Regression Concepts Using R

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In this exercise, we will use the patient data and understand the following:

1. Importing the datset from a csv file
2. Understanding the strucutre and summary of the data
3. Typecasting a variable to a proper data type
4. Creating derived variables and interaction variables
5. Analyzing the corelation amongst variables
6. Releveling the factor variable and understand its impact
7. Building the regression model using caret package
8. Writing the model equation and interpreting the model summary
9. Analayzing the statistics to acertain the validity of the model

There are bugs/missing code in the entire exercise. The participants are expected to work upon them.

Here are some useful links:

1. Refer link to know more about different ways of dummy variable coding
2. Read about interaction variable coding
3. Refer link to know about adding lables to factors
4. Refer link to relevel factor variables
5. Read about the issues in stepwise regression
6. The issues arising out of multi-colinearity is discussed here or here
7. The residual diagonstic can be interpreted from here
8. Read to understand the distinction between **outliers** and **influential cases**
9. Change NAs to a new label
10. Sampling of data can be tricky and change the outcome of the model.
11. Issues with rJava installation may get resolved by following link or by link

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Code starts here

We are going to use below mentioned libraries for demonstrating logistic regression:

```
library(stats)    #for regression
library(caret)    #for data partition
library(car)      #for VIF
library(sandwich) #for variance, covariance matrix
```

Data Import and Manipulation

1. Importing a data set

Give the correct path to the data

```
raw.data <- read.csv("/Users/Rahul/Documents/Datasets/Mission Hospital-Case
Data.csv",
    header = TRUE, sep = ",", na.strings = c("", " ", "NA"))
```

Note that `echo = FALSE` parameter prevents printing the R code that generated the plot.

2a. Structure and Summary of the dataset

There are 175 NA values in Past Medical History Code. However, rather than treating these as missing values, it represents that there is no past medical history for these patients. These NA may be marked as "None". But while doing so, the code will give an error as we are trying to add a new level to factor variable (**raw.data$Past.MEDICAL.HISTORY.CODE**). In order to add a new level, first we will need to typecast this variable as a character variable, add a new level and then re-typecast them as Factor variable.

```
str(raw.data)
```

```
## 'data.frame':    250 obs. of  62 variables:
##  $ SL.                              : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ AGE                              : num  58 59 82 46 60 75 73 71 72 61
...
##  $ GENDER                           : Factor w/ 2 levels "F","M": 2 2 2 2
2 2 2 2 2 2 ...
##  $ MALE                             : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ Age.Gender                       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ MARITAL.STATUS                   : Factor w/ 2 levels
"MARRIED","UNMARRIED": 1 1 1 1 1 1 1 1 1 1 ...
##  $ UNMARRIED                        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ KEY.COMPLAINTS..CODE             : Factor w/ 13 levels "ACHD","CAD-
DVD",..: 7 2 4 2 2 2 4 4 2 4 ...
##  $ ACHD                             : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ CAD.DVD                          : int  0 1 0 1 1 1 0 0 1 0 ...
##  $ CAD.SVD                          : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ CAD.TVD                          : int  0 0 1 0 0 0 1 1 0 1 ...
##  $ CAD.VSD                          : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ OS.ASD                           : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ other..heart                     : int  1 0 0 0 0 0 0 0 0 0 ...
##  $ other..respiratory               : int  0 0 0 0 0 0 0 0 0 0 ...
```

```
##  $ other.general                      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ other.nervous                      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ other.tertalogy                    : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ PM.VSD                             : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ RHD                                : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ BODY.WEIGHT                        : int  49 41 47 80 58 45 60 44 72 77
...
##  $ Gender.Weight                      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ BODY.HEIGHT                        : int  160 155 164 173 175 140 170
164 174 175 ...
##  $ Gender.Body.Height                 : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ HR.PULSE                           : int  118 78 100 122 72 130 108 60
95 66 ...
##  $ BP..HIGH                           : int  100 70 110 110 180 215 160 130
100 140 ...
##  $ BP.LOW                             : int  80 50 80 80 100 140 90 90 50
90 ...
##  $ RR                                 : int  32 28 20 24 18 42 24 22 25 22
...
##  $ PAST.MEDICAL.HISTORY.CODE          : Factor w/ 7 levels
"Diabetes1","Diabetes2",..: NA NA 2 3 2 NA 2 NA 2 NA ...
##  $ Diabetes1                          : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ Diabetes2                          : int  0 0 1 0 1 0 1 0 1 0 ...
##  $ hypertension1                      : int  0 0 0 1 0 0 0 0 0 0 ...
##  $ hypertension2                      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ hypertension3                      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ other                              : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ HB                                 : int  11 11 12 12 10 12 15 10 10 14
...
##  $ UREA                               : num  33 95 15 74 48 29 31 37 32 15
...
##  $ CREATININE                         : num  0.8 1.7 0.8 1.5 1.9 1 1.6 1.5
1.2 0.4 ...
##  $ MODE.OF.ARRIVAL                    : Factor w/ 3 levels
"AMBULANCE","TRANSFERRED",..: 1 1 3 1 1 1 3 3 1 3 ...
##  $ AMBULANCE                          : int  1 1 0 1 1 1 0 0 1 0 ...
##  $ TRANSFERRED                        : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ STATE.AT.THE.TIME.OF.ARRIVAL       : Factor w/ 2 levels
"ALERT","CONFUSED": 1 1 1 1 1 1 1 1 1 1 ...
##  $ ALERT                              : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ TYPE.OF.ADMSN                      : Factor w/ 2 levels
"ELECTIVE","EMERGENCY": 2 2 1 2 2 2 1 2 2 1 ...
##  $ ELECTIVE                           : int  0 0 1 0 0 0 1 0 0 1 ...
##  $ TOTAL.COST.TO.HOSPITAL             : num  660293 809130 362231 629990
444876 ...
##  $ Ln.Total.Cost.                     : num  13.4 13.6 12.8 13.4 13 ...
##  $ TOTAL.AMOUNT.BILLED.TO.THE.PATIENT: int  474901 944819 390000 324910
254673 499987 660504 248580 691297 247654 ...
##  $ CONCESSION                         : int  0 96422 30000 0 10000 0 504 0
0 0 ...
```

```
##  $ ACTUAL.RECEIVABLE.AMOUNT          : int  474901 848397 360000 324910
244673 499987 660000 248580 691297 247654 ...
##  $ TOTAL.LENGTH.OF.STAY              : int  25 41 18 14 24 31 15 24 26 20
...
##  $ LENGTH.OF.STAY...ICU              : int  12 20 9 13 12 9 15 11 9 4 ...
##  $ LENGTH.OF.STAY..WARD              : int  13 21 9 1 12 22 0 13 17 16 ...
##  $ IMPLANT.USED..Y.N.                : Factor w/ 2 levels "N","Y": 2 2 1 2
1 1 1 1 1 1 ...
##  $ IMPLANT                           : int  1 1 0 1 0 0 0 0 0 0 ...
##  $ COST.OF.IMPLANT                   : int  38000 39690 0 89450 0 0 0 0 0
0 ...
##  $ Y.hat                             : num  260518 262706 313011 234272
264893 ...
##  $ APE                               : num  0.605 0.675 0.136 0.628 0.405
...
##  $ X                                 : logi  NA NA NA NA NA NA ...
##  $ X.1                               : logi  NA NA NA NA NA NA ...
##  $ S.D                               : num  1.01e+05 NA 1.28 3.90e+05 NA
...
```

```
summary(raw.data)
```

```
##       SL.              AGE         GENDER         MALE
##  Min.   :  1.00   Min.   : 0.03   F   : 82   Min.   :0.0000
##  1st Qu.: 62.75   1st Qu.: 6.00   M   :166   1st Qu.:0.0000
##  Median :124.50   Median :15.50   NA's:  2   Median :0.0000
##  Mean   :124.50   Mean   :28.88              Mean   :0.3306
##  3rd Qu.:186.25   3rd Qu.:55.00              3rd Qu.:1.0000
##  Max.   :248.00   Max.   :88.00              Max.   :1.0000
##  NA's   :2        NA's   :2                  NA's   :2
##    Age.Gender       MARITAL.STATUS   UNMARRIED
##  Min.   : 0.000   MARRIED  :108    Min.   :-0.8985
##  1st Qu.: 0.000   UNMARRIED:140    1st Qu.: 0.0000
##  Median : 0.000   NA's     :  2    Median : 1.0000
##  Mean   : 7.206                    Mean   : 0.5586
##  3rd Qu.: 4.250                    3rd Qu.: 1.0000
##  Max.   :78.000                    Max.   : 1.0000
##  NA's   :2                         NA's   :1
##    KEY.COMPLAINTS..CODE      ACHD            CAD.DVD
##  other- heart:55        Min.   :0.00000   Min.   :0.0000
##  CAD-DVD     :27        1st Qu.:0.00000   1st Qu.:0.0000
##  RHD         :26        Median :0.00000   Median :0.0000
##  CAD-TVD     :24        Mean   :0.07661   Mean   :0.1089
##  ACHD        :19        3rd Qu.:0.00000   3rd Qu.:0.0000
##  (Other)     :61        Max.   :1.00000   Max.   :1.0000
##  NA's        :38        NA's   :2         NA's   :2
##     CAD.SVD            CAD.TVD           CAD.VSD             OS.ASD
##  Min.   :0.000000   Min.   :0.00000   Min.   :0.000000   Min.   :0.00000
##  1st Qu.:0.000000   1st Qu.:0.00000   1st Qu.:0.000000   1st Qu.:0.00000
##  Median :0.000000   Median :0.00000   Median :0.000000   Median :0.00000
```

```
##  Mean   :0.008065   Mean   :0.09677   Mean   :0.004032   Mean   :0.06048
##  3rd Qu.:0.000000   3rd Qu.:0.00000   3rd Qu.:0.000000   3rd Qu.:0.00000
##  Max.   :1.000000   Max.   :1.00000   Max.   :1.000000   Max.   :1.00000
##  NA's   :2          NA's   :2         NA's   :2          NA's   :2
##   other..heart    other..respiratory other.general      other.nervous
##  Min.   :0.0000   Min.   :0.00000    Min.   :0.000000   Min.   :0.0000
##  1st Qu.:0.0000   1st Qu.:0.00000    1st Qu.:0.000000   1st Qu.:0.0000
##  Median :0.0000   Median :0.00000    Median :0.000000   Median :0.0000
##  Mean   :0.2218   Mean   :0.06048    Mean   :0.004032   Mean   :0.0121
##  3rd Qu.:0.0000   3rd Qu.:0.00000    3rd Qu.:0.000000   3rd Qu.:0.0000
##  Max.   :1.0000   Max.   :1.00000    Max.   :1.000000   Max.   :1.0000
##  NA's   :2        NA's   :2          NA's   :2          NA's   :2
##  other.tertalogy       PM.VSD             RHD          BODY.WEIGHT
##  Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   Min.   : 2.00
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:15.00
##  Median :0.00000   Median :0.00000   Median :0.0000   Median :41.00
##  Mean   :0.07258   Mean   :0.02419   Mean   :0.1048   Mean   :37.54
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.0000   3rd Qu.:58.25
##  Max.   :1.00000   Max.   :1.00000   Max.   :1.0000   Max.   :85.00
##  NA's   :2         NA's   :2         NA's   :2        NA's   :2
##  Gender.Weight    BODY.HEIGHT    Gender.Body.Height    HR.PULSE
##  Min.   : 0.00   Min.   : 19.0   Min.   :  0.00     Min.   : 41.00
##  1st Qu.: 0.00   1st Qu.:105.0   1st Qu.:  0.00     1st Qu.: 78.00
##  Median : 0.00   Median :147.5   Median :  0.00     Median : 90.00
##  Mean   :10.51   Mean   :130.2   Mean   : 40.47     Mean   : 92.23
##  3rd Qu.:12.25   3rd Qu.:160.0   3rd Qu.: 81.00     3rd Qu.:104.00
##  Max.   :77.00   Max.   :185.0   Max.   :167.00     Max.   :155.00
##  NA's   :2       NA's   :2       NA's   :2          NA's   :2
##     BP..HIGH       BP.LOW             RR        PAST.MEDICAL.HISTORY.CODE
##  Min.   : 70   Min.   : 39.00   Min.   :12.00   hypertension1: 20
##  1st Qu.:100   1st Qu.: 60.00   1st Qu.:22.00   other        : 15
##  Median :110   Median : 70.00   Median :24.00   hypertension2: 13
##  Mean   :115   Mean   : 71.88   Mean   :23.54   Diabetes1    : 10
##  3rd Qu.:130   3rd Qu.: 80.00   3rd Qu.:24.00   Diabetes2    :  9
##  Max.   :215   Max.   :140.00   Max.   :42.00   (Other)      :  8
##  NA's   :25    NA's   :25       NA's   :2       NA's         :175
##    Diabetes1         Diabetes2       hypertension1     hypertension2
##  Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000
##  Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000
##  Mean   :0.04032   Mean   :0.03629   Mean   :0.09274   Mean   :0.05242
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000
##  Max.   :1.00000   Max.   :1.00000   Max.   :1.00000   Max.   :1.00000
##  NA's   :2         NA's   :2         NA's   :2         NA's   :2
##  hypertension3         other               HB             UREA
##  Min.   :0.00000   Min.   :0.00000   Min.   : 5.00   Min.   :  2.00
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:11.00   1st Qu.: 18.00
##  Median :0.00000   Median :0.00000   Median :12.00   Median : 22.00
##  Mean   :0.02016   Mean   :0.06048   Mean   :12.93   Mean   : 26.58
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:14.00   3rd Qu.: 30.00
```

```
##  Max.   :1.00000   Max.   :1.00000   Max.   :26.00   Max.   :143.00
##  NA's   :2         NA's   :2         NA's   :4       NA's   :15
##    CREATININE       MODE.OF.ARRIVAL   AMBULANCE      TRANSFERRED
##  Min.   :0.100   AMBULANCE  : 30    Min.   :0.000   Min.   :0.00000
##  1st Qu.:0.300   TRANSFERRED:  4    1st Qu.:0.000   1st Qu.:0.00000
##  Median :0.700   WALKED IN  :214    Median :0.000   Median :0.00000
##  Mean   :0.747   NA's       :  2    Mean   :0.121   Mean   :0.01613
##  3rd Qu.:1.000                      3rd Qu.:0.000   3rd Qu.:0.00000
##  Max.   :5.200                      Max.   :1.000   Max.   :1.00000
##  NA's   :35                         NA's   :2       NA's   :2
##  STATE.AT.THE.TIME.OF.ARRIVAL     ALERT         TYPE.OF.ADMSN
##  ALERT   :247                 Min.   :0.000   ELECTIVE :216
##  CONFUSED:  1                 1st Qu.:1.000   EMERGENCY: 32
##  NA's    :  2                 Median :1.000   NA's     :  2
##                               Mean   :0.996
##                               3rd Qu.:1.000
##                               Max.   :1.000
##                               NA's   :2
##     ELECTIVE     TOTAL.COST.TO.HOSPITAL Ln.Total.Cost.
##  Min.   :0.000   Min.   : 46093         Min.   :10.74
##  1st Qu.:1.000   1st Qu.:131653         1st Qu.:11.79
##  Median :1.000   Median :162660         Median :12.00
##  Mean   :0.871   Mean   :198723         Mean   :12.06
##  3rd Qu.:1.000   3rd Qu.:220614         3rd Qu.:12.30
##  Max.   :1.000   Max.   :887350         Max.   :13.70
##  NA's   :2       NA's   :2              NA's   :2
##  TOTAL.AMOUNT.BILLED.TO.THE.PATIENT   CONCESSION
##  Min.   : 43641                     Min.   :     0
##  1st Qu.:150000                     1st Qu.:     0
##  Median :150000                     Median : 10000
##  Mean   :182721                     Mean   : 17643
##  3rd Qu.:202638                     3rd Qu.: 37500
##  Max.   :944819                     Max.   :123132
##  NA's   :2                          NA's   :2
##  ACTUAL.RECEIVABLE.AMOUNT TOTAL.LENGTH.OF.STAY LENGTH.OF.STAY...ICU
##  Min.   : 31000           Min.   : 3.00        Min.   : 0.000
##  1st Qu.:112500           1st Qu.: 8.00        1st Qu.: 1.000
##  Median :122400           Median :10.00        Median : 2.000
##  Mean   :167894           Mean   :11.61        Mean   : 3.476
##  3rd Qu.:197000           3rd Qu.:13.00        3rd Qu.: 4.000
##  Max.   :848397           Max.   :41.00        Max.   :30.000
##  NA's   :2                NA's   :2            NA's   :2
##  LENGTH.OF.STAY..WARD IMPLANT.USED..Y.N.    IMPLANT       COST.OF.IMPLANT
##  Min.   : 0.000       N   :199           Min.   :0.0000   Min.   :     0
##  1st Qu.: 6.000       Y   : 49           1st Qu.:0.0000   1st Qu.:     0
##  Median : 7.000       NA's:  2           Median :0.0000   Median :     0
##  Mean   : 8.153                          Mean   :0.1976   Mean   :  8544
##  3rd Qu.:10.000                          3rd Qu.:0.0000   3rd Qu.:     0
##  Max.   :22.000                          Max.   :1.0000   Max.   :196848
##  NA's   :2                               NA's   :2        NA's   :2
```

```
##      Y.hat             APE              X             X.1
##  Min.   :133733   Min.   :0.000013   Mode:logical   Mode:logical
##  1st Qu.:146784   1st Qu.:0.125760   NA's:250       NA's:250
##  Median :167562   Median :0.280740
##  Mean   :196827   Mean   :0.417690
##  3rd Qu.:253957   3rd Qu.:0.550740
##  Max.   :326134   Max.   :4.287823
##  NA's   :2        NA's   :1
##       S.D
##  Min.   :     1.3
##  1st Qu.: 50550.6
##  Median :101100.0
##  Mean   :163728.2
##  3rd Qu.:245591.7
##  Max.   :390083.4
##  NA's   :247
```

```
raw.data$PAST.MEDICAL.HISTORY.CODE[raw.data$PAST.MEDICAL.HISTORY.CODE ==
"Hypertension1"] <- "hypertension1"

raw.data$PAST.MEDICAL.HISTORY.CODE <-
as.character(raw.data$PAST.MEDICAL.HISTORY.CODE)

raw.data$PAST.MEDICAL.HISTORY.CODE[is.na(raw.data$PAST.MEDICAL.HISTORY.CODE)]
<- "None"

raw.data$PAST.MEDICAL.HISTORY.CODE <-
as.factor(raw.data$PAST.MEDICAL.HISTORY.CODE)
```

