MDA611 Assignment 2

2023-05-14

```
#Data Cleaning
#from the given A2customer csv file, CustID column was removed before importing as it can cause redunda

#imported data turned out to be as follows
df <- read.csv('A2Customer.csv')
head(df)
```

```
##       Sex SeniorCard Married HasChildren LengthOfPlan BundledPlan
## 1 Female          1      No          No           28         Yes
## 2   Male          0     Yes          No           12         Yes
## 3   Male          0      No          No            1         Yes
## 4 Female          0     Yes         Yes           30         Yes
## 5   Male          0      No          No           38         Yes
## 6 Female          0      No          No           14         Yes
##   MultipleLinesPlan InternetServicePlan OnlineSecurityEnabled
## 1               Yes          Fiber optic                    No
## 2                No          Fiber optic                   Yes
## 3                No          Fiber optic                    No
## 4               Yes                   No    No internet service
## 5               Yes          Fiber optic                   Yes
## 6                No                  DSL                   Yes
##   OnlineBackupEnabled DeviceProtectionEnabled   TechSupportEnabled
## 1                  No                     Yes                  Yes
## 2                 Yes                     Yes                   No
## 3                  No                      No                   No
## 4 No internet service     No internet service  No internet service
## 5                 Yes                      No                   No
## 6                  No                      No                  Yes
##       StreamingTVPlan StreamingMoviesPlan    ContractType ElectronicBilling
## 1                 Yes                 Yes Month-to-month               Yes
## 2                  No                  No Month-to-month               Yes
## 3                 Yes                  No Month-to-month               Yes
## 4 No internet service No internet service       Two year               Yes
## 5                 Yes                 Yes       One year               Yes
## 6                  No                  No       One year                No
##       PaymentType MonthlyFees TotalFees Switched
## 1 Electronic check      103.30   2890.65      Yes
## 2 Electronic check       84.60    959.90       No
## 3 Electronic check       79.95     79.95      Yes
## 4     Mailed check       25.10    789.55       No
## 5 Electronic check      104.85   3887.25       No
## 6     Mailed check       55.70    795.15       No
```

```r
#installing necessary packages
install.packages("caret",repos="http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/kv/q8v8kt9n5dg8h7tfdqqxl0v00000gn/T//RtmpYjoT3u/downloaded_packages
```

```r
install.packages("ggthemes",repos="http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/kv/q8v8kt9n5dg8h7tfdqqxl0v00000gn/T//RtmpYjoT3u/downloaded_packages
```

```r
install.packages("party",repos="http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/kv/q8v8kt9n5dg8h7tfdqqxl0v00000gn/T//RtmpYjoT3u/downloaded_packages
```

```r
install.packages("tidyverse",repos="http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/kv/q8v8kt9n5dg8h7tfdqqxl0v00000gn/T//RtmpYjoT3u/downloaded_packages
```

```r
install.packages("randomForest",repos="http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/kv/q8v8kt9n5dg8h7tfdqqxl0v00000gn/T//RtmpYjoT3u/downloaded_packages
```

```r
#importing libraries
library(plyr)
library(corrplot)
```

```
## corrplot 0.92 loaded
```

```r
library(ggplot2)
library(gridExtra)
library(ggthemes)
library(caret)
```

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

```r
library(MASS)
library(randomForest)
```

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

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


##
## Attaching package: 'randomForest'


## The following object is masked from 'package:gridExtra':
##
##      combine


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

```
library(party)
```

```
## Loading required package: grid


## Loading required package: mvtnorm


## Loading required package: modeltools


## Loading required package: stats4


##
## Attaching package: 'modeltools'


## The following object is masked from 'package:plyr':
##
##      empty


## Loading required package: strucchange


## Loading required package: zoo


##
## Attaching package: 'zoo'


## The following objects are masked from 'package:base':
##
##      as.Date, as.Date.numeric


## Loading required package: sandwich
```

```
str(df)
```
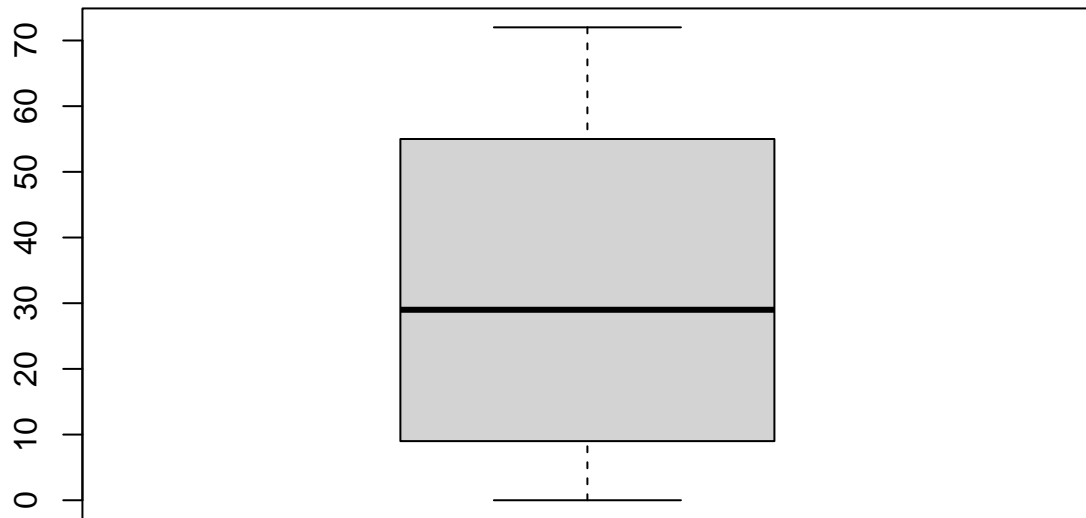
```
## 'data.frame':    7045 obs. of  20 variables:
##  $ Sex                   : chr  "Female" "Male" "Male" "Female" ...
##  $ SeniorCard            : int  1 0 0 0 0 0 1 0 0 0 ...
##  $ Married               : chr  "No" "Yes" "No" "Yes" ...
##  $ HasChildren           : chr  "No" "No" "No" "Yes" ...
##  $ LengthOfPlan          : int  28 12 1 30 38 14 65 68 13 47 ...
##  $ BundledPlan           : chr  "Yes" "Yes" "Yes" "Yes" ...
##  $ MultipleLinesPlan     : chr  "Yes" "No" "No" "Yes" ...
##  $ InternetServicePlan   : chr  "Fiber optic" "Fiber optic" "Fiber optic" "No" ...
##  $ OnlineSecurityEnabled : chr  "No" "Yes" "No" "No internet service" ...
##  $ OnlineBackupEnabled   : chr  "No" "Yes" "No" "No internet service" ...
##  $ DeviceProtectionEnabled: chr  "Yes" "Yes" "No" "No internet service" ...
##  $ TechSupportEnabled    : chr  "Yes" "No" "No" "No internet service" ...
##  $ StreamingTVPlan       : chr  "Yes" "No" "Yes" "No internet service" ...
##  $ StreamingMoviesPlan   : chr  "Yes" "No" "No" "No internet service" ...
##  $ ContractType          : chr  "Month-to-month" "Month-to-month" "Month-to-month" "Two year" ...
##  $ ElectronicBilling     : chr  "Yes" "Yes" "Yes" "Yes" ...
##  $ PaymentType           : chr  "Electronic check" "Electronic check" "Electronic check" "Mailed ch
##  $ MonthlyFees           : num  103.3 84.6 80 25.1 104.8 ...
##  $ TotalFees             : num  2891 960 80 790 3887 ...
##  $ Switched              : chr  "Yes" "No" "Yes" "No" ...
```
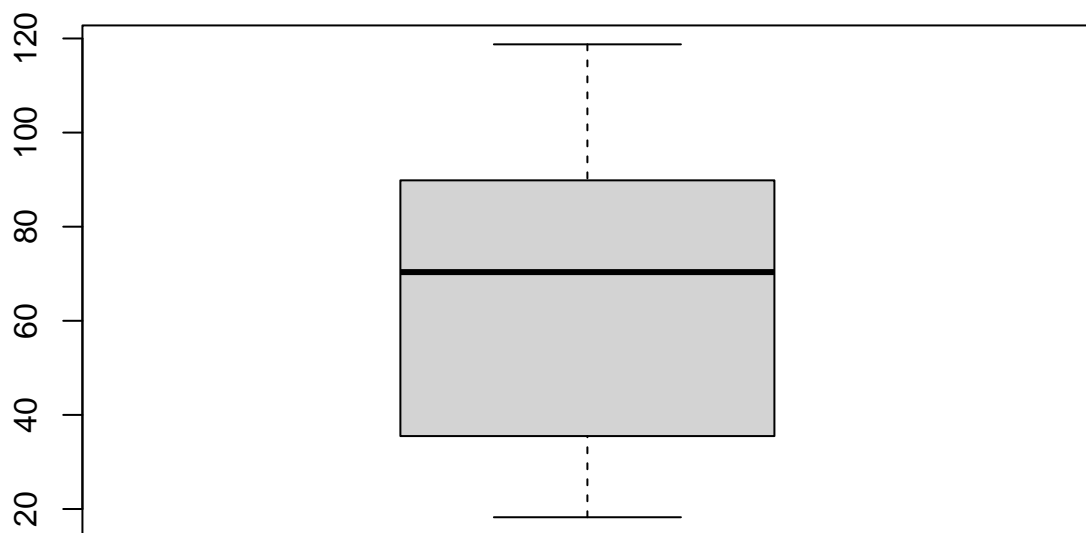
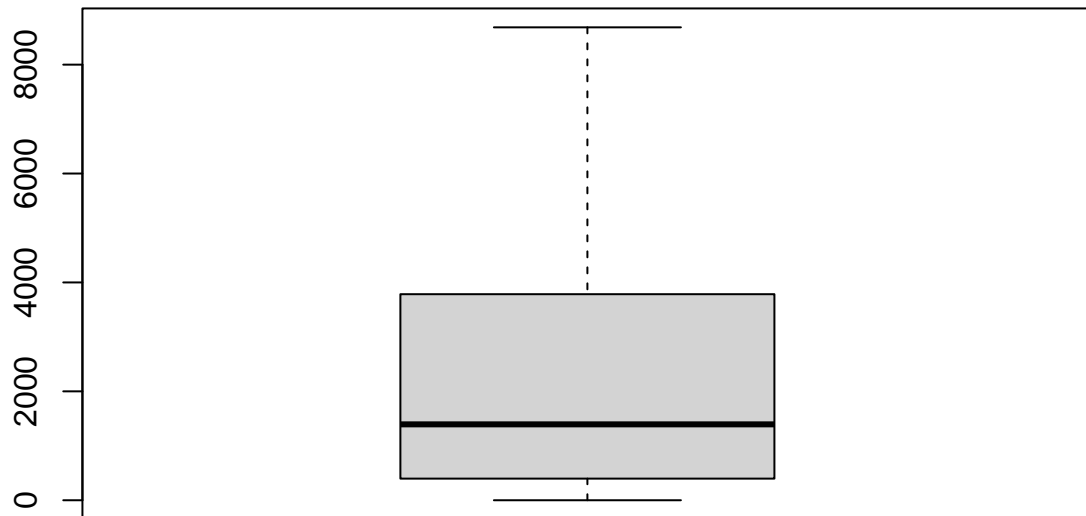```r
sum(is.na(df))
```

```
## [1] 0
```

```r
# Create a boxplot to check whether their exists any outliers in the dataset
boxplot(df$LengthOfPlan)
```

```
boxplot(df$MonthlyFees)
```
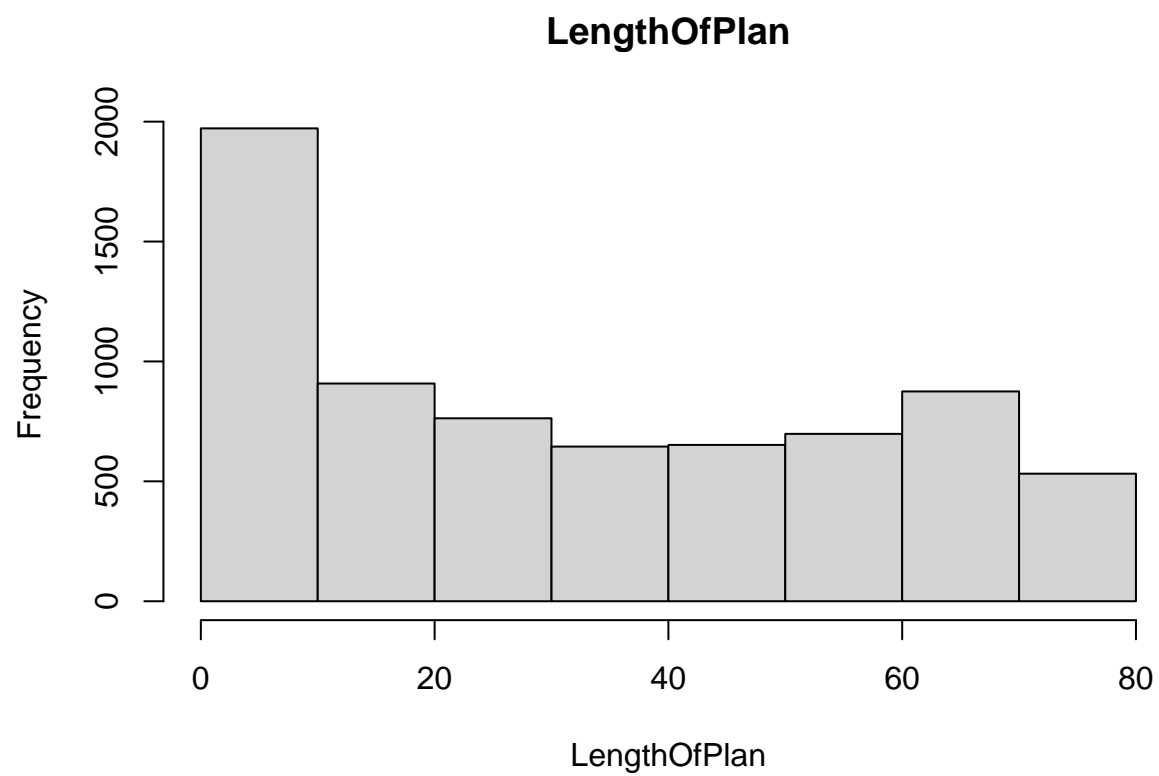
```
boxplot(df$TotalFees)
```

