R Notebook

Loading the dataset after downloading from Kaggle. Data Source: https://www.kaggle.com/c/prudential-life-insurance-assessment#description

```
library(readr)
train <- read.csv("C:/Users/Sagar Ghiya/Desktop/Github/Prudential/train.csv")</pre>
```

Checking the structure of data

```
str(train)
```

```
59381 obs. of 128 variables:
  'data.frame':
   $ Id
                         : int
                                2 5 6 7 8 10 11 14 15 16 ...
##
   $ Product_Info_1
                                1 1 1 1 1 1 1 1 1 1 ...
                         : int
   $ Product_Info_2
                        : Factor w/ 19 levels "A1","A2","A3",...: 17 1 19 18 16 16 8 16 17 19 ...
##
   $ Product_Info_3
                                10 26 26 10 26 26 10 26 26 21 ...
##
   $ Product_Info_4
                                0.0769 0.0769 0.0769 0.4872 0.2308 ...
                         : num
##
   $ Product_Info_5
                         : int
                                2 2 2 2 2 3 2 2 2 2 ...
##
   $ Product_Info_6
                         : int
                                1 3 3 3 3 1 3 3 3 3 ...
##
  $ Product_Info_7
                                1 1 1 1 1 1 1 1 1 1 . . .
                         : int
                                0.6418 0.0597 0.0299 0.1642 0.4179 ...
## $ Ins_Age
                         : num
## $ Ht
                         : num
                                0.582 0.6 0.745 0.673 0.655 ...
## $ Wt.
                         : num 0.149 0.132 0.289 0.205 0.234 ...
## $ BMI
                         : num
                                0.323 0.272 0.429 0.352 0.424 ...
##
  $ Employment_Info_1 : num
                               0.028 0 0.03 0.042 0.027 0.325 0.11 0.12 0.165 0.025 ...
   $ Employment Info 2 : int
                                12 1 9 9 9 15 1 12 9 1 ...
##
  $ Employment Info 3 : int
                               1 3 1 1 1 1 3 1 1 3 ...
   $ Employment Info 4 : num
                                0 0 0 0 0 0 NA 0 0 0 ...
##
   $ Employment Info 5 : int
                                3 2 2 3 2 2 3 2 2 3 ...
##
   $ Employment Info 6 : num
                                NA 0.0018 0.03 0.2 0.05 1 0.8 1 1 0.05 ...
##
   $ InsuredInfo_1
                        : int
                                1 1 1 2 1 1 1 1 1 2 ...
  $ InsuredInfo_2
                         : int
                                2 2 2 2 2 2 2 2 2 2 ...
##
   $ InsuredInfo_3
                                6 6 8 8 6 8 3 6 3 3 ...
                         : int
##
   $ InsuredInfo_4
                        : int
                                3 3 3 3 3 3 3 2 3 ...
##
                               1 1 1 1 1 1 1 1 1 1 ...
  $ InsuredInfo_5
                         : int
##
   $ InsuredInfo_6
                                2 2 1 2 2 1 2 1 1 2 ...
                         : int
##
   $ InsuredInfo_7
                        : int
                                1 1 1 1 1 1 1 1 1 1 ...
##
   $ Insurance_History_1: int
                               1 2 2 2 2 2 1 1 1 2 ...
##
  $ Insurance History 2: int
                               1 1 1 1 1 1 1 1 1 1 ...
##
  $ Insurance_History_3: int
                                3 3 1 1 1 3 3 3 3 3 ...
##
   $ Insurance History 4: int
                                1 1 3 3 3 2 2 1 2 1 ...
##
  $ Insurance_History_5: num  0.000667 0.000133 NA NA NA ...
  $ Insurance History 7: int
                                1 1 3 3 3 1 1 1 1 1 ...
## $ Insurance_History_8: int
                                1 3 2 2 2 3 1 1 1 3 ...
   $ Insurance_History_9: int
##
                                2 2 3 3 3 2 2 2 2 2 ...
## $ Family Hist 1
                        : int 2 2 3 3 2 2 3 2 3 3 ...
  $ Family_Hist_2
                         : num
                              NA 0.188 0.304 0.42 0.464 ...
   $ Family_Hist_3
##
                                0.598 NA NA NA NA ...
                         : num
                         : num
##
   $ Family_Hist_4
                               NA 0.0845 0.2254 0.3521 0.4085 ...
##
  $ Family_Hist_5
                         : num
                               0.527 NA NA NA NA ...
   $ Medical_History_1 : int
                                4 5 10 0 NA 6 5 6 4 NA ...
   $ Medical_History_2 : int
##
                                112 412 3 350 162 491 600 145 16 162 ...
   $ Medical_History_3 : int 2 2 2 2 2 2 3 2 2 2 ...
```

```
$ Medical_History_4 : int 1 1 2 2 2 2 2 2 2 2 ...
## $ Medical_History_5 : int
                              1 1 1 1 1 1 1 1 1 1 ...
## $ Medical History 6 : int
                               3 3 3 3 3 3 3 3 3 ...
## $ Medical_History_7 : int
                               2 2 2 2 2 2 2 2 2 2 ...
   $ Medical_History_8 : int
                               2 2 2 2 2 2 2 2 2 2 . . .
## $ Medical_History_9 : int
                              1 1 2 2 2 2 1 1 1 2 ...
   $ Medical History 10 : int
                              NA NA NA NA NA NA NA NA NA ...
##
   $ Medical_History_11 : int
                               3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_12 : int
                               2 2 2 2 2 2 2 2 2 2 . . .
##
   $ Medical_History_13 : int
                               3 3 3 3 3 3 3 3 3 ...
   $ Medical_History_14 : int
                              3 3 3 3 3 3 3 3 3 3 . . .
##
   $ Medical_History_15 : int
                               240 O NA NA NA NA NA NA NA ...
##
   $ Medical_History_16 : int  3 1 1 1 1 1 1 1 3 ...
## $ Medical_History_17 : int
                              3 3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_18 : int
                              1 1 1 1 1 2 1 1 1 1 ...
##
   $ Medical_History_19 : int
                               1 1 1 1 1 1 1 1 1 1 . . .
##
   $ Medical_History_20 : int  2 2 2 2 2 2 2 2 2 2 ...
## $ Medical History 21 : int
                              1 1 1 2 1 2 1 1 1 1 ...
## $ Medical_History_22 : int
                              2 2 2 2 2 2 2 2 2 2 ...
##
   $ Medical_History_23 : int
                              3 3 3 3 3 3 3 3 1 ...
## $ Medical_History_24 : int NA ...
## $ Medical_History_25 : int
                              1 1 2 1 2 1 1 1 1 1 ...
## $ Medical_History_26 : int
                               3 3 2 3 2 3 3 3 3 3 ...
                               3 3 3 3 3 3 3 3 3 . . .
##
   $ Medical_History_27 : int
## $ Medical_History_28 : int
                              1 1 1 1 1 1 1 1 1 1 ...
## $ Medical_History_29 : int
                              3 3 3 3 3 3 1 3 1 3 ...
##
   $ Medical_History_30 : int
                               2 2 2 2 2 2 2 2 2 2 . . .
##
   $ Medical_History_31 : int  3 3 3 3 3 3 3 3 3 3 ...
## $ Medical_History_32 : int
                              NA NA NA NA NA NA NA NA NA ...
## $ Medical_History_33 : int
                              1 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_34 : int
                               3 1 3 3 3 1 3 3 3 3 ...
##
   $ Medical_History_35 : int
                              1 1 1 1 1 1 1 1 1 1 ...
## $ Medical_History_36 : int
                              2 2 3 2 3 2 2 2 2 2 ...
## $ Medical_History_37 : int
                               2 2 2 2 2 2 2 2 2 2 ...
##
   $ Medical_History_38 : int
                               1 1 1 1 1 1 1 1 1 1 ...
## $ Medical_History_39 : int
                              3 3 3 3 3 3 3 3 3 3 . . .
## $ Medical History 40 : int
                              3 3 3 3 3 3 3 3 3 3 ...
## $ Medical_History_41 : int
                               3 1 1 1 1 3 3 1 3 1 ...
##
   $ Medical_Keyword_1 : int
                               0 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_2 : int 0000000000...
## $ Medical Keyword 3 : int
                              0 0 0 0 0 0 0 0 0 0 ...
## $ Medical Keyword 4 : int
                              0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_5 : int
                              0000000000...
## $ Medical_Keyword_6 : int
                              0 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_7 : int
                               0 0 0 0 0 0 0 0 0 0 ...
   $ Medical_Keyword_8 : int
##
                               0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_9 : int
                               0 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_10 : int
                               0 0 0 0 0 0 0 0 0 0 ...
                              0 0 0 0 0 0 0 0 0 0 ...
   $ Medical_Keyword_11 : int
##
   $ Medical_Keyword_12 : int
                               0 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_13 : int
                              0 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_14 : int 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_15 : int 0 0 0 0 0 0 0 0 1 ...
   $ Medical Keyword 16 : int 0000000000...
```

```
## $ Medical_Keyword_17 : int    0 0 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_18 : int    0 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_19 : int    0 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_20 : int    0 0 0 0 0 0 0 1 0 ...
## [list output truncated]
```

Calculating the total number of missing values in the dataset

```
sum(is.na(train))
```

[1] 393103

Displaying each column with the number of missing values it has

```
sapply(train, function(x) sum(is.na(x)))
```

```
##
                     Id
                              Product_Info_1
                                                   Product_Info_2
##
##
        Product_Info_3
                              Product_Info_4
                                                   Product_Info_5
##
                                                                 0
##
        Product Info 6
                              Product Info 7
                                                           Ins Age
##
                      0
                                            0
                                                                 0
                     Ηt
                                           Wt
                                                               BMI
##
##
                      0
                                            0
                                                                 0
                           Employment_Info_2
                                                Employment_Info_3
##
     Employment_Info_1
##
##
     Employment_Info_4
                          Employment_Info_5
                                                Employment_Info_6
##
                   6779
                                                             10854
##
         InsuredInfo_1
                               InsuredInfo_2
                                                    InsuredInfo_3
##
                                                                 0
##
         InsuredInfo 4
                               InsuredInfo 5
                                                    InsuredInfo 6
##
                                                                 0
##
         InsuredInfo_7 Insurance_History_1 Insurance_History_2
##
   Insurance_History_3 Insurance_History_4 Insurance_History_5
##
##
                                            Λ
                                                             25396
                      \cap
##
   Insurance_History_7 Insurance_History_8 Insurance_History_9
##
                                                                 0
##
         Family_Hist_1
                               Family_Hist_2
                                                    Family_Hist_3
##
                                       28656
                                                             34241
##
         Family_Hist_4
                               Family_Hist_5
                                                Medical_History_1
##
                  19184
                                       41811
                                                              8889
##
     Medical_History_2
                          Medical_History_3
                                                Medical_History_4
##
                                                                 0
##
     Medical_History_5
                          Medical_History_6
                                                Medical_History_7
##
##
     Medical_History_8
                          Medical_History_9
                                               Medical_History_10
##
##
    Medical_History_11
                         Medical_History_12
                                               Medical_History_13
##
                         Medical_History_15
                                               Medical History 16
##
    Medical_History_14
                                       44596
##
##
    Medical_History_17
                         Medical_History_18
                                               Medical_History_19
##
##
    Medical_History_20
                         Medical_History_21
                                               Medical_History_22
##
```

```
Medical_History_25
##
    Medical_History_23
                         Medical_History_24
##
                                       55580
##
    Medical History 26
                         Medical History 27
                                              Medical History 28
##
##
    Medical History 29
                         Medical_History_30
                                              Medical History 31
##
                      0
##
    Medical History 32
                         Medical_History_33
                                              Medical History 34
##
##
    Medical_History_35
                         Medical_History_36
                                              Medical_History_37
##
                      0
##
    Medical_History_38
                         Medical_History_39
                                              Medical_History_40
##
                      0
##
    Medical_History_41
                          Medical_Keyword_1
                                               Medical_Keyword_2
##
                                                                0
##
     Medical_Keyword_3
                          Medical_Keyword_4
                                               Medical_Keyword_5
##
##
     Medical_Keyword_6
                          Medical_Keyword_7
                                               Medical_Keyword_8
##
##
     Medical_Keyword_9
                         Medical_Keyword_10
                                              Medical_Keyword_11
##
##
    Medical_Keyword_12
                         Medical_Keyword_13
                                              Medical_Keyword_14
##
##
    Medical_Keyword_15
                         Medical_Keyword_16
                                              Medical_Keyword_17
##
##
    Medical_Keyword_18
                         Medical Keyword 19
                                              Medical Keyword 20
##
##
    Medical_Keyword_21
                         Medical_Keyword_22
                                              Medical_Keyword_23
##
##
                         Medical_Keyword_25
                                              Medical_Keyword_26
    Medical_Keyword_24
##
##
    Medical_Keyword_27
                         Medical_Keyword_28
                                              Medical_Keyword_29
##
##
    Medical_Keyword_30
                         Medical_Keyword_31
                                              Medical_Keyword_32
##
##
    Medical Keyword 33
                         Medical Keyword 34
                                              Medical Keyword 35
##
##
    Medical Keyword 36
                         Medical Keyword 37
                                              Medical Keyword 38
##
##
    Medical_Keyword_39
                         Medical Keyword 40
                                              Medical Keyword 41
##
##
    Medical Keyword 42
                         Medical Keyword 43
                                              Medical Keyword 44
##
##
    Medical_Keyword_45
                         Medical Keyword 46
                                              Medical Keyword 47
##
                                                                0
##
    Medical_Keyword_48
                                    Response
##
```

Removing columns that have large number of missing values as this would hamper our analysis. In all, 13 columns have missing values. 1 column only has 19 missing values, whereas other 12 have at least 6779 missing values. So removing these 12 columns from the data frame.

```
train_new1 <- train[,-c(16,18,30,35,36,37,38,39,48,53,62,70)]
```