Create a new data frame and store the raw data copy. This is being done to have a copy of the raw data intact for further manipulation if needed.

```
new.data <- raw.data[, c(-1, -4, -5, -7, -9:-21, -23, -25, -31:-36, -41, -42,
    -44, -46, -48, -56, -58:-62)]
new.data <- na.omit(new.data)  # listwise deletion of missing
```

3a. Correlation among Variables

From the numeric attribute in the data, it will of interest to analyze the variables which are corelated to each other. High corelation amongst variable may result in the issue of **multi-colinearity** in the model.

```
correlationMatrix <- cor(new.data[, c(1, 7:10, 12:14, 18:24, 26)])
print(correlationMatrix)
```

```
##                                        AGE     HR.PULSE    BP..HIGH
## AGE                             1.00000000 -0.451244005  0.58656780
## HR.PULSE                       -0.45124400  1.000000000 -0.29163412
## BP..HIGH                        0.58656780 -0.291634124  1.00000000
## BP.LOW                          0.46545550 -0.207449219  0.77298853
## RR                             -0.23480792  0.373233721 -0.08309698
```

```
## HB                                  -0.21849870  0.099654811 -0.08392965
## UREA                                 0.28568989 -0.024115762  0.09639492
## CREATININE                           0.70849144 -0.334538256  0.44300126
## TOTAL.COST.TO.HOSPITAL               0.49918592 -0.060194555  0.21756095
## TOTAL.AMOUNT.BILLED.TO.THE.PATIENT   0.49932971 -0.057115599  0.22629958
## CONCESSION                          -0.38706554  0.199744235 -0.29482834
## ACTUAL.RECEIVABLE.AMOUNT             0.54955029 -0.103888398  0.28100749
## TOTAL.LENGTH.OF.STAY                 0.34517109  0.009432666  0.12161925
## LENGTH.OF.STAY...ICU                 0.49472755 -0.080920600  0.18986251
## LENGTH.OF.STAY..WARD                -0.01321377  0.097867560 -0.02581442
## COST.OF.IMPLANT                      0.14886888 -0.044193648 -0.01621976
##                                           BP.LOW          RR          HB
## AGE                                  0.465455500 -0.23480792 -0.21849870
## HR.PULSE                            -0.207449219  0.37323372  0.09965481
## BP..HIGH                             0.772988535 -0.08309698 -0.08392965
## BP.LOW                               1.000000000 -0.01569492  0.03468884
## RR                                  -0.015694922  1.00000000  0.03551983
## HB                                   0.034688841  0.03551983  1.00000000
## UREA                                 0.043500316  0.06318983 -0.09670059
## CREATININE                           0.319224146 -0.15830983 -0.22771802
## TOTAL.COST.TO.HOSPITAL               0.211650056  0.04572571 -0.09422928
## TOTAL.AMOUNT.BILLED.TO.THE.PATIENT   0.199455448  0.06994042 -0.10141016
## CONCESSION                          -0.265444201  0.19567060  0.17308650
## ACTUAL.RECEIVABLE.AMOUNT             0.262555455  0.03910597 -0.11850792
## TOTAL.LENGTH.OF.STAY                 0.107979390  0.17024882 -0.02483995
## LENGTH.OF.STAY...ICU                 0.141540924  0.05138801 -0.13113079
## LENGTH.OF.STAY..WARD                 0.007833746  0.19557658  0.10441442
## COST.OF.IMPLANT                      0.061072583  0.05194928 -0.07064192
##                                            UREA  CREATININE
## AGE                                  0.28568989  0.70849144
## HR.PULSE                            -0.02411576 -0.33453826
## BP..HIGH                             0.09639492  0.44300126
## BP.LOW                               0.04350032  0.31922415
## RR                                   0.06318983 -0.15830983
## HB                                  -0.09670059 -0.22771802
## UREA                                 1.00000000  0.63917958
## CREATININE                           0.63917958  1.00000000
## TOTAL.COST.TO.HOSPITAL               0.28068028  0.51605814
## TOTAL.AMOUNT.BILLED.TO.THE.PATIENT   0.28324263  0.49946442
## CONCESSION                          -0.07309794 -0.27399988
## ACTUAL.RECEIVABLE.AMOUNT             0.28301870  0.52374603
## TOTAL.LENGTH.OF.STAY                 0.23601057  0.35459975
## LENGTH.OF.STAY...ICU                 0.25439972  0.48685662
## LENGTH.OF.STAY..WARD                 0.08392070  0.01665721
## COST.OF.IMPLANT                      0.24741685  0.19856159
##                                     TOTAL.COST.TO.HOSPITAL
## AGE                                              0.49918592
## HR.PULSE                                        -0.06019455
## BP..HIGH                                         0.21756095
## BP.LOW                                           0.21165006
```

```
## RR                                                 0.04572571
## HB                                                -0.09422928
## UREA                                               0.28068028
## CREATININE                                         0.51605814
## TOTAL.COST.TO.HOSPITAL                             1.00000000
## TOTAL.AMOUNT.BILLED.TO.THE.PATIENT                 0.79971528
## CONCESSION                                        -0.08280661
## ACTUAL.RECEIVABLE.AMOUNT                           0.77012057
## TOTAL.LENGTH.OF.STAY                               0.69772333
## LENGTH.OF.STAY...ICU                               0.84745307
## LENGTH.OF.STAY..WARD                               0.14441239
## COST.OF.IMPLANT                                    0.47986318
##                                    TOTAL.AMOUNT.BILLED.TO.THE.PATIENT
## AGE                                                         0.49932971
## HR.PULSE                                                   -0.05711560
## BP..HIGH                                                    0.22629958
## BP.LOW                                                      0.19945545
## RR                                                          0.06994042
## HB                                                         -0.10141016
## UREA                                                        0.28324263
## CREATININE                                                  0.49946442
## TOTAL.COST.TO.HOSPITAL                                      0.79971528
## TOTAL.AMOUNT.BILLED.TO.THE.PATIENT                          1.00000000
## CONCESSION                                                  0.07128904
## ACTUAL.RECEIVABLE.AMOUNT                                    0.93057489
## TOTAL.LENGTH.OF.STAY                                        0.63274839
## LENGTH.OF.STAY...ICU                                        0.64058348
## LENGTH.OF.STAY..WARD                                        0.25678908
## COST.OF.IMPLANT                                             0.33145494
##                                     CONCESSION ACTUAL.RECEIVABLE.AMOUNT
## AGE                                -0.38706554                0.54955029
## HR.PULSE                            0.19974424               -0.10388840
## BP..HIGH                           -0.29482834                0.28100749
## BP.LOW                             -0.26544420                0.26255546
## RR                                  0.19567060                0.03910597
## HB                                  0.17308650               -0.11850792
## UREA                               -0.07309794                0.28301870
## CREATININE                         -0.27399988                0.52374603
## TOTAL.COST.TO.HOSPITAL             -0.08280661                0.77012057
## TOTAL.AMOUNT.BILLED.TO.THE.PATIENT  0.07128904                0.93057489
## CONCESSION                          1.00000000               -0.11758682
## ACTUAL.RECEIVABLE.AMOUNT           -0.11758682                1.00000000
## TOTAL.LENGTH.OF.STAY                0.01068904                0.61237607
## LENGTH.OF.STAY...ICU               -0.08786860                0.64942890
## LENGTH.OF.STAY..WARD                0.10330812                0.21882633
## COST.OF.IMPLANT                    -0.11763011                0.32354920
##                                    TOTAL.LENGTH.OF.STAY
## AGE                                         0.345171087
## HR.PULSE                                    0.009432666
## BP..HIGH                                    0.121619250
```

```
## BP.LOW                                          0.107979390
## RR                                              0.170248825
## HB                                             -0.024839945
## UREA                                            0.236010569
## CREATININE                                      0.354599755
## TOTAL.COST.TO.HOSPITAL                          0.697723335
## TOTAL.AMOUNT.BILLED.TO.THE.PATIENT              0.632748391
## CONCESSION                                      0.010689039
## ACTUAL.RECEIVABLE.AMOUNT                        0.612376067
## TOTAL.LENGTH.OF.STAY                            1.000000000
## LENGTH.OF.STAY...ICU                            0.721035337
## LENGTH.OF.STAY..WARD                            0.707134187
## COST.OF.IMPLANT                                 0.112062033
##                                    LENGTH.OF.STAY...ICU
## AGE                                             0.49472755
## HR.PULSE                                       -0.08092060
## BP..HIGH                                        0.18986251
## BP.LOW                                          0.14154092
## RR                                              0.05138801
## HB                                             -0.13113079
## UREA                                            0.25439972
## CREATININE                                      0.48685662
## TOTAL.COST.TO.HOSPITAL                          0.84745307
## TOTAL.AMOUNT.BILLED.TO.THE.PATIENT              0.64058348
## CONCESSION                                     -0.08786860
## ACTUAL.RECEIVABLE.AMOUNT                        0.64942890
## TOTAL.LENGTH.OF.STAY                            0.72103534
## LENGTH.OF.STAY...ICU                            1.00000000
## LENGTH.OF.STAY..WARD                            0.02179490
## COST.OF.IMPLANT                                 0.18278343
##                                    LENGTH.OF.STAY..WARD COST.OF.IMPLANT
## AGE                                         -0.013213772     0.14886888
## HR.PULSE                                     0.097867560    -0.04419365
## BP..HIGH                                    -0.025814415    -0.01621976
## BP.LOW                                       0.007833746     0.06107258
## RR                                           0.195576581     0.05194928
## HB                                           0.104414424    -0.07064192
## UREA                                         0.083920703     0.24741685
## CREATININE                                   0.016657206     0.19856159
## TOTAL.COST.TO.HOSPITAL                       0.144412386     0.47986318
## TOTAL.AMOUNT.BILLED.TO.THE.PATIENT           0.256789081     0.33145494
## CONCESSION                                   0.103308121    -0.11763011
## ACTUAL.RECEIVABLE.AMOUNT                     0.218826327     0.32354920
## TOTAL.LENGTH.OF.STAY                         0.707134187     0.11206203
## LENGTH.OF.STAY...ICU                         0.021794904     0.18278343
## LENGTH.OF.STAY..WARD                         1.000000000    -0.02250497
## COST.OF.IMPLANT                             -0.022504973     1.00000000

# find attributes that are highly corrected (ideally >0.7)
highlyCorrelated <- findCorrelation(correlationMatrix, cutoff = 0.7, names =
```

```
TRUE)
print(highlyCorrelated)
```

```
## [1] "AGE"                        "ACTUAL.RECEIVABLE.AMOUNT"
## [3] "TOTAL.COST.TO.HOSPITAL"     "LENGTH.OF.STAY...ICU"
## [5] "TOTAL.LENGTH.OF.STAY"       "BP..HIGH"
```