```r
# Visualize the distribution of numerical variables using histograms
hist(df$LengthOfPlan, breaks = 10, main = "LengthOfPlan", xlab = "LengthOfPlan")
```
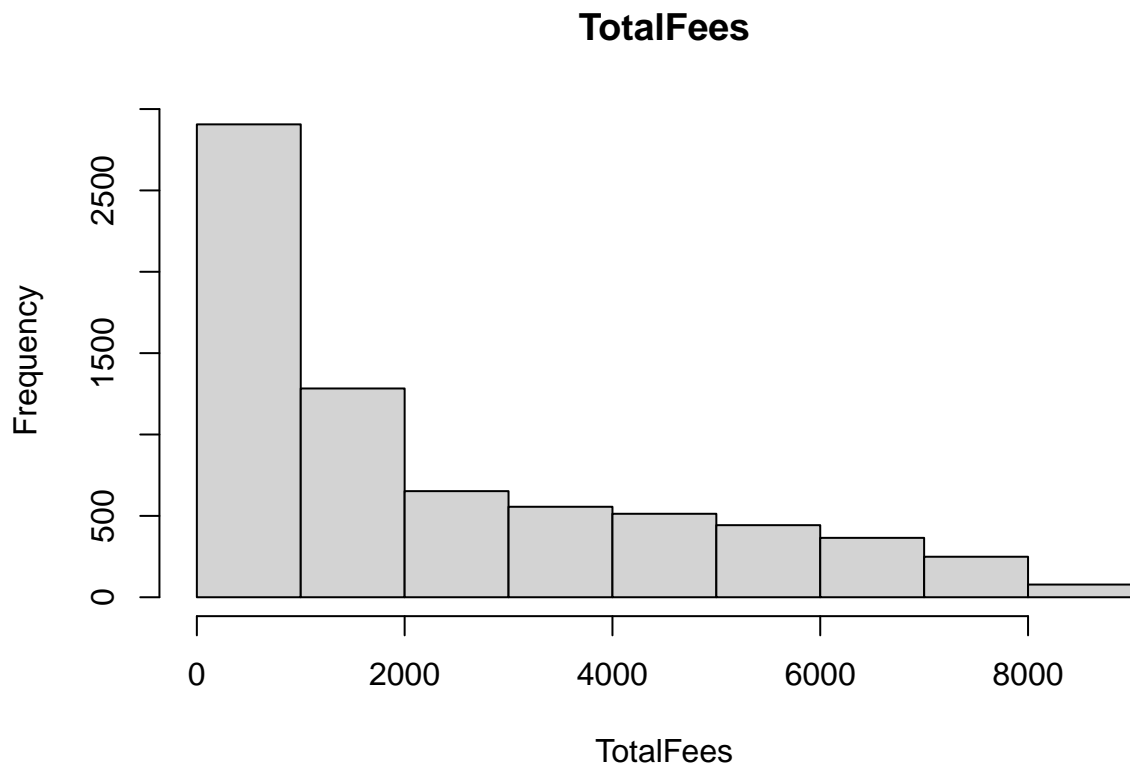
LengthOfPlan


```
hist(df$MonthlyFees, breaks = 10, main = "MonthlyFees", xlab = "MonthlyFees")
```

MonthlyFees


```
hist(df$TotalFees, breaks = 10, main = "TotalFees", xlab = "TotalFees")
```

TotalFees


```
#Following the Central Limit Theoreom, it can be assumed that numerical variables are normally distribu
#more than 7000 values

#no outliers detected from the boxplots

#after examining the dataset, we do chi-square test on 4 categorial variables to check if there is sign
#If their association is proved then we do cramerV test to check their correlation and decide on which

cont_table <- table(df$OnlineSecurityEnabled, df$OnlineBackupEnabled)
chi_square_result <- chisq.test(cont_table)
chi_square_value <- chi_square_result$statistic
p_value <- chi_square_result$p.value
n <- sum(chi_square_result$observed)
k <- min(dim(chi_square_result$observed))


cramers_v <- sqrt(chi_square_value/ (n * (k - 1)))


print(chi_square_result)
```

```
##
##  Pearson's Chi-squared test
##
## data:  cont_table
## X-squared = 7272.1, df = 4, p-value < 2.2e-16
```

```
print(p_value)
```

```
## [1] 0
```

```
print(cramers_v)
```

```
## X-squared
## 0.7184112
```

```
#Value of CramerV coeffient close to one suggests that the two variables are highly correlated.
#Thus keeping one of them is the best choice
```

```
cont_table1 <- table(df$OnlineSecurityEnabled, df$TechSupportEnabled)
chi_square_result1 <- chisq.test(cont_table1)
chi_square_value1 <- chi_square_result1$statistic
p_value1 <- chi_square_result1$p.value
n <- sum(chi_square_result1$observed)
k <- min(dim(chi_square_result1$observed))
cramers_v1 <- sqrt(chi_square_value1 / (n * (k - 1)))


print(chi_square_result1)
```

```
##
##  Pearson's Chi-squared test
##
## data:  cont_table1
## X-squared = 7571, df = 4, p-value < 2.2e-16
```

```
print(p_value1)
```

```
## [1] 0
```

```
print(cramers_v1)
```

```
## X-squared
## 0.7330272
```

```
#Value of CramerV coeffient close to one suggests that the two variables are highly correlated. Thus k
```

```
cont_table2 <- table(df$OnlineSecurityEnabled, df$DeviceProtectionEnabled)
chi_square_result2 <- chisq.test(cont_table2)
chi_square_value2 <- chi_square_result2$statistic
p_value2 <- chi_square_result2$p.value
n <- sum(chi_square_result2$observed)
k <- min(dim(chi_square_result2$observed))
cramers_v2 <- sqrt(chi_square_value2 / (n * (k - 1)))


print(chi_square_result2)
```

```
## 
##  Pearson's Chi-squared test
## 
## data:  cont_table2
## X-squared = 7249, df = 4, p-value < 2.2e-16
```

```
print(p_value2)
```

```
## [1] 0
```

```
print(cramers_v2)
```

```
## X-squared
## 0.7172696
```

```
#Value of CramerV coefficent close to one suggests that the two variables are highly correlated. Thus k
```

```
#columns OnlineSecurityEnabled, OnlineBackupEnabled, DeviceProtectionEnabled, TechSupportEnabled, Strea
cols_recode1 <- c(9:14)
for(i in 1:ncol(df[,cols_recode1])) {
        df[,cols_recode1][,i] <- as.factor(mapvalues
                                        (df[,cols_recode1][,i], from =c("No internet service"),to=
}
```

```
print(df[,11])
```

```
##     [1] Yes Yes No  No  No  No  Yes No  No  Yes Yes Yes Yes No  No  No  Yes No 
##    [19] No  Yes No  No  No  Yes No  Yes Yes No  Yes Yes Yes No  No  No  No  Yes
##    [37] No  Yes Yes No  Yes No  Yes No  No  No  Yes No  No  No  No  No  No  No 
##    [55] No  Yes No  No  No  No  No  No  No  Yes Yes No  No  Yes Yes No  No  Yes
##    [73] No  No  No  No  No  No  No  Yes No  No  Yes No  No  Yes No  Yes Yes No 
##    [91] No  No  Yes No  No  No  No  Yes Yes No  No  Yes No  Yes No  No  Yes Yes
##   [109] No  No  Yes Yes No  Yes No  Yes No  No  No  Yes No  No  Yes No  Yes No 
##   [127] No  No  No  No  Yes No  No  No  No  No  Yes No  No  No  No  Yes No  No 
##   [145] No  Yes Yes No  No  No  No  No  No  No  No  No  Yes Yes No  Yes Yes Yes
##   [163] No  Yes No  No  No  No  No  Yes No  Yes No  No  No  No  Yes No  Yes No 
##   [181] Yes No  Yes No  Yes No  Yes No  No  No  No  No  No  No  No  No  Yes No 
##   [199] No  No  No  No  No  No  Yes No  No  No  No  Yes No  Yes No  No  No  Yes
##   [217] Yes No  Yes No  No  No  Yes No  No  No  No  Yes No  No  Yes No  No  No 
##   [235] Yes No  Yes Yes Yes No  No  No  No  No  Yes No  No  Yes No  No  No  No 
##   [253] Yes Yes No  Yes No  No  No  No  No  No  No  No  No  Yes No  No  No  No 
##   [271] Yes No  No  No  Yes No  No  No  No  No  Yes No  No  Yes No  No  No  Yes
##   [289] No  No  No  No  Yes Yes No  No  No  No  Yes Yes Yes No  No  Yes No  No 
##   [307] Yes Yes No  No  No  No  No  Yes Yes No  No  No  Yes Yes Yes No  No  No 
##   [325] No  No  No  No  No  No  No  No  No  Yes Yes Yes No  Yes No  Yes No  Yes
##   [343] No  No  No  No  Yes Yes Yes No  Yes Yes No  Yes No  No  No  No  No  No 
##   [361] No  Yes No  Yes No  No  Yes No  No  Yes Yes No  Yes No  Yes No  No  No 
##   [379] No  No  Yes No  No  No  No  No  No  No  Yes Yes Yes Yes No  No  No  No 
##   [397] No  Yes No  Yes Yes Yes Yes Yes No  No  No  No  No  No  No  Yes Yes No 
##   [415] Yes Yes Yes Yes Yes Yes Yes Yes No  No  No  No  Yes Yes No  Yes Yes No 
##   [433] Yes Yes No  Yes No  No  No  Yes No  No  Yes No  Yes No  Yes Yes No  Yes
```

12

