Assignment-8.R

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2020-11-03

GitHub Link:

.R File: https://github.com/kunwangRU/Survival-Analysis-of-Patients-with-Heart-Failure/blob/master/Logistic%20Regression%20(Assignment%208).R

```
#Loading Packages
library(dplyr)

##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

library(ggplot2)

## Warning: package 'ggplot2' was built under R version 3.6.3

library(cowplot)

## Warning: package 'cowplot' was built under R version 3.6.3

library(regclass)

## Warning: package 'regclass' was built under R version 3.6.3

## Loading required package: bestglm

## Warning: package 'bestglm' was built under R version 3.6.3

## Loading required package: leaps

## Warning: package 'leaps' was built under R version 3.6.3

## Loading required package: VGAM

## Warning: package 'VGAM' was built under R version 3.6.3

## Loading required package: stats4

## Loading required package: splines
## Loading required package: rpart

## Loading required package: randomForest

## Warning: package 'randomForest' was built under R version 3.6.3

## randomForest 4.6-14

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

##
## Attaching package: 'randomForest'

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

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

## Important regclass change from 1.3:
## All functions that had a . in the name now have an _
## all.correlations -> all_correlations, cor.demo -> cor_demo, etc.

library(caret)

## Warning: package 'caret' was built under R version 3.6.3

## Loading required package: lattice

## Warning: package 'lattice' was built under R version 3.6.3

##
## Attaching package: 'lattice'

## The following object is masked from 'package:regclass':
##
##     qq

##
## Attaching package: 'caret'

## The following object is masked from 'package:VGAM':
##
##     predictors

library(e1071)

## Warning: package 'e1071' was built under R version 3.6.3

library(pROC)

## Warning: package 'pROC' was built under R version 3.6.3
## Type 'citation("pROC")' for a citation.
```

```
##
## Attaching package: 'pROC'
```

```
## The following objects are masked from 'package:stats':
##
##     cov, smooth, var
```

```
#Loading dataset
rawdata <-read.csv("C:/Users/wangk/Desktop/Rutgers/Rutgers Courseware/Fall
2020/Multivariate Analysis/heart_failure_clinical_records_dataset.csv")
View(rawdata)

#Identifying different columns names
names(rawdata)
```

```
##  [1] "age"                      "anaemia"
##  [3] "creatinine_phosphokinase" "diabetes"
##  [5] "ejection_fraction"        "high_blood_pressure"
##  [7] "platelets"                "serum_creatinine"
##  [9] "serum_sodium"             "sex"
## [11] "smoking"                  "time"
## [13] "DEATH_EVENT"
```

```
#Data Summary
str(rawdata)
```

```
## 'data.frame':    299 obs. of  13 variables:
##  $ age                     : num  75 55 65 50 65 90 75 60 65 80 ...
##  $ anaemia                 : int  0 0 0 1 1 1 1 1 0 1 ...
##  $ creatinine_phosphokinase: int  582 7861 146 111 160 47 246 315 157 123
...
##  $ diabetes                : int  0 0 0 0 1 0 0 1 0 0 ...
##  $ ejection_fraction       : int  20 38 20 20 20 40 15 60 65 35 ...
##  $ high_blood_pressure     : int  1 0 0 0 0 1 0 0 0 1 ...
##  $ platelets               : num  265000 263358 162000 210000 327000 ...
##  $ serum_creatinine        : num  1.9 1.1 1.3 1.9 2.7 2.1 1.2 1.1 1.5 9.4
...
##  $ serum_sodium            : int  130 136 129 137 116 132 137 131 138 133
...
##  $ sex                     : Factor w/ 2 levels "Female","male": 2 2 2 2 1
2 2 2 1 2 ...
##  $ smoking                 : int  0 0 1 0 0 1 0 1 0 1 ...
##  $ time                    : int  4 6 7 7 8 8 10 10 10 10 ...
##  $ DEATH_EVENT             : Factor w/ 2 levels "Death","No Death": 2 2 2
2 2 2 2 2 2 2 ...