3b. Derived variables

Deriving BMI to drop of Weight and Height as variables. Both of them where highly corelated to age. Droping Cretanine as a variable as it is highly corleated to age.

```
new.data$BMI <- new.data$BODY.WEIGHT/((new.data$BODY.HEIGHT/10) ^ 2)
new.data$I_COST.OF.IMPLANT <-
model.matrix(~new.data$IMPLANT.USED..Y.N.)[,2]*new.data$COST.OF.IMPLANT
filter.data <- new.data[,c(-5:-6)]
```

3c. Relevel

By default, the base category/reference category selected is ordered alphabetically. In this code chunk we are just changing the base category for PAST.MEDICAL.HISTORY.CODE variable.

The base category can be releveled using the function **relevel()**.

```
filter.data$PAST.MEDICAL.HISTORY.CODE <-
relevel(filter.data$PAST.MEDICAL.HISTORY.CODE,
    ref = "None")
```

4. Create train and test datase vct

Reserve 80% for *training* and 20% of *test*

Correct the error in the below code chunk

```
set.seed(2341)
trainIndex <- createDataPartition(filter.data$TOTAL.COST.TO.HOSPITAL, p = 1,
    list = FALSE)
data.train <- filter.data[trainIndex, ]
data.test <- filter.data[-trainIndex, ]
```

Transformation of variables may be needed to validate the model assumptions.

```
data.train$Log.Cost.Treatment <- log(data.train$TOTAL.COST.TO.HOSPITAL)
data.test$Log.Cost.Treatment <- log(data.test$TOTAL.COST.TO.HOSPITAL)
```

We can pull the specific attribute needed to build the model in another data frame. This agian is more of a hygine practice to not touch the **train** and **test** data set directly.

Correct the error in the below code chunk

```
reg.train.data <- as.data.frame(data.train[,c("AGE",
                                              "HR.PULSE",
                                              "BP..HIGH",
                                              "RR",
                                              "HB",
                                              "UREA",
                                              #"TOTAL.LENGTH.OF.STAY",
                                              "BMI",
                                              #"COST.OF.IMPLANT",
                                              #"IMPLANT.USED..Y.N.",
                                              "I_COST.OF.IMPLANT",
                                              "GENDER",
                                              "MARITAL.STATUS",
                                              "KEY.COMPLAINTS..CODE",
                                              "PAST.MEDICAL.HISTORY.CODE",
                                              "MODE.OF.ARRIVAL",
                                              #"STATE.AT.THE.TIME.OF.ARRIVAL",
                                              "TYPE.OF.ADMSN",
                                              "TOTAL.COST.TO.HOSPITAL"
                                              #"Log.Cost.Treatment"
)])
```

Correct the error in the below code chunk

```
reg.test.data <- as.data.frame(data.test[,c("AGE",
                                              "HR.PULSE",
                                              "BP..HIGH",
                                              "RR",
                                              "HB",
                                              "UREA",
                                              #"TOTAL.LENGTH.OF.STAY",
                                              "BMI",
                                              #"COST.OF.IMPLANT",
                                              #"IMPLANT.USED..Y.N.",
                                              "I_COST.OF.IMPLANT",
                                              "GENDER",
                                              "MARITAL.STATUS",
                                              "KEY.COMPLAINTS..CODE",
                                              "PAST.MEDICAL.HISTORY.CODE",
                                              "MODE.OF.ARRIVAL",
                                              #"STATE.AT.THE.TIME.OF.ARRIVAL",
                                              "TYPE.OF.ADMSN",
                                              "TOTAL.COST.TO.HOSPITAL"
                                              #"Log.Cost.Treatment"
)])
```

Model Building: Using the caret() package

There are a number of models which can be built using caret package. To get the names of all the models possible.

```
names(getModelInfo())
```

```
##   [1] "ada"                "AdaBag"             "AdaBoost.M1"
##   [4] "adaboost"           "amdai"              "ANFIS"
##   [7] "avNNet"             "awnb"               "awtan"
##  [10] "bag"                "bagEarth"           "bagEarthGCV"
##  [13] "bagFDA"             "bagFDAGCV"          "bartMachine"
##  [16] "bayesglm"           "bdk"                "binda"
##  [19] "blackboost"         "blasso"             "blassoAveraged"
##  [22] "Boruta"             "bridge"             "brnn"
##  [25] "BstLm"              "bstSm"              "bstTree"
##  [28] "C5.0"               "C5.0Cost"           "C5.0Rules"
##  [31] "C5.0Tree"           "cforest"            "chaid"
##  [34] "CSimca"             "ctree"              "ctree2"
##  [37] "cubist"             "dda"                "deepboost"
##  [40] "DENFIS"             "dnn"                "dwdLinear"
##  [43] "dwdPoly"            "dwdRadial"          "earth"
##  [46] "elm"                "enet"               "enpls.fs"
##  [49] "enpls"              "evtree"             "extraTrees"
##  [52] "fda"                "FH.GBML"            "FIR.DM"
##  [55] "foba"               "FRBCS.CHI"          "FRBCS.W"
##  [58] "FS.HGD"             "gam"                "gamboost"
##  [61] "gamLoess"           "gamSpline"          "gaussprLinear"
##  [64] "gaussprPoly"        "gaussprRadial"      "gbm"
##  [67] "gcvEarth"           "GFS.FR.MOGUL"       "GFS.GCCL"
##  [70] "GFS.LT.RS"          "GFS.THRIFT"         "glm"
##  [73] "glmboost"           "glmnet"             "glmStepAIC"
##  [76] "gpls"               "hda"                "hdda"
##  [79] "hdrda"              "HYFIS"              "icr"
##  [82] "J48"                "JRip"               "kernelpls"
##  [85] "kknn"               "knn"                "krlsPoly"
##  [88] "krlsRadial"         "lars"               "lars2"
##  [91] "lasso"              "lda"                "lda2"
##  [94] "leapBackward"       "leapForward"        "leapSeq"
##  [97] "Linda"              "lm"                 "lmStepAIC"
## [100] "LMT"                "loclda"             "logicBag"
## [103] "LogitBoost"         "logreg"             "lssvmLinear"
## [106] "lssvmPoly"          "lssvmRadial"        "lvq"
## [109] "M5"                 "M5Rules"            "manb"
## [112] "mda"                "Mlda"               "mlp"
## [115] "mlpML"              "mlpSGD"             "mlpWeightDecay"
## [118] "mlpWeightDecayML"   "multinom"           "nb"
## [121] "nbDiscrete"         "nbSearch"           "neuralnet"
## [124] "nnet"               "nnls"               "nodeHarvest"
## [127] "oblique.tree"       "OneR"               "ordinalNet"
```

```
## [130] "ORFlog"              "ORFpls"              "ORFridge"
## [133] "ORFsvm"              "ownn"                "pam"
## [136] "parRF"               "PART"                "partDSA"
## [139] "pcaNNet"             "pcr"                 "pda"
## [142] "pda2"                "penalized"           "PenalizedLDA"
## [145] "plr"                 "pls"                 "plsRglm"
## [148] "polr"                "ppr"                 "protoclass"
## [151] "pythonKnnReg"        "qda"                 "QdaCov"
## [154] "qrf"                 "qrnn"                "randomGLM"
## [157] "ranger"              "rbf"                 "rbfDDA"
## [160] "Rborist"             "rda"                 "relaxo"
## [163] "rf"                  "rFerns"              "RFlda"
## [166] "rfRules"             "ridge"               "rlda"
## [169] "rlm"                 "rmda"                "rocc"
## [172] "rotationForest"      "rotationForestCp"    "rpart"
## [175] "rpart1SE"            "rpart2"              "rpartCost"
## [178] "rpartScore"          "rqlasso"             "rqnc"
## [181] "RRF"                 "RRFglobal"           "rrlda"
## [184] "RSimca"              "rvmLinear"           "rvmPoly"
## [187] "rvmRadial"           "SBC"                 "sda"
## [190] "sddaLDA"             "sddaQDA"             "sdwd"
## [193] "simpls"              "SLAVE"               "slda"
## [196] "smda"                "snn"                 "sparseLDA"
## [199] "spikeslab"           "spls"                "stepLDA"
## [202] "stepQDA"             "superpc"             "svmBoundrangeString"
## [205] "svmExpoString"       "svmLinear"           "svmLinear2"
## [208] "svmLinearWeights"    "svmPoly"             "svmRadial"
## [211] "svmRadialCost"       "svmRadialSigma"      "svmRadialWeights"
## [214] "svmSpectrumString"   "tan"                 "tanSearch"
## [217] "treebag"             "vbmpRadial"          "vglmAdjCat"
## [220] "vglmContRatio"       "vglmCumulative"      "widekernelpls"
## [223] "WM"                  "wsrf"                "xgbLinear"
## [226] "xgbTree"             "xyf"
```

To get the info on specific model:

```
getModelInfo()$lmStepAIC$type
```

```
## [1] "Regression"
```

The below chunk of code is standarized way of building model using caret package. Setting in the control parameters for the model. Cross validation sample with k folds will split the data into equal sized sample. The model will be repeatedly built on k-1 folds and tested on left out fold. The error reported in the model is an average error across all the models.

```
objControl <- trainControl(method = "cv", number = 3, returnResamp = 'final',
                           summaryFunction = defaultSummary,
                           #summaryFunction = twoClassSummary, defaultSummary
                           classProbs = FALSE,
                           savePredictions = TRUE)
```

The search grid is basically a model fine tuning option. The paramter inside the **expan.grid()** function varies according to model. The **complete** list of tuning paramter for different models.

```
#This parameter is for glmnet. Need not be executed if method  is lmStepAIC
searchGrid <-  expand.grid(alpha = c(1:10)*0.1,
                           lambda = c(1:5)/10)
```

The model building starts here. > 1. **metric= "ROC"** uses ROC curve to select the best model.Accuracy, Kappa are other options. To use this change twoClassSummary to defaultSummary in **ObjControl** 2. **verbose = FALSE**: does not show the processing output on console