```
##  [451] Yes Yes No  No  No  No  No  No  No  No  No  No  No  Yes No  Yes No  Yes
##  [469] Yes No  Yes No  No  No  Yes Yes No  No  No  Yes No  No  Yes No  No  Yes
##  [487] No  Yes No  No  No  Yes No  No  No  No  No  No  Yes Yes No  Yes Yes Yes
##  [505] No  No  No  No  Yes Yes Yes No  Yes No  No  No  Yes Yes No  No  Yes No
##  [523] No  Yes Yes No  No  No  No  No  No  No  No  Yes Yes No  Yes No  No  No
##  [541] No  Yes Yes Yes No  No  Yes No  No  No  Yes No  No  No  Yes No  No  Yes
##  [559] Yes Yes No  Yes No  Yes No  No  No  No  No  No  Yes Yes Yes No  No  No
##  [577] No  Yes Yes No  No  No  Yes No  No  No  No  Yes Yes Yes Yes No  No  Yes
##  [595] Yes No  No  No  Yes No  No  No  No  No  No  No  No  Yes No  No  No  No
##  [613] No  No  No  Yes Yes No  No  No  No  No  No  No  No  Yes No  No  No  No
##  [631] No  No  No  Yes Yes No  Yes Yes No  No  No  Yes No  No  No  No  No  Yes
##  [649] No  No  Yes No  No  No  No  Yes No  Yes Yes No  Yes No  No  No  No  No
##  [667] No  Yes Yes No  No  No  Yes No  No  No  No  No  Yes No  No  Yes Yes No
##  [685] No  No  No  Yes No  Yes No  Yes Yes Yes No  No  No  Yes Yes No  Yes Yes
##  [703] Yes No  Yes No  No  No  No  Yes No  Yes Yes No  No  No  No  No  Yes No
##  [721] No  No  No  No  Yes No  No  Yes Yes Yes Yes Yes No  No  No  No  No  No
##  [739] No  Yes Yes No  Yes No  Yes No  No  Yes Yes Yes No  No  No  No  No  No
##  [757] Yes No  Yes No  Yes No  Yes No  No  No  No  No  No  Yes No  Yes No  Yes
##  [775] Yes No  Yes Yes Yes Yes No  Yes No  No  No  Yes No  No  No  No  Yes No
##  [793] Yes No  No  No  No  Yes No  Yes No  No  No  No  No  Yes No  No  No  Yes
##  [811] No  No  No  No  No  No  Yes No  No  No  No  No  No  No  Yes No  No  Yes
##  [829] No  No  Yes No  Yes Yes No  No  No  No  No  No  No  Yes No  Yes Yes No
##  [847] No  No  No  Yes No  Yes No  No  Yes No  Yes Yes No  No  Yes Yes No  Yes
##  [865] No  No  Yes No  No  No  No  Yes No  Yes Yes Yes Yes Yes Yes Yes No  Yes
##  [883] No  Yes No  Yes Yes No  Yes No  Yes Yes Yes No  Yes Yes No  No  Yes Yes
##  [901] No  No  Yes Yes No  Yes Yes No  No  No  No  No  Yes Yes No  Yes Yes No
##  [919] No  Yes No  No  No  No  No  Yes No  No  No  No  No  Yes No  No  Yes Yes
##  [937] No  Yes No  Yes No  Yes Yes No  No  No  No  Yes Yes Yes No  No  No  Yes
##  [955] No  Yes No  No  No  No  No  No  No  Yes Yes Yes Yes No  Yes No  No  No
##  [973] No  No  Yes No  No  No  No  No  No  No  No  Yes Yes Yes No  Yes No  No
##  [991] Yes No  No  Yes No  No  No  No  No  No  No  Yes No  Yes No  No  Yes No
## [1009] No  Yes Yes No  No  No  No  No  Yes No  No  No  No  No  No  No  No  Yes
## [1027] Yes Yes Yes No  No  No  No  No  No  No  Yes No  Yes No  No  No  No  Yes
## [1045] Yes No  Yes No  No  No  No  No  No  No  No  No  No  No  No  No  No  No
## [1063] No  Yes Yes No  No  No  No  No  No  No  No  No  No  Yes No  No  No  No
## [1081] No  No  No  Yes No  Yes Yes No  Yes No  No  Yes No  No  No  No  No  No
## [1099] No  No  No  No  No  Yes No  Yes Yes No  No  No  Yes No  No  No  No  Yes
## [1117] No  No  Yes Yes No  Yes No  No  No  No  Yes No  No  No  Yes No  Yes Yes
## [1135] Yes Yes Yes Yes No  No  No  Yes No  Yes Yes Yes No  No  No  No  No  No
## [1153] Yes Yes No  No  Yes Yes No  Yes Yes No  No  Yes No  Yes No  Yes No  No
## [1171] Yes No  No  No  No  No  Yes Yes No  No  No  No  No  Yes No  No  No  No
## [1189] Yes No  No  No  No  Yes No  No  No  Yes No  Yes No  No  No  No  Yes Yes
## [1207] No  Yes Yes No  No  Yes No  No  No  Yes No  No  No  No  Yes No  No  No
## [1225] Yes No  Yes No  No  No  Yes No  Yes No  Yes No  No  No  No  No  No  No
## [1243] Yes No  No  Yes No  Yes No  No  Yes No  No  No  No  No  No  No  No  No
## [1261] No  No  No  Yes Yes No  No  No  Yes No  No  No  No  Yes No  No  No  Yes
## [1279] No  No  Yes No  Yes No  Yes No  Yes Yes No  No  Yes No  No  No  Yes No
## [1297] No  No  No  No  Yes Yes Yes No  No  Yes Yes Yes Yes Yes No  No  Yes Yes
## [1315] No  No  No  No  Yes Yes No  No  Yes Yes No  No  Yes No  Yes No  Yes Yes
## [1333] No  Yes No  Yes Yes No  Yes Yes Yes No  No  No  No  No  No  No  Yes No
## [1351] No  No  Yes No  No  Yes No  No  No  Yes No  No  No  No  No  No  No  No
## [1369] Yes Yes Yes No  No  No  No  Yes No  No  No  No  No  No  No  No  Yes No
## [1387] No  Yes No  No  No  Yes Yes No  Yes Yes No  No  Yes Yes Yes No  No  Yes
## [1405] No  No  No  No  No  Yes No  Yes No  No  No  Yes No  Yes No  Yes Yes No
```