```

```
summary(rawdata)
```

```
##       age           anaemia       creatinine_phosphokinase
##  Min.   :40.00   Min.   :0.0000   Min.   :  23.0
##  1st Qu.:51.00   1st Qu.:0.0000   1st Qu.: 116.5
##  Median :60.00   Median :0.0000   Median : 250.0
##  Mean   :60.83   Mean   :0.4314   Mean   : 581.8
##  3rd Qu.:70.00   3rd Qu.:1.0000   3rd Qu.: 582.0
##  Max.   :95.00   Max.   :1.0000   Max.   :7861.0
##     diabetes      ejection_fraction high_blood_pressure   platelets
##  Min.   :0.0000   Min.   :14.00     Min.   :0.0000      Min.   : 25100
##  1st Qu.:0.0000   1st Qu.:30.00     1st Qu.:0.0000      1st Qu.:212500
##  Median :0.0000   Median :38.00     Median :0.0000      Median :262000
##  Mean   :0.4181   Mean   :38.08     Mean   :0.3512      Mean   :263358
##  3rd Qu.:1.0000   3rd Qu.:45.00     3rd Qu.:1.0000      3rd Qu.:303500
##  Max.   :1.0000   Max.   :80.00     Max.   :1.0000      Max.   :850000
##  serum_creatinine  serum_sodium       sex         smoking
##  Min.   :0.500    Min.   :113.0   Female:105   Min.   :0.0000
##  1st Qu.:0.900    1st Qu.:134.0   male  :194   1st Qu.:0.0000
##  Median :1.100    Median :137.0                Median :0.0000
##  Mean   :1.394    Mean   :136.6                Mean   :0.3211
##  3rd Qu.:1.400    3rd Qu.:140.0                3rd Qu.:1.0000
##  Max.   :9.400    Max.   :148.0                Max.   :1.0000
##       time          DEATH_EVENT
##  Min.   :  4.0   Death   :203
##  1st Qu.: 73.0   No Death: 96
##  Median :115.0
##  Mean   :130.3
##  3rd Qu.:203.0
##  Max.   :285.0
```

```
head(rawdata)
```

```
##   age anaemia creatinine_phosphokinase diabetes ejection_fraction
## 1  75       0                      582        0                20
## 2  55       0                     7861        0                38
## 3  65       0                      146        0                20
## 4  50       1                      111        0                20
## 5  65       1                      160        1                20
## 6  90       1                       47        0                40
##   high_blood_pressure platelets serum_creatinine serum_sodium    sex
## 1                   1    265000              1.9          130   male
## 2                   0    263358              1.1          136   male
## 3                   0    162000              1.3          129   male
## 4                   0    210000              1.9          137   male
## 5                   0    327000              2.7          116 Female
## 6                   1    204000              2.1          132   male
##   smoking time DEATH_EVENT
## 1       0    4    No Death
## 2       0    6    No Death
## 3       1    7    No Death
## 4       0    7    No Death
## 5       0    8    No Death
## 6       1    8    No Death
```

```
dim(rawdata)

## [1] 299  13

#Data Cleaning

#Checking for missing values
is.null(rawdata)

## [1] FALSE

##The "FALSE" output shows there is no missing data in the dataset.

#Transforming data (Converting 0,1's to meaningful form)

data <- rawdata %>%
  mutate(anaemia = ifelse(anaemia ==1, "Yes", "No"),
         high_blood_pressure = ifelse(high_blood_pressure ==1, "Yes", "No"),
         diabetes = ifelse(diabetes ==1, "Yes", "No"),
         smoking =ifelse(smoking ==1,"Yes","No"),
         DEATH_EVENT=ifelse(DEATH_EVENT=="No Death", "Survived", "Death")
  ) %>%
  mutate_if(is.character, as.factor) %>%
  dplyr::select(age, anaemia, creatinine_phosphokinase, diabetes,
ejection_fraction, high_blood_pressure, platelets,serum_creatinine,
serum_sodium, sex, smoking, time, DEATH_EVENT)

View(data)
str(data)

## 'data.frame':    299 obs. of  13 variables:
##  $ age                     : num  75 55 65 50 65 90 75 60 65 80 ...
##  $ anaemia                 : Factor w/ 2 levels "No","Yes": 1 1 1 2 2 2 2
2 1 2 ...