The factor names at times may not be consistent. R may expect **"Not.Joined"** but the actual level may be **"Not Joined"** This is corrected by using **make.names()** function to give syntactically valid names.

```
#lg.train.data$StatusFactor <- as.factor(ifelse(lg.train.data$Status ==
"Joined", 1,0))
set.seed(766)
#levels(reg.train.data$Status) <-
make.names(levels(factor(reg.train.data$Status)))
regCaretModel <- train(reg.train.data[,1:14],
                       reg.train.data[,15],
                       method = 'lmStepAIC',
                       trControl = objControl,
                       metric = "Rsquared",
                       tuneGrid = NULL,
                       verbose = FALSE)

## Start:  AIC=2502.58
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + MARITAL.STATUS + KEY.COMPLAINTS..CODE +
##     PAST.MEDICAL.HISTORY.CODE + MODE.OF.ARRIVAL + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - KEY.COMPLAINTS..CODE       11 1.3437e+11 9.9587e+11 2496.1
## - MODE.OF.ARRIVAL             2 1.3266e+10 8.7477e+11 2500.2
## - HB                          1 1.3157e+07 8.6152e+11 2500.6
## - UREA                        1 1.8242e+08 8.6169e+11 2500.6
## - GENDER                      1 3.5215e+08 8.6186e+11 2500.6
## - BP..HIGH                    1 4.6141e+08 8.6197e+11 2500.6
## - MARITAL.STATUS              1 2.4569e+09 8.6396e+11 2500.9
## - BMI                         1 5.6561e+09 8.6716e+11 2501.3
## - PAST.MEDICAL.HISTORY.CODE   6 9.9677e+10 9.6118e+11 2502.3
## <none>                                     8.6151e+11 2502.6
## - HR.PULSE                    1 1.6272e+10 8.7778e+11 2502.6
## - TYPE.OF.ADMSN               1 2.1265e+10 8.8277e+11 2503.2
## - RR                          1 3.5343e+10 8.9685e+11 2504.9
## - AGE                         1 6.3700e+10 9.2521e+11 2508.2
```

```
## - I_COST.OF.IMPLANT          1 3.0762e+11 1.1691e+12 2533.2
##
## Step:  AIC=2496.08
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + MARITAL.STATUS +
PAST.MEDICAL.HISTORY.CODE +
##     MODE.OF.ARRIVAL + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - MODE.OF.ARRIVAL             2 6.8314e+09 1.0027e+12 2492.8
## - HB                          1 5.3622e+07 9.9593e+11 2494.1
## - GENDER                      1 5.1888e+08 9.9639e+11 2494.1
## - BP..HIGH                    1 4.4984e+09 1.0004e+12 2494.6
## - BMI                         1 4.6846e+09 1.0006e+12 2494.6
## - MARITAL.STATUS              1 5.9360e+09 1.0018e+12 2494.7
## - UREA                        1 1.0620e+10 1.0065e+12 2495.2
## <none>                                     9.9587e+11 2496.1
## - TYPE.OF.ADMSN               1 2.0508e+10 1.0164e+12 2496.3
## - HR.PULSE                    1 2.0978e+10 1.0169e+12 2496.3
## - RR                          1 2.6299e+10 1.0222e+12 2496.9
## - PAST.MEDICAL.HISTORY.CODE   6 1.3227e+11 1.1281e+12 2497.4
## - AGE                         1 7.4468e+10 1.0703e+12 2501.8
## - I_COST.OF.IMPLANT           1 3.7156e+11 1.3674e+12 2528.0
##
## Step:  AIC=2492.82
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + MARITAL.STATUS +
PAST.MEDICAL.HISTORY.CODE +
##     TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - HB                          1 7.6696e+07 1.0028e+12 2490.8
## - GENDER                      1 1.2125e+09 1.0039e+12 2490.9
## - BMI                         1 4.8586e+09 1.0076e+12 2491.3
## - BP..HIGH                    1 5.4691e+09 1.0082e+12 2491.4
## - MARITAL.STATUS              1 6.8013e+09 1.0095e+12 2491.5
## - UREA                        1 1.3114e+10 1.0158e+12 2492.2
## <none>                                     1.0027e+12 2492.8
## - HR.PULSE                    1 1.9637e+10 1.0223e+12 2492.9
## - RR                          1 2.5581e+10 1.0283e+12 2493.5
## - PAST.MEDICAL.HISTORY.CODE   6 1.4286e+11 1.1456e+12 2495.1
## - TYPE.OF.ADMSN               1 4.7679e+10 1.0504e+12 2495.8
## - AGE                         1 7.7172e+10 1.0799e+12 2498.8
## - I_COST.OF.IMPLANT           1 3.7373e+11 1.3764e+12 2524.7
##
## Step:  AIC=2490.82
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + UREA + BMI + I_COST.OF.IMPLANT
+
##     GENDER + MARITAL.STATUS + PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN
##
```

```
##                              Df  Sum of Sq        RSS    AIC
## - GENDER                      1 1.1743e+09 1.0040e+12 2488.9
## - BMI                         1 4.7839e+09 1.0076e+12 2489.3
## - BP..HIGH                    1 5.6670e+09 1.0084e+12 2489.4
## - MARITAL.STATUS              1 6.8008e+09 1.0096e+12 2489.6
## - UREA                        1 1.3055e+10 1.0158e+12 2490.2
## <none>                                     1.0028e+12 2490.8
## - HR.PULSE                    1 1.9647e+10 1.0224e+12 2490.9
## - RR                          1 2.5608e+10 1.0284e+12 2491.5
## - PAST.MEDICAL.HISTORY.CODE   6 1.4290e+11 1.1457e+12 2493.1
## - TYPE.OF.ADMSN               1 4.7630e+10 1.0504e+12 2493.8
## - AGE                         1 7.9518e+10 1.0823e+12 2497.0
## - I_COST.OF.IMPLANT           1 3.7437e+11 1.3771e+12 2522.8
##
## Step:  AIC=2488.95
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + UREA + BMI + I_COST.OF.IMPLANT
+
##     MARITAL.STATUS + PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - BP..HIGH                    1 5.6163e+09 1.0096e+12 2487.6
## - BMI                         1 5.7088e+09 1.0097e+12 2487.6
## - MARITAL.STATUS              1 6.6300e+09 1.0106e+12 2487.7
## - UREA                        1 1.4193e+10 1.0181e+12 2488.4
## <none>                                     1.0040e+12 2488.9
## - HR.PULSE                    1 2.0839e+10 1.0248e+12 2489.2
## - RR                          1 2.5977e+10 1.0299e+12 2489.7
## - PAST.MEDICAL.HISTORY.CODE   6 1.4197e+11 1.1459e+12 2491.1
## - TYPE.OF.ADMSN               1 4.9541e+10 1.0535e+12 2492.1
## - AGE                         1 8.2212e+10 1.0862e+12 2495.4
## - I_COST.OF.IMPLANT           1 3.7346e+11 1.3774e+12 2520.8
##
## Step:  AIC=2487.55
## .outcome ~ AGE + HR.PULSE + RR + UREA + BMI + I_COST.OF.IMPLANT +
##     MARITAL.STATUS + PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - BMI                         1 6.1175e+09 1.0157e+12 2486.2
## - MARITAL.STATUS              1 8.1096e+09 1.0177e+12 2486.4
## - UREA                        1 1.4465e+10 1.0240e+12 2487.1
## <none>                                     1.0096e+12 2487.6
## - HR.PULSE                    1 2.1858e+10 1.0314e+12 2487.8
## - RR                          1 2.7191e+10 1.0368e+12 2488.4
## - PAST.MEDICAL.HISTORY.CODE   6 1.3651e+11 1.1461e+12 2489.1
## - TYPE.OF.ADMSN               1 6.1035e+10 1.0706e+12 2491.8
## - AGE                         1 7.6905e+10 1.0865e+12 2493.4
## - I_COST.OF.IMPLANT           1 3.9679e+11 1.4064e+12 2521.0
##
## Step:  AIC=2486.19
## .outcome ~ AGE + HR.PULSE + RR + UREA + I_COST.OF.IMPLANT + MARITAL.STATUS
```

```
+
##     PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - MARITAL.STATUS              1 7.8225e+09 1.0235e+12 2485.0
## - UREA                        1 1.3919e+10 1.0296e+12 2485.7
## <none>                                     1.0157e+12 2486.2
## - HR.PULSE                    1 2.1951e+10 1.0376e+12 2486.5
## - RR                          1 2.6870e+10 1.0426e+12 2487.0
## - PAST.MEDICAL.HISTORY.CODE   6 1.3647e+11 1.1522e+12 2487.7
## - TYPE.OF.ADMSN               1 6.0448e+10 1.0761e+12 2490.4
## - AGE                         1 7.6920e+10 1.0926e+12 2492.0
## - I_COST.OF.IMPLANT           1 3.9997e+11 1.4157e+12 2519.7
##
## Step:  AIC=2485.01
## .outcome ~ AGE + HR.PULSE + RR + UREA + I_COST.OF.IMPLANT +
PAST.MEDICAL.HISTORY.CODE +
##     TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - UREA                        1 1.4427e+10 1.0379e+12 2484.5
## <none>                                     1.0235e+12 2485.0
## - HR.PULSE                    1 2.3008e+10 1.0465e+12 2485.4
## - RR                          1 2.4919e+10 1.0484e+12 2485.6
## - PAST.MEDICAL.HISTORY.CODE   6 1.3866e+11 1.1622e+12 2486.6
## - TYPE.OF.ADMSN               1 6.5565e+10 1.0891e+12 2489.7
## - AGE                         1 1.2118e+11 1.1447e+12 2495.0
## - I_COST.OF.IMPLANT           1 3.9259e+11 1.4161e+12 2517.8
##
## Step:  AIC=2484.51
## .outcome ~ AGE + HR.PULSE + RR + I_COST.OF.IMPLANT +
PAST.MEDICAL.HISTORY.CODE +
##     TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - HR.PULSE                    1 1.9370e+10 1.0573e+12 2484.5
## <none>                                     1.0379e+12 2484.5
## - RR                          1 2.2298e+10 1.0602e+12 2484.8
## - PAST.MEDICAL.HISTORY.CODE   6 1.4747e+11 1.1854e+12 2486.7
## - TYPE.OF.ADMSN               1 5.1139e+10 1.0891e+12 2487.7
## - AGE                         1 1.0952e+11 1.1475e+12 2493.2
## - I_COST.OF.IMPLANT           1 3.8023e+11 1.4182e+12 2515.9
##
## Step:  AIC=2484.49
## .outcome ~ AGE + RR + I_COST.OF.IMPLANT + PAST.MEDICAL.HISTORY.CODE +
##     TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## <none>                                     1.0573e+12 2484.5
## - RR                          1 3.3153e+10 1.0905e+12 2485.8
```

```
## - PAST.MEDICAL.HISTORY.CODE  6 1.5584e+11 1.2131e+12 2487.2
## - TYPE.OF.ADMSN              1 5.8403e+10 1.1157e+12 2488.2
## - AGE                        1 9.0150e+10 1.1475e+12 2491.2
## - I_COST.OF.IMPLANT          1 3.7657e+11 1.4339e+12 2515.1
## Start:  AIC=2503.44
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + MARITAL.STATUS + KEY.COMPLAINTS..CODE +
##     PAST.MEDICAL.HISTORY.CODE + MODE.OF.ARRIVAL + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - MODE.OF.ARRIVAL             2 9.6480e+09 7.4606e+11 2500.8
## - MARITAL.STATUS              1 3.9484e+06 7.3642e+11 2501.4
## - HB                          1 1.5275e+09 7.3794e+11 2501.7
## - BMI                         1 2.0413e+09 7.3846e+11 2501.7
## - RR                          1 2.3889e+09 7.3880e+11 2501.8
## - BP..HIGH                    1 2.4218e+09 7.3884e+11 2501.8
## - TYPE.OF.ADMSN               1 4.5587e+09 7.4097e+11 2502.1
## - GENDER                      1 8.4151e+09 7.4483e+11 2502.7
## - UREA                        1 1.2402e+10 7.4882e+11 2503.2
## <none>                                     7.3642e+11 2503.4
## - KEY.COMPLAINTS..CODE        9 1.4448e+11 8.8090e+11 2504.8
## - AGE                         1 3.0396e+10 7.6681e+11 2505.8
## - HR.PULSE                    1 4.6106e+10 7.8252e+11 2508.0
## - PAST.MEDICAL.HISTORY.CODE  6 1.9715e+11 9.3357e+11 2517.1
## - I_COST.OF.IMPLANT           1 1.6412e+11 9.0053e+11 2523.2
##
## Step:  AIC=2500.84
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + MARITAL.STATUS + KEY.COMPLAINTS..CODE +
##     PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - MARITAL.STATUS              1 7.3771e+04 7.4606e+11 2498.8
## - TYPE.OF.ADMSN               1 4.6970e+08 7.4653e+11 2498.9
## - HB                          1 1.0442e+09 7.4711e+11 2499.0
## - BMI                         1 1.9759e+09 7.4804e+11 2499.1
## - BP..HIGH                    1 2.1962e+09 7.4826e+11 2499.2
## - RR                          1 6.0169e+09 7.5208e+11 2499.7
## - GENDER                      1 7.4841e+09 7.5355e+11 2499.9
## <none>                                     7.4606e+11 2500.8
## - UREA                        1 1.5112e+10 7.6118e+11 2501.0
## - KEY.COMPLAINTS..CODE        9 1.3771e+11 8.8378e+11 2501.1
## - AGE                         1 3.2108e+10 7.7817e+11 2503.4
## - HR.PULSE                    1 4.9062e+10 7.9513e+11 2505.7
## - PAST.MEDICAL.HISTORY.CODE  6 1.9010e+11 9.3616e+11 2513.4
## - I_COST.OF.IMPLANT           1 1.6807e+11 9.1413e+11 2520.8
##
## Step:  AIC=2498.84
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + KEY.COMPLAINTS..CODE +
```

```
PAST.MEDICAL.HISTORY.CODE +
##     TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - TYPE.OF.ADMSN               1 4.7404e+08 7.4654e+11 2496.9
## - HB                          1 1.0702e+09 7.4713e+11 2497.0
## - BMI                         1 1.9780e+09 7.4804e+11 2497.1
## - BP..HIGH                    1 2.2039e+09 7.4827e+11 2497.2
## - RR                          1 6.0307e+09 7.5209e+11 2497.7
## - GENDER                      1 7.4840e+09 7.5355e+11 2497.9
## <none>                                     7.4606e+11 2498.8
## - UREA                        1 1.5385e+10 7.6145e+11 2499.1
## - KEY.COMPLAINTS..CODE        9 1.3859e+11 8.8465e+11 2499.2
## - HR.PULSE                    1 5.1205e+10 7.9727e+11 2504.0
## - AGE                         1 5.8484e+10 8.0455e+11 2505.0
## - PAST.MEDICAL.HISTORY.CODE   6 1.9137e+11 9.3743e+11 2511.5
## - I_COST.OF.IMPLANT           1 1.6958e+11 9.1565e+11 2519.0
##
## Step:  AIC=2496.91
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + KEY.COMPLAINTS..CODE +
PAST.MEDICAL.HISTORY.CODE
##
##                              Df  Sum of Sq        RSS    AIC
## - HB                          1 9.2142e+08 7.4746e+11 2495.0
## - BMI                         1 1.9451e+09 7.4848e+11 2495.2
## - BP..HIGH                    1 2.3039e+09 7.4884e+11 2495.2
## - RR                          1 6.0043e+09 7.5254e+11 2495.8
## - GENDER                      1 7.9023e+09 7.5444e+11 2496.1
## <none>                                     7.4654e+11 2496.9
## - UREA                        1 2.3356e+10 7.6989e+11 2498.2
## - KEY.COMPLAINTS..CODE        9 1.5593e+11 9.0247e+11 2499.4
## - HR.PULSE                    1 5.3350e+10 7.9989e+11 2502.4
## - AGE                         1 6.1796e+10 8.0833e+11 2503.5
## - PAST.MEDICAL.HISTORY.CODE   6 1.9126e+11 9.3780e+11 2509.5
## - I_COST.OF.IMPLANT           1 1.6974e+11 9.1627e+11 2517.0
##
## Step:  AIC=2495.04
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + UREA + BMI + I_COST.OF.IMPLANT
+
##     GENDER + KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE
##
##                              Df  Sum of Sq        RSS    AIC
## - BMI                         1 2.2739e+09 7.4973e+11 2493.4
## - BP..HIGH                    1 2.4840e+09 7.4994e+11 2493.4
## - RR                          1 5.7885e+09 7.5325e+11 2493.9
## - GENDER                      1 7.8295e+09 7.5529e+11 2494.2
## <none>                                     7.4746e+11 2495.0
## - UREA                        1 2.3560e+10 7.7102e+11 2496.4
## - KEY.COMPLAINTS..CODE        9 1.6769e+11 9.1515e+11 2498.9
```

```
## - HR.PULSE                   1 5.5698e+10 8.0316e+11 2500.8
## - AGE                        1 6.1335e+10 8.0879e+11 2501.6
## - PAST.MEDICAL.HISTORY.CODE  6 1.9116e+11 9.3862e+11 2507.6
## - I_COST.OF.IMPLANT          1 1.6897e+11 9.1643e+11 2515.1
##
## Step:  AIC=2493.37
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + UREA + I_COST.OF.IMPLANT +