```
## [1423] No  No  No  No  No  No  No  No  No  Yes No  Yes No  No  No  No  No  No
## [1441] No  Yes No  No  No  Yes No  Yes No  Yes No  No  No  No  Yes No  Yes No
## [1459] No  No  Yes No  No  No  No  No  No  No  No  No  Yes Yes No  No  Yes Yes
## [1477] No  No  Yes Yes No  Yes Yes No  No  No  No  Yes Yes No  No  No  No  Yes
## [1495] Yes No  No  No  No  No  No  Yes No  No  Yes No  No  No  No  Yes No  Yes
## [1513] No  No  Yes No  No  No  No  No  No  Yes No  Yes No  Yes No  No  Yes Yes
## [1531] No  Yes No  No  Yes Yes No  No  No  Yes Yes Yes No  Yes Yes No  No  No
## [1549] No  Yes Yes No  No  No  No  No  No  No  No  No  No  Yes No  No  Yes No
## [1567] No  Yes No  Yes No  No  Yes Yes No  No  Yes No  No  Yes Yes No  Yes Yes
## [1585] No  Yes No  No  No  No  Yes No  No  No  No  No  No  No  No  Yes Yes No
## [1603] No  Yes No  No  Yes No  Yes Yes No  No  No  No  No  Yes No  No  No  No
## [1621] No  No  Yes No  No  Yes No  Yes No  No  No  No  No  No  No  No  No  No
## [1639] Yes Yes Yes No  No  No  Yes No  No  No  No  No  No  No  No  Yes Yes Yes
## [1657] No  Yes No  No  No  Yes Yes Yes No  Yes Yes No  Yes No  Yes No  No  No
## [1675] Yes No  No  No  Yes Yes Yes No  No  Yes No  No  No  No  No  No  Yes Yes
## [1693] No  No  No  No  No  Yes Yes Yes No  Yes No  No  Yes No  No  No  No  Yes
## [1711] No  No  No  Yes Yes Yes No  No  No  No  Yes No  Yes Yes No  No  No  Yes
## [1729] No  Yes No  Yes Yes No  No  No  Yes No  Yes No  No  No  Yes No  Yes Yes
## [1747] Yes Yes Yes No  No  No  No  Yes No  No  No  No  No  Yes Yes No  No  Yes
## [1765] No  Yes No  No  No  No  No  No  No  No  No  No  No  No  No  Yes No  No
## [1783] Yes No  No  Yes No  Yes No  No  Yes No  Yes No  No  Yes No  No  No  Yes
## [1801] No  No  No  No  No  No  No  Yes Yes Yes No  No  No  No  Yes No  Yes Yes
## [1819] No  Yes No  No  No  Yes No  No  No  Yes No  No  Yes Yes Yes No  No  No
## [1837] Yes Yes No  No  No  Yes No  No  No  No  Yes No  No  No  Yes No  Yes Yes
## [1855] No  No  Yes No  No  Yes Yes Yes Yes Yes No  No  No  No  Yes No  No  No
## [1873] Yes No  No  No  No  No  Yes Yes No  No  Yes No  No  No  No  No  No  No
## [1891] Yes No  No  No  Yes Yes No  No  No  No  No  No  No  Yes No  No  No  Yes
## [1909] No  No  Yes Yes No  No  Yes Yes No  No  No  No  No  No  Yes Yes No  No
## [1927] Yes No  No  No  No  Yes Yes No  No  No  No  Yes No  No  No  Yes No  No
## [1945] No  Yes Yes No  No  No  No  Yes No  No  Yes No  No  No  Yes No  No  No
## [1963] No  No  No  No  Yes Yes No  Yes Yes Yes No  No  No  No  No  Yes No  Yes
## [1981] No  Yes Yes Yes No  No  Yes No  No  No  Yes No  No  No  No  Yes No  No
## [1999] No  No  No  Yes No  No  No  No  No  Yes No  No  No  No  No  Yes No  Yes
## [2017] Yes Yes No  Yes No  No  Yes Yes Yes No  No  Yes No  No  No  Yes Yes No
## [2035] No  No  Yes No  No  No  Yes No  No  Yes No  Yes Yes No  No  Yes No  No
## [2053] Yes No  Yes No  Yes No  No  Yes No  No  Yes Yes Yes No  No  No  Yes Yes
## [2071] Yes No  No  No  Yes Yes No  No  Yes No  Yes No  No  No  Yes Yes Yes Yes
## [2089] No  No  Yes Yes Yes No  No  No  No  No  No  No  Yes Yes No  Yes No  No
## [2107] No  No  No  Yes Yes Yes No  No  No  No  No  Yes Yes Yes Yes Yes No  Yes
## [2125] No  No  Yes Yes No  Yes Yes Yes No  No  No  Yes Yes No  Yes No  No  No
## [2143] No  Yes No  No  No  No  Yes No  No  No  Yes No  No  No  Yes No  No  No
## [2161] Yes Yes No  No  No  No  No  Yes No  No  No  No  No  No  Yes No  No  Yes
## [2179] No  No  No  No  Yes Yes No  No  No  Yes No  No  Yes No  Yes Yes Yes No
## [2197] No  No  No  No  Yes No  No  No  No  No  No  Yes Yes Yes No  No  No  Yes
## [2215] No  No  Yes No  Yes Yes Yes Yes No  Yes Yes Yes No  No  No  No  No  No
## [2233] No  Yes Yes Yes No  No  Yes No  No  No  No  Yes No  Yes Yes No  Yes Yes
## [2251] Yes No  No  Yes Yes Yes No  No  Yes Yes Yes No  Yes Yes No  No  No  Yes
## [2269] No  No  No  No  Yes No  Yes No  No  No  Yes No  No  Yes No  No  Yes No
## [2287] No  No  No  Yes No  No  No  Yes Yes Yes No  No  No  Yes No  No  Yes No
## [2305] No  Yes No  No  No  Yes No  No  No  No  No  No  Yes Yes Yes No  Yes No
## [2323] No  No  No  No  Yes No  No  No  No  No  Yes No  Yes Yes No  No  No  No
## [2341] No  No  No  Yes No  Yes No  No  No  No  No  No  No  Yes No  Yes No  No
## [2359] No  No  No  No  Yes Yes No  No  Yes Yes Yes Yes No  Yes No  No  No  No
## [2377] Yes No  No  No  No  Yes No  No  Yes Yes Yes No  No  No  No  Yes No  No
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## [2395] No   No   No   No   No   No   No   No   No   Yes  No   Yes  No   No   Yes  No   No   No
## [2413] No   No   No   Yes  Yes  Yes  Yes  No   No   No   Yes  Yes  No   No   No   Yes  No   No
## [2431] No   No   Yes  Yes  No   Yes  No   No   No   Yes  No   Yes  No   Yes  Yes  No   No   No
## [2449] No   Yes  No   Yes  No   No   No   No   Yes  No   No   No   Yes  No   No   No   No   Yes
## [2467] Yes  No   No   No   No   No   Yes  No   Yes  No   Yes  No   Yes  No   No   No   No   No
## [2485] Yes  No   No   Yes  No   No   No   No   Yes  Yes  Yes  Yes  Yes  Yes  Yes  No   No   No
## [2503] Yes  Yes  Yes  Yes  Yes  No   Yes  Yes  No   No   No   No   No   Yes  Yes  No   No   Yes
## [2521] No   Yes  Yes  No   No   No   No   No   No   Yes  Yes  No   No   No   No   No   No   Yes
## [2539] No   Yes  Yes  No   No   No   No   No   Yes  No   No   Yes  Yes  Yes  No   No   Yes  No
## [2557] No   No   Yes  No   No   No   No   No   No   Yes  No   No   No   No   No   No   Yes  No
## [2575] No   Yes  Yes  Yes  No   No   No   No   Yes  No   No   No   No   No   No   Yes  Yes  Yes
## [2593] No   No   No   No   No   Yes  Yes  Yes  No   No   No   Yes  No   No   No   No   Yes  No
## [2611] No   No   Yes  No   No   No   Yes  Yes  No   No   Yes  No   No   No   Yes  No   Yes  No
## [2629] No   Yes  Yes  Yes  No   No   No   No   No   No   No   No   Yes  No   Yes  No   No   Yes
## [2647] Yes  No   Yes  No   No   No   No   No   Yes  No   Yes  No   Yes  Yes  No   Yes  Yes  Yes
## [2665] No   Yes  Yes  No   No   No   Yes  No   No   No   No   No   No   No   No   Yes  Yes  No
## [2683] Yes  No   No   No   No   Yes  No   No   No   No   Yes  No   Yes  No   No   Yes  No   Yes
## [2701] No   Yes  No   No   No   Yes  No   No   No   No   No   No   No   Yes  Yes  No   No   No
## [2719] No   No   No   No   No   No   No   No   No   No   No   No   Yes  No   Yes  Yes  Yes  Yes
## [2737] No   No   No   No   Yes  No   No   No   Yes  Yes  No   No   Yes  No   No   Yes  No   No
## [2755] Yes  No   No   No   Yes  No   No   No   No   Yes  Yes  No   No   No   No   Yes  No   Yes
## [2773] No   Yes  No   Yes  No   Yes  No   No   No   No   No   No   Yes  Yes  No   Yes  Yes  No
## [2791] No   No   Yes  Yes  No   No   Yes  No   No   No   No   Yes  No   No   Yes  No   No   No
## [2809] No   No   Yes  No   No   No   No   Yes  No   No   Yes  Yes  No   Yes  No   Yes  Yes  Yes
## [2827] Yes  No   Yes  No   No   Yes  No   No   Yes  No   No   No   Yes  No   No   Yes  Yes  Yes
## [2845] No   Yes  Yes  Yes  No   No   Yes  Yes  Yes  Yes  No   Yes  No   No   No   Yes  Yes  No
## [2863] Yes  No   Yes  Yes  No   Yes  Yes  No   Yes  Yes  No   No   No   No   No   Yes  No   No
## [2881] No   No   No   Yes  No   Yes  No   No   No   No   No   No   No   Yes  Yes  No   Yes  No
## [2899] No   Yes  No   Yes  No   No   No   Yes  No   No   Yes  Yes  No   Yes  Yes  Yes  Yes  No
## [2917] No   Yes  No   No   No   Yes  No   Yes  No   Yes  No   No   No   No   No   Yes  Yes  No
## [2935] Yes  No   No   Yes  No   No   No   No   No   No   No   No   No   Yes  No   No   Yes  Yes
## [2953] No   No   No   No   No   No   No   No   No   No   No   No   No   No   Yes  Yes  No   Yes
## [2971] Yes  Yes  Yes  No   Yes  No   No   Yes  No   Yes  No   Yes  Yes  No   No   No   No   No
## [2989] Yes  No   No   Yes  Yes  No   No   No   Yes  Yes  No   Yes  Yes  No   Yes  No   No   No
## [3007] No   No   No   No   No   No   No   No   Yes  No   Yes  No   Yes  No   Yes  No   Yes  Yes
## [3025] No   Yes  No   No   Yes  Yes  No   No   No   No   Yes  No   No   No   Yes  No   No   No
## [3043] No   Yes  No   Yes  No   No   No   No   No   Yes  No   No   No   No   No   No   Yes  Yes
## [3061] Yes  No   No   Yes  No   No   No   No   No   No   No   No   No   Yes  Yes  No   No   Yes
## [3079] Yes  Yes  No   No   No   Yes  No   No   No   No   Yes  No   No   No   No   No   No   Yes
## [3097] No   No   Yes  No   No   No   Yes  Yes  No   Yes  No   No   Yes  No   No   No   Yes  Yes
## [3115] Yes  No   No   Yes  No   No   No   No   No   No   Yes  No   No   No   Yes  No   Yes  No
## [3133] Yes  Yes  No   Yes  No   No   No   No   No   Yes  Yes  No   No   No   Yes  Yes  Yes  Yes
## [3151] No   No   No   Yes  No   No   No   No   Yes  No   No   Yes  Yes  No   No   No   No   No
## [3169] No   No   No   No   No   Yes  No   No   No   No   No   No   Yes  Yes  No   No   No   No
## [3187] No   Yes  No   No   No   No   Yes  No   No   No   Yes  No   Yes  No   Yes  Yes  No   No
## [3205] Yes  Yes  No   No   No   No   No   Yes  Yes  Yes  Yes  No   Yes  No   No   No   Yes  Yes
## [3223] No   Yes  No   No   Yes  Yes  No   No   No   No   No   No   No   No   Yes  No   No   No
## [3241] No   No   No   Yes  Yes  No   No   No   No   No   Yes  Yes  Yes  No   No   No   No   No
## [3259] No   No   No   Yes  No   Yes  Yes  No   Yes  Yes  No   No   Yes  No   No   Yes  No   No
## [3277] No   No   No   No   Yes  No   Yes  No   No   No   Yes  Yes  No   No   No   No   No   No
## [3295] No   No   No   No   No   Yes  No   Yes  Yes  Yes  Yes  Yes  Yes  Yes  No   No   No   Yes
## [3313] Yes  No   Yes  No   No   Yes  Yes  Yes  No   Yes  No   Yes  No   Yes  Yes  Yes  No   No
## [3331] No   No   No   Yes  No   Yes  Yes  No   Yes  No   Yes  No   No   Yes  No   Yes  No   No
## [3349] Yes  No   Yes  Yes  No   No   Yes  Yes  No   No   Yes  Yes  No   No   No   No   No   Yes
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## [3367] No  No  No  Yes No  No  No  No  No  Yes No  Yes Yes Yes Yes Yes No  No
## [3385] No  No  No  No  No  No  Yes No  Yes No  Yes No  No  No  No  No  No  No
## [3403] No  No  Yes No  No  No  Yes No  No  No  Yes Yes No  No  Yes Yes Yes No
## [3421] Yes Yes Yes Yes No  No  No  No  No  Yes No  No  No  No  No  No  Yes Yes
## [3439] No  Yes Yes Yes No  Yes No  No  Yes No  No  No  No  No  Yes No  No  No
## [3457] Yes Yes No  Yes Yes Yes No  No  No  No  No  Yes No  No  Yes No  Yes No
## [3475] No  No  Yes No  No  Yes No  No  No  Yes No  No  No  Yes No  No  No  Yes
## [3493] No  Yes Yes No  No  No  No  No  No  No  Yes No  No  Yes No  No  Yes No
## [3511] Yes No  No  No  No  No  Yes Yes Yes No  No  Yes Yes No  Yes No  No  No
## [3529] No  No  No  No  No  No  No  Yes No  Yes No  No  No  No  Yes Yes No  Yes
## [3547] No  No  No  No  Yes No  Yes Yes Yes Yes No  Yes No  No  Yes No  Yes No
## [3565] Yes No  No  Yes No  No  No  No  Yes No  No  No  No  No  No  No  No  No
## [3583] No  No  No  No  No  Yes No  Yes Yes Yes No  No  No  No  No  No  No  Yes
## [3601] No  No  Yes No  Yes No  No  No  Yes No  No  Yes No  Yes No  No  No  Yes
## [3619] Yes No  Yes Yes No  No  No  No  Yes No  Yes No  No  Yes No  Yes Yes No
## [3637] No  Yes Yes Yes No  No  No  Yes No  Yes No  Yes No  No  No  No  No  No
## [3655] No  No  Yes No  No  Yes No  Yes No  No  Yes No  No  Yes No  No  No  No
## [3673] No  No  No  No  No  No  Yes Yes No  No  No  No  No  No  Yes No  No  No
## [3691] Yes No  No  Yes No  No  No  No  No  Yes No  No  No  Yes No  No  Yes Yes
## [3709] No  Yes Yes No  Yes No  Yes Yes Yes No  No  No  No  Yes Yes No  Yes No
## [3727] No  No  No  No  No  Yes No  Yes Yes No  No  No  Yes Yes Yes Yes Yes No
## [3745] No  Yes No  No  Yes Yes Yes Yes No  Yes No  No  Yes No  No  Yes No  Yes
## [3763] No  Yes No  Yes No  No  No  No  No  No  No  Yes No  Yes No  No  No  No
## [3781] No  No  No  No  Yes No  No  No  No  Yes No  No  Yes No  No  No  No  Yes
## [3799] No  No  No  Yes Yes No  No  Yes No  Yes No  Yes No  Yes No  No  No  No
## [3817] No  No  No  No  Yes No  Yes No  Yes No  No  Yes No  No  No  Yes No  No
## [3835] No  No  Yes No  No  No  Yes Yes No  No  No  Yes No  No  No  No  Yes Yes
## [3853] Yes Yes No  No  No  Yes Yes Yes Yes No  No  Yes No  Yes No  Yes Yes Yes
## [3871] No  No  Yes No  Yes No  Yes Yes No  No  No  Yes Yes No  Yes Yes No  No
## [3889] No  Yes Yes No  No  No  No  No  No  No  No  No  No  No  Yes No  No  No
## [3907] Yes No  Yes No  Yes No  No  No  No  No  No  No  Yes No  No  No  No  Yes
## [3925] No  No  No  No  No  No  No  Yes No  Yes No  Yes Yes Yes No  Yes No  Yes
## [3943] Yes No  No  No  No  No  No  Yes No  Yes No  No  No  No  No  Yes Yes
## [3961] No  No  No  Yes No  No  Yes No  Yes No  No  No  No  Yes No  No  No  No
## [3979] Yes No  Yes Yes Yes No  No  Yes No  No  No  No  Yes Yes Yes Yes No  Yes
## [3997] No  No  No  Yes No  Yes No  Yes No  Yes Yes Yes No  No  No  No  No  No
## [4015] Yes No  No  No  No  No  Yes No  No  No  Yes No  Yes No  No  No  Yes Yes
## [4033] No  Yes No  No  Yes No  No  No  No  Yes Yes No  No  Yes No  No  No  No
## [4051] Yes Yes Yes Yes Yes Yes No  No  No  No  No  Yes No  No  No  No  No  No
## [4069] No  No  Yes No  No  Yes No  No  Yes Yes No  No  No  No  Yes No  No  Yes
## [4087] Yes Yes Yes No  No  No  Yes No  No  No  No  Yes No  No  No  No  No  Yes
## [4105] No  No  No  Yes Yes No  Yes No  No  No  No  No  Yes Yes No  Yes Yes Yes
## [4123] No  No  Yes No  No  No  Yes Yes No  No  No  No  Yes No  No  No  No  No
## [4141] No  No  No  No  No  No  Yes Yes Yes No  No  Yes Yes No  No  Yes Yes No
## [4159] Yes Yes No  No  No  No  Yes Yes No  Yes Yes No  No  Yes No  Yes No  No
## [4177] No  Yes No  Yes Yes No  No  No  No  No  No  No  No  Yes No  Yes No  No
## [4195] No  No  Yes No  No  Yes Yes No  Yes No  No  No  No  No  No  No  No  Yes
## [4213] No  Yes No  No  No  Yes Yes No  Yes Yes No  No  Yes Yes Yes No  No  No
## [4231] No  No  Yes No  Yes No  No  Yes Yes No  Yes Yes No  No  No  No  No  No
## [4249] No  No  No  Yes No  No  No  Yes Yes Yes No  Yes No  Yes No  No  No  No
## [4267] No  No  No  Yes Yes No  Yes Yes Yes No  No  No  No  Yes No  Yes Yes Yes
## [4285] Yes No  No  Yes No  Yes No  No  No  Yes No  No  No  Yes No  No  No  Yes
## [4303] No  Yes Yes No  No  No  No  Yes Yes No  Yes Yes Yes Yes Yes No  No  No
## [4321] No  No  No  Yes Yes Yes Yes No  No  Yes Yes No  No  Yes No  No  No  No
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## [4339] No  Yes No  No  Yes No  No  No  Yes Yes Yes No  Yes Yes Yes No  No  Yes
## [4357] Yes No  Yes Yes No  Yes No  Yes No  No  Yes No  Yes Yes No  Yes Yes No
## [4375] No  No  No  Yes No  Yes No  No  No  Yes No  No  Yes No  Yes No  No  No
## [4393] No  Yes No  No  Yes No  No  Yes No  No  No  No  No  Yes No  No  No  No
## [4411] No  No  Yes Yes Yes No  Yes Yes Yes No  No  No  Yes No  Yes No  No  Yes
## [4429] No  No  No  No  No  No  No  No  No  No  Yes Yes No  Yes No  No  No  Yes
## [4447] No  No  Yes Yes No  Yes No  No  No  No  No  Yes Yes Yes No  Yes Yes No
## [4465] No  Yes No  Yes No  No  No  Yes Yes Yes Yes No  No  No  Yes No  No  No
## [4483] No  No  No  No  Yes Yes No  Yes No  Yes Yes Yes Yes No  No  No  Yes No
## [4501] Yes Yes No  No  No  Yes Yes No  Yes No  No  No  No  No  No  Yes Yes No
## [4519] No  No  Yes Yes Yes Yes Yes No  No  No  No  No  Yes Yes No  Yes Yes No
## [4537] Yes No  No  Yes No  No  Yes No  Yes Yes No  Yes Yes No  No  Yes No  No
## [4555] No  No  Yes Yes Yes No  No  No  Yes No  No  No  Yes No  Yes Yes No  No
## [4573] No  Yes No  No  No  No  No  No  Yes No  No  Yes Yes No  No  No  No  No
## [4591] Yes No  No  No  Yes No  No  Yes No  No  No  Yes No  No  No  No  No  No
## [4609] No  Yes No  No  Yes No  Yes Yes Yes No  Yes No  No  Yes Yes Yes No  Yes
## [4627] No  No  No  No  Yes Yes No  Yes No  No  No  No  Yes No  No  No  No  No
## [4645] No  Yes Yes Yes No  No  No  No  Yes No  No  Yes No  No  No  No  No  No
## [4663] No  Yes Yes No  No  No  No  Yes No  No  No  No  No  No  Yes No  No  Yes
## [4681] No  Yes Yes Yes No  No  No  No  No  No  No  No  Yes No  Yes Yes No  Yes
## [4699] Yes Yes No  No  Yes Yes No  Yes Yes No  No  No  No  No  No  Yes No  Yes
## [4717] Yes No  No  Yes Yes No  No  Yes No  No  Yes No  Yes No  Yes Yes Yes No
## [4735] No  No  No  Yes No  No  Yes No  Yes Yes No  Yes Yes No  No  Yes Yes No
## [4753] No  Yes No  No  No  No  Yes No  Yes No  No  No  Yes No  No  No  Yes No
## [4771] Yes No  Yes No  Yes No  No  No  No  No  No  Yes No  Yes No  No  Yes No
## [4789] No  Yes Yes No  Yes No  No  Yes Yes No  No  No  Yes No  No  Yes No  No
## [4807] No  No  No  Yes No  Yes No  No  Yes No  No  Yes No  No  No  No  No  No
## [4825] No  No  No  Yes Yes No  No  Yes No  No  Yes Yes No  No  No  No  No  No
## [4843] No  Yes Yes Yes Yes No  Yes No  No  No  Yes Yes No  No  No  No  No  Yes
## [4861] Yes No  Yes No  No  No  Yes No  Yes No  No  No  No  Yes No  No  No  No
## [4879] No  No  No  No  Yes Yes No  Yes Yes Yes No  No  Yes No  No  No  No  No
## [4897] No  Yes Yes No  No  Yes Yes Yes No  No  No  No  No  No  Yes Yes No  No
## [4915] Yes Yes No  No  Yes No  Yes No  Yes Yes No  No  No  No  No  No  Yes Yes
## [4933] No  No  No  No  Yes No  No  Yes Yes Yes No  No  No  No  No  Yes No  Yes
## [4951] No  No  No  No  No  No  Yes No  Yes No  No  No  No  No  Yes No  Yes Yes
## [4969] No  No  No  Yes No  No  No  No  No  No  Yes No  No  No  No  Yes No  No
## [4987] Yes Yes No  No  No  No  No  No  No  Yes No  No  No  No  No  Yes No  No
## [5005] No  No  No  Yes No  Yes No  Yes Yes No  No  Yes Yes Yes No  Yes No  Yes
## [5023] No  Yes Yes Yes No  No  Yes No  Yes No  No  No  No  No  Yes Yes No  No
## [5041] Yes No  No  Yes Yes No  No  No  No  Yes No  No  No  No  Yes No  Yes
## [5059] No  No  No  Yes Yes Yes No  No  No  No  No  No  No  No  No  No  No
## [5077] Yes Yes No  Yes Yes Yes Yes Yes No  No  Yes No  No  No  No  Yes No  Yes
## [5095] Yes No  No  No  Yes No  Yes Yes Yes No  No  Yes Yes No  Yes No  No  Yes
## [5113] Yes No  Yes No  No  No  No  No  Yes No  No  No  No  No  No  No  No  Yes
## [5131] No  No  Yes No  No  No  No  Yes Yes Yes No  No  No  No  Yes No  Yes No
## [5149] No  No  Yes No  No  Yes No  Yes No  No  No  No  No  Yes No  No  No  Yes
## [5167] No  No  No  No  Yes No  No  Yes Yes Yes Yes No  No  Yes No  No  Yes Yes
## [5185] No  No  No  No  Yes No  No  No  No  Yes No  No  No  No  No  No  No  No
## [5203] No  No  Yes No  No  No  No  No  Yes Yes No  Yes No  Yes No  Yes No  No
## [5221] No  No  No  No  No  No  No  No  No  Yes Yes No  No  No  Yes Yes Yes
## [5239] No  Yes No  No  No  No  Yes No  No  No  Yes No  No  No  Yes No  Yes Yes
## [5257] Yes No  Yes No  No  No  No  Yes No  No  No  No  No  Yes No  No  Yes No
## [5275] No  No  Yes Yes No  Yes No  No  No  Yes Yes No  No  Yes No  No  No  No
## [5293] Yes Yes No  No  No  No  No  No  No  Yes No  No  Yes Yes No  No  Yes No
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## [5311] No  Yes Yes Yes Yes No  Yes Yes No  No  No  Yes No  No  No  No  Yes Yes
## [5329] No  No  No  No  No  No  Yes No  No  Yes Yes No  Yes No  No  Yes No  Yes
## [5347] No  Yes No  No  No  No  No  No  No  No  Yes Yes Yes No  No  No  No  No
## [5365] No  No  No  Yes Yes No  No  No  No  Yes No  No  Yes No  No  No  No  No
## [5383] Yes No  No  Yes No  No  No  No  No  Yes No  Yes Yes No  Yes Yes Yes No
## [5401] No  Yes No  No  No  No  No  No  No  No  Yes No  Yes No  No  No  Yes No
## [5419] No  No  No  Yes No  No  No  Yes Yes No  No  Yes No  No  Yes No  No  Yes
## [5437] Yes No  Yes Yes No  Yes No  Yes No  No  No  No  No  No  Yes No  No  Yes
## [5455] No  No  No  Yes Yes No  Yes No  No  No  No  No  Yes No  No  No  No  Yes
## [5473] Yes Yes No  No  No  No  No  No  No  No  Yes No  No  No  No  Yes No  No
## [5491] No  No  Yes No  Yes No  No  No  Yes Yes Yes Yes No  Yes Yes No  No  No
## [5509] Yes Yes No  Yes No  Yes Yes No  No  No  Yes No  No  No  No  No  Yes Yes
## [5527] Yes Yes No  No  No  No  No  Yes No  No  No  No  No  No  No  Yes Yes No
## [5545] No  No  Yes No  No  Yes Yes No  No  No  No  Yes No  No  No  No  No  No
## [5563] No  No  No  No  Yes Yes No  No  No  No  Yes No  No  Yes Yes No  No  No
## [5581] Yes No  No  No  Yes Yes Yes No  No  Yes Yes Yes No  No  Yes Yes No  No
## [5599] No  No  Yes No  No  No  No  Yes No  Yes No  Yes Yes No  No  No  Yes No
## [5617] No  Yes Yes No  No  No  No  No  No  Yes Yes No  No  No  No  Yes No  Yes
## [5635] No  Yes No  No  No  No  No  No  No  Yes No  No  No  Yes No  No  No  No
## [5653] Yes Yes No  Yes No  No  No  Yes No  No  No  No  No  No  Yes No  Yes
## [5671] No  No  No  Yes No  No  No  Yes No  Yes No  No  Yes No  No  No  No  No
## [5689] No  No  Yes No  No  Yes Yes Yes No  No  No  Yes No  No  No  Yes Yes No
## [5707] No  No  No  Yes No  Yes Yes Yes No  No  No  No  No  No  Yes Yes Yes
## [5725] No  No  Yes No  Yes Yes Yes No  No  Yes Yes No  Yes Yes Yes No  Yes No
## [5743] Yes No  No  No  Yes No  Yes No  No  No  No  Yes No  Yes No  Yes No  Yes
## [5761] No  No  No  Yes Yes No  Yes No  No  No  No  Yes No  No  Yes Yes Yes No
## [5779] No  No  Yes No  Yes No  No  No  Yes Yes Yes No  No  No  No  Yes No  No
## [5797] Yes No  No  No  No  No  Yes No  Yes No  Yes Yes No  Yes No  No  No  Yes
## [5815] Yes Yes No  No  No  No  Yes Yes Yes Yes No  Yes No  No  Yes No  Yes No
## [5833] No  No  Yes No  No  Yes No  No  No  No  No  No  Yes No  Yes Yes No  Yes
## [5851] No  No  No  No  No  Yes Yes Yes Yes No  Yes Yes No  Yes No  No  No  No
## [5869] No  Yes Yes Yes No  No  Yes Yes Yes Yes Yes Yes No  No  Yes No  No  Yes
## [5887] No  No  Yes No  Yes Yes No  No  No  Yes No  Yes Yes No  Yes Yes No  No
## [5905] No  No  No  Yes No  Yes Yes Yes No  Yes No  No  No  No  Yes No  No  No
## [5923] No  No  Yes Yes No  No  No  Yes Yes No  Yes No  No  No  No  Yes No  No
## [5941] No  Yes No  No  No  No  No  No  No  Yes Yes Yes No  No  No  No  Yes No
## [5959] No  Yes No  Yes Yes Yes No  No  No  No  Yes No  No  Yes No  No  No  No
## [5977] No  Yes Yes No  Yes No  No  No  No  No  No  No  No  No  Yes No  No  No
## [5995] Yes No  Yes No  Yes Yes Yes No  No  No  Yes No  No  No  No  No  Yes No
## [6013] Yes No  Yes Yes No  No  Yes No  Yes Yes Yes No  Yes No  Yes Yes No  Yes
## [6031] Yes No  No  Yes No  No  No  No  Yes Yes No  No  No  No  Yes No  No  No
## [6049] No  No  No  No  Yes Yes Yes No  No  No  Yes No  No  No  No  No  No  No
## [6067] Yes No  Yes No  Yes Yes Yes No  No  No  Yes No  No  No  No  No  No  No
## [6085] No  Yes No  Yes No  No  No  No  No  No  No  Yes Yes No  No  No  No  Yes
## [6103] No  Yes No  Yes Yes No  No  No  No  No  No  Yes No  No  No  No  No  No
## [6121] No  No  Yes No  Yes No  No  No  No  No  Yes No  Yes Yes No  No  Yes Yes
## [6139] Yes Yes No  No  No  No  Yes No  No  No  No  Yes No  No  No  Yes Yes No
## [6157] No  No  No  No  No  Yes No  Yes No  Yes No  Yes No  Yes No  Yes No  No
## [6175] Yes No  No  Yes No  Yes No  No  Yes No  No  Yes No  Yes Yes No  No  Yes
## [6193] No  No  No  Yes Yes No  No  No  No  Yes No  No  No  Yes No  No  No  No
## [6211] No  Yes Yes Yes Yes No  No  Yes No  No  No  No  No  No  Yes No  No  No
## [6229] No  No  Yes Yes No  No  Yes No  No  No  Yes No  No  Yes No  No  No  Yes
## [6247] Yes No  No  No  Yes No  No  No  No  Yes No  No  No  Yes No  No  Yes No
## [6265] Yes Yes Yes No  No  Yes No  Yes No  No  Yes No  No  No  No  No  No  No
```