Now 1 column remains that has 19 missing values. Checking the structure of that column so that a proper imputation strategy can be decided.

```
str(train_new1$Employment_Info_1)
    num [1:59381] 0.028 0 0.03 0.042 0.027 0.325 0.11 0.12 0.165 0.025 ...
Since the variable is continuous missing values can be imputed with the mean of the column. Using Machine
Learning technique for data imputation is not a good idea as the dataset has more than 100 features.
train_new1$Employment_Info_1[is.na(train_new1$Employment_Info_1)] = mean(train_new1$Employment_Info_1,
Checking one final time that all the missing values have been removed.
sum(is.na(train_new1))
## [1] 0
First column is the "ID" column and will add no value to analysis. So removing it.
train_new2 <- train_new1[,-1]</pre>
Again checking the structure of data to figure out columns that will have to be dummy coded.
str(train_new2)
                    59381 obs. of 115 variables:
## 'data.frame':
                          : int 1 1 1 1 1 1 1 1 1 1 ...
   $ Product_Info_1
##
                          : Factor w/ 19 levels "A1", "A2", "A3", ...: 17 1 19 18 16 16 8 16 17 19 ...
##
    $ Product Info 2
                                 10 26 26 10 26 26 10 26 26 21 ...
## $ Product_Info_3
                          : int
##
  $ Product Info 4
                                 0.0769 0.0769 0.0769 0.4872 0.2308 ...
                          : num
                                 2 2 2 2 2 3 2 2 2 2 ...
## $ Product_Info_5
                          : int
##
    $ Product_Info_6
                                 1 3 3 3 3 1 3 3 3 3 ...
                          : int
##
   $ Product_Info_7
                                1 1 1 1 1 1 1 1 1 1 . . .
                          : int
##
   $ Ins_Age
                          : num
                                 0.6418 0.0597 0.0299 0.1642 0.4179 ...
##
   $ Ht
                                 0.582 0.6 0.745 0.673 0.655 ...
                          : num
##
    $ Wt
                                 0.149 0.132 0.289 0.205 0.234 ...
                          : num
##
   $ BMI
                                 0.323 0.272 0.429 0.352 0.424 ...
                          : num
##
    $ Employment_Info_1
                         : num
                                 0.028 0 0.03 0.042 0.027 0.325 0.11 0.12 0.165 0.025 ...
##
    $ Employment_Info_2
                         : int
                                 12 1 9 9 9 15 1 12 9 1 ...
##
    $ Employment_Info_3
                         : int
                                 1 3 1 1 1 1 3 1 1 3 ...
##
   $ Employment_Info_5 : int
                                 3 2 2 3 2 2 3 2 2 3 ...
##
   $ InsuredInfo_1
                          : int
                                 1 1 1 2 1 1 1 1 1 2 ...
    $ InsuredInfo_2
                                 2 2 2 2 2 2 2 2 2 2 . . .
##
                          : int
##
    $ InsuredInfo_3
                                 6 6 8 8 6 8 3 6 3 3 ...
                          : int
##
  $ InsuredInfo 4
                                 3 3 3 3 3 3 3 2 3 ...
                          : int
##
  $ InsuredInfo_5
                                 1 1 1 1 1 1 1 1 1 1 ...
                          : int
##
    $ InsuredInfo 6
                                 2 2 1 2 2 1 2 1 1 2 ...
                          : int
##
   $ InsuredInfo_7
                                 1 1 1 1 1 1 1 1 1 1 ...
                          : int
##
   $ Insurance_History_1: int
                                 1 2 2 2 2 2 1 1 1 2 ...
##
    $ Insurance_History_2: int
                                 1 1 1 1 1 1 1 1 1 1 ...
    $ Insurance_History_3: int
                                 3 3 1 1 1 3 3 3 3 3 ...
##
##
                                 1 1 3 3 3 2 2 1 2 1 ...
    $ Insurance_History_4: int
##
   $ Insurance_History_7: int
                                 1 1 3 3 3 1 1 1 1 1 ...
##
    $ Insurance_History_8: int
                                 1 3 2 2 2 3 1 1 1 3 ...
##
    $ Insurance_History_9: int
                                 2 2 3 3 3 2 2 2 2 2 ...
##
  $ Family_Hist_1
                                 2 2 3 3 2 2 3 2 3 3 ...
                         : int
                                 112 412 3 350 162 491 600 145 16 162 ...
##
    $ Medical_History_2 : int
##
    $ Medical_History_3
                         : int
                                 2 2 2 2 2 2 3 2 2 2 ...
```

1 1 2 2 2 2 2 2 2 2 ...

1 1 1 1 1 1 1 1 1 1 ...

##

\$ Medical_History_4 : int

\$ Medical_History_5 : int

```
$ Medical History 6 : int  3 3 3 3 3 3 3 3 3 ...
##
                                2 2 2 2 2 2 2 2 2 2 . . .
   $ Medical_History_7 : int
   $ Medical History 8 : int
                                2 2 2 2 2 2 2 2 2 2 ...
##
   $ Medical_History_9 : int
                                1 1 2 2 2 2 1 1 1 2 ...
##
   $ Medical_History_11 : int
                                3 3 3 3 3 3 3 3 3 . . .
                                2 2 2 2 2 2 2 2 2 2 . . .
##
   $ Medical History 12 : int
   $ Medical History 13 : int
                                3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_14 : int
                                3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_16 : int
                                3 1 1 1 1 1 1 1 3 ...
##
   $ Medical_History_17 : int
                                3 3 3 3 3 3 3 3 3 ...
   $ Medical_History_18 : int
                                1 1 1 1 1 2 1 1 1 1 ...
##
   $ Medical_History_19 : int
                                1 1 1 1 1 1 1 1 1 1 ...
##
   $ Medical_History_20 : int
                                2 2 2 2 2 2 2 2 2 2 ...
##
   $ Medical_History_21 : int
                                1 1 1 2 1 2 1 1 1 1 ...
##
   $ Medical_History_22 : int
                                2 2 2 2 2 2 2 2 2 2 . . .
##
   $ Medical_History_23 : int
                                3 3 3 3 3 3 3 3 1 ...
                                1 1 2 1 2 1 1 1 1 1 ...
##
   $ Medical_History_25 : int
##
   $ Medical History 26 : int
                                3 3 2 3 2 3 3 3 3 3 ...
   $ Medical_History_27 : int
##
                                3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_28 : int
                                1 1 1 1 1 1 1 1 1 1 ...
##
   $ Medical_History_29 : int
                                3 3 3 3 3 3 1 3 1 3 ...
   $ Medical_History_30 : int
                                2 2 2 2 2 2 2 2 2 2 . . .
   $ Medical_History_31 : int
                                3 3 3 3 3 3 3 3 3 ...
##
                                1 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_33 : int
##
   $ Medical History 34 : int
                                3 1 3 3 3 1 3 3 3 3 ...
   $ Medical_History_35 : int
                                1 1 1 1 1 1 1 1 1 1 ...
##
   $ Medical_History_36 : int
                                2 2 3 2 3 2 2 2 2 2 ...
                                2 2 2 2 2 2 2 2 2 2 . . .
##
   $ Medical_History_37 : int
##
   $ Medical_History_38 : int
                                1 1 1 1 1 1 1 1 1 1 ...
   $ Medical_History_39 : int
                                3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_40 : int
                                3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_41 : int
                                3 1 1 1 1 3 3 1 3 1 ...
##
   $ Medical_Keyword_1 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_2 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical Keyword 3 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_4 : int
                                0 0 0 0 0 0 0 0 0 0 ...
   $ Medical Keyword 5 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_6 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_7 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_8 : int
                                0 0 0 0 0 0 0 0 0 0 ...
   $ Medical Keyword 9 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical Keyword 10 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical Keyword 11 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
                                0 0 0 0 0 0 0 0 0 0 ...
   $ Medical_Keyword_12 : int
   $ Medical_Keyword_13 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_14 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_15 : int
                                0 0 0 0 0 0 0 0 0 1 ...
##
   $ Medical_Keyword_16 : int
                                0 0 0 0 0 0 0 0 0 0 ...
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_17 : int
##
   $ Medical_Keyword_18 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_19 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_20 : int
                                0 0 0 0 0 0 0 0 1 0 ...
   $ Medical_Keyword_21 : int
                                0 0 0 0 0 0 0 0 0 0 ...
   $ Medical Keyword 22 : int 0 0 0 0 1 0 0 0 0 ...
```

```
$ Medical_Keyword_23 : int    0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_24 : int
                             0000000000...
## $ Medical Keyword 25 : int
                             0 0 0 0 0 0 0 0 0 1 ...
## $ Medical_Keyword_26 : int 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_27 : int 0 0 0 0 0 0 0 0 0 ...
## $ Medical Keyword 28 : int 0 0 0 0 0 0 0 0 0 ...
  $ Medical Keyword 29 : int
                             0000000000...
##
   $ Medical_Keyword_30 : int
                             0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_31 : int
                             0000000000...
## $ Medical_Keyword_32 : int
                             0 0 0 1 0 0 0 0 0 0 ...
  $ Medical_Keyword_33 : int
                             0 0 0 0 0 0 0 0 0 0 ...
    [list output truncated]
##
```