##  $ creatinine_phosphokinase: int  582 7861 146 111 160 47 246 315 157 123
...
##  $ diabetes                : Factor w/ 2 levels "No","Yes": 1 1 1 1 2 1 1
2 1 1 ...
##  $ ejection_fraction       : int  20 38 20 20 20 40 15 60 65 35 ...
##  $ high_blood_pressure     : Factor w/ 2 levels "No","Yes": 2 1 1 1 1 2 1
1 1 2 ...
##  $ platelets               : num  265000 263358 162000 210000 327000 ...
##  $ serum_creatinine        : num  1.9 1.1 1.3 1.9 2.7 2.1 1.2 1.1 1.5 9.4
...
##  $ serum_sodium            : int  130 136 129 137 116 132 137 131 138 133
...
##  $ sex                     : Factor w/ 2 levels "Female","male": 2 2 2 2 1
2 2 2 1 2 ...
##  $ smoking                 : Factor w/ 2 levels "No","Yes": 1 1 2 1 1 2 1
2 1 2 ...
##  $ time                    : int  4 6 7 7 8 8 10 10 10 10 ...
##  $ DEATH_EVENT             : Factor w/ 2 levels "Death","Survived": 2 2 2
2 2 2 2 2 2 2 ...
```

```
summary(data)
```

```
##       age        anaemia   creatinine_phosphokinase diabetes
##  Min.   :40.00   No :170   Min.   :  23.0           No :174
##  1st Qu.:51.00   Yes:129   1st Qu.: 116.5           Yes:125
##  Median :60.00             Median : 250.0
##  Mean   :60.83             Mean   : 581.8
##  3rd Qu.:70.00             3rd Qu.: 582.0
##  Max.   :95.00             Max.   :7861.0
##  ejection_fraction high_blood_pressure   platelets      serum_creatinine
##  Min.   :14.00     No :194             Min.   : 25100   Min.   :0.500
##  1st Qu.:30.00     Yes:105             1st Qu.:212500   1st Qu.:0.900
##  Median :38.00                         Median :262000   Median :1.100
##  Mean   :38.08                         Mean   :263358   Mean   :1.394
##  3rd Qu.:45.00                         3rd Qu.:303500   3rd Qu.:1.400
##  Max.   :80.00                         Max.   :850000   Max.   :9.400
##   serum_sodium       sex       smoking         time         DEATH_EVENT
##  Min.   :113.0   Female:105   No :203   Min.   :  4.0   Death   :203
##  1st Qu.:134.0   male  :194   Yes: 96   1st Qu.: 73.0   Survived: 96
##  Median :137.0                          Median :115.0
##  Mean   :136.6                          Mean   :130.3
##  3rd Qu.:140.0                          3rd Qu.:203.0
##  Max.   :148.0                          Max.   :285.0
```

```
dataset<-data
attach(dataset)
```

```
#Simple logistic model 1
#Implementing simple logistic model using our independent variable sex to
predict patient's death or survival
xtabs(~ DEATH_EVENT + sex, data=dataset)
```

```
##              sex
## DEATH_EVENT Female male
##    Death        71  132
##    Survived     34   62
```

```
logistic_simple <- glm(DEATH_EVENT ~ sex, data=dataset, family="binomial")
summary(logistic_simple)
```

```
##
## Call:
## glm(formula = DEATH_EVENT ~ sex, family = "binomial", data = dataset)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -0.8846  -0.8776  -0.8776   1.5017   1.5105
##
```

```
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)    
## (Intercept) -0.73632    0.20856  -3.531 0.000415 ***
## sexmale     -0.01935    0.25923  -0.075 0.940504    
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## (Dispersion parameter for binomial family taken to be 1)
## 
##     Null deviance: 375.35  on 298  degrees of freedom
## Residual deviance: 375.34  on 297  degrees of freedom
## AIC: 379.34
## 
## Number of Fisher Scoring iterations: 4

#The intercept is the log(odds) a female that can survive.