```
## [6283] Yes Yes No  Yes No  No  No  Yes Yes No  No  Yes No  Yes No  Yes No  No
## [6301] No  No  No  No  Yes Yes No  Yes No  No  No  Yes No  No  No  No  No  Yes
## [6319] No  No  No  No  No  No  No  Yes No  No  No  No  No  No  No  Yes Yes No
## [6337] Yes No  No  No  No  No  Yes No  Yes No  No  No  No  No  No  No  Yes No
## [6355] Yes No  Yes No  No  No  Yes Yes No  Yes No  Yes No  No  Yes No  Yes Yes
## [6373] No  No  No  No  Yes No  No  No  No  No  No  Yes Yes No  No  No  Yes Yes
## [6391] No  No  No  No  No  No  Yes No  No  No  No  No  No  No  No  Yes No  No
## [6409] No  No  No  No  No  No  Yes No  Yes No  No  Yes No  No  Yes No  Yes No
## [6427] No  Yes No  Yes No  Yes Yes No  No  No  Yes Yes No  No  No  No  Yes Yes
## [6445] No  No  Yes Yes No  No  No  Yes No  No  No  Yes No  No  No  Yes No  No
## [6463] Yes No  No  Yes No  Yes No  No  Yes No  Yes No  No  Yes No  No  No  No
## [6481] Yes Yes Yes No  No  Yes Yes No  No  Yes No  No  No  No  No  No  No  No
## [6499] No  No  No  Yes No  No  No  No  Yes No  No  No  No  No  No  No  No  Yes
## [6517] No  Yes No  No  No  Yes Yes Yes No  No  Yes No  Yes No  No  No  No  No
## [6535] No  Yes No  Yes No  No  Yes Yes Yes Yes No  No  No  No  No  Yes No  Yes
## [6553] Yes No  Yes Yes No  No  No  No  No  No  No  Yes Yes No  No  No  Yes Yes
## [6571] Yes Yes No  No  No  Yes Yes Yes Yes No  No  Yes No  Yes Yes No  No  No
## [6589] Yes Yes No  Yes Yes No  No  No  Yes No  No  No  No  No  No  No  No  No
## [6607] No  No  No  No  No  No  No  No  No  No  Yes No  Yes No  Yes No  No  No
## [6625] No  No  No  No  No  Yes No  No  No  Yes Yes Yes No  No  Yes Yes No  Yes
## [6643] No  Yes Yes No  No  Yes No  Yes No  No  No  No  Yes Yes No  No  No  No
## [6661] No  Yes No  Yes No  No  No  No  No  No  Yes Yes Yes No  No  No  Yes No
## [6679] No  Yes No  No  Yes No  No  Yes Yes No  Yes No  Yes No  Yes No  No  Yes
## [6697] No  Yes Yes No  No  No  No  Yes No  Yes No  No  No  No  No  Yes Yes No
## [6715] No  No  Yes Yes No  Yes Yes Yes No  No  Yes No  No  No  No  No  No  No
## [6733] No  No  Yes Yes Yes Yes No  No  No  Yes No  No  No  No  No  No  Yes Yes
## [6751] No  No  No  No  No  No  No  No  Yes No  No  No  No  No  No  No  Yes No
## [6769] Yes No  No  Yes Yes No  No  Yes No  Yes No  Yes No  No  No  No  Yes No
## [6787] No  No  No  No  No  No  No  Yes No  Yes No  Yes No  Yes No  No  Yes No
## [6805] No  Yes No  No  Yes Yes No  Yes Yes Yes No  Yes No  No  Yes No  No  No
## [6823] Yes No  No  Yes No  No  No  No  No  No  No  Yes Yes Yes No  No  No  No
## [6841] No  No  No  No  Yes Yes No  Yes Yes No  No  No  No  No  No  No  Yes No
## [6859] No  No  Yes No  No  No  No  Yes No  Yes Yes No  Yes No  No  No  No  No
## [6877] No  Yes No  No  No  Yes Yes No  Yes No  Yes No  Yes No  No  Yes No  No
## [6895] No  No  No  Yes No  Yes No  No  Yes No  No  Yes No  No  No  No  No  No
## [6913] No  Yes No  No  No  No  No  Yes No  No  No  No  Yes Yes Yes No  No  No
## [6931] No  No  No  No  Yes Yes Yes No  Yes No  No  Yes No  Yes No  No  No  Yes
## [6949] Yes No  No  Yes No  No  Yes No  No  No  Yes No  Yes Yes Yes No  No  Yes
## [6967] Yes No  No  No  No  No  Yes Yes No  No  No  Yes No  No  Yes No  Yes Yes
## [6985] No  Yes Yes No  No  Yes No  No  No  Yes No  No  Yes No  Yes Yes No  No
## [7003] No  No  Yes Yes No  Yes No  Yes No  No  Yes Yes No  Yes Yes No  No  No
## [7021] No  No  No  No  No  No  Yes No  Yes No  Yes Yes No  No  No  No  No  Yes
## [7039] No  No  Yes Yes No  No  No
## Levels: No Yes
```