Converting the columns that need to be dummy coded into type "factor" because dummy.data.frame function only dummy codes columns that are "factor" type.

```
train_new2[,c(1,2,3,5,6,7)] <- lapply(train_new2[,c(1,2,3,5,6,7)],factor)
train_new2[,13:66] <- lapply(train_new2[,13:66],factor)</pre>
```

```
str(train_new2)
```

```
## 'data.frame':
                    59381 obs. of 115 variables:
                         : Factor w/ 2 levels "1", "2": 1 1 1 1 1 1 1 1 1 1 ...
   $ Product_Info_1
                         : Factor w/ 19 levels "A1", "A2", "A3",...: 17 1 19 18 16 16 8 16 17 19 ...
  $ Product_Info_2
                         : Factor w/ 34 levels "1", "2", "3", "4", ...: 9 23 23 9 23 23 9 23 23 19 ...
##
   $ Product_Info_3
##
   $ Product_Info_4
                         : num 0.0769 0.0769 0.0769 0.4872 0.2308 ...
                         : Factor w/ 2 levels "2", "3": 1 1 1 1 1 2 1 1 1 1 ...
##
  $ Product_Info_5
                         : Factor w/ 2 levels "1", "3": 1 2 2 2 2 1 2 2 2 2 ...
##
   $ Product_Info_6
##
   $ Product_Info_7
                         : Factor w/ 3 levels "1", "2", "3": 1 1 1 1 1 1 1 1 1 1 ...
##
                                0.6418 0.0597 0.0299 0.1642 0.4179 ...
   $ Ins_Age
## $ Ht
                               0.582 0.6 0.745 0.673 0.655 ...
## $ Wt
                         : num 0.149 0.132 0.289 0.205 0.234 ...
## $ BMI
                                0.323 0.272 0.429 0.352 0.424 ...
## $ Employment_Info_1 : num 0.028 0 0.03 0.042 0.027 0.325 0.11 0.12 0.165 0.025 ...
  $ Employment_Info_2 : Factor w/ 36 levels "1","2","3","4",..: 11 1 8 8 8 14 1 11 8 1 ...
   $ Employment_Info_3 : Factor w/ 2 levels "1", "3": 1 2 1 1 1 1 2 1 1 2 ...
##
   $ Employment Info 5 : Factor w/ 2 levels "2", "3": 2 1 1 2 1 1 2 1 1 2 ...
##
                         : Factor w/ 3 levels "1", "2", "3": 1 1 1 2 1 1 1 1 1 2 ...
##
  $ InsuredInfo 1
                         : Factor w/ 2 levels "2", "3": 1 1 1 1 1 1 1 1 1 1 ...
  $ InsuredInfo_2
                         : Factor w/ 11 levels "1","2","3","4",...: 6 6 8 8 6 8 3 6 3 3 ...
##
  $ InsuredInfo_3
                         : Factor w/ 2 levels "2", "3": 2 2 2 2 2 2 2 1 2 ...
##
   $ InsuredInfo_4
##
                         : Factor w/ 2 levels "1", "3": 1 1 1 1 1 1 1 1 1 1 ...
  $ InsuredInfo_5
                         : Factor w/ 2 levels "1", "2": 2 2 1 2 2 1 2 1 1 2 ...
##
  $ InsuredInfo_6
                         : Factor w/ 2 levels "1", "3": 1 1 1 1 1 1 1 1 1 1 ...
##
   $ InsuredInfo_7
##
   $ Insurance_History_1: Factor w/ 2 levels "1","2": 1 2 2 2 2 2 1 1 1 2 ...
  $ Insurance_History_2: Factor w/ 3 levels "1","2","3": 1 1 1 1 1 1 1 1 1 1 ...
##
##
  $ Insurance_History_3: Factor w/ 3 levels "1","2","3": 3 3 1 1 1 3 3 3 3 3 ...
   $ Insurance_History_4: Factor w/ 3 levels "1","2","3": 1 1 3 3 3 2 2 1 2 1 ...
##
   $ Insurance_History_7: Factor w/ 3 levels "1","2","3": 1 1 3 3 3 1 1 1 1 1 ...
##
  $ Insurance_History_8: Factor w/ 3 levels "1","2","3": 1 3 2 2 2 3 1 1 1 3 ...
   $ Insurance_History_9: Factor w/ 3 levels "1","2","3": 2 2 3 3 3 2 2 2 2 2 ...
##
##
   $ Family Hist 1
                         : Factor w/ 3 levels "1", "2", "3": 2 2 3 3 2 2 3 2 3 3 ...
## $ Medical_History_2 : Factor w/ 579 levels "1","2","3","5",..: 103 369 3 313 149 437 534 132 14 14
## $ Medical History 3 : Factor w/ 3 levels "1", "2", "3": 2 2 2 2 2 2 3 2 2 2 ...
## $ Medical_History_4 : Factor w/ 2 levels "1","2": 1 1 2 2 2 2 2 2 2 2 ...
```

```
$ Medical History 5 : Factor w/ 3 levels "1","2","3": 1 1 1 1 1 1 1 1 1 1 ...
##
   $ Medical_History_6 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 3 ...
   $ Medical History 7 : Factor w/ 3 levels "1", "2", "3": 2 2 2 2 2 2 2 2 2 2 ...
   $ Medical_History_8 : Factor w/ 3 levels "1","2","3": 2 2 2 2 2 2 2 2 2 2 ...
##
   $ Medical_History_9 : Factor w/ 3 levels "1","2","3": 1 1 2 2 2 2 1 1 1 2 ...
   $ Medical History 11 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_12 : Factor w/ 3 levels "1","2","3": 2 2 2 2 2 2 2 2 2 2 ...
   $ Medical History 13 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_14 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_16 : Factor w/ 3 levels "1","2","3": 3 1 1 1 1 1 1 1 3 ...
##
   $ Medical_History_17 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 3 ...
   $ Medical_History_18 : Factor w/ 3 levels "1","2","3": 1 1 1 1 1 2 1 1 1 1 ...
##
   $ Medical_History_19 : Factor w/ 3 levels "1","2","3": 1 1 1 1 1 1 1 1 1 1 1 ...
##
   $ Medical_History_20 : Factor w/ 3 levels "1","2","3": 2 2 2 2 2 2 2 2 2 ...
##
##
   $ Medical_History_21 : Factor w/ 3 levels "1","2","3": 1 1 1 2 1 2 1 1 1 1 ...
##
   $ Medical_History_22 : Factor w/ 2 levels "1","2": 2 2 2 2 2 2 2 2 2 2 ...
   $ Medical_History_23 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 1 ...
##
   $ Medical History 25 : Factor w/ 3 levels "1","2","3": 1 1 2 1 2 1 1 1 1 1 ...
##
   $ Medical_History_26 : Factor w/ 3 levels "1","2","3": 3 3 2 3 2 3 3 3 3 3 ...
##
   $ Medical_History_27 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 3 ...
##
##
   $ Medical_History_28 : Factor w/ 3 levels "1","2","3": 1 1 1 1 1 1 1 1 1 1 1 ...
   $ Medical History 29 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 1 3 1 3 ...
   $ Medical_History_30 : Factor w/ 3 levels "1","2","3": 2 2 2 2 2 2 2 2 2 ...
##
   $ Medical History 31 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 3 ...
##
   $ Medical History 33 : Factor w/ 2 levels "1","3": 1 2 2 2 2 2 2 2 2 2 ...
##
   $ Medical_History_34 : Factor w/ 3 levels "1","2","3": 3 1 3 3 3 1 3 3 3 3 ...
   $ Medical_History_35 : Factor w/ 3 levels "1","2","3": 1 1 1 1 1 1 1 1 1 1 ...
##
   $ Medical_History_36 : Factor w/ 3 levels "1","2","3": 2 2 3 2 3 2 2 2 2 2 ...
   $ Medical_History_37 : Factor w/ 3 levels "1","2","3": 2 2 2 2 2 2 2 2 2 2 ...
##
   $ Medical_History_38 : Factor w/ 2 levels "1","2": 1 1 1 1 1 1 1 1 1 1 1 ...
   $ Medical_History_39 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 3 ...
##
   \ Medical_History_40 : Factor w/ 3 levels "1","2","3": 3 3 3 3 3 3 3 3 3 ...
##
   $ Medical_History_41 : Factor w/ 3 levels "1","2","3": 3 1 1 1 1 3 3 1 3 1 ...
##
   $ Medical_Keyword_1 : int 0 0 0 0 0 0 0 0 0 ...
##
##
   $ Medical_Keyword_2 : int
                                0 0 0 0 0 0 0 0 0 0 ...
                              0000000000...
##
   $ Medical_Keyword_3 : int
   $ Medical Keyword 4 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_5 : int
                                0 0 0 0 0 0 0 0 0 0 ...
   $ Medical_Keyword_6 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
##
                               0 0 0 0 0 0 0 0 0 0 ...
   $ Medical_Keyword_7 : int
   $ Medical Keyword 8 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical Keyword 9 : int
                               0 0 0 0 0 0 0 0 0 0 ...
   $ Medical Keyword 10 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
                               0 0 0 0 0 0 0 0 0 0 ...
   $ Medical_Keyword_11 : int
   $ Medical_Keyword_12 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_13 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_14 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_15 : int
                                0 0 0 0 0 0 0 0 0 1 ...
   $ Medical_Keyword_16 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_17 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
   $ Medical_Keyword_18 : int
                                0 0 0 0 0 0 0 0 0 0 ...
##
  $ Medical_Keyword_19 : int
                                0 0 0 0 0 0 0 0 0 0 ...
   $ Medical_Keyword_20 : int  0 0 0 0 0 0 0 1 0 ...
   $ Medical Keyword 21 : int 0 0 0 0 0 0 0 0 0 ...
```

```
## $ Medical_Keyword_22 : int 0 0 0 0 1 0 0 0 0 ...
## $ Medical_Keyword_23 : int 0 0 0 0 0 0 0 0 0 ...
## $ Medical Keyword 24 : int 0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_25 : int 0 0 0 0 0 0 0 0 1 ...
## $ Medical_Keyword_26 : int 0 0 0 0 0 0 0 0 0 ...
## $ Medical Keyword 27 : int 0 0 0 0 0 0 0 0 0 ...
## $ Medical Keyword 28 : int 0 0 0 0 0 0 0 0 0 ...
   $ Medical_Keyword_29 : int  0 0 0 0 0 0 0 0 0 ...
##
##
   $ Medical_Keyword_30 : int  0 0 0 0 0 0 0 0 0 ...
## $ Medical_Keyword_31 : int 0 0 0 0 0 0 0 0 0 ...
  $ Medical_Keyword_32 : int  0 0 0 1 0 0 0 0 0 ...
   $ Medical_Keyword_33 : int    0 0 0 0 0 0 0 0 0 ...
##
    [list output truncated]
```

Removing columns that have too many factor levels. If I don't remove these, it goes to around 800+ columns only adding to computation.

```
train_new3 <- train_new2[,-c(2,3,13,18,31)]
```

Dummy coding the dataframe. After dummy coding, there are around 206 variables or columns in the dataframe.

```
library(dummies)
```

```
## dummies-1.5.6 provided by Decision Patterns
train_new4 <- dummy.data.frame(train_new3)</pre>
```

Next step is outlier detection. Checking continuous value columns for values that are 3 standard deviations away from the mean. However the data is already normalized to decrease the effect of outliers. There is nothing more that can be done at this stage for the outliers.

Also the fact that target variable is ordinal. So when risk category is maximum (8), the values ideally will be more. This is because many columns are based on fact that how many medical words does application contain and so on. With more such words, application becomes more risky and falls in category 8.

```
sum(abs((train_new4[,3] - mean(train_new4[,3]))/sd(train_new4[,3]))>3)
## [1] 0
sum(abs((train_new4[,11] - mean(train_new4[,11]))/sd(train_new4[,11]))>3)
## [1] 1
sum(abs((train_new4[,12] - mean(train_new4[,12]))/sd(train_new4[,12]))>3)
## [1] 51
sum(abs((train_new4[,13] - mean(train_new4[,13]))/sd(train_new4[,13]))>3)
## [1] 496
sum(abs((train_new4[,14] - mean(train_new4[,14]))/sd(train_new4[,14]))>3)
## [1] 709
sum(abs((train_new4[,15] - mean(train_new4[,15]))/sd(train_new4[,15]))>3)
```

Next moving to machine learning models. Splitting the data into test and train in 70:30 ratio.

[1] 945

require(caTools) ## Loading required package: caTools set.seed(123)

```
set.seed(123)
sample <- sample.split(train_new4, SplitRatio = .70)
trn <- subset(train_new4, sample == TRUE)
tst <- subset(train_new4, sample == FALSE)</pre>
```

Checking if the response variable or target variable is more or less evenly split. This is to avoid situations when there are lots of cases with particular category in test dataset and they don't occur much in train dataset and hence not accurately modeled.

But the split seems good.

```
table(trn$Response)
##
##
              2
                     3
                                         6
       1
                           4
                                  5
                                               7
    4287
           4602
                   691
                         998
                               3804
                                     7783
                                            5635 13619
table(tst$Response)
##
##
            2
                 3
                             5
                                  6
                                        7
## 1920 1950
               322
                    430 1628 3450 2392 5870
```

Source for PCA: https://www.analyticsvidhya.com/blog/2016/03/practical-guide-principal-component-analysis-python/processing the principal component analysis-python/processing the principal component analysis-python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/python/pyt

For fitting machine learning models, PCA needs to be applied to reduce the 200+ columns.

Extracting the columns without target variable.

```
prin_comp <- prcomp(trn[,1:204])</pre>
```

Checking the attributes of PCA.

```
names(prin_comp)
```

```
## [1] "sdev" "rotation" "center" "scale" "x"
```

Let's check the center's of the columns.

prin_comp\$center

```
##
        Product_Info_11
                              Product_Info_12
                                                     Product_Info_4
           9.739974e-01
                                 2.600256e-02
##
                                                       3.297252e-01
##
        Product_Info_52
                              Product_Info_53
                                                    Product_Info_61
##
           9.928535e-01
                                 7.146479e-03
                                                       1.649967e-01
        Product_Info_63
                              Product_Info_71
                                                    Product Info 72
##
                                 9.774741e-01
                                                       0.00000e+00
##
           8.350033e-01
##
        Product_Info_73
                                       Ins_Age
                                                                  Ht.
                                 4.055486e-01
##
           2.252589e-02
                                                       7.071906e-01
##
                      Wt
                                           BMI
                                                  Employment_Info_1
##
           2.924968e-01
                                 4.694037e-01
                                                       7.776541e-02
                           Employment_Info_33
##
     Employment_Info_31
                                                 Employment_Info_52
##
           8.494652e-01
                                 1.505348e-01
                                                       8.561288e-01
##
     Employment_Info_53
                               InsuredInfo_11
                                                     InsuredInfo_12
##
                                 7.942732e-01
           1.438712e-01
                                                       2.014534e-01
##
         InsuredInfo_13
                               InsuredInfo_22
                                                     InsuredInfo_23
           4.273401e-03
                                 9.928294e-01
                                                       7.170622e-03
##
```

```
##
         InsuredInfo 42
                               InsuredInfo 43
                                                     InsuredInfo 51
##
           1.168787e-01
                                 8.831213e-01
                                                       9.866004e-01
##
         InsuredInfo 53
                               InsuredInfo 61
                                                     InsuredInfo 62
##
                                 5.898501e-01
                                                       4.101499e-01
           1.339965e-02
##
         InsuredInfo 71
                               InsuredInfo_73 Insurance_History_11
           9.809991e-01
                                 1.900094e-02
##
                                                       2.722181e-01
   Insurance_History_12 Insurance_History_21 Insurance_History_22
##
           7.277819e-01
                                 9.729351e-01
                                                       0.00000e+00
   Insurance_History_23 Insurance_History_31 Insurance_History_32
##
           2.706487e-02
                                 4.248775e-01
                                                       2.414351e-05
   Insurance_History_33 Insurance_History_41 Insurance_History_42
##
           5.750984e-01
                                 4.699775e-01
                                                       1.041551e-01
##
   Insurance_History_43 Insurance_History_71 Insurance_History_72
           4.258674e-01
                                 5.269321e-01
##
                                                       4.717642e-02
   Insurance_History_73 Insurance_History_81 Insurance_History_82
##
           4.258915e-01
                                 2.613776e-01
                                                       4.258915e-01
##
   Insurance_History_83 Insurance_History_91 Insurance_History_92
##
           3.127309e-01
                                 8.184650e-03
                                                       5.658756e-01
##
   Insurance_History_93
                               Family_Hist_11
                                                     Family_Hist_12
##
           4.259398e-01
                                 9.150390e-03
                                                       2.935368e-01
##
         Family_Hist_13
                           Medical_History_31
                                                 Medical_History_32
##
                                                       8.983558e-01
           6.973128e-01
                                 2.414351e-05
##
                                                 Medical_History_42
     Medical_History_33
                           Medical_History_41
##
           1.016200e-01
                                 3.438760e-01
                                                       6.561240e-01
##
     Medical_History_51
                           Medical History 52
                                                 Medical History 53
##
           9.924431e-01
                                 7.508631e-03
                                                       4.828702e-05
##
     Medical_History_61
                           Medical_History_62
                                                 Medical_History_63
##
           5.458847e-02
                                 4.828702e-05
                                                       9.453632e-01
##
     Medical_History_71
                           Medical_History_72
                                                 Medical_History_73
##
           8.643376e-03
                                 9.699172e-01
                                                       2.143944e-02
##
     Medical_History_81
                           Medical_History_82
                                                 Medical_History_83
##
           2.163258e-02
                                 9.122383e-01
                                                       6.612907e-02
##
     Medical_History_91
                           Medical_History_92
                                                 Medical_History_93
##
           2.311500e-01
                                 7.688018e-01
                                                       4.828702e-05
##
    Medical_History_111
                          Medical_History_112
                                                Medical_History_113
                                                       9.957025e-01
##
           1.376180e-03
                                 2.921365e-03
##
    Medical_History_121
                          Medical_History_122
                                                Medical History 123
##
                                                       5.618195e-02
           0.000000e+00
                                 9.438181e-01
##
    Medical_History_131
                          Medical_History_132
                                                Medical_History_133
##
           1.152853e-01
                                 4.828702e-05
                                                       8.846665e-01
##
    Medical_History_141
                          Medical_History_142
                                                Medical History 143
                                                       9.727178e-01
##
           4.273401e-03
                                 2.300876e-02
                          Medical_History_162
                                                Medical_History_163
##
    Medical_History_161
##
           8.353654e-01
                                 2.414351e-05
                                                       1.646104e-01
##
    Medical_History_171
                          Medical_History_172
                                                Medical_History_173
##
           2.414351e-05
                                 2.153601e-02
                                                       9.784398e-01
##
    Medical_History_181
                          Medical_History_182
                                                Medical_History_183
##
           9.466428e-01
                                 5.316401e-02
                                                       1.931481e-04
##
                          Medical_History_192
                                                Medical_History_193
    Medical_History_191
##
           9.658852e-01
                                 3.399406e-02
                                                       1.207175e-04
##
    Medical_History_201
                          Medical_History_202
                                                Medical_History_203
##
           1.501726e-02
                                 9.849586e-01
                                                       2.414351e-05
##
    Medical_History_211
                          Medical_History_212
                                                Medical_History_213
##
           8.898090e-01
                                 1.100944e-01
                                                       9.657404e-05
```