##     GENDER + KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE
##
##                              Df  Sum of Sq        RSS    AIC
## - BP..HIGH                    1 2.5500e+09 7.5228e+11 2491.7
## - RR                          1 5.4846e+09 7.5522e+11 2492.2
## - GENDER                      1 9.1208e+09 7.5885e+11 2492.7
## <none>                                     7.4973e+11 2493.4
## - UREA                        1 2.3802e+10 7.7354e+11 2494.8
## - KEY.COMPLAINTS..CODE        9 1.6596e+11 9.1570e+11 2497.0
## - HR.PULSE                    1 5.7695e+10 8.0743e+11 2499.4
## - AGE                         1 6.2558e+10 8.1229e+11 2500.0
## - PAST.MEDICAL.HISTORY.CODE   6 1.9237e+11 9.4210e+11 2506.0
## - I_COST.OF.IMPLANT           1 1.7028e+11 9.2002e+11 2513.5
##
## Step:  AIC=2491.74
## .outcome ~ AGE + HR.PULSE + RR + UREA + I_COST.OF.IMPLANT + GENDER +
##     KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE
##
##                              Df  Sum of Sq        RSS    AIC
## - RR                          1 4.2251e+09 7.5651e+11 2490.3
## - GENDER                      1 7.7718e+09 7.6005e+11 2490.8
## <none>                                     7.5228e+11 2491.7
## - UREA                        1 2.3603e+10 7.7589e+11 2493.1
## - KEY.COMPLAINTS..CODE        9 1.7820e+11 9.3049e+11 2496.7
## - HR.PULSE                    1 5.9405e+10 8.1169e+11 2497.9
## - AGE                         1 6.5245e+10 8.1753e+11 2498.7
## - PAST.MEDICAL.HISTORY.CODE   6 1.9117e+11 9.4345e+11 2504.2
## - I_COST.OF.IMPLANT           1 1.8451e+11 9.3680e+11 2513.4
##
## Step:  AIC=2490.34
## .outcome ~ AGE + HR.PULSE + UREA + I_COST.OF.IMPLANT + GENDER +
##     KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE
##
##                              Df  Sum of Sq        RSS    AIC
## - GENDER                      1 8.5281e+09 7.6504e+11 2489.6
## <none>                                     7.5651e+11 2490.3
## - UREA                        1 2.5785e+10 7.8229e+11 2492.0
## - KEY.COMPLAINTS..CODE        9 1.7890e+11 9.3540e+11 2495.3
## - AGE                         1 6.7231e+10 8.2374e+11 2497.5
## - HR.PULSE                    1 8.0454e+10 8.3696e+11 2499.3
## - PAST.MEDICAL.HISTORY.CODE   6 1.9531e+11 9.5181e+11 2503.2
## - I_COST.OF.IMPLANT           1 1.8511e+11 9.4162e+11 2512.0
##
```

```
## Step:  AIC=2489.55
## .outcome ~ AGE + HR.PULSE + UREA + I_COST.OF.IMPLANT +
KEY.COMPLAINTS..CODE +
##     PAST.MEDICAL.HISTORY.CODE
##
##                             Df  Sum of Sq        RSS    AIC
## <none>                                     7.6504e+11 2489.6
## - UREA                       1 2.2243e+10 7.8728e+11 2490.7
## - AGE                        1 6.5992e+10 8.3103e+11 2496.5
## - KEY.COMPLAINTS..CODE       9 2.1092e+11 9.7595e+11 2497.8
## - HR.PULSE                   1 8.1521e+10 8.4656e+11 2498.5
## - PAST.MEDICAL.HISTORY.CODE  6 1.9949e+11 9.6452e+11 2502.6
## - I_COST.OF.IMPLANT          1 1.8638e+11 9.5142e+11 2511.1
## Start:  AIC=2506.79
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + MARITAL.STATUS + KEY.COMPLAINTS..CODE +
##     PAST.MEDICAL.HISTORY.CODE + MODE.OF.ARRIVAL + TYPE.OF.ADMSN
##
##                             Df  Sum of Sq        RSS    AIC
## - UREA                       1 1.6290e+08 4.0095e+11 2504.8
## - GENDER                     1 1.7576e+08 4.0096e+11 2504.8
## - BMI                        1 2.4305e+09 4.0321e+11 2505.5
## - HB                         1 2.6196e+09 4.0340e+11 2505.5
## - MARITAL.STATUS             1 3.8346e+09 4.0462e+11 2505.8
## - TYPE.OF.ADMSN              1 6.7679e+09 4.0755e+11 2506.7
## <none>                                     4.0078e+11 2506.8
## - BP..HIGH                   1 7.4217e+09 4.0820e+11 2506.8
## - HR.PULSE                   1 1.0093e+10 4.1088e+11 2507.6
## - RR                         1 1.0913e+10 4.1170e+11 2507.8
## - MODE.OF.ARRIVAL            2 1.8444e+10 4.1923e+11 2507.8
## - PAST.MEDICAL.HISTORY.CODE  6 5.5178e+10 4.5596e+11 2509.1
## - AGE                        1 1.6554e+10 4.1734e+11 2509.3
## - KEY.COMPLAINTS..CODE      12 1.1325e+11 5.1403e+11 2510.4
## - I_COST.OF.IMPLANT          1 3.1670e+11 7.1749e+11 2569.4
##
## Step:  AIC=2504.84
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + BMI + I_COST.OF.IMPLANT +
##     GENDER + MARITAL.STATUS + KEY.COMPLAINTS..CODE +
PAST.MEDICAL.HISTORY.CODE +
##     MODE.OF.ARRIVAL + TYPE.OF.ADMSN
##
##                             Df  Sum of Sq        RSS    AIC
## - GENDER                     1 2.5371e+08 4.0120e+11 2502.9
## - BMI                        1 2.5387e+09 4.0348e+11 2503.5
## - HB                         1 2.7105e+09 4.0366e+11 2503.6
## - MARITAL.STATUS             1 4.2996e+09 4.0525e+11 2504.0
## - TYPE.OF.ADMSN              1 6.7172e+09 4.0766e+11 2504.7
## <none>                                     4.0095e+11 2504.8
## - BP..HIGH                   1 7.5321e+09 4.0848e+11 2504.9
## - HR.PULSE                   1 1.0188e+10 4.1113e+11 2505.6
```

```
## - MODE.OF.ARRIVAL            2 1.8557e+10 4.1950e+11 2505.9
## - RR                         1 1.1204e+10 4.1215e+11 2505.9
## - PAST.MEDICAL.HISTORY.CODE  6 5.5210e+10 4.5616e+11 2507.2
## - AGE                        1 1.7526e+10 4.1847e+11 2507.6
## - KEY.COMPLAINTS..CODE      12 1.2738e+11 5.2833e+11 2511.5
## - I_COST.OF.IMPLANT          1 3.1893e+11 7.1988e+11 2567.8
##
## Step:  AIC=2502.91
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + BMI + I_COST.OF.IMPLANT +
##     MARITAL.STATUS + KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE +
##     MODE.OF.ARRIVAL + TYPE.OF.ADMSN
##
##                             Df  Sum of Sq        RSS    AIC
## - BMI                        1 2.4180e+09 4.0362e+11 2501.6
## - HB                         1 2.8876e+09 4.0409e+11 2501.7
## - MARITAL.STATUS             1 4.1934e+09 4.0539e+11 2502.1
## - TYPE.OF.ADMSN              1 6.6160e+09 4.0782e+11 2502.7
## <none>                                    4.0120e+11 2502.9
## - BP..HIGH                   1 7.4176e+09 4.0862e+11 2502.9
## - HR.PULSE                   1 1.0173e+10 4.1137e+11 2503.7
## - RR                         1 1.1189e+10 4.1239e+11 2504.0
## - MODE.OF.ARRIVAL            2 1.8723e+10 4.1992e+11 2504.0
## - PAST.MEDICAL.HISTORY.CODE  6 5.5051e+10 4.5625e+11 2505.2
## - AGE                        1 1.7273e+10 4.1847e+11 2505.6
## - KEY.COMPLAINTS..CODE      12 1.3112e+11 5.3232e+11 2510.3
## - I_COST.OF.IMPLANT          1 3.2071e+11 7.2191e+11 2566.1
##
## Step:  AIC=2501.58
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + I_COST.OF.IMPLANT +
##     MARITAL.STATUS + KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE +
##     MODE.OF.ARRIVAL + TYPE.OF.ADMSN
##
##                             Df  Sum of Sq        RSS    AIC
## - HB                         1 3.1553e+09 4.0677e+11 2500.4
## - MARITAL.STATUS             1 3.8175e+09 4.0743e+11 2500.6
## - BP..HIGH                   1 6.6047e+09 4.1022e+11 2501.4
## - TYPE.OF.ADMSN              1 6.6099e+09 4.1023e+11 2501.4
## <none>                                    4.0362e+11 2501.6
## - HR.PULSE                   1 9.9563e+09 4.1357e+11 2502.3
## - MODE.OF.ARRIVAL            2 1.8823e+10 4.2244e+11 2502.6
## - RR                         1 1.1399e+10 4.1502e+11 2502.7
## - PAST.MEDICAL.HISTORY.CODE  6 5.5611e+10 4.5923e+11 2503.9
## - AGE                        1 1.6072e+10 4.1969e+11 2503.9
## - KEY.COMPLAINTS..CODE      12 1.3167e+11 5.3528e+11 2508.9
## - I_COST.OF.IMPLANT          1 3.2357e+11 7.2718e+11 2564.9
##
## Step:  AIC=2500.44
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + I_COST.OF.IMPLANT +
##     MARITAL.STATUS + KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE +
##     MODE.OF.ARRIVAL + TYPE.OF.ADMSN
```

```
##
##                              Df  Sum of Sq        RSS    AIC
## - MARITAL.STATUS              1 3.8439e+09 4.1062e+11 2499.5
## - BP..HIGH                    1 6.1272e+09 4.1290e+11 2500.1
## - TYPE.OF.ADMSN               1 7.0848e+09 4.1386e+11 2500.4
## <none>                                     4.0677e+11 2500.4
## - RR                          1 1.0787e+10 4.1756e+11 2501.3
## - HR.PULSE                    1 1.1039e+10 4.1781e+11 2501.4
## - MODE.OF.ARRIVAL             2 1.8697e+10 4.2547e+11 2501.4
## - AGE                         1 1.7985e+10 4.2476e+11 2503.2
## - PAST.MEDICAL.HISTORY.CODE   6 5.8140e+10 4.6491e+11 2503.3
## - KEY.COMPLAINTS..CODE       12 1.2867e+11 5.3544e+11 2506.9
## - I_COST.OF.IMPLANT           1 3.2371e+11 7.3048e+11 2563.4
##
## Step:  AIC=2499.48
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + I_COST.OF.IMPLANT +
##     KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE + MODE.OF.ARRIVAL +
##     TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - BP..HIGH                    1 6.5640e+09 4.1718e+11 2499.2
## <none>                                     4.1062e+11 2499.5
## - TYPE.OF.ADMSN               1 8.9419e+09 4.1956e+11 2499.9
## - RR                          1 1.0498e+10 4.2111e+11 2500.3
## - HR.PULSE                    1 1.0909e+10 4.2153e+11 2500.4
## - MODE.OF.ARRIVAL             2 2.2940e+10 4.3356e+11 2501.5
## - PAST.MEDICAL.HISTORY.CODE   6 5.8289e+10 4.6891e+11 2502.2
## - AGE                         1 1.8031e+10 4.2865e+11 2502.3
## - KEY.COMPLAINTS..CODE       12 1.3228e+11 5.4290e+11 2506.5
## - I_COST.OF.IMPLANT           1 3.2419e+11 7.3480e+11 2562.1
##
## Step:  AIC=2499.25
## .outcome ~ AGE + HR.PULSE + RR + I_COST.OF.IMPLANT + KEY.COMPLAINTS..CODE
+
##     PAST.MEDICAL.HISTORY.CODE + MODE.OF.ARRIVAL + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - TYPE.OF.ADMSN               1 6.6573e+09 4.2384e+11 2499.0
## <none>                                     4.1718e+11 2499.2
## - RR                          1 8.2903e+09 4.2547e+11 2499.4
## - MODE.OF.ARRIVAL             2 1.9769e+10 4.3695e+11 2500.4
## - HR.PULSE                    1 1.2563e+10 4.2974e+11 2500.5
## - AGE                         1 1.3828e+10 4.3101e+11 2500.9
## - PAST.MEDICAL.HISTORY.CODE   6 5.6919e+10 4.7410e+11 2501.4
## - KEY.COMPLAINTS..CODE       12 1.2734e+11 5.4452e+11 2504.8
## - I_COST.OF.IMPLANT           1 3.4007e+11 7.5725e+11 2563.4
##
## Step:  AIC=2499
## .outcome ~ AGE + HR.PULSE + RR + I_COST.OF.IMPLANT + KEY.COMPLAINTS..CODE
+
```

```
##     PAST.MEDICAL.HISTORY.CODE + MODE.OF.ARRIVAL
##
##                              Df  Sum of Sq        RSS    AIC
## <none>                                     4.2384e+11 2499.0
## - HR.PULSE                    1 1.2993e+10 4.3683e+11 2500.3
## - RR                          1 1.3221e+10 4.3706e+11 2500.4
## - AGE                         1 1.4949e+10 4.3879e+11 2500.8
## - PAST.MEDICAL.HISTORY.CODE  6 5.8505e+10 4.8234e+11 2501.4
## - KEY.COMPLAINTS..CODE      12 1.2104e+11 5.4488e+11 2502.9
## - MODE.OF.ARRIVAL             2 3.4898e+10 4.5874e+11 2503.8
## - I_COST.OF.IMPLANT           1 3.4201e+11 7.6585e+11 2562.7
## Start:  AIC=3762.44
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + MARITAL.STATUS + KEY.COMPLAINTS..CODE +
##     PAST.MEDICAL.HISTORY.CODE + MODE.OF.ARRIVAL + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - MODE.OF.ARRIVAL             2 1.0958e+09 1.1659e+12 3758.6
## - HB                          1 2.0395e+08 1.1650e+12 3760.5
## - TYPE.OF.ADMSN               1 2.5301e+08 1.1650e+12 3760.5
## - GENDER                      1 1.5050e+09 1.1663e+12 3760.6
## - UREA                        1 2.6227e+09 1.1674e+12 3760.8
## - BMI                         1 3.3399e+09 1.1681e+12 3760.9
## - BP..HIGH                    1 3.5713e+09 1.1684e+12 3760.9
## - MARITAL.STATUS              1 5.4837e+09 1.1703e+12 3761.2
## - KEY.COMPLAINTS..CODE      12 1.7525e+11 1.3400e+12 3761.3
## <none>                                     1.1648e+12 3762.4
## - RR                          1 1.9368e+10 1.1842e+12 3763.1
## - HR.PULSE                    1 3.4598e+10 1.1994e+12 3765.2
## - PAST.MEDICAL.HISTORY.CODE  6 1.4163e+11 1.3064e+12 3769.1
## - AGE                         1 6.3938e+10 1.2287e+12 3769.1
## - I_COST.OF.IMPLANT           1 4.2992e+11 1.5947e+12 3811.6
##
## Step:  AIC=3758.59
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + HB + UREA + BMI +
##     I_COST.OF.IMPLANT + GENDER + MARITAL.STATUS + KEY.COMPLAINTS..CODE +
##     PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - HB                          1 1.2774e+08 1.1660e+12 3756.6
## - GENDER                      1 1.7904e+09 1.1677e+12 3756.8
## - UREA                        1 3.1155e+09 1.1690e+12 3757.0
## - BMI                         1 3.2540e+09 1.1691e+12 3757.0
## - BP..HIGH                    1 3.5152e+09 1.1694e+12 3757.1
## - MARITAL.STATUS              1 5.9755e+09 1.1719e+12 3757.4
## - KEY.COMPLAINTS..CODE      12 1.7827e+11 1.3441e+12 3757.8
## - TYPE.OF.ADMSN               1 1.0007e+10 1.1759e+12 3758.0
## <none>                                     1.1659e+12 3758.6
## - RR                          1 2.1220e+10 1.1871e+12 3759.5
## - HR.PULSE                    1 3.5230e+10 1.2011e+12 3761.4
```

```
## - AGE                          1 6.5342e+10 1.2312e+12 3765.5
## - PAST.MEDICAL.HISTORY.CODE  6 1.4706e+11 1.3129e+12 3766.0
## - I_COST.OF.IMPLANT          1 4.3294e+11 1.5988e+12 3808.1
##
## Step:  AIC=3756.61
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + UREA + BMI + I_COST.OF.IMPLANT
+
##     GENDER + MARITAL.STATUS + KEY.COMPLAINTS..CODE +
PAST.MEDICAL.HISTORY.CODE +
##     TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - GENDER                      1 1.7931e+09 1.1678e+12 3754.9
## - UREA                        1 3.1023e+09 1.1691e+12 3755.0
## - BMI                         1 3.1428e+09 1.1691e+12 3755.0
## - BP..HIGH                    1 3.5134e+09 1.1695e+12 3755.1
## - MARITAL.STATUS              1 6.0573e+09 1.1721e+12 3755.5
## - TYPE.OF.ADMSN               1 1.0066e+10 1.1761e+12 3756.0
## - KEY.COMPLAINTS..CODE      12 1.8184e+11 1.3478e+12 3756.2
## <none>                                    1.1660e+12 3756.6
## - RR                          1 2.1342e+10 1.1873e+12 3757.6
## - HR.PULSE                    1 3.5122e+10 1.2011e+12 3759.4
## - AGE                         1 6.7271e+10 1.2333e+12 3763.8
## - PAST.MEDICAL.HISTORY.CODE  6 1.4753e+11 1.3135e+12 3764.0
## - I_COST.OF.IMPLANT          1 4.3356e+11 1.5996e+12 3806.1
##
## Step:  AIC=3754.86
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + UREA + BMI + I_COST.OF.IMPLANT
+
##     MARITAL.STATUS + KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE +
##     TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - UREA                        1 2.5004e+09 1.1703e+12 3753.2
## - BP..HIGH                    1 3.1038e+09 1.1709e+12 3753.3
## - BMI                         1 3.8444e+09 1.1716e+12 3753.4
## - MARITAL.STATUS              1 5.6852e+09 1.1735e+12 3753.7
## - TYPE.OF.ADMSN               1 1.1201e+10 1.1790e+12 3754.4
## <none>                                    1.1678e+12 3754.9
## - KEY.COMPLAINTS..CODE      12 1.9103e+11 1.3588e+12 3755.6
## - RR                          1 2.1683e+10 1.1895e+12 3755.9
## - HR.PULSE                    1 3.5463e+10 1.2033e+12 3757.7
## - AGE                         1 6.5906e+10 1.2337e+12 3761.8
## - PAST.MEDICAL.HISTORY.CODE  6 1.4634e+11 1.3141e+12 3762.1
## - I_COST.OF.IMPLANT          1 4.3759e+11 1.6054e+12 3804.7
##
## Step:  AIC=3753.21
## .outcome ~ AGE + HR.PULSE + BP..HIGH + RR + BMI + I_COST.OF.IMPLANT +
##     MARITAL.STATUS + KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE +
##     TYPE.OF.ADMSN
```

