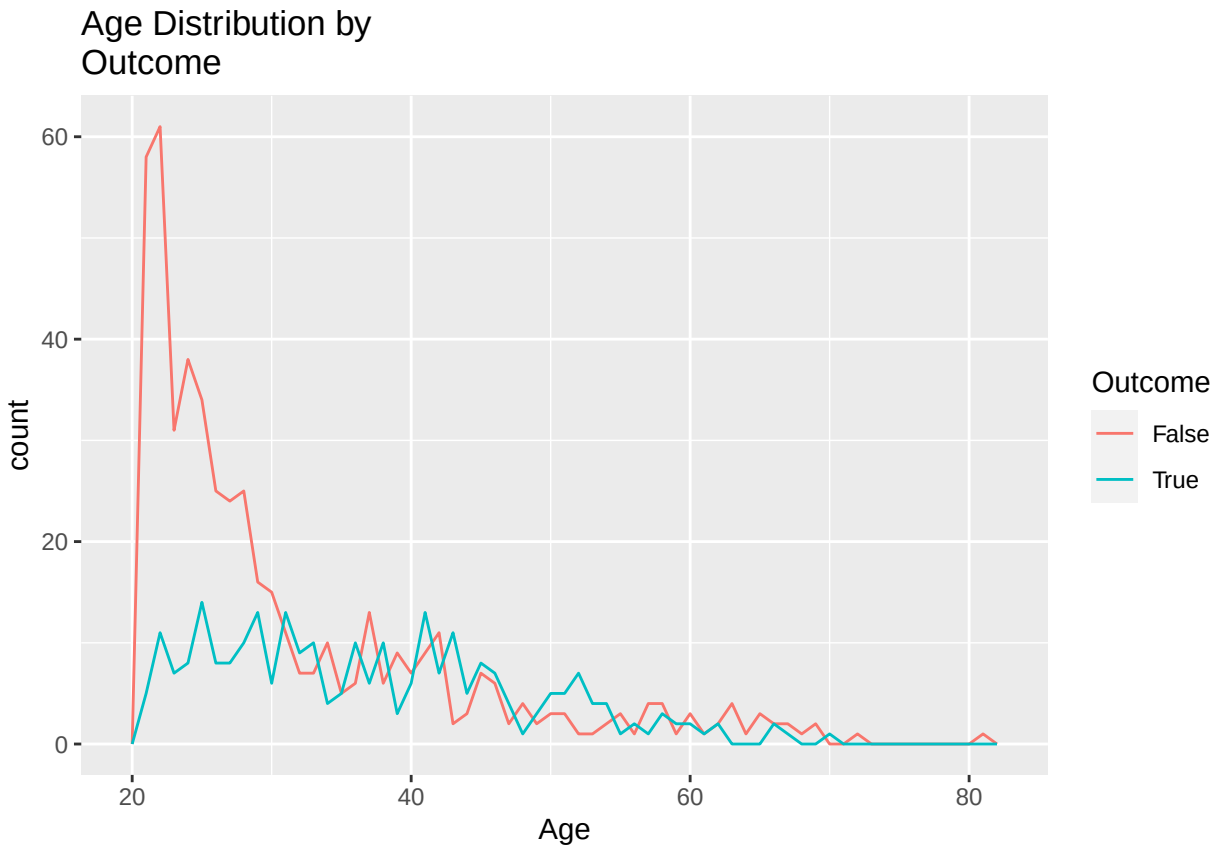



```
# We ransfer the predicted missing values into the main data set
# ---
#
data$Glucose <- mice_complete$Glucose
data$BloodPressure <- mice_complete$BloodPressure
data$SkinThickness <- mice_complete$SkinThickness
data$Insulin<- mice_complete$Insulin
data$BMI <- mice_complete$BMI
```

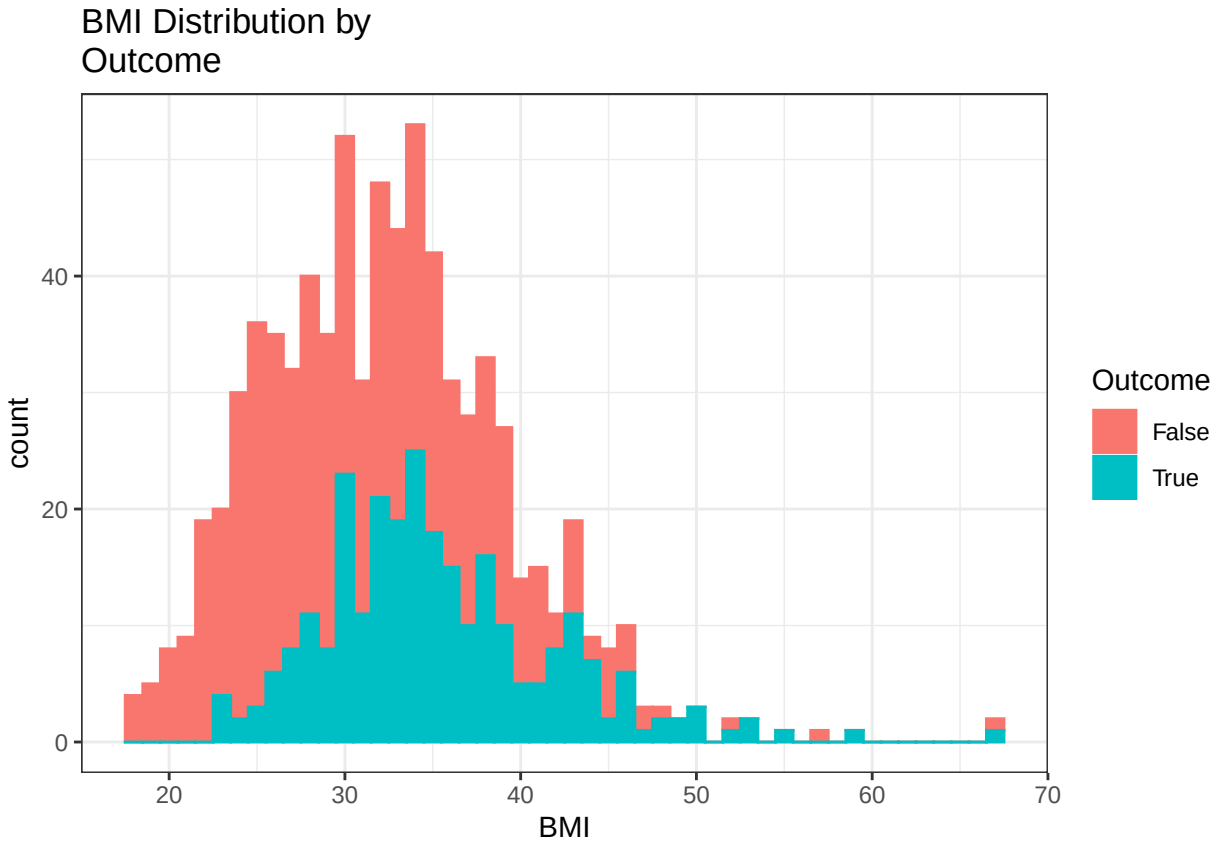
```
# Now checking whether there are still many missing values
# ---
#
missmap(data)
```



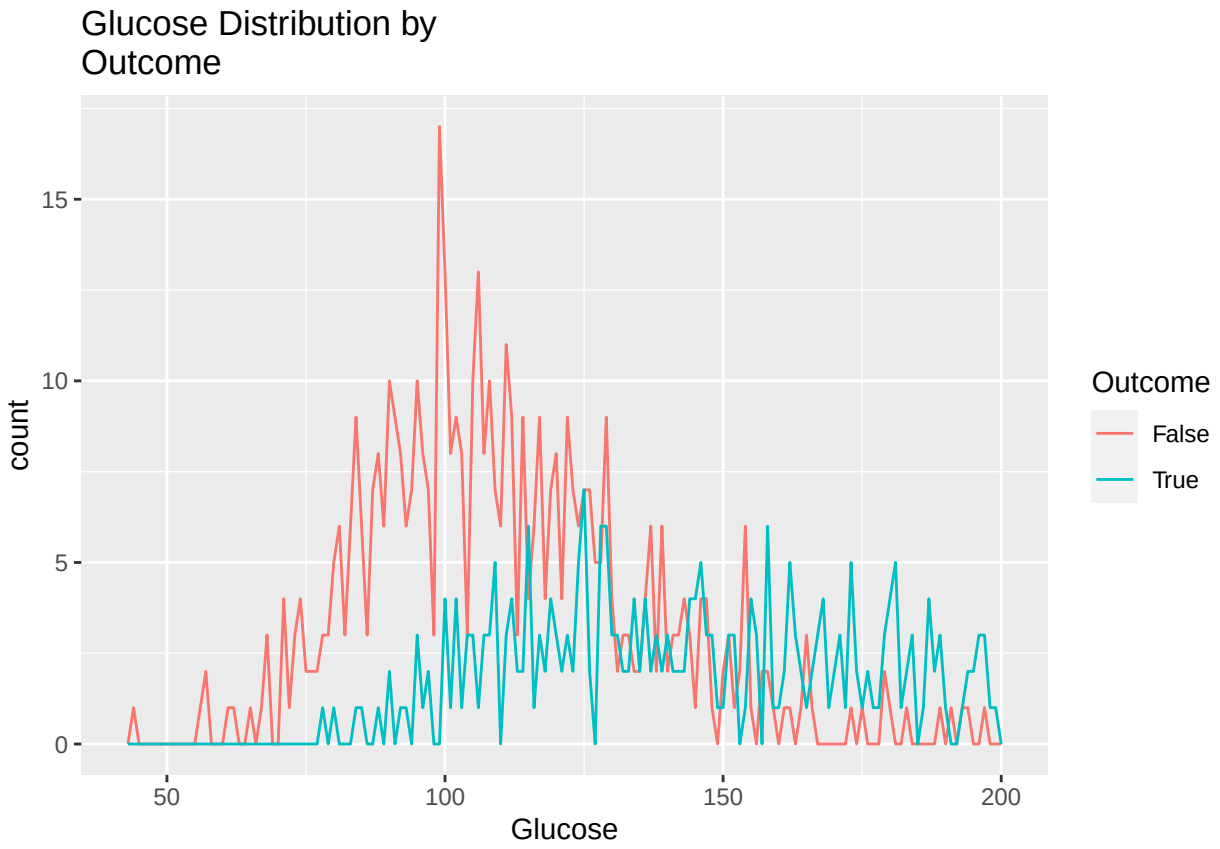

```
# Creating some visualisations to take a look at each variable
# ---
# Visualisation 1
#
ggplot(data, aes(Age, colour = Outcome)) +
geom_freqpoly(binwidth = 1) + labs(title="Age Distribution by
Outcome")
```




```
# Visualisation 3
# ---
#
P <- ggplot(data, aes(x=BMI, fill=Outcome, color=Outcome)) +
geom_histogram(binwidth = 1) + labs(title="BMI Distribution by
Outcome")
P + theme_bw()
```




```
# Visualisation 4
# ---
#
ggplot(data, aes(Glucose, colour = Outcome)) +
geom_freqpoly(binwidth = 1) + labs(title="Glucose Distribution by