шш	M-1:1 II:-+ 001	M-1:1 II:-+ 000	M-141 III-+ 021
##	Medical_History_221	Medical_History_222	Medical_History_231
##	1.810763e-02	9.818924e-01	2.361477e-01
##	Medical_History_232	Medical_History_233	Medical_History_251
##	2.414351e-05	7.638282e-01	8.093387e-01
##	Medical_History_252	Medical_History_253	Medical_History_261
##	1.868225e-01	3.838818e-03	4.828702e-05
##	Medical_History_262	Medical_History_263	Medical_History_271
##	1.905889e-01	8.093629e-01	9.778121e-03
##	Medical_History_272	Medical_History_273	Medical_History_281
##	1.690046e-04	9.900529e-01	9.326638e-01
##	Medical_History_282	Medical_History_283	Medical_History_291
##	6.731210e-02	2.414351e-05	2.284700e-01
##	Medical_History_292	Medical_History_293	Medical_History_301
##	2.414351e-05	7.715058e-01	7.243053e-05
##	Medical_History_302	Medical_History_303	
			Medical_History_311
##	9.596562e-01	4.027137e-02	7.267196e-03
##	Medical_History_312	Medical_History_313	Medical_History_331
##	2.414351e-05	9.927087e-01	9.671890e-02
##	Medical_History_333	Medical_History_341	Medical_History_342
##	9.032811e-01	1.554359e-01	2.414351e-05
##	Medical_History_343	Medical_History_351	Medical_History_352
##	8.445399e-01	9.988894e-01	4.828702e-05
##	Medical_History_353	Medical_History_361	Medical_History_362
##	1.062314e-03	1.154060e-02	7.978464e-01
##	Medical_History_363	Medical_History_371	Medical_History_372
##	1.906130e-01	6.156595e-02	9.383858e-01
##	Medical_History_373	Medical_History_381	Medical_History_382
##	4.828702e-05	9.950506e-01	4.949419e-03
##	Medical_History_391	Medical_History_392	Medical_History_393
##	8.556460e-02	4.828702e-05	9.143871e-01
##	Medical_History_401	Medical_History_402	Medical_History_403
##	1.617615e-02	0.00000e+00	9.838238e-01
##	Medical_History_411	Medical_History_412	Medical_History_413
##	6.780463e-01	0.00000e+00	3.219537e-01
##	Medical_Keyword_1	Medical_Keyword_2	Medical_Keyword_3
##	4.239600e-02	9.005529e-03	4.988049e-02
##	Medical_Keyword_4	Medical_Keyword_5	Medical_Keyword_6
##	1.479997e-02	8.426085e-03	1.277192e-02
##	Medical_Keyword_7	Medical_Keyword_8	Medical_Keyword_9
##	1.381009e-02	1.055071e-02	6.929187e-03
##	Medical_Keyword_10	Medical_Keyword_11	Medical_Keyword_12
##	3.732586e-02	5.765470e-02	9.657404e-03
##	Medical_Keyword_13	Medical_Keyword_14	Medical_Keyword_15
##	6.108308e-03	7.460344e-03	1.901060e-01
##	Medical_Keyword_16	Medical_Keyword_17	Medical_Keyword_18
##	1.231319e-02	9.488399e-03	7.750066e-03
##	Medical_Keyword_19	Medical_Keyword_20	Medical_Keyword_21
##	9.126246e-03	8.426085e-03	1.463097e-02
##	Medical_Keyword_22	Medical_Keyword_23	Medical_Keyword_24
##	3.824332e-02	9.686376e-02	1.902509e-02
##	Medical_Keyword_25	Medical_Keyword_26	Medical_Keyword_27
##	8.918612e-02	1.364108e-02	1.166131e-02
##	Medical_Keyword_28	Medical_Keyword_29	Medical_Keyword_30
##	1.504141e-02	1.158888e-02	2.455395e-02

```
##
     Medical_Keyword_31
                           Medical_Keyword_32
                                                 Medical_Keyword_33
##
           1.103358e-02
                                 2.069099e-02
                                                       2.267075e-02
##
     Medical Keyword 34
                           Medical Keyword 35
                                                 Medical Keyword 36
##
           2.061856e-02
                                 6.808470e-03
                                                       9.947126e-03
##
     Medical_Keyword_37
                           Medical_Keyword_38
                                                 Medical_Keyword_39
##
           6.649122e-02
                                 6.567034e-03
                                                       1.344793e-02
##
     Medical Keyword 40
                           Medical Keyword 41
                                                 Medical Keyword 42
##
           5.613366e-02
                                 9.874695e-03
                                                       4.580024e-02
##
     Medical_Keyword_43
                           Medical_Keyword_44
                                                 Medical Keyword 45
##
           1.122673e-02
                                 7.412057e-03
                                                       1.376180e-02
##
     Medical_Keyword_46
                           Medical_Keyword_47
                                                 Medical_Keyword_48
##
           8.691663e-03
                                 2.047370e-02
                                                       5.400903e-02
```