#sexmale is the log(odds ratio) that tells us if a sample has sex=male, the
odds of survival are on a log scale 0.019 times lesser than if a sample has
sex=female
#However, sex is not a significant predictor for death event

#Calculating the overall "Pseudo R-squared" and its p-value
ll.null <- logistic_simple$null.deviance/-2
ll.proposed <- logistic_simple$deviance/-2
ll.null

## [1] -187.6744

ll.proposed

## [1] -187.6716

## McFadden's Pseudo R^2 = [ LL(Null) - LL(Proposed) ] / LL(Null)
(ll.null - ll.proposed) / ll.null

## [1] 1.483129e-05

## chi-square value = 2*(LL(Proposed) - LL(Null))
## p-value = 1 - pchisq(chi-square value, df = 2-1)
1 - pchisq(2*(ll.proposed - ll.null), df=1)

## [1] 0.9405237

1 - pchisq((logistic_simple$null.deviance - logistic_simple$deviance), df=1)

## [1] 0.9405237

#Checking what logistic regression is predicting, given that a patient is
either female or male (and no other data about them).
predicted.data <-
data.frame(probability.of.death_event=logistic_simple$fitted.values,sex=datas
et$sex)
predicted.data
```

```
##     probability.of.death_event    sex
## 1                    0.3195876   male
## 2                    0.3195876   male
## 3                    0.3195876   male
## 4                    0.3195876   male
## 5                    0.3238095 Female
## 6                    0.3195876   male
## 7                    0.3195876   male
## 8                    0.3195876   male
## 9                    0.3238095 Female
## 10                   0.3195876   male
## 11                   0.3195876   male
## 12                   0.3195876   male
## 13                   0.3195876   male
## 14                   0.3195876   male
## 15                   0.3238095 Female
## 16                   0.3195876   male
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## 18                   0.3195876   male
## 19                   0.3238095 Female
## 20                   0.3238095 Female
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## 23                   0.3195876   male
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## 295                  0.3195876   male
## 296                  0.3238095 Female
## 297                      0.3238095 Female
## 298                      0.3195876   male
## 299                      0.3195876   male
```

```
## There are only two probabilities (one for females and one for males),so we can summarize the predicted probabilities.
xtabs(~ probability.of.death_event + sex, data=predicted.data)
```

```
##                              sex
## probability.of.death_event Female male
##          0.31958762886608       0  194
##          0.323809523809605    105    0
```

```
#Simple logistic model 2
#Implementing simple logistic model using our independent variable age to predict patient's death or survival
logistic_simple2 <- glm(DEATH_EVENT ~ age, data=dataset, family="binomial")
summary(logistic_simple2)
```

```
## 
## Call:
## glm(formula = DEATH_EVENT ~ age, family = "binomial", data = dataset)
## 
## Deviance Residuals: 
##     Min       1Q   Median       3Q      Max  
## -1.4276  -0.8993  -0.6922   1.2344   1.9251  
## 
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)    
## (Intercept) -3.65433    0.70662  -5.172 2.32e-07 ***
## age          0.04695    0.01107   4.241 2.23e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## (Dispersion parameter for binomial family taken to be 1)
## 
##     Null deviance: 375.35  on 298  degrees of freedom
## Residual deviance: 355.99  on 297  degrees of freedom
## AIC: 359.99
## 
## Number of Fisher Scoring iterations: 4
```

```
#Age is a significant predictor for death event
#For every one year increase in Age the odds of survival on a log scale is expected to increase by 0.047

#Calculating the overall "Pseudo R-squared" and its p-value
ll.null_age <- logistic_simple2$null.deviance/-2
ll.proposed_age <- logistic_simple2$deviance/-2
ll.null_age
```

```
## [1] -187.6744

ll.proposed_age

## [1] -177.9964

## McFadden's Pseudo R^2 = [ LL(Null) - LL(Proposed) ] / LL(Null)
(ll.null_age - ll.proposed_age) / ll.null_age

## [1] 0.051568

## chi-square value = 2*(LL(Proposed) - LL(Null))
## p-value = 1 - pchisq(chi-square value, df = 2-1)
1 - pchisq(2*(ll.proposed_age - ll.null_age), df=1)

## [1] 1.084786e-05

1 - pchisq((logistic_simple2$null.deviance - logistic_simple2$deviance),
df=1)

## [1] 1.084786e-05

#Checking what logistic regression is predicting with Age as the predictor