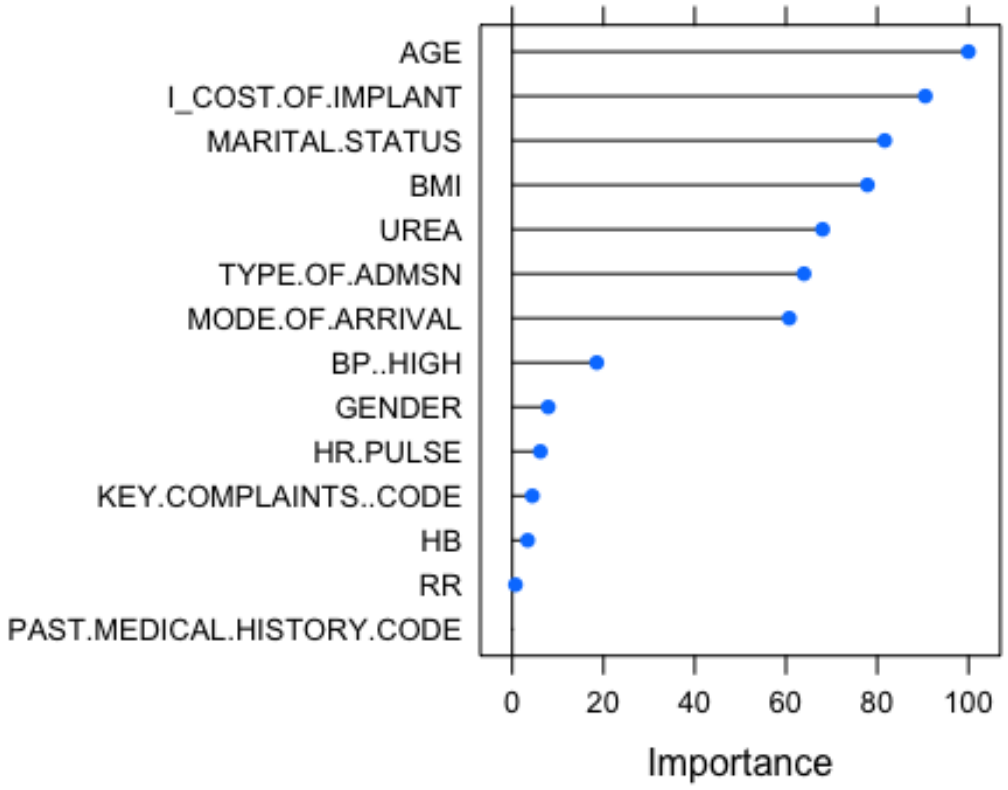
```
##
##                              Df  Sum of Sq        RSS    AIC
## - BP..HIGH                    1 3.0523e+09 1.1734e+12 3751.6
## - BMI                         1 3.9615e+09 1.1743e+12 3751.8
## - MARITAL.STATUS              1 5.0861e+09 1.1754e+12 3751.9
## <none>                                     1.1703e+12 3753.2
## - TYPE.OF.ADMSN               1 2.0911e+10 1.1912e+12 3754.1
## - RR                          1 2.2035e+10 1.1923e+12 3754.2
## - KEY.COMPLAINTS..CODE       12 1.9504e+11 1.3653e+12 3754.3
## - HR.PULSE                    1 3.5421e+10 1.2057e+12 3756.1
## - AGE                         1 6.5540e+10 1.2358e+12 3760.1
## - PAST.MEDICAL.HISTORY.CODE   6 1.5184e+11 1.3221e+12 3761.1
## - I_COST.OF.IMPLANT           1 4.6041e+11 1.6307e+12 3805.3
##
## Step:  AIC=3751.63
## .outcome ~ AGE + HR.PULSE + RR + BMI + I_COST.OF.IMPLANT + MARITAL.STATUS
+
##     KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - BMI                         1 4.2164e+09 1.1776e+12 3750.2
## - MARITAL.STATUS              1 5.4124e+09 1.1788e+12 3750.4
## <none>                                     1.1734e+12 3751.6
## - RR                          1 2.0668e+10 1.1940e+12 3752.5
## - TYPE.OF.ADMSN               1 2.4080e+10 1.1974e+12 3752.9
## - KEY.COMPLAINTS..CODE       12 1.9717e+11 1.3705e+12 3753.0
## - HR.PULSE                    1 3.5716e+10 1.2091e+12 3754.5
## - AGE                         1 6.2558e+10 1.2359e+12 3758.1
## - PAST.MEDICAL.HISTORY.CODE   6 1.4958e+11 1.3229e+12 3759.2
## - I_COST.OF.IMPLANT           1 4.8719e+11 1.6605e+12 3806.2
##
## Step:  AIC=3750.22
## .outcome ~ AGE + HR.PULSE + RR + I_COST.OF.IMPLANT + MARITAL.STATUS +
##     KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN
##
##                              Df  Sum of Sq        RSS    AIC
## - MARITAL.STATUS              1 5.2280e+09 1.1828e+12 3748.9
## <none>                                     1.1776e+12 3750.2
## - RR                          1 2.0189e+10 1.1978e+12 3751.0
## - KEY.COMPLAINTS..CODE       12 1.9528e+11 1.3728e+12 3751.2
## - TYPE.OF.ADMSN               1 2.4068e+10 1.2016e+12 3751.5
## - HR.PULSE                    1 3.6597e+10 1.2142e+12 3753.2
## - AGE                         1 6.3011e+10 1.2406e+12 3756.7
## - PAST.MEDICAL.HISTORY.CODE   6 1.4995e+11 1.3275e+12 3757.8
## - I_COST.OF.IMPLANT           1 4.8796e+11 1.6655e+12 3804.7
##
## Step:  AIC=3748.94
## .outcome ~ AGE + HR.PULSE + RR + I_COST.OF.IMPLANT + KEY.COMPLAINTS..CODE
+
##     PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN
```

```
##
##                              Df  Sum of Sq        RSS    AIC
## <none>                                     1.1828e+12 3748.9
## - RR                          1 1.9358e+10 1.2022e+12 3749.6
## - KEY.COMPLAINTS..CODE       12 1.9955e+11 1.3823e+12 3750.4
## - TYPE.OF.ADMSN               1 2.6000e+10 1.2088e+12 3750.5
## - HR.PULSE                    1 3.9644e+10 1.2224e+12 3752.3
## - PAST.MEDICAL.HISTORY.CODE   6 1.4751e+11 1.3303e+12 3756.1
## - AGE                         1 8.6123e+10 1.2689e+12 3758.4
## - I_COST.OF.IMPLANT           1 4.8314e+11 1.6659e+12 3802.8
```