Rotation gives us the loadings of the PCA

prin_comp\$rotation

```
##
                                  PC1
                                                PC2
                                                              PC3
## Product_Info_11
                        -6.997923e-04
                                       6.096115e-03 -4.639264e-03
                                                     4.639264e-03
## Product_Info_12
                         6.997923e-04 -6.096115e-03
## Product_Info_4
                         4.494245e-03
                                      5.087014e-03
                                                    7.573793e-02
                                      1.299026e-03 -1.831530e-03
## Product_Info_52
                         1.434949e-03
## Product Info 53
                        -1.434949e-03 -1.299026e-03 1.831530e-03
## Product_Info_61
                        -2.929762e-03 8.360394e-03 -4.099050e-03
## Product Info 63
                         2.929762e-03 -8.360394e-03 4.099050e-03
## Product_Info_71
                         3.854239e-03 5.499028e-03
                                                     2.762266e-03
## Product_Info_72
                         0.000000e+00 0.000000e+00
                                                     0.000000e+00
## Product Info 73
                        -3.854239e-03 -5.499028e-03 -2.762266e-03
## Ins Age
                        -4.396332e-02 -9.490514e-03 -8.422023e-02
## Ht
                        -4.998172e-03 -1.018384e-02 9.025012e-03
## Wt
                        -6.415581e-03 -1.161065e-02 -9.090499e-03
## BMI
                        -5.932708e-03 -9.291807e-03 -2.565669e-02
## Employment_Info_1
                        -8.136221e-03 -1.166721e-03 9.704451e-03
                         3.589012e-05 1.859470e-02 1.370783e-01
## Employment_Info_31
  Employment_Info_33
                        -3.589012e-05 -1.859470e-02 -1.370783e-01
   Employment_Info_52
                        -1.572940e-02 3.991377e-03 5.401763e-02
## Employment_Info_53
                         1.572940e-02 -3.991377e-03 -5.401763e-02
## InsuredInfo_11
                        -5.113415e-02 -1.055498e-01 -1.060345e-01
## InsuredInfo 12
                         4.819931e-02 1.040788e-01 1.042906e-01
## InsuredInfo 13
                         2.934834e-03 1.471021e-03 1.743891e-03
## InsuredInfo 22
                        -1.875172e-03 2.045222e-03 -1.502328e-03
  InsuredInfo 23
                         1.875172e-03 -2.045222e-03
                                                    1.502328e-03
## InsuredInfo_42
                        -2.323782e-04 -3.211974e-02 5.556379e-03
## InsuredInfo 43
                         2.323782e-04 3.211974e-02 -5.556379e-03
## InsuredInfo 51
                        -4.570373e-03 4.149013e-03 9.724226e-05
## InsuredInfo 53
                         4.570373e-03 -4.149013e-03 -9.724226e-05
  InsuredInfo_61
                        -3.244456e-02 -5.390998e-02 9.835408e-02
  InsuredInfo_62
                         3.244456e-02 5.390998e-02 -9.835408e-02
                        -6.912050e-03 -5.583892e-04 -1.960833e-03
## InsuredInfo_71
  InsuredInfo_73
                         6.912050e-03 5.583892e-04 1.960833e-03
  Insurance_History_11 -1.737699e-01 -3.716646e-02 -6.073907e-02
  Insurance_History_12
                        1.737699e-01
                                       3.716646e-02
                                                     6.073907e-02
   Insurance_History_21
                         3.360637e-03
                                       1.096433e-02
                                                     1.594720e-02
   Insurance_History_22  0.000000e+00  0.000000e+00 -1.469368e-39
## Insurance_History_23 -3.360637e-03 -1.096433e-02 -1.594720e-02
```

```
## Insurance_History_31 3.130195e-01 -5.380414e-02 -5.014286e-02
## Insurance_History_32 1.429726e-05 -1.276946e-05 1.979952e-05
## Insurance History 33 -3.130338e-01 5.381691e-02 5.012306e-02
## Insurance_History_41 -2.681909e-01
                                      4.665264e-02 9.864037e-03
## Insurance_History_42 -4.518233e-02 7.647576e-03 4.099719e-02
## Insurance History 43 3.133732e-01 -5.430022e-02 -5.086122e-02
## Insurance_History_71 -2.865744e-01 5.698364e-02 8.164533e-02
## Insurance_History_72 -2.678138e-02 -2.693700e-03 -3.080990e-02
## Insurance_History_73 3.133558e-01 -5.428994e-02 -5.083543e-02
## Insurance_History_81 -1.668960e-01 -3.614011e-02 -6.119718e-02
## Insurance_History_82 3.133869e-01 -5.424422e-02 -5.084379e-02
## Insurance_History_83 -1.464909e-01 9.038433e-02 1.120410e-01
## Insurance_History_91 -3.418690e-03 2.811038e-04 -2.783185e-03
## Insurance_History_92 -3.099434e-01 5.407264e-02 5.366249e-02
## Insurance_History_93 3.133621e-01 -5.435374e-02 -5.087931e-02
## Family_Hist_11
                        -1.286234e-04 -1.396826e-03 -2.740455e-03
## Family_Hist_12
                        -3.566083e-02 -4.847540e-02 -1.599098e-01
## Family Hist 13
                        3.578945e-02 4.987222e-02 1.626502e-01
## Medical_History_31
                        -1.362789e-05 -5.286135e-06 -1.125038e-05
## Medical History 32
                        2.168742e-02 -1.087180e-02 5.685868e-02
## Medical_History_33
                        -2.167379e-02 1.087709e-02 -5.684743e-02
## Medical History 41
                        -2.394230e-02 -1.200121e-01 -1.242025e-01
## Medical_History_42
                        2.394230e-02 1.200121e-01 1.242025e-01
## Medical History 51
                        8.310055e-04 8.499369e-04 2.347029e-03
## Medical History 52
                        -8.407827e-04 -9.010248e-04 -2.377185e-03
## Medical_History_53
                        9.777181e-06 5.108796e-05 3.015586e-05
## Medical_History_61
                        -1.404848e-02 -1.994463e-02 -4.719906e-02
## Medical_History_62
                        -2.586752e-05 -1.355659e-05 2.178330e-05
## Medical_History_63
                        1.407435e-02 1.995819e-02 4.717728e-02
## Medical_History_71
                        -1.785910e-03 -1.121133e-03 -7.052767e-03
                        4.885962e-03 1.478846e-02 1.214896e-02
## Medical_History_72
## Medical_History_73
                        -3.100052e-03 -1.366733e-02 -5.096197e-03
## Medical_History_81
                        -3.041064e-03 -1.387714e-02 -5.430058e-03
## Medical_History_82
                        1.674629e-02 3.044507e-02 6.526053e-02
## Medical History 83
                        -1.370523e-02 -1.656793e-02 -5.983048e-02
                        -3.650451e-02 -4.970741e-02 -1.959116e-01
## Medical_History_91
## Medical History 92
                         3.650663e-02 4.973982e-02 1.959390e-01
## Medical_History_93
                        -2.114788e-06 -3.240934e-05 -2.741833e-05
## Medical_History_111
                        -1.381713e-04 2.474675e-03 -1.433693e-03
## Medical_History_112
                        -4.163771e-04 -5.901013e-04 -2.099668e-03
## Medical History 113
                         5.545484e-04 -1.884574e-03 3.533361e-03
## Medical History 121
                         0.000000e+00 0.000000e+00 0.000000e+00
## Medical History 122
                         1.204528e-02 1.336785e-02 4.512831e-02
## Medical_History_123
                        -1.204528e-02 -1.336785e-02 -4.512831e-02
## Medical_History_131
                        -7.178472e-03 -4.530161e-02 -9.462402e-02
## Medical_History_132
                        -2.768785e-05 -2.697718e-06 -3.182861e-05
## Medical_History_133
                         7.206160e-03 4.530431e-02 9.465585e-02
## Medical_History_141
                        -4.161391e-04 -2.030787e-03 -3.384167e-03
## Medical_History_142
                        -3.179235e-03 -1.140247e-02 -6.863751e-03
## Medical_History_143
                         3.595374e-03 1.343326e-02 1.024792e-02
                         3.554343e-02 5.561834e-02 1.638143e-01
## Medical_History_161
## Medical_History_162
                        -1.044964e-05 6.033525e-05 -2.541026e-05
## Medical_History_163
                        -3.553298e-02 -5.567868e-02 -1.637889e-01
                         1.684199e-05 -1.671030e-05 9.293249e-06
## Medical History 171
```

```
## Medical History 172
                        -3.201657e-03 -4.845022e-03 -1.615002e-02
## Medical_History_173
                         3.184815e-03 4.861732e-03 1.614073e-02
## Medical History 181
                         9.246700e-03 9.361943e-03 3.809176e-02
## Medical_History_182
                        -9.194686e-03 -9.258442e-03 -3.795339e-02
## Medical History 183
                        -5.201373e-05 -1.035015e-04 -1.383684e-04
## Medical History 191
                         1.263174e-03 1.044405e-03 2.493520e-02
## Medical_History_192
                        -1.196189e-03 -1.013578e-03 -2.490905e-02
                        -6.698493e-05 -3.082659e-05 -2.614916e-05
## Medical_History_193
## Medical_History_201
                        -1.176549e-03 -3.136598e-03 -1.476313e-02
## Medical_History_202
                         1.159709e-03 3.156674e-03 1.475275e-02
## Medical_History_203
                         1.683973e-05 -2.007596e-05
                                                    1.037273e-05
## Medical_History_211
                         2.369987e-02 3.137723e-02 1.007239e-01
## Medical_History_212
                        -2.364384e-02 -3.134373e-02 -1.006540e-01
## Medical_History_213
                        -5.602638e-05 -3.349651e-05 -6.991717e-05
## Medical_History_221
                        -2.202820e-03 -3.878471e-03 -1.152611e-02
## Medical_History_222
                         2.202820e-03 3.878471e-03 1.152611e-02
## Medical_History_231
                        -5.427146e-02 -5.106875e-02 -2.515729e-01
## Medical History 232
                        -1.498219e-05 -1.816676e-05 -2.469606e-05
                         5.428644e-02 5.108692e-02 2.515976e-01
## Medical_History_233
## Medical History 251
                        -3.740345e-02 -3.747431e-01 1.299078e-01
## Medical_History_252
                         3.654862e-02 3.692689e-01 -1.265707e-01
## Medical History 253
                         8.548305e-04 5.474120e-03 -3.337079e-03
## Medical_History_261
                         4.571810e-06 6.060093e-05 -8.044613e-05
## Medical History 262
                         3.737937e-02 3.746595e-01 -1.298351e-01
## Medical History 263
                        -3.738394e-02 -3.747201e-01 1.299155e-01
## Medical History 271
                        -1.939411e-03 -2.806063e-03 -9.532680e-03
## Medical_History_272
                        -7.022053e-05 -7.846849e-05 -6.850613e-05
## Medical_History_273
                         2.009631e-03 2.884531e-03 9.601187e-03
## Medical_History_281
                        -7.830031e-04 9.961696e-03 4.619832e-02
## Medical_History_282
                         7.964956e-04 -9.959944e-03 -4.621932e-02
                        -1.349257e-05 -1.752176e-06 2.100366e-05
## Medical_History_283
## Medical_History_291
                        -4.183776e-02 -6.354217e-02 -2.107947e-01
## Medical_History_292
                         1.911935e-05 -6.506293e-06 1.914001e-05
## Medical_History_293
                         4.181864e-02 6.354868e-02 2.107755e-01
## Medical History 301
                        -4.104419e-05 -1.532975e-05 -4.522112e-05
                         1.208017e-02 1.118001e-02 3.016739e-02
## Medical_History_302
## Medical History 303
                        -1.203913e-02 -1.116468e-02 -3.012216e-02
## Medical_History_311
                         3.547533e-04 -8.441706e-04 -2.352159e-03
## Medical_History_312
                        -1.135605e-05 8.274166e-07 2.604505e-05
## Medical_History_313
                        -3.433973e-04 8.433432e-04 2.326114e-03
## Medical History 331
                         1.350857e-03 -4.056285e-02 -3.570554e-02
## Medical History 333
                        -1.350857e-03 4.056285e-02 3.570554e-02
## Medical History 341
                        -1.218860e-02 -2.818132e-02 -7.047396e-02
## Medical_History_342
                        -1.396676e-05 -1.390132e-05 1.336844e-06
## Medical_History_343
                         1.220257e-02 2.819522e-02 7.047262e-02
                         1.419743e-04 -9.042853e-05 7.711657e-04
## Medical_History_351
## Medical_History_352
                        -2.768785e-05 -2.697718e-06 -3.182861e-05
## Medical_History_353
                        -1.142864e-04 9.312625e-05 -7.393371e-04
## Medical_History_361
                         7.485970e-04 -2.740305e-03 -5.325015e-03
                        -3.805802e-02 -3.718798e-01 1.352402e-01
## Medical_History_362
## Medical_History_363
                         3.730942e-02 3.746201e-01 -1.299152e-01
## Medical_History_371
                        -8.864355e-04 -9.228076e-03 -2.695292e-02
## Medical_History_372
                         9.052698e-04 9.199967e-03 2.699654e-02
## Medical History 373
                       -1.883437e-05 2.810892e-05 -4.361862e-05
```

```
## Medical History 381
                        -1.866203e-04 2.198719e-03 2.575576e-03
## Medical_History_382
                         1.866203e-04 -2.198719e-03 -2.575576e-03
## Medical History 391
                        -1.020053e-02 -1.009914e-02 -7.367554e-02
## Medical_History_392
                        -2.768785e-05 -2.697718e-06 -3.182861e-05
## Medical History 393
                         1.022822e-02
                                      1.010184e-02 7.370737e-02
## Medical History 401
                         1.559236e-03 -7.893891e-03 -8.231872e-03
## Medical History 402
                         0.000000e+00 0.000000e+00 0.000000e+00
## Medical_History_403
                        -1.559236e-03
                                       7.893891e-03
                                                     8.231872e-03
## Medical History 411
                         4.462212e-02
                                       8.180312e-02
                                                     2.642852e-01
## Medical_History_412
                         0.000000e+00 0.000000e+00 0.000000e+00
## Medical_History_413
                        -4.462212e-02 -8.180312e-02 -2.642852e-01
## Medical_Keyword_1
                        -1.120497e-02 -1.468540e-02 -5.514409e-02
## Medical_Keyword_2
                        -9.104068e-04 -1.565051e-03 -5.875041e-03
## Medical_Keyword_3
                        -4.391689e-03 -6.295527e-03 -4.757720e-02
## Medical_Keyword_4
                        -2.209051e-03 -3.208756e-03 -9.758488e-03
## Medical_Keyword_5
                        -1.426139e-03 -1.464336e-03 -7.105245e-03
## Medical_Keyword_6
                        -2.025414e-03 -8.072136e-04 -9.919257e-03
## Medical Keyword 7
                        -2.008876e-03 -4.202816e-03 -8.327705e-03
## Medical_Keyword_8
                        -1.981892e-04 -1.528076e-03 -9.306113e-03
## Medical Keyword 9
                        -1.169554e-03 -1.838693e-03 -5.497955e-03
## Medical_Keyword_10
                        -9.354118e-03 -1.039749e-02 -4.125910e-02
## Medical_Keyword_11
                        -2.760358e-04 -7.444638e-03 -2.337891e-02
## Medical_Keyword_12
                        -1.787147e-03 -3.215499e-03 -1.033512e-02
## Medical Keyword 13
                        -1.849181e-03 -1.608863e-03 -6.221631e-03
## Medical Keyword 14
                        -1.967099e-03 -1.922412e-03 -9.253912e-03
## Medical_Keyword_15
                        -4.384655e-02 -4.212284e-02 -2.158735e-01
## Medical_Keyword_16
                        -2.784912e-03 -3.358423e-03 -9.747611e-03
## Medical_Keyword_17
                        -1.094923e-03 -1.555386e-03 -8.645153e-03
                        -8.745246e-04 -2.666069e-03 -5.035594e-03
## Medical_Keyword_18
## Medical_Keyword_19
                        -2.097726e-03 -3.139659e-03 -7.769255e-03
## Medical_Keyword_20
                        -1.505151e-03 -2.522884e-03 -7.227991e-03
## Medical_Keyword_21
                        -1.972079e-03 -4.391401e-03 -1.132486e-02
## Medical_Keyword_22
                        -1.392715e-02 -1.537678e-02 -4.345158e-02
## Medical_Keyword_23
                         1.323965e-03 -4.031570e-02 -3.574195e-02
## Medical_Keyword_24
                        -5.753787e-03 -7.624351e-03 -1.596944e-02
                        -2.733739e-02 -2.686726e-02 -9.928778e-02
## Medical_Keyword_25
## Medical Keyword 26
                        -2.949299e-03 -2.156371e-03 -6.879501e-03
## Medical_Keyword_27
                        -3.591186e-03 -4.803393e-03 -1.856906e-02
## Medical_Keyword_28
                        -3.604736e-03 -4.627868e-03 -1.624599e-02
## Medical_Keyword_29
                        -2.669819e-03 -1.786444e-03 -1.174318e-02
## Medical Keyword 30
                                      1.335770e-04 -1.871023e-02
                         4.814956e-06
## Medical Keyword 31
                        -2.065068e-03 -3.297941e-03 -1.156344e-02
## Medical Keyword 32
                        -2.713079e-03 -5.890267e-03 -1.214279e-02
## Medical_Keyword_33
                        -6.690770e-03 -5.494035e-03 -2.439891e-02
## Medical_Keyword_34
                        -2.162116e-03 -2.521357e-03 -1.237293e-02
## Medical_Keyword_35
                        -1.495565e-03 -5.614432e-04 -5.387388e-03
## Medical_Keyword_36
                        -2.005294e-03 -3.105971e-03 -7.484256e-03
## Medical_Keyword_37
                        -1.080899e-02 -1.758668e-02 -5.533983e-02
## Medical_Keyword_38
                        -2.544562e-03 -3.094019e-03 -4.783997e-03
## Medical_Keyword_39
                        -6.204958e-04 -2.271293e-03 -1.059712e-02
                        -4.468333e-03 -2.044171e-02 -4.396997e-02
## Medical_Keyword_40
## Medical_Keyword_41
                        -3.473488e-03 -3.787766e-03 -8.001222e-03
## Medical_Keyword_42
                        -4.278974e-03 -2.093094e-02 -4.272023e-02
## Medical Keyword 43
                        -4.259219e-03 -3.313682e-03 -1.132461e-02
```

```
## Medical Keyword 44
                       -1.166923e-03 -1.819966e-03 -5.768909e-03
                       -1.786618e-03 -2.772662e-03 -1.098377e-02
## Medical_Keyword_45
## Medical Keyword 46
                        -2.729668e-03 -3.765434e-03 -1.161406e-02
## Medical_Keyword_47
                        -3.469539e-03 -6.726067e-03 -2.372238e-02
## Medical Keyword 48
                        -1.403279e-02 -1.986711e-02 -4.664291e-02
##
                                  PC4
                                               PC5
                                                             PC6
## Product Info 11
                        1.089200e-02 -2.813192e-03 1.489313e-02
                        -1.089200e-02 2.813192e-03 -1.489313e-02
## Product Info 12
## Product_Info_4
                        -3.089328e-02 1.550907e-02 -3.662247e-02
## Product_Info_52
                        4.568033e-03 -1.136645e-04 -2.007930e-04
## Product_Info_53
                        -4.568033e-03 1.136645e-04 2.007930e-04
                       -1.377118e-02 1.436701e-02 8.312210e-03
## Product_Info_61
## Product_Info_63
                        1.377118e-02 -1.436701e-02 -8.312210e-03
## Product_Info_71
                        5.313382e-03 -2.400846e-03 1.660907e-04
## Product_Info_72
                        1.110223e-16 2.428613e-16 -1.665335e-16
## Product_Info_73
                        -5.313382e-03 2.400846e-03 -1.660907e-04
                       -1.558076e-02 -1.341936e-02 7.521316e-02
## Ins_Age
## Ht
                       -5.573701e-02 -3.703404e-03 1.557557e-03
                       -5.218451e-02 3.929709e-04 1.678384e-02
## Wt
## BMI
                        -3.156413e-02 4.399064e-03 2.692273e-02
## Employment_Info_1
                       -1.986051e-02 6.629560e-03 1.884761e-03
## Employment_Info_31
                       -1.008152e-01 7.999563e-03 -6.173495e-02
## Employment_Info_33
                        1.008152e-01 -7.999563e-03 6.173495e-02
                        -1.893647e-01 1.940412e-02 4.371086e-02
## Employment Info 52
## Employment Info 53
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## InsuredInfo 11
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## Medical_History_183
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## Product Info 71
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## Wt
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## InsuredInfo_73
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## Insurance_History_12 2.478388e-02 -1.031737e-02 -4.111765e-02
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## Insurance_History_22 4.163336e-17 1.387779e-17 1.387779e-17
## Insurance_History_23 -1.286248e-02 1.029628e-02 4.010243e-03
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## Insurance_History_33 -6.373580e-03 -4.359753e-03 -4.255442e-03
## Insurance History 41 1.495989e-02 -2.310631e-03 -8.894513e-02
## Insurance_History_42 -2.224931e-02 -7.398750e-04 8.573031e-02
## Insurance_History_43 7.289416e-03 3.050506e-03 3.214818e-03
## Insurance History 71 -5.522136e-02 2.839029e-02 1.079096e-01
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## InsuredInfo 71
## InsuredInfo 73
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## Insurance_History_12 -1.220604e-02 -4.060561e-02 -1.423521e-02
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## Insurance_History_82 -7.734304e-04 8.294853e-03 -1.894017e-03
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## Medical_History_403
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## Wt
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## InsuredInfo 13
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## Insurance_History_21 -2.223452e-02 5.386962e-02 2.296456e-02
## Insurance_History_22 9.714451e-17 -5.551115e-17 -7.632783e-17
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## Insurance History 42 -2.195070e-02 -1.283636e-02 3.393452e-02
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## Insurance_History_82
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## Family_Hist_13
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## Product Info 12
## Product Info 4
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## Product Info 52
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## Product_Info_72
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## Ht
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## Wt
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## BMI
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## Employment Info 31
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## InsuredInfo 12
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## InsuredInfo 13
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## InsuredInfo_42
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## InsuredInfo_53
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## InsuredInfo_62
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## InsuredInfo 73
## Insurance History 11 -5.128319e-03 -4.793025e-02 4.398872e-03
## Insurance_History_12 5.128319e-03 4.793025e-02 -4.398872e-03
## Insurance_History_21 -2.591930e-02 5.556926e-02 1.694361e-01
## Insurance_History_22 0.000000e+00 -1.353084e-16 8.326673e-17
## Insurance History 23 2.591930e-02 -5.556926e-02 -1.694361e-01
## Insurance History 31 -3.821651e-03 -6.917394e-02 8.710320e-03
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## Insurance_History_82 -4.105479e-03 -6.942039e-02 8.226968e-03
## Insurance_History_83 1.103720e-02 1.052313e-01 -1.425935e-02
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## Medical_History_113
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                         2.209160e-03 7.521354e-03 6.411966e-02
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## Medical History 143
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## Medical History 233
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## Medical_History_263
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                                     1.475084e-03 -2.801510e-04
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Insurance_History_31 -4.149224e-05 6.220764e-04
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## Insurance_History_72 7.266634e-03 2.978770e-03 8.038420e-04
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## Medical_History_172
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## Medical_History_173
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## Medical History 181
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## Medical Keyword 17
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## Product_Info_12
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## Product Info 4
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## Product Info 52
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## Product_Info_72
## Product_Info_73
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## Ht
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## Wt
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## Employment Info 33
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## Employment_Info_52
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## Employment Info 53
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## InsuredInfo_42
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## InsuredInfo_53
## InsuredInfo_61
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## InsuredInfo 73
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## Insurance History 12 -1.060719e-03 -6.470541e-03 -6.849218e-03
## Insurance_History_21 5.710009e-03 -4.678657e-03 -1.489859e-05
## Insurance_History_22 3.816392e-17 -8.977194e-17 -2.220446e-16
## Insurance_History_23 -5.710009e-03 4.678657e-03 1.489859e-05
## Insurance History 31 5.912404e-05 -1.740147e-03 -5.290578e-03
## Insurance History 32 3.584462e-06 -9.771012e-04 9.209396e-04
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## Insurance_History_43 2.358540e-04 3.234761e-03 4.948252e-04
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## Insurance_History_72 -6.072888e-03 8.501517e-03 1.242110e-02
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## Insurance_History_81 7.302880e-05 -1.518302e-02 -1.675782e-02
## Insurance_History_82 1.001795e-03 2.309087e-03 -3.724875e-05
## Insurance_History_83 -1.074824e-03 1.287394e-02 1.679507e-02
## Insurance_History_91 2.520187e-03 2.329204e-02 3.748105e-02
## Insurance_History_92 -2.062396e-03 -2.599122e-02 -3.802478e-02
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## Family_Hist_13
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## Medical History 32
## Medical History 33
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## Medical_History_132
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## Wt
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## BMI
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## InsuredInfo_23
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## InsuredInfo 71
## InsuredInfo 73
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## Insurance_History_81 5.796073e-04 7.937134e-03
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## Insurance_History_82    1.826845e-03   -4.030708e-04    3.499742e-03
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## Medical History 52
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## Medical History 143
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## Insurance_History_21 4.152327e-04 7.456768e-04 -4.853959e-03
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## Insurance History 23 -8.675223e-05 1.518186e-03 6.624564e-04
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## Insurance_History_82 7.795866e-03 1.491841e-03 1.613641e-03
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## Insurance_History_91 -4.339154e-02 -2.580460e-02 -9.215872e-03
## Insurance_History_92 3.889401e-02 2.453122e-02 7.276720e-03
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## InsuredInfo 42
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## Wt
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## InsuredInfo 43
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## Insurance History 91 -1.234176e-02 -7.117355e-03 4.812942e-03
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## Medical_Keyword_44
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## Medical_Keyword_45
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## Medical Keyword 46
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## Medical Keyword 47
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## Medical_Keyword_48
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                                                    1.800575e-05
## Product_Info_12
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                                                   2.842882e-05
## Product_Info_4
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## Product_Info_52
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## Product_Info_61
## Product_Info_63
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## Product_Info_71
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## Product Info 72
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## Product_Info_73
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## Ins Age
                        -3.632436e-04 -1.328588e-04 9.922807e-05
                         2.645138e-03 -2.866961e-05 -1.324085e-02
## Ht
## Wt
                        -5.533354e-03 3.169072e-03 1.949426e-02
## BMI
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## Employment Info 33
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## Employment_Info_53
                         4.300248e-05 8.559619e-06 4.569195e-06
## InsuredInfo_11
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## InsuredInfo_12
                         1.089045e-04 6.256314e-07 -2.109864e-04
## InsuredInfo_13
                        -1.846023e-04
                                      1.451222e-05 1.639307e-04
## InsuredInfo_22
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## InsuredInfo_23
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                        -4.129164e-05 -4.235233e-05 1.591275e-04
## InsuredInfo_42
## InsuredInfo 43
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## InsuredInfo 51
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## InsuredInfo 53
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## Insurance_History_12 6.619919e-05 3.116304e-04 4.951055e-05
## Insurance_History_21 8.029974e-05
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## Insurance_History_22 -2.430348e-15
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## Insurance_History_23 -8.029974e-05 -1.451182e-04 -2.583578e-05
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## Insurance_History_32 -8.710410e-05 1.041165e-03 -1.784381e-04
## Insurance_History_33 -1.100880e-05 1.286556e-03 6.756550e-05
## Insurance_History_41 7.332748e-03 -3.114422e-01 -2.649589e-03
## Insurance_History_42 7.074367e-03 -3.117615e-01 -2.780522e-03
## Insurance_History_43 -1.440711e-02 6.232038e-01 5.430112e-03
## Insurance_History_71 6.725652e-04 -8.938544e-03 -1.878957e-04
## Insurance_History_72 6.920562e-04 -8.883891e-03 -1.048361e-04
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## Insurance_History_83 -2.344551e-03
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## Insurance_History_91 -5.405909e-03
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                                                   1.552027e-03
## Insurance History 92 -5.529551e-03 2.538990e-01 2.513129e-03
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## Family_Hist_12
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                                     4.579891e-05 -5.307139e-05
## Family_Hist_13
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                                      2.656516e-05 8.120920e-05
## Medical_History_31
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## Medical_History_32
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                                      1.554708e-04
                                                   2.225544e-04
## Medical_History_33
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## Medical_History_41
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## Medical History 62
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## Medical_History_63
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## Medical_History_71
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## Medical History 72
## Medical History 73
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## Medical History 81
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## Medical_History_92
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## Medical_History_93
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## Medical_History_112
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## Medical_History_113
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## Medical_History_121
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## Medical History 122
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                        1.305495e-04
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## Medical_History_133
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## Medical_History_141
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## Medical History 143
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## Medical History 161
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## Medical_History_173
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## Medical_History_251
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## Medical_History_252
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## Medical_History_253
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## Medical_History_263
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                        -1.370044e-01 7.988858e-04 -1.779218e-02
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## Medical History 273
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## Medical History 292
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## Medical History 362
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## Product Info 71
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## Product Info 72
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## Product Info 73
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## Wt
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## Insurance_History_31 -1.667075e-03 3.584275e-03 -1.498010e-02
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## Insurance_History_23 8.157851e-06 -4.914424e-05 -5.411380e-04
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## Product_Info_4
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## Product Info 61
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## Family_Hist_12
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## Family_Hist_13
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## Wt
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## Insurance_History_31 -1.395845e-01 3.592404e-02 -9.173725e-02
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  Insurance_History_41 7.096766e-02 -3.341344e-02 4.075511e-02
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## Insurance_History_91 -3.936169e-03 5.266177e-02 3.690002e-02
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## Insurance_History_82 3.915516e-02 -7.799574e-02 1.475129e-02
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## Family Hist 13
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                       -8.890458e-17 1.176359e-17 6.179952e-17
## Medical_Keyword_45
                       -7.494548e-18 1.369661e-16 8.324301e-17
## Medical Keyword 46
                       -7.036472e-17 2.146043e-17 -1.257675e-17
## Medical_Keyword_47
                       -1.307548e-16 5.347827e-17 -5.992928e-17
## Medical Keyword 48
                       -1.700029e-16 1.204549e-16 4.891920e-16
```