predicted.data_age <-
data.frame(probability.of.death_event=logistic_simple2$fitted.values,age=data
set$age)
predicted.data_age

##     probability.of.death_event    age
## 1                    0.4667769 75.000
## 2                    0.2550066 55.000
## 3                    0.3537520 65.000
## 4                    0.2130169 50.000
## 5                    0.3537520 65.000
## 6                    0.6390307 90.000
## 7                    0.4667769 75.000
## 8                    0.3020960 60.000
## 9                    0.3537520 65.000
## 10                   0.5253933 80.000
## 11                   0.4667769 75.000
## 12                   0.3222531 62.000
## 13                   0.1763050 45.000
## 14                   0.2130169 50.000
## 15                   0.2052522 49.000
## 16                   0.5487349 82.000
## 17                   0.6059477 87.000
## 18                   0.1763050 45.000
## 19                   0.4090636 70.000
## 20                   0.1976995 48.000
## 21                   0.3537520 65.000
## 22                   0.3537520 65.000
## 23                   0.3865737 68.000
## 24                   0.2375814 53.000
## 25                   0.4667769 75.000
## 26                   0.5253933 80.000
## 27                   0.6912370 95.000
## 28                   0.4090636 70.000
## 29                   0.2826740 58.000
## 30                   0.5487349 82.000
## 31                   0.6811277 94.000
## 32                   0.5833183 85.000
## 33                   0.2130169 50.000
## 34                   0.2130169 50.000
## 35                   0.3537520 65.000
## 36                   0.3977647 69.000
## 37                   0.6390307 90.000
## 38                   0.5487349 82.000
## 39                   0.3020960 60.000
## 40                   0.3020960 60.000
## 41                   0.4090636 70.000
## 42                   0.2130169 50.000
## 43                   0.4090636 70.000
## 44                   0.4319405 72.000
## 45                   0.3020960 60.000
## 46                   0.2130169 50.000
## 47                   0.2209936 51.000
## 48                   0.3020960 60.000
## 49                   0.5253933 80.000
## 50                   0.2732518 57.000
## 51                   0.3865737 68.000
## 52                   0.2375814 53.000
## 53                   0.3020960 60.000
## 54                   0.4090636 70.000
## 55                   0.3020960 60.000
## 56                   0.6912370 95.000
## 57                   0.4090636 70.000
## 58                   0.3020960 60.000
## 59                   0.2052522 49.000
## 60                   0.4319405 72.000
## 61                   0.1763050 45.000
## 62                   0.2130169 50.000
## 63                   0.2550066 55.000
## 64                   0.1763050 45.000
## 65                   0.1763050 45.000
## 66                   0.3020960 60.000
## 67                   0.1567734 42.000
## 68                   0.4319405 72.000
## 69                   0.4090636 70.000
## 70                   0.3537520 65.000
## 71                   0.1506664 41.000
## 72                   0.2826740 58.000
## 73                   0.5833183 85.000
## 74                   0.3537520 65.000
## 75                   0.3977647 69.000
## 76                   0.3020960 60.000
## 77                   0.4090636 70.000
## 78                   0.1567734 42.000
## 79                   0.4667769 75.000
## 80                   0.2550066 55.000
## 81                   0.4090636 70.000
## 82                   0.3755013 67.000
## 83                   0.3020960 60.000
## 84                   0.5136743 79.000
## 85                   0.2922903 59.000
## 86                   0.2209936 51.000
## 87                   0.2550066 55.000
## 88                   0.3537520 65.000
## 89                   0.1695902 44.000
## 90                   0.2732518 57.000
## 91                   0.4090636 70.000
## 92                   0.3020960 60.000
## 93                   0.1567734 42.000
## 94                   0.3020960 60.000
## 95                   0.2826740 58.000
## 96                   0.2826740 58.000
## 97                   0.3325916 63.000
## 98                   0.4090636 70.000
## 99                   0.3020960 60.000
## 100                  0.3325916 63.000
## 101                  0.3537520 65.000
## 102                  0.4667769 75.000
## 103                  0.5253933 80.000
## 104                  