```r
#column MulitpleLines has No internet service option other than "yes" and "no". That option is also con
df$MultipleLinesPlan <- as.factor(mapvalues(df$MultipleLinesPlan,
                                            from=c("No phone service"),
                                            to=c("No")))
```

```r
#SeniorCard column has 1 and 0  which are changed to yes and no and then factored for model
df$SeniorCard <- as.factor(mapvalues(df$SeniorCard,
                                     from=c("0","1"),
                                     to=c("No", "Yes")))
```
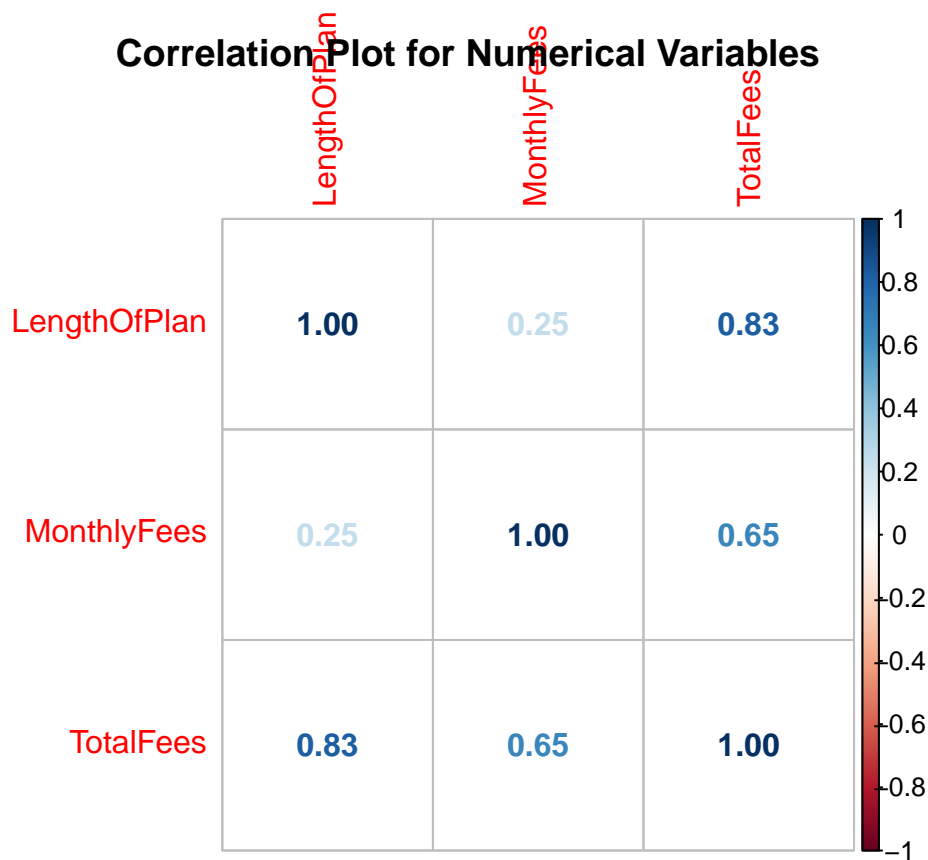
```
#factorizing the remaining categorical variables so that they can be fed onto the main model

remaining_cat <- c('Sex','Married', 'HasChildren','BundledPlan', 'InternetServicePlan', 'ContractType',
for (var in remaining_cat) {
  df[[var]] <- factor(df[[var]])
}
```

```
#correlation of numeric variables

numeric_var <- sapply(df, is.numeric)
corr.matrix <- cor(df[,numeric_var])
corrplot(corr.matrix,
         main = "\n\nCorrelation Plot for Numerical Variables", method ='number')
```


Correlation Plot for Numerical Variables

```
group_lop <- function(LengthOfPlan){
    if (LengthOfPlan >= 0 & LengthOfPlan <= 12){
        return('0-12 Month')
    }else if(LengthOfPlan > 12 & LengthOfPlan <= 24){
        return('12-24 Month')
    }else if (LengthOfPlan > 24 & LengthOfPlan <= 48){
        return('24-48 Month')
    }else if (LengthOfPlan > 48 & LengthOfPlan <=60){
        return('48-60 Month')
    }else if (LengthOfPlan > 60){
        return('> 60 Month')
```

```
    }
}
df$lop_group <- sapply(df$LengthOfPlan,group_lop)
df$lop_group <- as.factor(df$lop_group)
```

```
str(df)
```

```
## 'data.frame':    7045 obs. of  21 variables:
##  $ Sex                  : Factor w/ 2 levels "Female","Male": 1 2 2 1 2 1 1 1 1 1 ...
##  $ SeniorCard           : Factor w/ 2 levels "No","Yes": 2 1 1 1 1 1 2 1 1 1 ...
##  $ Married              : Factor w/ 2 levels "No","Yes": 1 2 1 2 1 1 2 2 1 1 ...
##  $ HasChildren          : Factor w/ 2 levels "No","Yes": 1 1 1 2 1 1 1 2 1 1 ...
##  $ LengthOfPlan         : int  28 12 1 30 38 14 65 68 13 47 ...
##  $ BundledPlan          : Factor w/ 2 levels "No","Yes": 2 2 2 2 2 2 2 2 2 2 ...
##  $ MultipleLinesPlan    : Factor w/ 2 levels "No","Yes": 2 1 1 2 2 1 2 2 1 2 ...
##  $ InternetServicePlan  : Factor w/ 3 levels "DSL","Fiber optic",..: 2 2 2 3 2 1 2 2 2 2 ...
##  $ OnlineSecurityEnabled: Factor w/ 2 levels "No","Yes": 1 2 1 1 2 2 2 1 1 2 ...
##  $ OnlineBackupEnabled  : Factor w/ 2 levels "No","Yes": 1 2 1 1 2 1 1 2 1 1 ...
##  $ DeviceProtectionEnabled: Factor w/ 2 levels "No","Yes": 2 2 1 1 1 1 2 1 1 2 ...
##  $ TechSupportEnabled   : Factor w/ 2 levels "No","Yes": 2 1 1 1 1 2 1 2 1 1 ...
##  $ StreamingTVPlan      : Factor w/ 2 levels "No","Yes": 2 1 2 1 2 1 2 2 1 2 ...
##  $ StreamingMoviesPlan  : Factor w/ 2 levels "No","Yes": 2 1 1 1 2 1 2 2 1 1 ...
##  $ ContractType         : Factor w/ 3 levels "Month-to-month",..: 1 1 1 3 2 2 1 3 1 2 ...
##  $ ElectronicBilling    : Factor w/ 2 levels "No","Yes": 2 2 2 2 2 1 1 2 2 1 ...
##  $ PaymentType          : Factor w/ 4 levels "Bank transfer (automatic)",..: 3 3 3 4 3 4 1 2 4 2 .
##  $ MonthlyFees          : num  103.3 84.6 80 25.1 104.8 ...
##  $ TotalFees            : num  2891 960 80 790 3887 ...
##  $ Switched             : Factor w/ 2 levels "No","Yes": 2 1 2 1 1 1 2 1 1 1 ...
##  $ lop_group            : Factor w/ 5 levels "> 60 Month","0-12 Month",..: 4 2 2 4 4 3 1 1 3 4 ...
```