Ensuring the dimensions after PCA match with our dataframe.

```
dim(prin_comp$x)
```

```
## [1] 41419 204
```

Creating biplot to check for feature importance.

```
biplot(prin_comp, scale = 0)
```

```
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
```

```
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
```

```
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

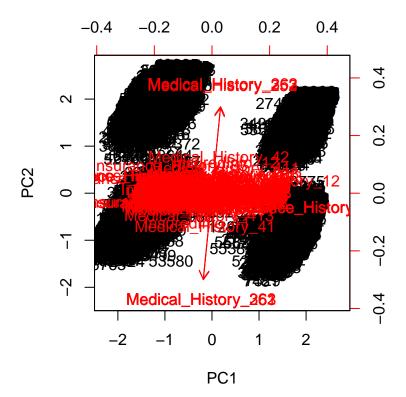
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length
## = arrow.len): zero-length arrow is of indeterminate angle and so skipped
```



Taking standard deviation values in a variable

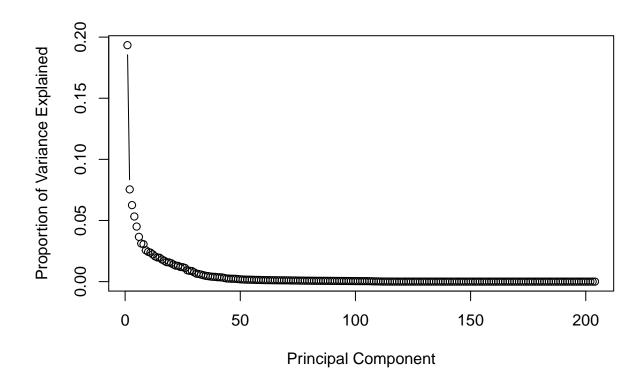
Calculating variance.

Let's see the the proportion of variance each component in PCA covers.

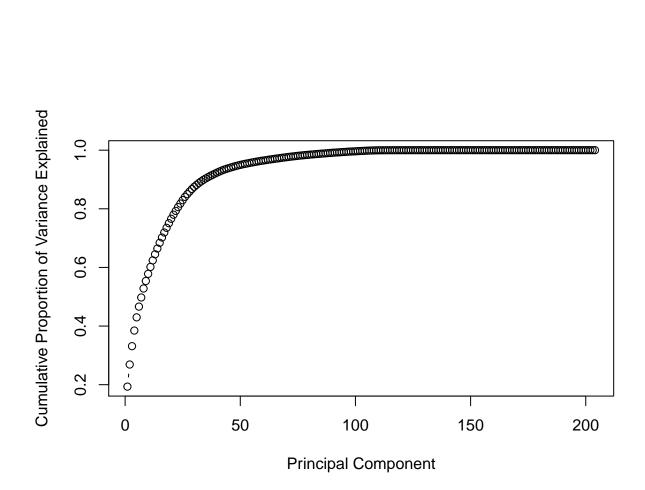
```
prop_varex <- pr_var/sum(pr_var)</pre>
prop_varex
     [1] 1.933997e-01 7.543438e-02 6.257017e-02 5.326379e-02 4.505276e-02
##
##
     [6] 3.661203e-02 3.116694e-02 3.059071e-02 2.564215e-02 2.435513e-02
##
    [11] 2.372451e-02 2.229416e-02 2.068007e-02 1.978211e-02 1.951306e-02
##
    [16] 1.805680e-02 1.706615e-02 1.592908e-02 1.572662e-02 1.505426e-02
##
    [21] 1.397120e-02 1.305580e-02 1.287993e-02 1.196984e-02 1.180792e-02
    [26] 1.115203e-02 9.283586e-03 8.832610e-03 8.662032e-03 7.543421e-03
##
##
    [31] 6.486017e-03 6.224257e-03 5.758938e-03 5.240480e-03 4.744615e-03
##
    [36] 4.518142e-03 4.167925e-03 3.966550e-03 3.887673e-03 3.654729e-03
    [41] 3.562191e-03 3.434088e-03 3.012093e-03 2.593960e-03 2.490049e-03
##
    [46] 2.351393e-03 2.320540e-03 2.286974e-03 2.101211e-03 1.884859e-03
##
##
    [51] 1.759971e-03 1.654269e-03 1.606076e-03 1.558703e-03 1.529764e-03
##
    [56] 1.461457e-03 1.411818e-03 1.376980e-03 1.326595e-03 1.245170e-03
##
    [61] 1.227570e-03 1.193540e-03 1.186199e-03 1.152726e-03 1.122230e-03
##
    [66] 1.114824e-03 1.079368e-03 1.076832e-03 1.063325e-03 1.045826e-03
    [71] 1.017792e-03 9.581210e-04 9.378947e-04 9.326266e-04 8.729614e-04
##
    [76] 8.239549e-04 8.047348e-04 7.743954e-04 7.504882e-04 7.363912e-04
##
##
    [81] 7.208984e-04 6.863028e-04 6.723195e-04 6.603384e-04 6.585432e-04
##
    [86] 6.510950e-04 6.412700e-04 6.340348e-04 6.185929e-04 6.047270e-04
    [91] 5.846467e-04 5.615818e-04 5.477802e-04 5.286778e-04 5.180483e-04
##
   [96] 5.057615e-04 4.821546e-04 4.685055e-04 4.632135e-04 4.356425e-04
##
## [101] 4.218612e-04 4.126577e-04 4.097477e-04 4.008886e-04 3.945421e-04
  [106] 3.708286e-04 2.957806e-04 2.498442e-04 2.140419e-04 1.711300e-04
## [111] 1.171724e-04 6.074804e-05 5.729411e-05 3.876877e-05 2.371180e-05
## [116] 2.101246e-05 1.983576e-05 1.954407e-05 9.625650e-06 8.530115e-06
## [121] 7.362718e-06 7.064297e-06 6.754781e-06 6.345418e-06 5.790601e-06
  [126] 5.655342e-06 4.141057e-06 4.080569e-06 2.895999e-06 2.895024e-06
  [131] 2.893775e-06 2.892128e-06 2.881946e-06 2.873805e-06 2.869247e-06
  [136] 2.814126e-06 1.903072e-06 1.546171e-06 1.341653e-06 1.072855e-06
## [141] 9.757059e-28 8.508084e-29 4.555014e-29 4.366768e-29 3.565740e-29
  [146] 1.388500e-29 3.722037e-30 2.781878e-30 1.988775e-30 1.552507e-30
## [151] 1.386987e-30 8.723926e-31 6.484950e-31 5.718048e-31 4.850579e-31
## [156] 3.566893e-31 3.266793e-31 2.646527e-31 2.357920e-31 1.873777e-31
## [161] 1.597176e-31 1.399641e-31 1.261121e-31 1.257051e-31 1.228244e-31
  [166] 1.185041e-31 1.031234e-31 9.059443e-32 8.708934e-32 8.507616e-32
## [171] 7.367782e-32 6.544515e-32 4.712896e-32 3.290099e-32 3.069614e-32
## [176] 2.853589e-32 2.704353e-32 2.407712e-32 1.897516e-32 1.826717e-32
## [181] 1.663419e-32 1.311372e-32 1.202531e-32 1.146370e-32 1.037943e-32
## [186] 9.550430e-33 7.193316e-33 6.297390e-33 5.729062e-33 4.506664e-33
## [191] 2.861688e-33 1.525508e-33 1.208396e-33 1.186323e-33 1.186323e-33
## [196] 1.186323e-33 1.186323e-33 1.186323e-33 1.186323e-33
## [201] 1.186323e-33 7.616205e-34 3.358474e-34 1.286158e-34
```