Model Evaluation

1. One useful plot from caret package is the variable importance plot

```
plot(varImp(regCaretModel, scale = TRUE))
```



Checking the if the model satisfies the assumpations of Linear Regression Model. Note that this evaluation is on training data.

The model summary gives the equation of the model as well as helps test the assumption that beta coeffiecents are not statically zero.

```r
summary(regCaretModel)
```

```
##
## Call:
## lm(formula = .outcome ~ AGE + HR.PULSE + RR + I_COST.OF.IMPLANT +
##     KEY.COMPLAINTS..CODE + PAST.MEDICAL.HISTORY.CODE + TYPE.OF.ADMSN,
##     data = dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -174560  -46953   -6504   29754  484685
##
## Coefficients:
##                                       Estimate Std. Error t value
## (Intercept)                         -8.984e+04  6.649e+04  -1.351
## AGE                                  1.607e+03  5.051e+02   3.181
## HR.PULSE                             1.024e+03  4.743e+02   2.158
## RR                                   3.317e+03  2.200e+03   1.508
## I_COST.OF.IMPLANT                    2.993e+00  3.973e-01   7.535
## KEY.COMPLAINTS..CODECAD-DVD          1.139e+05  3.895e+04   2.923
## KEY.COMPLAINTS..CODECAD-SVD          7.023e+04  7.856e+04   0.894
## KEY.COMPLAINTS..CODECAD-TVD          7.456e+04  3.979e+04   1.874
## KEY.COMPLAINTS..CODECAD-VSD          4.611e+04  9.589e+04   0.481
## KEY.COMPLAINTS..CODEOS-ASD           3.955e+04  3.573e+04   1.107
## KEY.COMPLAINTS..CODEother- heart     4.252e+04  2.760e+04   1.541
## KEY.COMPLAINTS..CODEother- respiratory  1.956e+04  4.838e+04   0.404
## KEY.COMPLAINTS..CODEother-general   -1.881e+05  1.035e+05  -1.817
## KEY.COMPLAINTS..CODEother-nervous    9.638e+04  9.573e+04   1.007
## KEY.COMPLAINTS..CODEother-tertalogy  5.745e+04  3.675e+04   1.563
## KEY.COMPLAINTS..CODEPM-VSD           3.638e+04  5.283e+04   0.689
## KEY.COMPLAINTS..CODERHD             -2.265e+04  3.743e+04  -0.605
## PAST.MEDICAL.HISTORY.CODEDiabetes1  -3.177e+04  3.759e+04  -0.845
## PAST.MEDICAL.HISTORY.CODEDiabetes2   1.105e+05  3.899e+04   2.833
## PAST.MEDICAL.HISTORY.CODEhypertension1 -1.696e+04  3.169e+04  -0.535
## PAST.MEDICAL.HISTORY.CODEhypertension2 -7.132e+04  3.919e+04  -1.820
## PAST.MEDICAL.HISTORY.CODEhypertension3  5.777e+04  5.884e+04   0.982
## PAST.MEDICAL.HISTORY.CODEother      -1.353e+04  2.868e+04  -0.472
## TYPE.OF.ADMSNEMERGENCY               4.442e+04  2.541e+04   1.748
##                                     Pr(>|t|)
## (Intercept)                          0.17880
## AGE                                  0.00181 **
## HR.PULSE                             0.03261 *
## RR                                   0.13375
## I_COST.OF.IMPLANT                   5.67e-12 ***
## KEY.COMPLAINTS..CODECAD-DVD          0.00404 **
## KEY.COMPLAINTS..CODECAD-SVD          0.37292
## KEY.COMPLAINTS..CODECAD-TVD          0.06305 .
## KEY.COMPLAINTS..CODECAD-VSD          0.63137
## KEY.COMPLAINTS..CODEOS-ASD           0.27021
## KEY.COMPLAINTS..CODEother- heart     0.12569
```

```
## KEY.COMPLAINTS..CODEother- respiratory  0.68664
## KEY.COMPLAINTS..CODEother-general       0.07130 .
## KEY.COMPLAINTS..CODEother-nervous       0.31577
## KEY.COMPLAINTS..CODEother-tertalogy     0.12033
## KEY.COMPLAINTS..CODEPM-VSD              0.49213
## KEY.COMPLAINTS..CODERHD                 0.54597
## PAST.MEDICAL.HISTORY.CODEDiabetes1      0.39947
## PAST.MEDICAL.HISTORY.CODEDiabetes2      0.00529 **
## PAST.MEDICAL.HISTORY.CODEhypertension1  0.59338
## PAST.MEDICAL.HISTORY.CODEhypertension2  0.07092 .
## PAST.MEDICAL.HISTORY.CODEhypertension3  0.32788
## PAST.MEDICAL.HISTORY.CODEother          0.63789
## TYPE.OF.ADMSNEMERGENCY                  0.08267 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 92250 on 139 degrees of freedom
## Multiple R-squared:  0.6107, Adjusted R-squared:  0.5463
## F-statistic: 9.481 on 23 and 139 DF,  p-value: < 2.2e-16
```

2. The residual analysis

The error term diagnostic is critical to understanding the behaviour of linear regression models. The two critical assumptions of linear regression are:

1. Error term should be normally distributed
2. Error term should have constant variance (**homoscedasticity**)

The **plot()** function when used on the regression object model gives us four different plots. The two important one to analyze there are:

1. Normal Q-Q
2. Scale-Location

1. Normal Q_Q plot

This plot shows if the error terms are normally distributed. In case, of normal distribution, the dots should appear close to the straight line with not much of a deviation.

2. Scale-Location

Also known as spread location plot, it shows if the residuals are equally spread along the range of predictors. It is desirable to see a horizontal straight line with with randomly spread points.

The other two plots are:

3. Residual vs. Fitted

There could be a non linear relationship between predictor variable (Xs) and the outcome variable (Y). This non linear relationship can show up in this plot which may suggest that

the model is mis-specified. It is desirable to see a horizontal straight line with with randomly spread points.

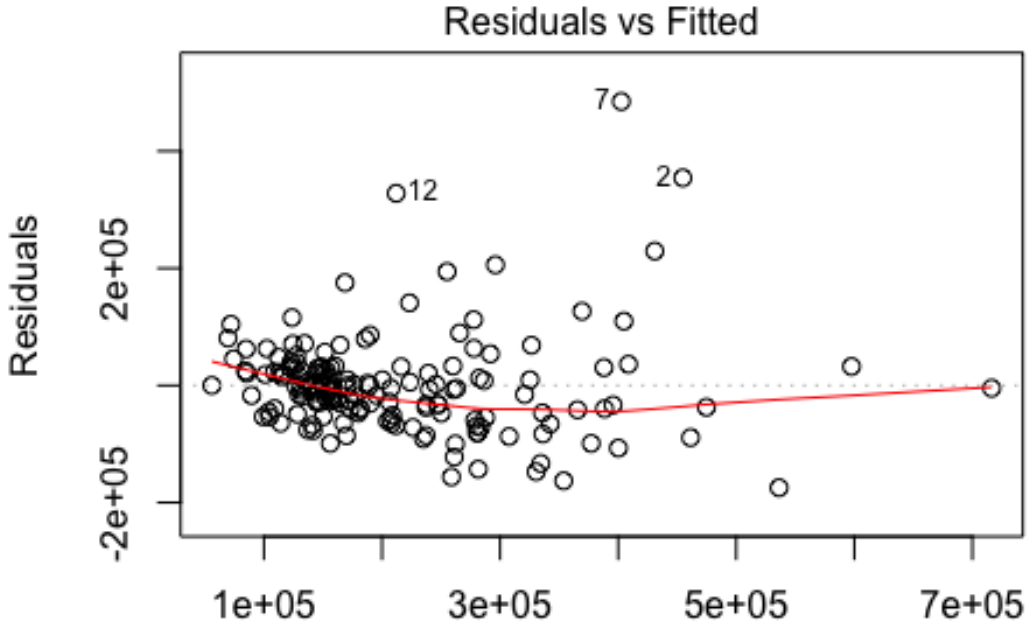
4. Residual vs. Leverage

The regression line can be influenced by outliers (extreme values in Y) or by data points with high leverage (extreme values in X). Not all the extreme values are influential cases in regression analysis.

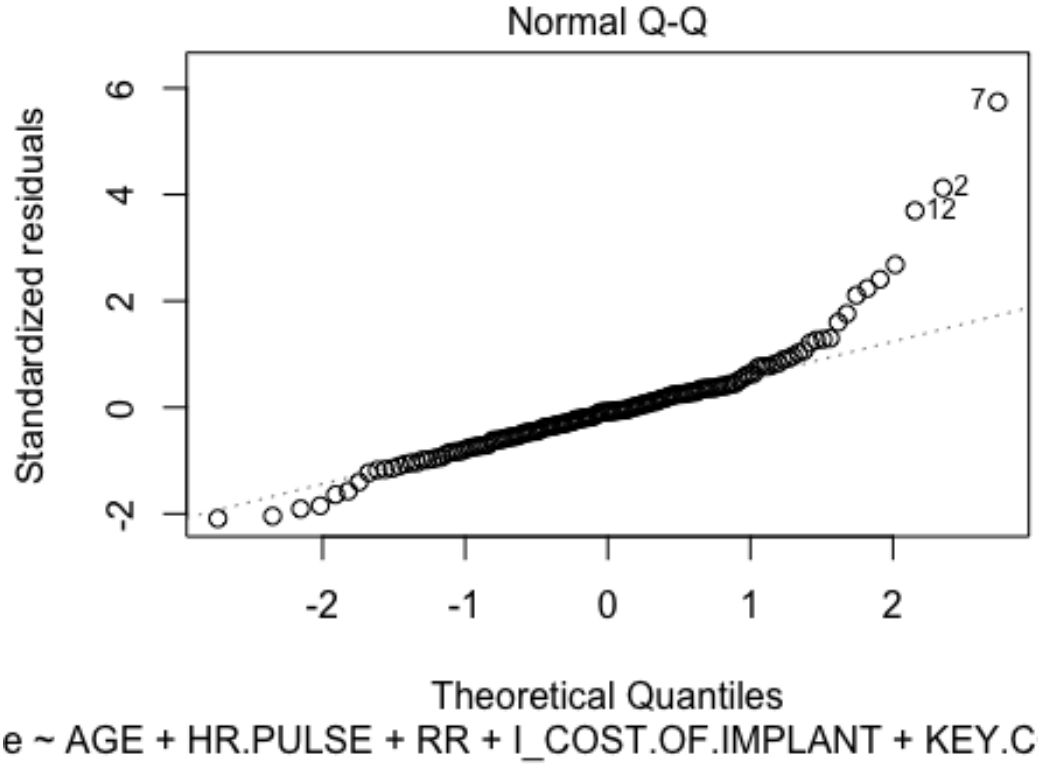
Even if data has extreme values, it may not be influential to determine the regression line. On the flip side, some cases could be very influential even if they do not seem to be an outlier. Influential cases are identified by cook's distance. In the plot, look for for outlying values at the upper right corner or at the lower right corner (cases outside of a dashed line i.e. Cook's distance).

```
plot(regCaretModel$finalModel)
```

```
## Warning: not plotting observations with leverage one:
##   54, 96, 100
```