```
#Plotting distributions to check each column
```
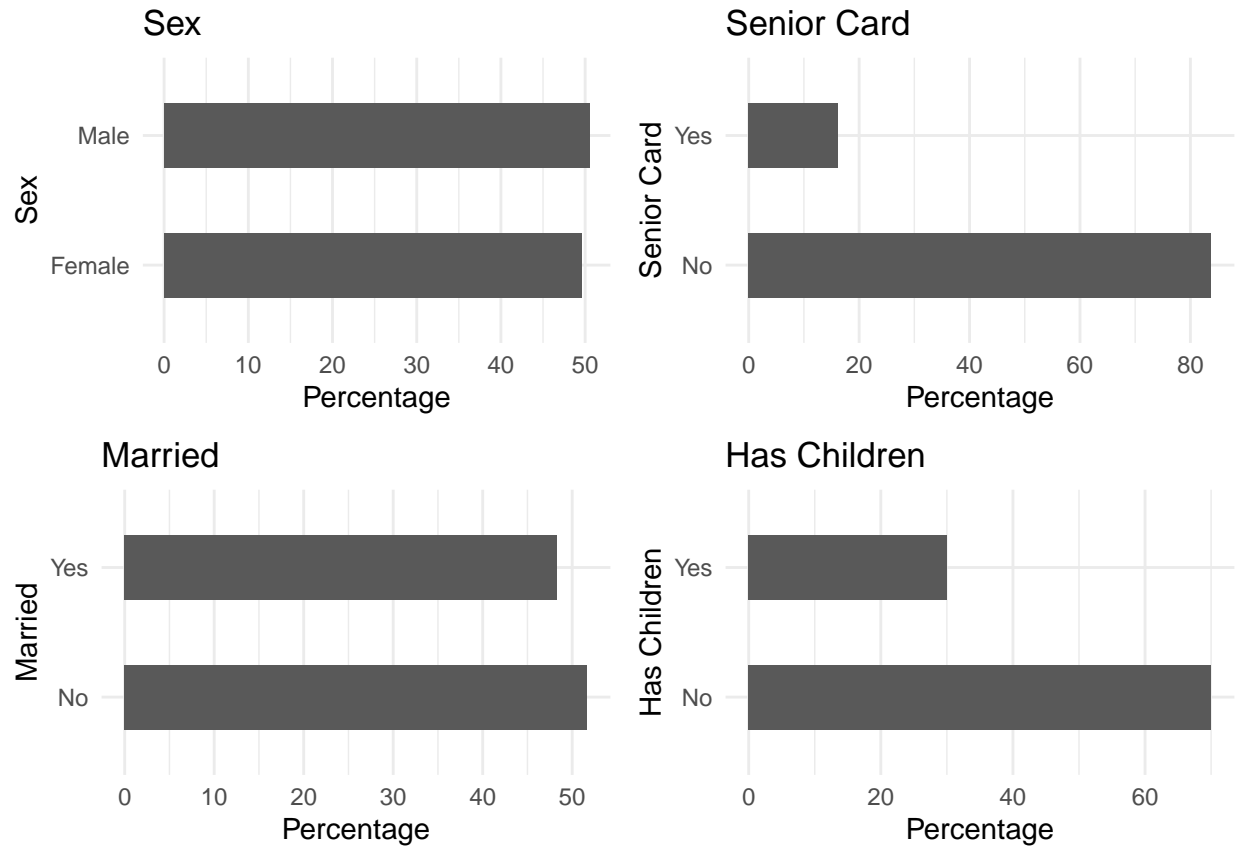
```
p1 <- ggplot(df, aes(x=Sex)) + ggtitle("Sex") + xlab("Sex") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() + 
p2 <- ggplot(df, aes(x=SeniorCard)) + ggtitle("Senior Card") + xlab("Senior Card") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() + 
p3 <- ggplot(df, aes(x=Married)) + ggtitle("Married") + xlab("Married") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() + 
p4 <- ggplot(df, aes(x=HasChildren)) + ggtitle("Has Children") + xlab("Has Children") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() + 
grid.arrange(p1, p2, p3, p4, ncol=2)
```
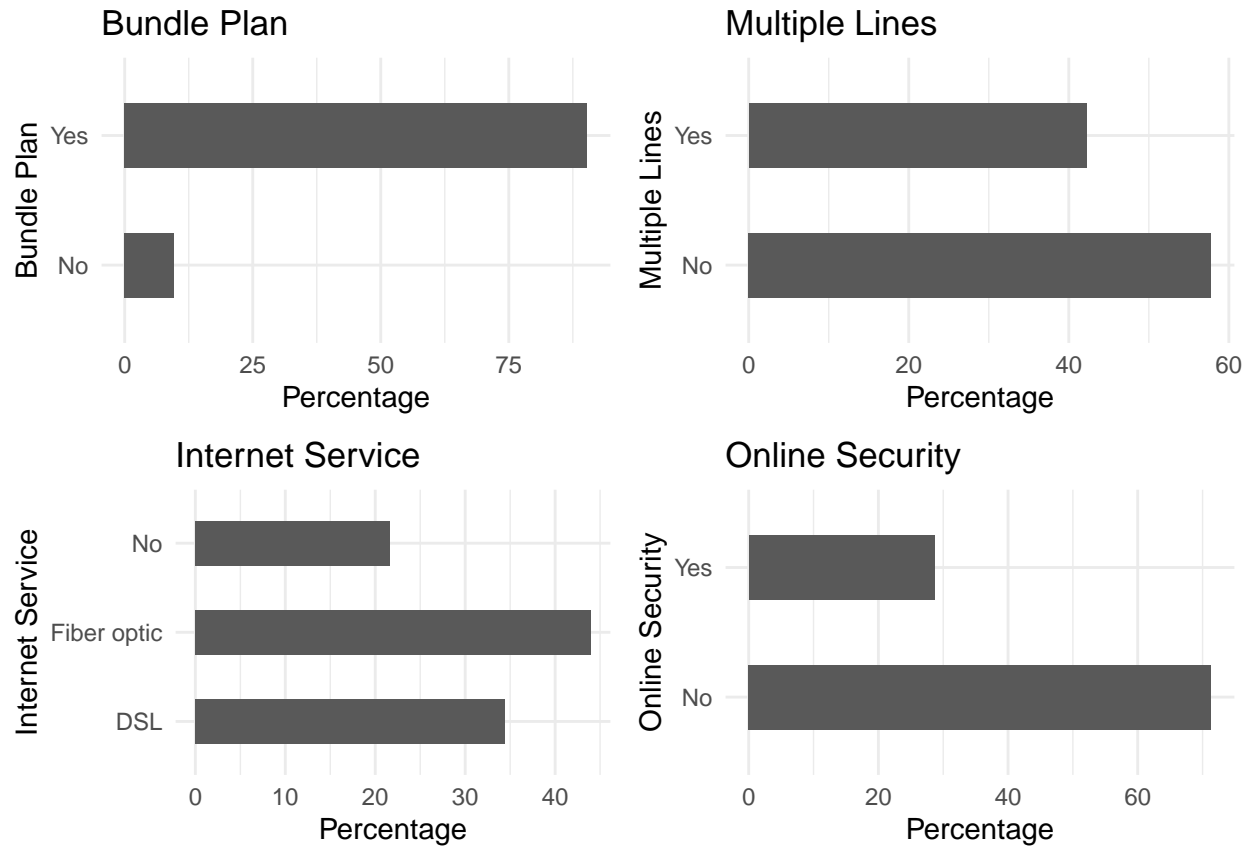
```
## Warning: The dot-dot notation ('..count..') was deprecated in ggplot2 3.4.0.
## i Please use 'after_stat(count)' instead.
## This warning is displayed once every 8 hours.
## Call 'lifecycle::last_lifecycle_warnings()' to see where this warning was
## generated.
```
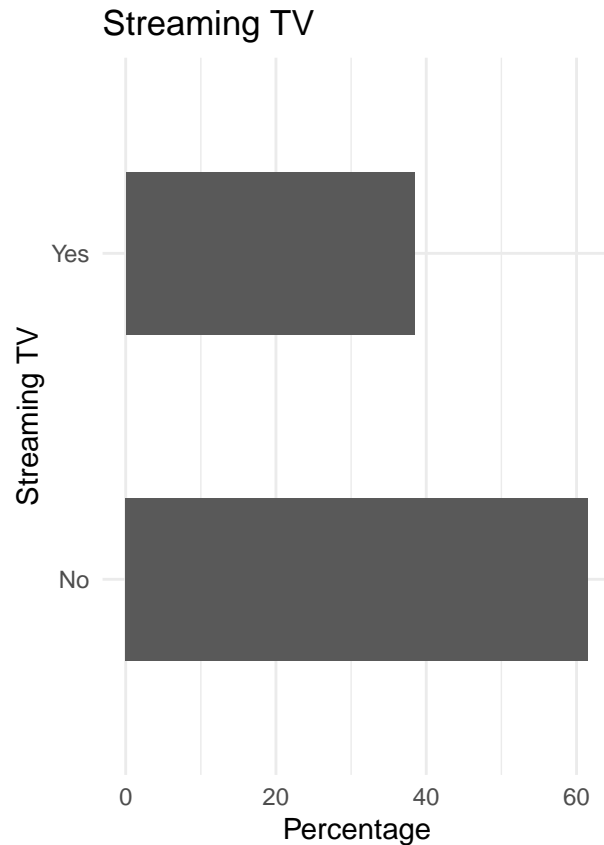
```
p5 <- ggplot(df, aes(x=BundledPlan)) + ggtitle("Bundle Plan") + xlab("Bundle Plan") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
p6 <- ggplot(df, aes(x=MultipleLinesPlan)) + ggtitle("Multiple Lines") + xlab("Multiple Lines") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
p7 <- ggplot(df, aes(x=InternetServicePlan)) + ggtitle("Internet Service") + xlab("Internet Service") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
p8 <- ggplot(df, aes(x=OnlineSecurityEnabled)) + ggtitle("Online Security") + xlab("Online Security") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
grid.arrange(p5, p6, p7, p8, ncol=2)
```

Bundle Plan

Multiple Lines

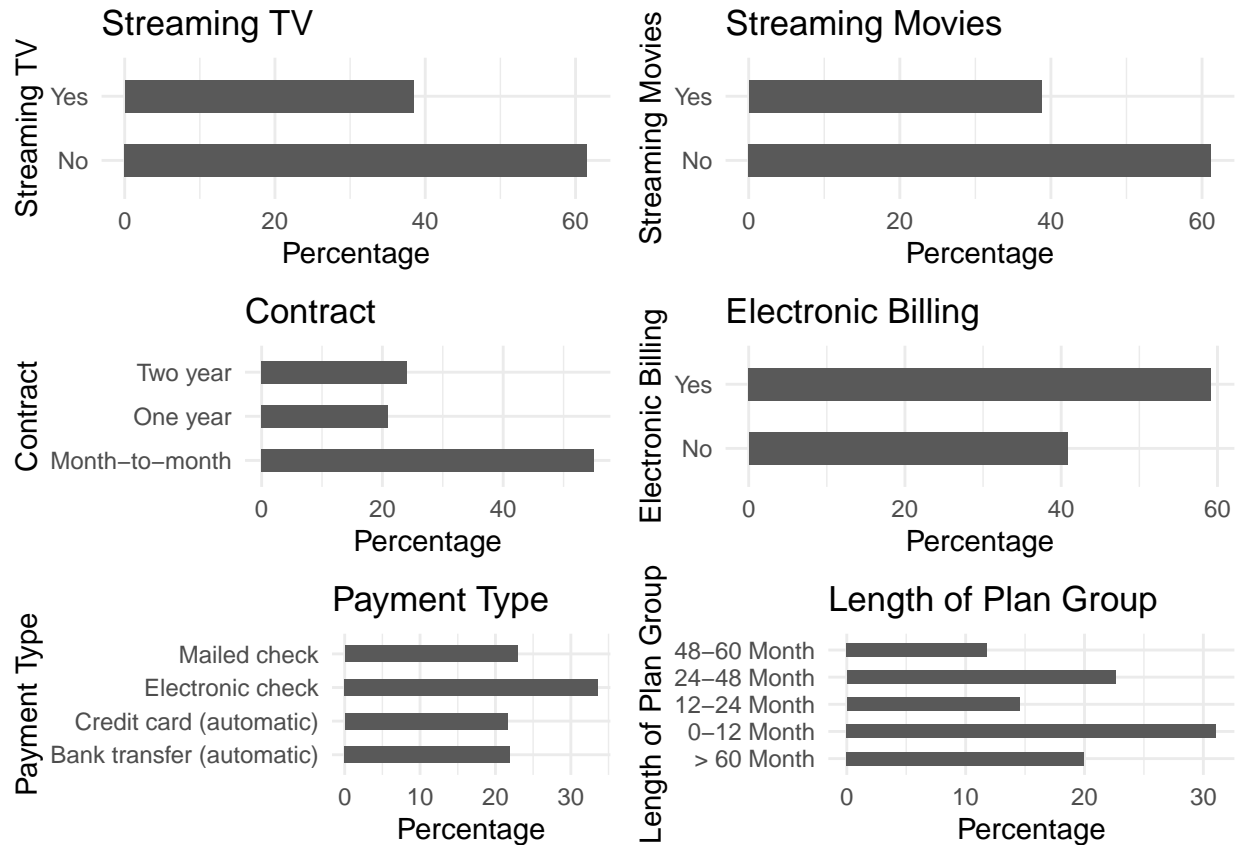## Internet Service

Online Security

```
p12 <- ggplot(df, aes(x=StreamingTVPlan)) + ggtitle("Streaming TV") + xlab("Streaming TV") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
grid.arrange(p12, ncol=2)
```

Streaming TV


```r
p13 <- ggplot(df, aes(x=StreamingMoviesPlan)) + ggtitle("Streaming Movies") + xlab("Streaming Movies") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
p14 <- ggplot(df, aes(x=ContractType)) + ggtitle("Contract") + xlab("Contract") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
p15 <- ggplot(df, aes(x=ElectronicBilling)) + ggtitle("Electronic Billing") + xlab("Electronic Billing")
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
p16 <- ggplot(df, aes(x=PaymentType)) + ggtitle("Payment Type") + xlab("Payment Type") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
p17 <- ggplot(df, aes(x=lop_group)) + ggtitle("Length of Plan Group") + xlab("Length of Plan Group") +
  geom_bar(aes(y = 100*(..count..)/sum(..count..)), width = 0.5) + ylab("Percentage") + coord_flip() +
grid.arrange(p12, p13, p14, p15, p16, p17, ncol=2)
```

Streaming TV

Streaming Movies

Contract

Electronic Billing

Payment Type

Length of Plan Group

```
#lengthofPlan and TotalFees are highly correlated to MonthlyFees so keeping only that in the analysis a
#OnlineBackupEnabled , DeviceProtectionEnabled and TechSupportEnabled were found to be highly correalte
```

```
df$LengthOfPlan <- NULL
df$TotalFees <- NULL
df$OnlineBackupEnabled <- NULL
df$DeviceProtectionEnabled <- NULL
df$TechSupportEnabled <- NULL
```

```
str(df)
```

```
## 'data.frame':    7045 obs. of  16 variables:
##  $ Sex                 : Factor w/ 2 levels "Female","Male": 1 2 2 1 2 1 1 1 1 1 ...
##  $ SeniorCard          : Factor w/ 2 levels "No","Yes": 2 1 1 1 1 1 2 1 1 1 ...
##  $ Married             : Factor w/ 2 levels "No","Yes": 1 2 1 2 1 1 2 2 1 1 ...
##  $ HasChildren         : Factor w/ 2 levels "No","Yes": 1 1 1 2 1 1 1 2 1 1 ...
##  $ BundledPlan         : Factor w/ 2 levels "No","Yes": 2 2 2 2 2 2 2 2 2 2 ...
##  $ MultipleLinesPlan   : Factor w/ 2 levels "No","Yes": 2 1 1 2 2 1 2 2 1 2 ...
##  $ InternetServicePlan : Factor w/ 3 levels "DSL","Fiber optic",..: 2 2 3 2 1 2 2 2 2 ...
##  $ OnlineSecurityEnabled: Factor w/ 2 levels "No","Yes": 1 2 1 1 2 2 2 1 1 2 ...
##  $ StreamingTVPlan     : Factor w/ 2 levels "No","Yes": 2 1 2 1 2 1 2 2 2 1 2 ...
##  $ StreamingMoviesPlan : Factor w/ 2 levels "No","Yes": 2 1 1 1 2 1 2 2 1 1 ...
##  $ ContractType        : Factor w/ 3 levels "Month-to-month",..: 1 1 1 3 2 2 1 3 1 2 ...
```

```
##  $ ElectronicBilling    : Factor w/ 2 levels "No","Yes": 2 2 2 2 2 1 1 2 2 1 ...
##  $ PaymentType          : Factor w/ 4 levels "Bank transfer (automatic)",..: 3 3 3 4 3 4 1 2 4 2 ...
##  $ MonthlyFees          : num  103.3 84.6 80 25.1 104.8 ...
##  $ Switched             : Factor w/ 2 levels "No","Yes": 2 1 2 1 1 1 2 1 1 1 ...
##  $ lop_group            : Factor w/ 5 levels "> 60 Month","0-12 Month",..: 4 2 2 4 4 3 1 1 3 4 ...
```

```r
#dividing the data into train and test sets
intrain<- createDataPartition(df$Switched,p=0.8,list=FALSE)
set.seed(2017)
training<- df[intrain,]
testing<- df[-intrain,]
```

```r
#70/30 ratio ensured
dim(training); dim(testing)
```

```
## [1] 5636    16
```

```
## [1] 1409    16
```

```r
#activating Logistic regression model
LogModel <- glm(Switched ~ .,family=binomial(),data=training)
print(summary(LogModel))
```