Making some exploratory plots for analysis.

Scree plot to figure out number of components that should be kept to cover most of the information in the dataset. It can be observed that first 50 components cover around 98% variance or information of the data. So keeping first 50 components for model building.



Similar things can be observed from cumulative plot.



Making data frame from principal components.

```
trn.data <- data.frame(prin_comp$x)</pre>
```

Taking the first 50 componets and adding the target variable column.

```
trn.data <- trn.data[,1:50]
trn.data_final <- data.frame(trn.data, Response = trn$Response)</pre>
```

Making predictions on test data to get principal components for test data.

```
tst.data <- predict(prin_comp, newdata = tst[,1:204])
tst.data <- tst.data[,1:50]
tst.data_final <- data.frame(tst.data, Response = tst$Response)</pre>
```

Ensuring the target variable is of type "factor"

```
trn.data_final$Response <- factor(trn.data_final$Response)
tst.data_final$Response <- factor(tst.data_final$Response)</pre>
```

Now starting to build machine learning models. First, let's check the accuracy of base model. This means that how much accuracy can be obtained without doing any machine learning.

Since category 8 occurs most frequently, we can consider or predict all cases as category 8. This gives accuracy as 32.82%. Thus aim for the project should be to build models that improve accuracy above 32%.

```
table(train$Response)
```

```
##
## 1 2 3 4 5 6 7 8
```

```
## 6207 6552 1013 1428 5432 11233 8027 19489 Accuracy for base model = (19489/59381) * 100 = 32.82\%
```

NaiveBayes

First model I am fitting is Naive Bayes. This is the only model that I am fitting on original dataset(having 206 columns) as columns obtained from PCA are continuous and Naive Bayes won't be a good model.

I decided to fit this model as majority of variables in original data frame are categorical and dummy coded.

```
library(e1071)
trn$Response <- factor(trn$Response)
tst$Response <- factor(tst$Response)
model_nb <- naiveBayes(Response~. , data = trn)

Making predictions on train data.
pred_trn <- predict(model_nb, trn[,1:204])</pre>
```

Forming confusion matrix for predictions

```
b <- table(pred_trn,trn$Response)
b</pre>
```

```
##
                            3
                                        5
                                                         8
                       2
                                  4
                                              6
                                                    7
##
   pred_trn
                 1
              655
                    388
                           13
                                 16
                                      128
                                            314
                                                 152
                                                       212
##
           1
##
           2
              434
                    597
                           24
                                 20
                                      222
                                            351
                                                 182
                                                       262
##
           3 1185 1371
                          242
                                164
                                      975 1517
                                                 639
                    901
                          333
                                695 1282 3108 2022 4320
##
              801
           5
              283
                    411
                                      257
                                                  140
##
                           15
                                  5
                                            353
                                                       169
                                  5
##
           6
              101
                    112
                            2
                                       58
                                            207
                                                   53
                                                      100
##
           7
              500
                    521
                           35
                                 37
                                      426 1079 1303 1263
##
              328
                    301
                           27
                                 56
                                      456
                                           854 1144 6384
```

Evaluating accuracy

```
(sum(diag(b))/sum(b)) *100
```

```
## [1] 24.96439
```

It is observed that accuracy is even less than base model accuracy. One possible reason that Naive Bayes doesn't work well is that columns are dependent on each other and the target variable is also ordinal.

Since Naive Bayes assumes that columns or features should be independent of each other, it doesn't work well.

Predicting on test dataset

```
pred_nb_tst <- predict(model_nb, tst[,1:204])</pre>
```

Making confusion matrix

```
a <- table(pred_nb_tst,tst$Response)
a
```

```
##
## pred_nb_tst
                               3
                                     4
                                           5
                                                6
                                                      7
                                                            8
                          2
                 252
                      174
                              18
                                    10
                                          70
                                              143
                                                     63
##
```

```
##
                 200
                      227
                             10
                                   9
                                       105
                                           172
                                                   70
                                                       101
                 507
                      586
                                                       411
##
              3
                             94
                                  64
                                       371 664
                                                  286
##
              4
                 387
                      396
                           162
                                 284
                                       547 1413
                                                  916 1905
##
              5
                 130
                      176
                              5
                                                        73
                                   4
                                       107
                                            166
                                                   57
##
              6
                  51
                       38
                              5
                                   3
                                        19
                                            105
                                                   35
              7
                 230
                      221
                                            447
                                                  492 566
##
                             17
                                   26
                                       209
                 163
                      132
                             11
                                   30
                                       200
                                            340
                                                  473 2668
Checking for accuracy
(sum(diag(a))/sum(a)) *100
## [1] 23.54415
```

Support Vector Machine with Gaussian Kernel

Some generic notes for future models

For all the models, I wanted to tune the parameters using caret package and k fold cross validation. However the simple model is taking too long to train. So making k folds and tuning would take couple of hours for a single model which is not feasible.

However I have manually tried different tuning values and selected one's that give best accuracy. Just that k fold wasn't possible. I am also demonstrating a small code below that shows that I can tune parameters using kfold.

```
library(caret) trctrl <- trainControl(method = "repeatedcv", number = 10, repeats = 3) svm radial <-
train(Response \sim ., data = trn.data\_final, method = "svmRadial", trControl = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trControl = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trControl = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trControl = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trControl = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trControl = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trControl = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trcontrol = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trcontrol = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trcontrol = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trcontrol = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = "svmRadial", trcontrol = trctrl, preProcess = c("center", train(Response \sim ., data = trn.data\_final, method = trol = 
"scale"), tuneLength = 10)
```

Training with SVM

```
library(kernlab)
model_svm_rbf <- ksvm(Response~. , data = trn.data_final, kernel = 'rbf')</pre>
```

Making predictions on train data

```
svm_pred_trn <- predict(model_svm_rbf, trn.data_final)</pre>
```

Building confusion matrix

```
sv_trn <- table(svm_pred_trn,trn.data_final$Response)</pre>
sv_trn
```

```
##
## svm_pred_trn
                            2
                                   3
                                          4
                                                 5
                                                       6
                                                              7
                                                                     8
               1
                  1794
                          267
                                  63
                                         44
                                              178
                                                     193
                                                            116
                                                                    61
                         1843
                                  49
                                         29
                                              340
                                                            154
                                                                    79
               2
                   415
                                                     307
##
                                  12
##
                      0
                             0
```

```
##
                 4
                        0
                               0
                                       0
                                              6
                                                      1
                                                             0
                                                                    0
                                                                            0
                 5
                       28
                              38
                                       3
                                                   330
                                                            23
                                                                   22
                                                                            7
##
                                              0
##
                 6
                      792
                             916
                                    375
                                            519
                                                   902
                                                         4271
                                                                  965
                                                                        1163
                 7
##
                      257
                             269
                                                   290
                                                                         142
                                      17
                                             13
                                                          486
                                                                 1567
                    1001
                            1269
                                    172
                                            387
                                                  1763
                                                         2503
                                                                 2811 12167
```

Evaluating accuracy on train data

```
(sum(diag(sv_trn))/sum(sv_trn)) *100
```

```
## [1] 53.09158
```

Predictions on test dataset

```
svm_pred_tst <- predict(model_svm_rbf, tst.data_final[,1:50])</pre>
```

Making Confusion matrix

```
sv_tst <- table(svm_pred_tst,tst.data_final$Response)
sv_tst</pre>
```

```
##
                                                            7
                                                                  8
##
   svm_pred_tst
                       1
                             2
                                   3
                                          4
                                                5
                                                      6
##
                     492
                           300
                                  32
                                         19
                                             107
                                                    210
                                                           88
                                                                 73
                                          7
##
                 2
                     295
                           379
                                  28
                                             142
                                                    251
                                                          106
                                                                 76
                 3
                                   0
                                          0
##
                       0
                             0
                                                1
                                                      0
                                                            0
                                                                  0
                 4
                       0
                             1
                                    1
                                          0
                                                0
                                                      0
                                                                   0
##
                 5
                      19
                            28
                                    2
                                          0
                                                     24
                                                           33
                                                                   4
##
                                               46
##
                 6
                     456
                           527
                                 168
                                       219
                                             447
                                                  1575
                                                          475
                                                                584
                 7
                           140
                                                                 70
##
                     133
                                   3
                                                    263
                                                          468
                                         11
                                             134
                     525
                           575
                                       174
                                             751 1127 1222 5063
                                  88
```

Evaluating accuracy

```
(sum(diag(sv_tst))/sum(sv_tst)) *100
```

```
## [1] 44.66652
```

For SVM: Train accuracy = 53% and test accuracy = 45%. SVM gives decent results given the complexity of the dataset.

Multinomial Regression

Multinomial regression is similar to logistic regression when there are more than 2 classes. It adopts a one-versus all approach in which it assumes one class as 1 and all the remaining classes as 0 and repeats this for all the classes.

It is linear classifier and makes 8 different hyperplanes in this case for classification.

I have tuned the max iterations parameter to a very large value so that it allows enough iterations for the gradient descent optimization to converge and reach global minima and give optimal weight values.

```
library(nnet)
```

```
## # weights: 416 (357 variable)
## initial value 86128.389215
## iter
        10 value 71111.216406
## iter
         20 value 70240.699543
## iter
         30 value 69709.178812
        40 value 68447.668990
## iter
         50 value 66537.997094
## iter
## iter
         60 value 65653.841707
## iter
         70 value 64458.400751
## iter
        80 value 63680.808879
## iter
        90 value 63472.646428
## iter 100 value 63339.129931
## iter 110 value 63190.441790
## iter 120 value 63149.562035
## iter 130 value 63107.123272
## iter 140 value 63063.742265
## iter 150 value 63051.838289
## iter 160 value 63017.783582
## iter 170 value 63006.812072
## iter 180 value 62993.037600
## iter 190 value 62984.686552
## iter 200 value 62975.751685
## iter 210 value 62971.620445
## iter 220 value 62967.616384
## iter 230 value 62966.781767
## iter 240 value 62966.075050
## iter 250 value 62965.971526
## iter 260 value 62965.837039
## iter 270 value 62965.715514
## iter 280 value 62965.694103
## final value 62965.686136
## converged
```

(sum(diag(mt))/sum(mt)) *100

From above it can be observed that at each iteration the value of cost function decreases till it reaches minimum.