0.1567734 42.000
## 105                  0.3020960 60.000
## 106                  0.4319405 72.000
## 107                  0.2550066 55.000
## 108                  0.1763050 45.000
## 109                  0.3325916 63.000
## 110                  0.1763050 45.000
## 111                  0.5833183 85.000
## 112                  0.2550066 55.000
## 113                  0.2130169 50.000
## 114                  0.4090636 70.000
## 115                  0.3020960 60.000
## 116                  0.2826740 58.000
## 117                  0.3020960 60.000
## 118                  0.5833183 85.000
## 119                  0.3537520 65.000
## 120                  0.5946833 86.000
## 121                  0.3020960 60.000
## 122                  0.3645575 66.000
## 123                  0.3020960 60.000
## 124                  0.3020960 60.000
## 125                  0.3020960 60.000
## 126                  0.1630804 43.000
## 127                  0.1832271 46.000
## 128                  0.2826740 58.000
## 129                  0.3120856 61.000
## 130                  0.2375814 53.000
## 131                  0.2375814 53.000
## 132                  0.3020960 60.000
## 133                  0.1832271 46.000
## 134                  0.3325916 63.000
## 135                  0.5370845 81.000
## 136                  0.4667769 75.000
## 137                  0.3537520 65.000
## 138                  0.3865737 68.000
## 139                  0.3222531 62.000
## 140                  0.2130169 50.000
## 141                  0.5253933 80.000
## 142                  0.1832271 46.000
## 143                  0.2130169 50.000
## 144                  0.3120856 61.000
## 145                  0.4319405 72.000
## 146                  0.2130169 50.000
## 147                  0.2291821 52.000
## 148                  0.3430939 64.000
## 149                  0.4667769 75.000
## 150                  0.3020960 60.000
## 151                  0.4319405 72.000
## 152                  0.3222531 62.000
## 153                  0.2130169 50.000
## 154                  0.2130169 50.000
## 155                  0.3537520 65.000
## 156                  0.3020960 60.000
## 157                  0.2291821 52.000
## 158                  0.2130169 50.000
## 159                  0.5833183 85.000
## 160                  0.2922903 59.000
## 161                  0.3645575 66.000
## 162                  0.1763050 45.000
## 163                  0.3325916 63.000
## 164                  0.2130169 50.000
## 165                  0.1763050 45.000
## 166                  0.5253933 80.000
## 167                  0.2375814 53.000
## 168                  0.2922903 59.000
## 169                  0.3537520 65.000
## 170                  0.4090636 70.000
## 171                  0.2209936 51.000
## 172                  0.2291821 52.000
## 173                  0.4090636 70.000
## 174                       0.2130169 50.000
## 175                       0.3537520 65.000
## 176                       0.3020960 60.000
## 177                       0.3977647 69.000
## 178                       0.2052522 49.000
## 179                       0.3325916 63.000
## 180                       0.2550066 55.000
## 181                       0.1447564 40.000
## 182                       0.2922903 59.000
## 183                       0.3537520 65.000
## 184                       0.4667769 75.000
## 185                       0.2826740 58.000
## 186                       0.3087390 60.667
## 187                       0.2130169 50.000
## 188                       0.3020960 60.000
## 189                       0.3087390 60.667
## 190                       0.1447564 40.000
## 191                       0.5253933 80.000
## 192                       0.3430939 64.000
## 193                       0.2130169 50.000
## 194                       0.4434953 73.000
## 195                       0.1763050 45.000
## 196                       0.4902041 77.000
## 197                       0.1763050 45.000
## 198                       0.3537520 65.000
## 199                       0.2130169 50.000
## 200                       0.3020960 60.000
## 201                       0.3325916 63.000
## 202                       0.1763050 45.000
## 203                       0.4090636 70.000
## 204                       0.3020960 60.000
## 205                       0.5019403 78.000
## 206                       0.2130169 50.000
## 207                       0.1447564 40.000
## 208                       0.5833183 