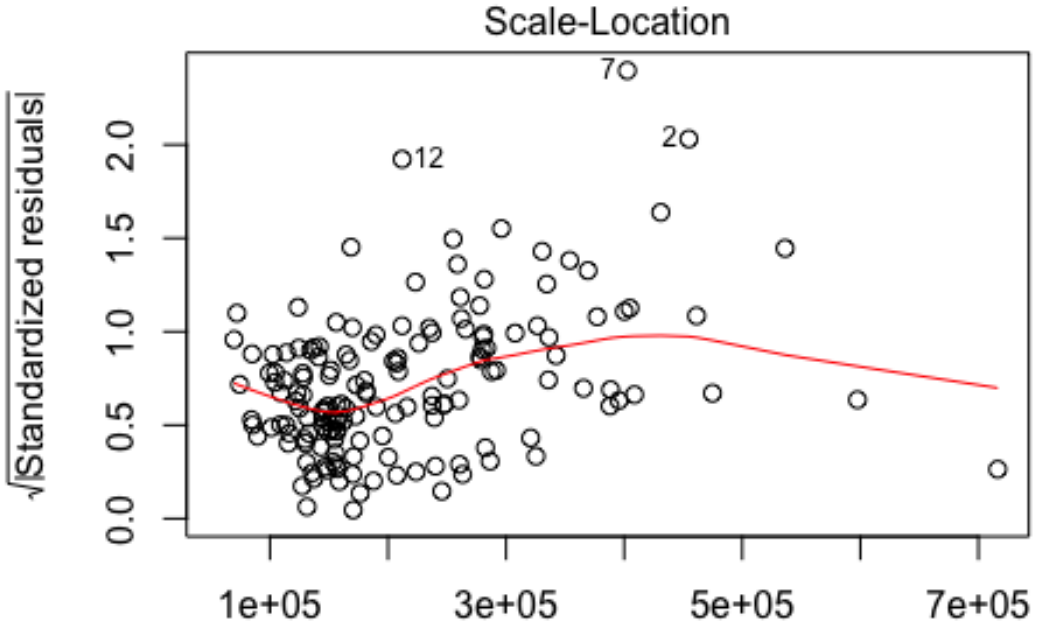


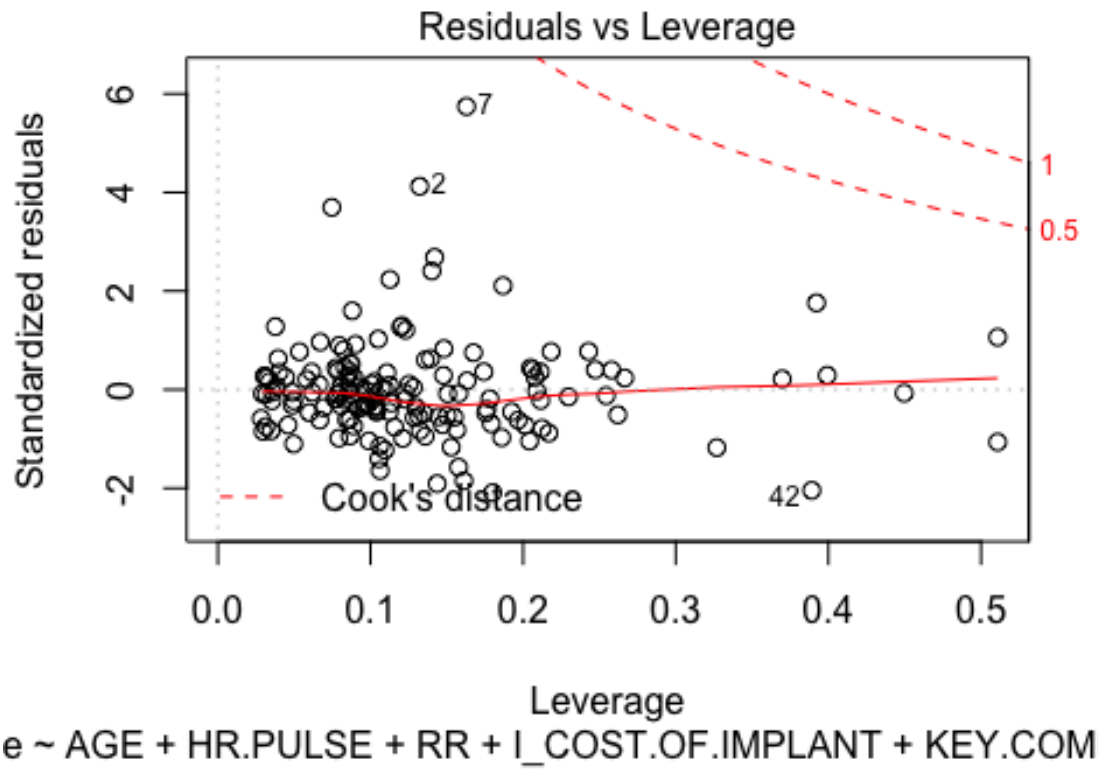
e ~ AGE + HR.PULSE + RR + I_COST.OF.IMPLANT + KEY.COMP



e ~ AGE + HR.PULSE + RR + I_COST.OF.IMPLANT + KEY.COMP

```
## Warning: not plotting observations with leverage one:
##   54, 96, 100
```

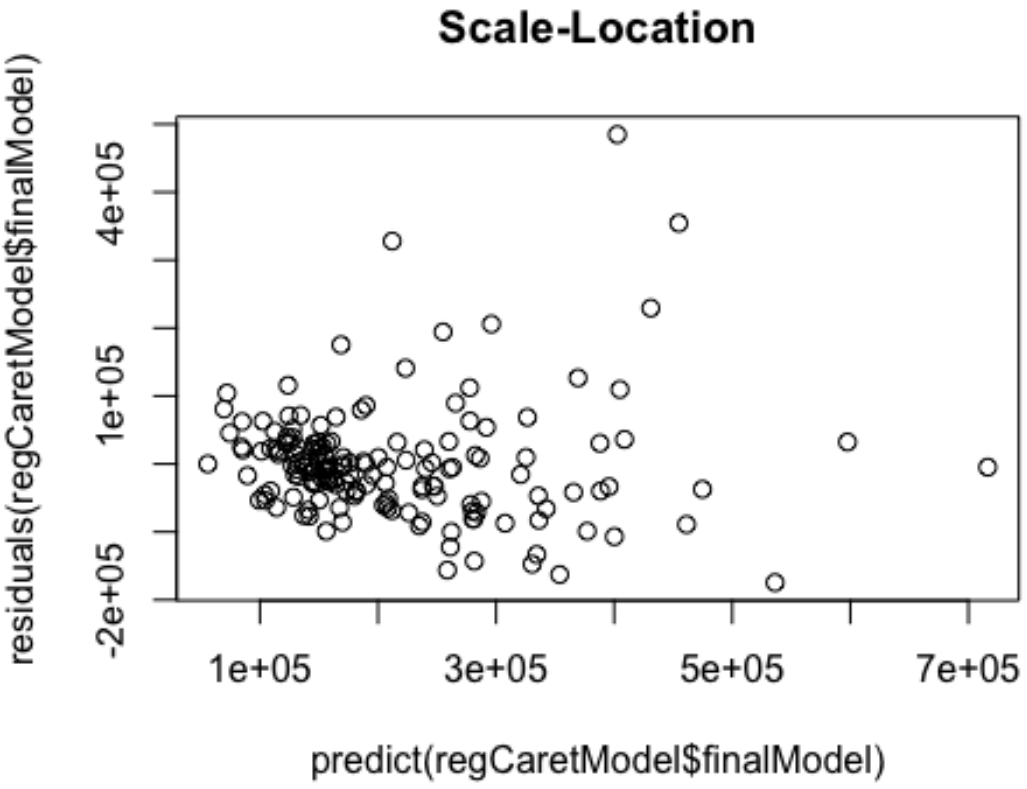

Scale-Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
7
2
12
1e+05
3e+05
5e+05
7e+05
Fitted values
e ~ AGE + HR.PULSE + RR + I_COST.OF.IMPLANT + KEY.COMP




```
#hist(residuals(RegModelStepwise), main = "Residuals", col = 'blue')
```

Visual inspection to check for heteroscedasticity in error terms

You may ignore the below code chuck. This is an elaboration of the scale-location plot obtained before.



Multi-colinearity

Variance Inflation Factor (VIF) is a measure of how much the variance of the estimated regrression coeffiecients are inflated as compared to when the predicator variable are not linearly related.

VIF = 1 : Not Correlated 1<VIF<5 : Moderately Correlated 5<VIF<=10: Highly Correlated

The square root of the VIF tells you how much larger the standard error is, compared with what it would be if that variable were uncorrelated with the other predictor variables in the model.

Say, if the square root of the VIF is 2.5; this means that the standard error for the coefficient of that predictor variable is 2.5 times as large as it would be if the predictor variable were uncorrelated with the other predictor variables

Generally the issue of multi-colinearity wil not arise, if the corelation amongst variable has been analyzed before model building and the one amongst the corelated variable has been dropped from the data.

```
vif(regCaretModel$finalModel)
```

```
##                                 GVIF Df GVIF^(1/(2*Df))
## AGE                         3.440817  1        1.854944
```

```
## HR.PULSE                    1.611905  1        1.269608
## RR                          1.310238  1        1.144656
## I_COST.OF.IMPLANT           1.758612  1        1.326127
## KEY.COMPLAINTS..CODE       11.374977 12        1.106619
## PAST.MEDICAL.HISTORY.CODE   4.232507  6        1.127759
## TYPE.OF.ADMSN               1.606061  1        1.267305
```

3. Model Validation on the Test Data

The **predict** function is used to get the predicted response on the new dataset. You may get an error message if the test data has got any new levels which was not there in the training set. This generally happens when the data has categorical variable with multiple levels.

```
RegTestPrediction = predict(regCaretModel$finalModel, reg.train.data,
interval = "confidence",
    level = 0.95, type = "response")
data.frame(RegTestPrediction, reg.train.data$TOTAL.COST.TO.HOSPITAL)
```

```
##           fit         lwr      upr reg.train.data.TOTAL.COST.TO.HOSPITAL
## 1   431011.62  362279.948 499743.3                                660293.00
## 2   454793.22  388467.019 521119.4                                809130.00
## 3   395667.21  319095.248 472239.2                                362231.00
## 4   597667.02  506965.221 688368.8                                629990.00
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## 33  388002.08  311861.767 464142.4                                418429.00
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## 37  260074.89  177213.314 342936.5                              293127.00
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## 103 189701.55    7314.861 372088.2                              189701.55
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## 106 181433.94  136798.547 226069.3                              139723.00
## 107 144715.11   87432.730 201997.5                              119685.64
## 108 336257.16  282583.631 389930.7                              253471.00
## 109 115523.15   57039.636 174006.7                              129684.00
## 110 145200.21  112353.958 178046.5                              167122.00
## 111 342430.12  280346.209 404514.0                              276458.00
## 112  69565.44   14774.684 124356.2                              150337.00
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## 138 172691.51  115792.052 229591.0                                146355.00
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## 150 137100.86  103037.257 171164.5                                 61340.00
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## 154 140545.00  -41841.689 322931.7                                140545.00
## 155 156189.17  115522.355 196856.0                                 57140.85
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## 166 258790.50  185557.609 332023.4                                102537.85
## 167 278616.18  196780.474 360451.9                                219126.24
## 168 237450.42  189423.448 285477.4                                204852.36
## 169 260521.28  189752.855 331289.7                                253368.00
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## 180 204622.13  134652.775 274591.5                                144134.00
## 181 112213.20   58576.812 165849.6                                160250.00
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## 184 127964.74   77229.224 178700.2                                166709.00
## 185 164386.52  108051.233 220721.8                                133873.00
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## 187 195314.62  131397.220 259232.0                                178428.00
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## 192 281539.84  222078.826 341000.9                                138535.00
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## 223 145710.58   85012.359 206408.8                    175576.00
## 224 206257.82  165977.821 246537.8                    177874.00
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## 227 132895.92   80315.684 185476.2                    114513.00
## 228 283635.59  217265.216 350006.0                    212287.00
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## 231 157284.81  102881.434 211688.2                    133436.00
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## 241 147609.92   89061.848 206158.0                    118607.00
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## 248 216249.69  171008.576 261490.8                    248112.00
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