Making predictions and thus confusion matrix on train data.

```
pred_logistic <- predict(model_logistic,trn.data_final[,1:50])</pre>
   <- table(pred_logistic, trn.data_final$Response)</pre>
mt
##
                                                                    7
##
   pred logistic
                         1
                                2
                                       3
                                              4
                                                      5
                                                             6
                                                                           8
##
                              620
                                      56
                                             31
                                                   234
                                                           486
                                                                  228
                                                                         121
                  1
                     1111
                      570
                              903
                                      39
                                             18
                                                   339
                                                           456
                                                                  178
                                                                         129
##
                 3
                                                      3
                                                             9
##
                        14
                                9
                                      18
                                              2
                                                                    1
                                                                           0
##
                  4
                        15
                               22
                                      20
                                             39
                                                     19
                                                            23
                                                                    7
                                                                          20
                 5
##
                        51
                               61
                                              0
                                                     86
                                                            43
                                                                          24
                                       8
                                                                   37
##
                  6
                     1026
                             1154
                                     396
                                            542
                                                   938
                                                         3169
                                                                 1015
                                                                        1343
                  7
##
                      347
                              398
                                       9
                                                   364
                                                           639
                                                                 1198
                                                                         158
                                             12
##
                     1153
                             1435
                                     145
                                            354
                                                  1821
                                                         2958
                                                                 2971 11824
Evaluating train accuracy
```

[1] 44.29851

Predictions and confusion matrix on test dataset

```
pred_logistic_tst <- predict(model_logistic, tst.data_final[,1:50])</pre>
mt1 <- table(pred_logistic_tst, tst.data_final$Response)</pre>
##
##
                                  2
                                        3
                                              4
                                                    5
                                                          6
                                                                7
                                                                     8
   pred_logistic_tst
                            1
                                                   97
                                285
                                             15
                                                       218
                                                                    46
##
                          477
                                       31
                                                              79
##
                      2
                          262
                                348
                                       20
                                              6
                                                  137
                                                       224
                                                              81
                                                                    70
##
                      3
                           10
                                  4
                                        5
                                              1
                                                    0
                                                          5
                                                                0
                                                                     3
                      4
                            6
                                  8
                                        9
                                              8
                                                    4
                                                         12
                                                                0
##
                                                                     7
##
                      5
                           21
                                 35
                                        5
                                              0
                                                   22
                                                         23
                                                              19
                                                                    15
##
                      6
                          434
                                497
                                     175
                                           226
                                                                   569
                                                 421 1467
                                                             443
                      7
##
                          159
                                171
                                        4
                                              4
                                                 172
                                                       297
                                                             504
                                                                    69
##
                         551
                                602
                                       73
                                           170
                                                 775 1204 1266 5091
Evaluating test accuracy
```

```
(sum(diag(mt1))/sum(mt1)) *100
```

```
## [1] 44.10422
```

For multinomial regression: Train accuracy: 44%; Test Accuracy = 44% Decent results but not as good as SVM.

Neural Networks with 10 neurons in hidden layer

Small snippet of code showing I can tune parameters with k fold CV and holdout method. However not feasible due to computation. But I tried many different parameters within computation capacity and used the best one with max accuracy.

```
\label{eq:control} \begin{split} & \operatorname{nnetGrid} < -\operatorname{expand.grid}(.\operatorname{size} = \operatorname{c}(10:20,10:20), \ .\operatorname{decay} = \operatorname{c}(0.01,0.001,0.0001)) \ \operatorname{ctrl} < -\operatorname{trainControl}(\operatorname{method} = \operatorname{"repeatedcv"}, \ \operatorname{number} = 10, \ \operatorname{repeats} = 3) \ \operatorname{model\_neural} < -\operatorname{train}(\operatorname{Response}_{\sim}. \ , \ \operatorname{data} = \operatorname{trn.data\_final}, \\ & \operatorname{method} = \operatorname{"nnet"}, \ \operatorname{tuneGrid} = \operatorname{nnetGrid}, \ \operatorname{trControl} = \operatorname{ctrl}, \ \operatorname{preProc} = \operatorname{c}(\operatorname{"center"}, \operatorname{"scale"}), \ \operatorname{maxit} = 10000) \end{split}
```

Training neural network. Here there are 10 neurons in one and only hidden layer. Decay rate is kept to be 0.001, this refers to the learning rate or the rate at which algorithm comes down the gradient to reach minima. Tuned max iterations to a large value so that there are enough iterations for convergence.

```
library(nnet)
model_neural <- nnet(Response~., data = trn.data_final, size = c(10), decay = 0.001, maxit = 10000)
## # weights: 598
## initial value 110273.903428
## iter 10 value 70872.885228
## iter
        20 value 65526.853296
## iter
         30 value 64500.013629
## iter
         40 value 63635.340140
## iter
         50 value 63254.022081
## iter
        60 value 62897.053656
        70 value 62576.166094
        80 value 62261.857242
## iter
        90 value 61790.731378
## iter 100 value 61374.490069
```

```
## iter 110 value 61104.627829
## iter 120 value 60805.906543
## iter 130 value 60409.480196
## iter 140 value 60066.528153
## iter 150 value 59840.582475
## iter 160 value 59701.869004
## iter 170 value 59567.622533
## iter 180 value 59462.552378
## iter 190 value 59344.884773
## iter 200 value 59174.655374
## iter 210 value 59055.598123
## iter 220 value 58980.750348
## iter 230 value 58925.901750
## iter 240 value 58881.998457
## iter 250 value 58851.217419
## iter 260 value 58792.487300
## iter 270 value 58717.334877
## iter 280 value 58661.209172
## iter 290 value 58594.946158
## iter 300 value 58537.597646
## iter 310 value 58471.528617
## iter 320 value 58419.363251
## iter 330 value 58332.741545
## iter 340 value 58263.673429
## iter 350 value 58204.134481
## iter 360 value 58158.161827
## iter 370 value 58108.532164
## iter 380 value 58063.522336
## iter 390 value 58034.216861
## iter 400 value 58013.993998
## iter 410 value 57981.029799
## iter 420 value 57932.349512
## iter 430 value 57887.163767
## iter 440 value 57840.663290
## iter 450 value 57788.705795
## iter 460 value 57747.796060
## iter 470 value 57716.332954
## iter 480 value 57699.901917
## iter 490 value 57688.390658
## iter 500 value 57681.795175
## iter 510 value 57676.031524
## iter 520 value 57654.462041
## iter 530 value 57630.142451
## iter 540 value 57605.681578
## iter 550 value 57590.005777
## iter 560 value 57571.189845
## iter 570 value 57559.122167
## iter 580 value 57547.516009
## iter 590 value 57541.340318
## iter 600 value 57534.871917
## iter 610 value 57529.547031
## iter 620 value 57526.601977
## iter 630 value 57524.150689
## iter 640 value 57521.539899
```

```
## iter 650 value 57519.537788
## iter 660 value 57517.496593
## iter 670 value 57515.412358
## iter 680 value 57513.696581
## iter 690 value 57511.952084
## iter 700 value 57508.399285
## iter 710 value 57505.778769
## iter 720 value 57499.381701
## iter 730 value 57492.056366
## iter 740 value 57489.565516
## iter 750 value 57486.967975
## iter 760 value 57483.356519
## iter 770 value 57469.716564
## iter 780 value 57458.882108
## iter 790 value 57453.662900
## iter 800 value 57450.247695
## iter 810 value 57449.375118
## iter 820 value 57449.036835
## iter 830 value 57448.673137
## iter 840 value 57448.183403
## iter 850 value 57447.918420
## iter 860 value 57447.723867
## iter 870 value 57447.666654
## iter 880 value 57447.604924
## iter 890 value 57447.444026
## iter 900 value 57447.270817
## iter 910 value 57447.207766
## iter 920 value 57447.128983
## iter 930 value 57447.045293
## iter 940 value 57446.947495
## iter 950 value 57446.908344
## iter 960 value 57446.864621
## iter 970 value 57446.773098
## iter 980 value 57446.542978
## iter 990 value 57446.342957
## iter1000 value 57445.898123
## iter1010 value 57441.109909
## iter1020 value 57435.473638
## iter1030 value 57430.553636
## iter1040 value 57427.404959
## iter1050 value 57425.854969
## iter1060 value 57425.310861
## iter1070 value 57424.695116
## iter1080 value 57422.484735
## iter1090 value 57414.001868
## iter1100 value 57411.118487
## iter1110 value 57407.675130
## iter1120 value 57405.304459
## iter1130 value 57405.075542
## iter1140 value 57404.971394
## iter1150 value 57404.897591
## iter1160 value 57404.755098
## iter1170 value 57404.569543
## iter1180 value 57404.427806
```

```
## iter1190 value 57404.335540

## iter1200 value 57404.212869

## iter1210 value 57404.168892

## iter1220 value 57404.126298

## iter1230 value 57404.060196

## iter1240 value 57404.037961

## final value 57404.027264

## converged
```

Making predictions from the neural network. Predictions come as probabilities since the activation function is sigmoid. Figure out class with maximum accuracy using for loop.

```
pred_nn <- predict(model_neural, trn.data_final[,1:50])
df_nn <- data.frame(pred_nn)
df_nn$new <- 0
for(i in 1:nrow(df_nn)) {
   df_nn[i,9] <- which.max(df_nn[i,1:8])
}</pre>
```

Making confusion matrix for train data

```
nn <- table(df_nn[,9], trn.data_final$Response)
nn</pre>
```

```
##
##
            1
                   2
                          3
                                 4
                                        5
                                               6
                                                      7
                                                             8
##
         1160
                 654
                         69
                                33
                                      302
                                             534
                                                    241
                                                           160
     1
##
     2
          595
                 893
                         39
                                 3
                                      485
                                             509
                                                    119
                                                            51
                  10
##
     3
            2
                         18
                                 1
                                       14
                                               0
                                                      0
                                                             0
##
     4
            5
                  12
                         10
                                33
                                        0
                                              24
                                                     16
                                                            23
##
     5
          303
                 590
                         93
                                 1
                                     1226
                                             334
                                                    100
                                                            43
##
     6
          981
                1204
                        376
                               495
                                     1021
                                            3451
                                                   1292
                                                          1058
     7
##
          328
                 319
                         10
                                13
                                      290
                                             688
                                                  1416
                                                           300
##
     8
          913
                 920
                         76
                               419
                                      466 2243
                                                  2451 11984
```

Evaluating train data accuracy

```
(sum(diag(nn))/sum(nn)) *100
```

```
## [1] 48.72402
```

Making predictions on test data

```
pred_nn_tst <- predict(model_neural, tst.data_final[,1:50])
df_nn_tst <- data.frame(pred_nn_tst)
df_nn_tst$new <- 0
for(i in 1:nrow(df_nn_tst)) {
   df_nn_tst[i,9] <- which.max(df_nn_tst[i,1:8])
}</pre>
```

Building confusion matrix on test data

```
nn_tst <- table(df_nn_tst[,9], tst.data_final$Response)
nn_tst</pre>
```

```
##
##
                2
                      3
                           4
                                 5
                                       6
                                            7
                                                  8
           1
                                                 66
##
        480 313
                     30
                           15 129
                                    280
                                           89
     1
##
     2
        266
              338
                     22
                           2 219
                                    247
                                           35
                                                 34
                                                  0
##
     3
                      9
                           0
                                 8
                                            0
           4
                                       0
                1
```

```
##
           4
                       3
                            15
                                   0
                                        9
                                              3
                                                   13
                                                   20
##
     5
         151
               257
                      56
                             1
                                480
                                      130
                                             55
##
     6
         438
               500
                     161
                           190
                                439 1465
                                            584
                                                  506
                                                  122
##
     7
                       6
         156
               144
                            10
                                131
                                      320
                                            588
         421
               394
                      35
                          197
                                222
                                      999 1038 5109
```

Evaluating accuracy on test data.

```
(sum(diag(nn_tst))/sum(nn_tst)) *100
```

```
## [1] 47.23305
```

For Neural Network: Train Accuracy = 49%; Test Accuracy = 47% Neural Network results outperform both SVM and Multinomial Regression

Ensemble model using voting

Trying to improve accuracy using voting. In this I have created data frame with 3 columns having predictions for all the 3 models implemented (excluding NaiveBayes).

Then created a new column for majority voting. If any 2 columns are same or predict same classes, the majority vote column takes that value. In rare case, if all the three models are predicting 3 different class for a case, then the majority vote column takes value from neural net prediction as neural network is giving best results.

Making data frame from 3 different predictions

```
vot_df <- data.frame(svm_pred_tst, pred_logistic_tst, df_nn_tst[,9])</pre>
```

Running for loop for each case. Majority vote in new column takes value which is there in atleast 2 columns. If all 3 columns have different classes, neural network class is predicted.

```
vot_df$new <- 0
for(i in 1:nrow(vot_df)) {
    if(vot_df[i,1] == vot_df[i,2])
       vot_df[i,4] = vot_df[i,1]
    else if(vot_df[i,1] == vot_df[i,3])
       vot_df[i,4] = vot_df[i,1]
    else if(vot_df[i,2] == vot_df[i,3])
       vot_df[i,4] = vot_df[i,2]
    else vot_df[i,4] = vot_df[i,3]
}</pre>
```

Building confusion matrix on ensemble model

```
ensemble <- table(vot_df$new, tst.data_final$Response)
ensemble</pre>
```

```
##
                  2
                                                 7
                                                       8
##
            1
                        3
                              4
                                     5
                                           6
##
         481
               297
                       32
                             15
                                   97
                                        221
                                                84
                                                      52
      1
      2
         261
               361
                       21
                              3
                                  158
                                        220
                                                52
                                                      42
##
##
      3
            3
                        3
                              0
                                     2
                                                 0
                                                       0
                  1
                                           0
##
      4
            2
                  2
                        1
                              3
                                     0
                                           6
                                                 2
                                                       3
##
      5
                 54
                       12
                              0
                                   48
                                          25
                                                22
                                                       4
           49
##
      6
         445
               503
                      180
                            227
                                  433 1533
                                               484
                                                     571
      7
                                                      69
##
         154
               158
                        3
                                  154
                                        290
                                              497
                              6
```

8 525 574 70 176 736 1155 1251 5129

Evaluating ensemble model

```
(sum(diag(ensemble))/sum(ensemble)) *100
```

[1] 44.84467

Test accuracy for ensemble =45% which is better than multinomial regression and SVM. However this approach doesn't give more accuracy than neural networks.

Having said that, neural networks have way more capability to give more better results when we add more hidden layers and more neurons in each layer. Unfortunately, I couldn't do that due to large computation that it will require.

Thus I conclude that Neural Networks is the way to go for the prudential dataset on Kaggle.

I observed that top performers in Kaggle for this dataset have been able to get accuracy close to 60%. I have been abe to reach 48% with neural network. Thus my goal in summer is to invest more time in this dataset to see what I can do or learn more that would help me reach that mark.