Outcome")
```




```
# Visualisation 5
# ---
#
ggpairs(data)
```

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

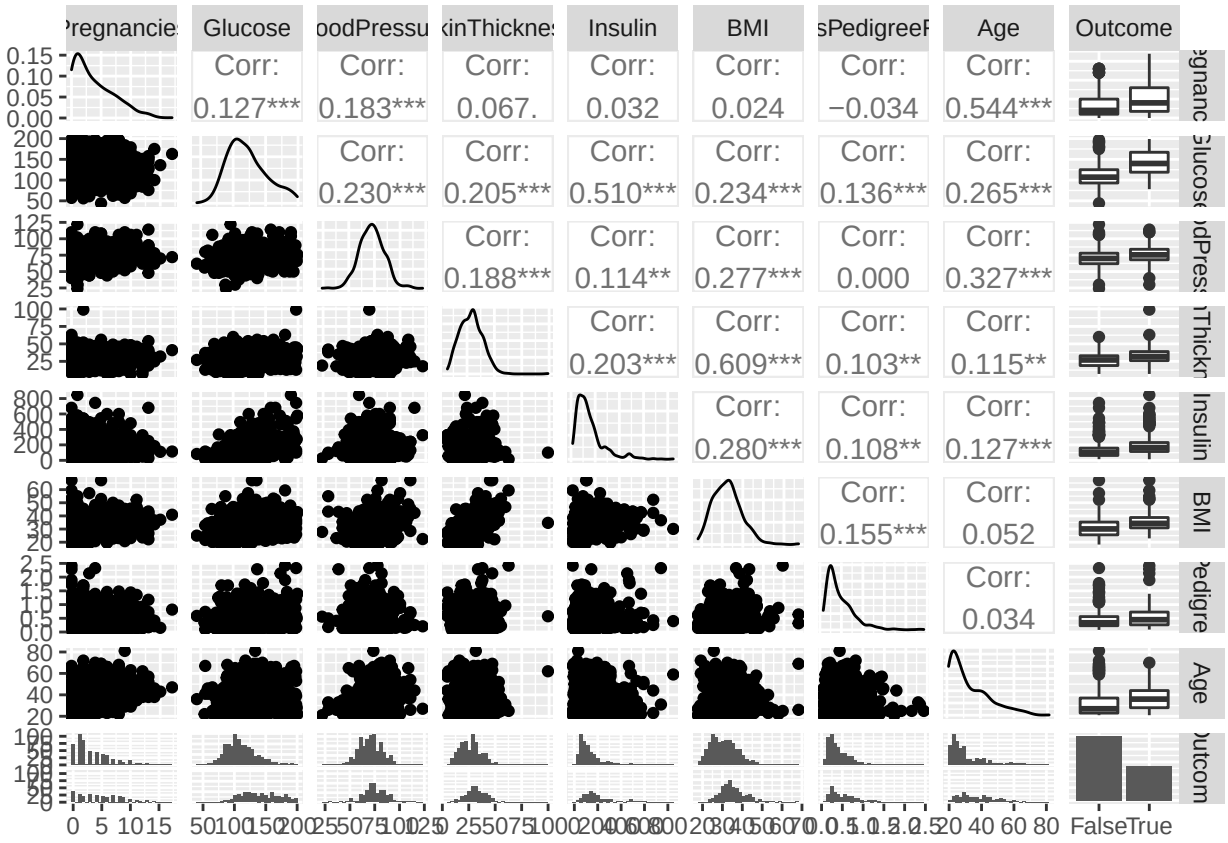


```
# Splitting data into training and test data sets
# ---
#
indxTrain <- createDataPartition(y = data$Outcome,p = 0.75,list =
FALSE)
training <- data[indxTrain,]
testing <- data[-indxTrain,]
```

```
# Checking dimensions of the split
# ---
#
prop.table(table(data$Outcome)) * 100
```

```
##
##    False     True
## 65.10417 34.89583
```

```
prop.table(table(training$Outcome)) * 100
```

```
##
##    False     True
## 65.10417 34.89583
```

```r
prop.table(table(testing$Outcome)) * 100
```

```
##
##    False     True
## 65.10417 34.89583
```

```r
# Comparing the outcome of the training and testing phase
# ---
# Creating objects x which holds the predictor variables and y which holds the response variables
# ---
#
x = training[,-9]
y = training$Outcome
```

```r
# Loading our inbuilt e1071 package that holds the Naive Bayes function.
# ---
#
library(e1071)
```

```r
# Now building our model
# ---
#
model = train(x,y,'nb',trControl=trainControl(method='cv',number=10))
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47

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## observation 48

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54

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## observation 57

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58

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## observation 1

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## observation 28

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## observation 14

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
# Model Evalution
# ---
# Predicting our testing set
#
Predict <- predict(model,newdata = testing )
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## observation 164
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 181
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
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## observation 190

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 191

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 192
```

```
# Getting the confusion matrix to see accuracy value and other parameter values
# ---
#
confusionMatrix(Predict, testing$Outcome )
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction False True
##      False   101   20
##      True     24   47
##
##                Accuracy : 0.7708
##                  95% CI : (0.7048, 0.8283)
##     No Information Rate : 0.651
##     P-Value [Acc > NIR] : 0.0002216
##
##                   Kappa : 0.5025
```

```
##
##  Mcnemar's Test P-Value : 0.6510766
##
##             Sensitivity : 0.8080
##             Specificity : 0.7015
##          Pos Pred Value : 0.8347
##          Neg Pred Value : 0.6620
##              Prevalence : 0.6510
##          Detection Rate : 0.5260
##    Detection Prevalence : 0.6302
##       Balanced Accuracy : 0.7547
##
##        'Positive' Class : False
##
```