```
##
## Call:
## glm(formula = Switched ~ ., family = binomial(), data = training)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.0275  -0.6693  -0.2845   0.6791   3.1393
##
## Coefficients:
##                                Estimate Std. Error z value Pr(>|z|)
## (Intercept)                   -0.844734   0.382434  -2.209 0.027186 *
## SexMale                       -0.013994   0.072372  -0.193 0.846676
## SeniorCardYes                  0.213210   0.093791   2.273 0.023011 *
## MarriedYes                    -0.099496   0.086458  -1.151 0.249810
## HasChildrenYes                -0.102068   0.100065  -1.020 0.307719
## BundledPlanYes                 0.294316   0.235967   1.247 0.212297
## MultipleLinesPlanYes           0.501635   0.100352   4.999 5.77e-07 ***
## InternetServicePlanFiber optic 1.801933  0.250845   7.183 6.80e-13 ***
## InternetServicePlanNo         -1.803617   0.305326  -5.907 3.48e-09 ***
## OnlineSecurityEnabledYes      -0.209269   0.106405  -1.967 0.049216 *
## StreamingTVPlanYes             0.707302   0.135876   5.205 1.93e-07 ***
## StreamingMoviesPlanYes         0.654817   0.135711   4.825 1.40e-06 ***
## ContractTypeOne year          -0.860241   0.119295  -7.211 5.55e-13 ***
## ContractTypeTwo year          -1.799611   0.203617  -8.838  < 2e-16 ***
## ElectronicBillingYes           0.321842   0.083273   3.865 0.000111 ***
## PaymentTypeCredit card (automatic) -0.064653 0.127301 -0.508 0.611540
## PaymentTypeElectronic check    0.338384   0.105446   3.209 0.001332 **
## PaymentTypeMailed check        0.080814   0.127634   0.633 0.526621
## MonthlyFees                   -0.038471   0.009357  -4.111 3.93e-05 ***
```

```
## lop_group0-12 Month                 1.592704   0.187838   8.479  < 2e-16 ***
## lop_group12-24 Month                0.800446   0.184510   4.338 1.44e-05 ***
## lop_group24-48 Month                0.407128   0.168650   2.414 0.015776 *
## lop_group48-60 Month                0.109310   0.185817   0.588 0.556352
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 6522.7  on 5635  degrees of freedom
## Residual deviance: 4692.3  on 5613  degrees of freedom
## AIC: 4738.3
##
## Number of Fisher Scoring iterations: 6
```

```
anova(LogModel, test="Chisq")
```

```
## Analysis of Deviance Table
##
## Model: binomial, link: logit
##
## Response: Switched
##
## Terms added sequentially (first to last)
##
##
##                    Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
## NULL                                5635     6522.7
## Sex                 1     0.05     5634     6522.7 0.8176601
## SeniorCard          1   106.40     5633     6416.3 < 2.2e-16 ***
## Married             1   161.78     5632     6254.5 < 2.2e-16 ***
## HasChildren         1    33.83     5631     6220.7 6.026e-09 ***
## BundledPlan         1     0.99     5630     6219.7 0.3191302
## MultipleLinesPlan   1     6.60     5629     6213.1 0.0102126 *
## InternetServicePlan 2   513.15     5627     5699.9 < 2.2e-16 ***
## OnlineSecurityEnabled 1 194.27     5626     5505.7 < 2.2e-16 ***
## StreamingTVPlan     1     3.90     5625     5501.8 0.0482139 *
## StreamingMoviesPlan 1     5.54     5624     5496.2 0.0185493 *
## ContractType        2   526.88     5622     4969.3 < 2.2e-16 ***
## ElectronicBilling   1    15.03     5621     4954.3 0.0001058 ***
## PaymentType         3    48.54     5618     4905.8 1.634e-10 ***
## MonthlyFees         1    54.59     5617     4851.2 1.483e-13 ***
## lop_group           4   158.90     5613     4692.3 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
#printing testing results and accuracy
testing$Switched <- as.character(testing$Switched)
testing$Switched[testing$Switched=="No"] <- 0
testing$Switched[testing$Switched=="Yes"] <- 1
fitted.results <- predict(LogModel,newdata=testing)
fitted.results <- ifelse(fitted.results > 0.5,"1","0")
misClasificError <- mean(fitted.results != testing$Switched)
print(paste('Logistic Regression Accuracy',1-misClasificError))
```

```
## [1] "Logistic Regression Accuracy 0.79347054648687"
```

```
fres = as.factor(fitted.results)
```

```
table(fitted.results)
```

```
## fitted.results
##    0    1
## 1232  177
```

```
cm1 <- confusionMatrix(table(testing$Switched,fres))
print(cm1)
```

```
## Confusion Matrix and Statistics
##
##    fres
##       0   1
##   0 988  47
##   1 244 130
##
##                Accuracy : 0.7935
##                  95% CI : (0.7714, 0.8143)
##     No Information Rate : 0.8744
##     P-Value [Acc > NIR] : 1
##
##                   Kappa : 0.3633
##
##  Mcnemar's Test P-Value : <2e-16
##
##             Sensitivity : 0.8019
##             Specificity : 0.7345
##          Pos Pred Value : 0.9546
##          Neg Pred Value : 0.3476
##              Prevalence : 0.8744
##          Detection Rate : 0.7012
##    Detection Prevalence : 0.7346
##       Balanced Accuracy : 0.7682
##
##        'Positive' Class : 0
##
```

```
#precision
truepositive <- 997
falsepositive <- 38
truenegative <- 115
falsenegative <- 259
precision <- (truepositive)/(truepositive+falsepositive)
recall <- (truepositive)/(truepositive+falsenegative)
f1score <- 2 * (precision * recall) / (precision + recall)
print(precision)
```

```
## [1] 0.963285
```

```
print(recall)
```

```
## [1] 0.7937898
```

```
print(f1score)
```

```
## [1] 0.8703623
```

```
library(MASS)
exp(cbind(OR=coef(LogModel), confint(LogModel)))
```

```
## Waiting for profiling to be done...
```

```
##                                        OR       2.5 %      97.5 %
## (Intercept)                         0.4296716 0.20253191 0.9074017
## SexMale                             0.9861036 0.85568608 1.1364280
## SeniorCardYes                       1.2376442 1.02960995 1.4872355
## MarriedYes                          0.9052933 0.76417303 1.0725316
## HasChildrenYes                      0.9029683 0.74172735 1.0981203
## BundledPlanYes                      1.3422079 0.84552618 2.1333880
## MultipleLinesPlanYes                1.6514196 1.35703226 2.0113329
## InternetServicePlanFiber optic      6.0613517 3.71119745 9.9268303
## InternetServicePlanNo               0.1647020 0.09047781 0.2997198
## OnlineSecurityEnabledYes            0.8111769 0.65815483 0.9989322
## StreamingTVPlanYes                  2.0285104 1.55491616 2.6494726
## StreamingMoviesPlanYes              1.9247904 1.47615884 2.5133912
## ContractTypeOne year                0.4230600 0.33395279 0.5332061
## ContractTypeTwo year                0.1653632 0.10952415 0.2436949
## ElectronicBillingYes                1.3796666 1.17220313 1.6248088
## PaymentTypeCredit card (automatic)  0.9373926 0.73015441 1.2029054
## PaymentTypeElectronic check         1.4026784 1.14158177 1.7261825
## PaymentTypeMailed check             1.0841697 0.84454534 1.3930943
## MonthlyFees                         0.9622598 0.94474300 0.9800700
## lop_group0-12 Month                 4.9170242 3.41315048 7.1306131
## lop_group12-24 Month                2.2265332 1.55459308 3.2058616
## lop_group24-48 Month                1.5024969 1.08243401 2.0978464
## lop_group48-60 Month                1.1155087 0.77499477 1.6068013
```

```
#installing packages for decision trees model
install.packages("survival",repos="http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##   /var/folders/kv/q8v8kt9n5dg8h7tfdqqxl0v00000gn/T//RtmpYjoT3u/downloaded_packages
```

```
install.packages("rpart",repos="http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##   /var/folders/kv/q8v8kt9n5dg8h7tfdqqxl0v00000gn/T//RtmpYjoT3u/downloaded_packages
```
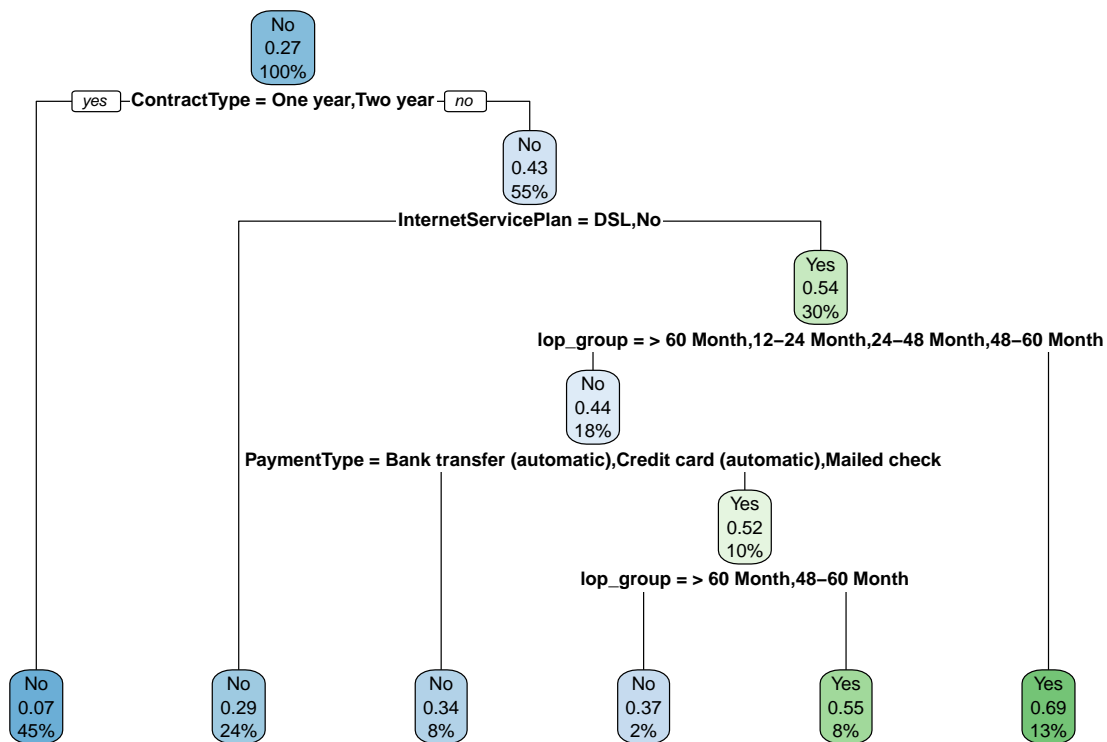
```
install.packages("rpart.plot",repos="http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##   /var/folders/kv/q8v8kt9n5dg8h7tfdqqxl0v00000gn/T//RtmpYjoT3u/downloaded_packages
```

```
library(rpart)  # For building decision trees
library(rpart.plot)  # For visualizing decision trees
```

```
#running decision trees model
modeldt <- rpart(Switched ~ ., data = training, method = "class")
```

```
rpart.plot(modeldt)
```



```
predictions <- predict(modeldt, newdata = testing, type = "class")
```

```
#pritnting test results
confusion_matrix <- table(actual = testing$Switched, predicted = predictions)
accuracy <- sum(diag(confusion_matrix)) / sum(confusion_matrix)
print(confusion_matrix)
```

```
##        predicted
## actual  No Yes
```

```
##      0 932 103
##      1 183 191
```

```
print(accuracy)
```

```
## [1] 0.7970192
```

```
truepositive1 <- 934
falsepositive1 <- 101
truenegative1 <- 188
falsenegative1 <- 186
precision1 <- (truepositive1)/(truepositive1+falsepositive1)
recall1 <- (truepositive1)/(truepositive1+falsenegative1)
f1score1 <- 2 * (precision1 * recall1) / (precision1 + recall1)
print(precision1)
```

```
## [1] 0.9024155
```

```
print(recall1)
```

```
## [1] 0.8339286
```

```
print(f1score1)
```

```
## [1] 0.8668213
```

```
#running random forest model for list of important features
modelrf <- randomForest(Switched ~ ., data = training, ntree = 100)
```

```
#printing important features in accordance with their Decrease in Gini Value
importance <- importance(modelrf)
print(importance)
```

```
##                      MeanDecreaseGini
## Sex                         42.59888
## SeniorCard                  34.78775
## Married                     40.09471
## HasChildren                 34.30728
## BundledPlan                 14.03285
## MultipleLinesPlan           32.73059
## InternetServicePlan        109.89800
## OnlineSecurityEnabled       43.46389
## StreamingTVPlan             32.31619
## StreamingMoviesPlan         31.06929
## ContractType               204.81941
## ElectronicBilling           46.47733
## PaymentType                129.49755
## MonthlyFees                309.48880
## lop_group                  196.35243
```

```
#10 of the most important features are as follows
sorted_importance <- importance[order(importance[, 1], decreasing = TRUE), ]
print(sorted_importance[1:10])
```

```
##           MonthlyFees         ContractType            lop_group
##             309.48880            204.81941            196.35243
##           PaymentType   InternetServicePlan      ElectronicBilling
##             129.49755            109.89800             46.47733
## OnlineSecurityEnabled                 Sex              Married
##              43.46389             42.59888             40.09471
##           SeniorCard
##              34.78775
```

```
predictions1 <- predict(modelrf, newdata = testing)
```

```
confusion_matrix1 <- table(actual = testing$Switched, predicted = predictions1)
accuracy1 <- sum(diag(confusion_matrix1)) / sum(confusion_matrix1)
print(confusion_matrix1)
```

```
##       predicted
## actual  No Yes
##      0 931 104
##      1 184 190
```

```
print(accuracy1)
```

```
## [1] 0.7955997
```

```
install.packages("tinytex",repos="http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##   /var/folders/kv/q8v8kt9n5dg8h7tfdqqxl0v00000gn/T//RtmpYjoT3u/downloaded_packages
```

```
tinytex::install_tinytex(force=TRUE)
```

```
## The directory /usr/local/bin is not writable. I recommend that you make it writable. See https://git
```