85.000
## 209                       0.3020960 60.000
## 210                       0.2052522 49.000
## 211                       0.4090636 70.000
## 212                       0.2130169 50.000
## 213                       0.5019403 78.000
## 214                       0.1976995 48.000
## 215                       0.3537520 65.000
## 216                       0.4434953 73.000
## 217                       0.4090636 70.000
## 218                       0.2461902 54.000
## 219                       0.3865737 68.000
## 220                       0.2550066 55.000
## 221                       0.4434953 73.000
## 222                       0.3537520 65.000
## 223                       0.1567734 42.000
## 224                  0.1903581 47.000
## 225                  0.2826740 58.000
## 226                  0.4667769 75.000
## 227                  0.2826740 58.000
## 228                  0.2550066 55.000
## 229                  0.3537520 65.000
## 230                  0.4319405 72.000
## 231                  0.3020960 60.000
## 232                  0.4090636 70.000
## 233                  0.1447564 40.000
## 234                  0.2375814 53.000
## 235                  0.2375814 53.000
## 236                  0.4902041 77.000
## 237                  0.4667769 75.000
## 238                  0.4090636 70.000
## 239                  0.3537520 65.000
## 240                  0.2550066 55.000
## 241                  0.4090636 70.000
## 242                  0.3537520 65.000
## 243                  0.1447564 40.000
## 244                  0.4434953 73.000
## 245                  0.2461902 54.000
## 246                  0.3120856 61.000
## 247                  0.2550066 55.000
## 248                  0.3430939 64.000
## 249                  0.1447564 40.000
## 250                  0.2375814 53.000
## 251                  0.2130169 50.000
## 252                  0.2550066 55.000
## 253                  0.2130169 50.000
## 254                  0.4090636 70.000
## 255                  0.2375814 53.000
## 256                  0.2291821 52.000
## 257                  0.3537520 65.000
## 258                  0.2826740 58.000
## 259                  0.1763050 45.000
## 260                  0.2375814 53.000
## 261                  0.2550066 55.000
## 262                  0.3222531 62.000
## 263                  0.3537520 65.000
## 264                  0.3865737 68.000
## 265                  0.3120856 61.000
## 266                  0.2130169 50.000
## 267                  0.2550066 55.000
## 268                  0.2640282 56.000
## 269                  0.1763050 45.000
## 270                  0.1447564 40.000
## 271                  0.1695902 44.000
## 272                  0.2209936 51.000
## 273                  0.3755013 67.000
## 274                  0.1567734 42.000
## 275                  0.3020960 60.000
## 276                  0.1763050 45.000
## 277                  0.4090636 70.000
## 278                  0.4090636 70.000
## 279                  0.2130169 50.000
## 280                  0.2550066 55.000
## 281                  0.4090636 70.000
## 282                  0.4090636 70.000
## 283                  0.1567734 42.000
## 284                  0.3537520 65.000
## 285                  0.2130169 50.000
## 286                  0.2550066 55.000
## 287                  0.3020960 60.000
## 288                  0.1763050 45.000
## 289                  0.3537520 65.000
## 290                  0.6390307 90.000
## 291                  0.1763050 45.000
## 292                  0.3020960 60.000
## 293                  0.2291821 52.000
## 294                  0.3325916 63.000
## 295                  0.3222531 62.000
## 296                  0.2550066 55.000
## 297                  0.1763050 45.000
## 298                  0.1763050 45.000
## 299                  0.2130169 50.000
```

```
#Implementing multiple logistic model using all the variables
logistic <- glm(DEATH_EVENT ~ ., data=dataset, family="binomial")
summary(logistic)
```

```
## 
## Call:
## glm(formula = DEATH_EVENT ~ ., family = "binomial", data = dataset)
## 
## Deviance Residuals: 
##     Min       1Q   Median       3Q      Max  
## -2.1848  -0.5706  -0.2401   0.4466   2.6668  
## 
## Coefficients:
##                            Estimate Std. Error z value Pr(>|z|)    
## (Intercept)               1.018e+01  5.657e+00   1.801 0.071774 .  
## age                       4.742e-02  1.580e-02   3.001 0.002690 ** 
## anaemiaYes               -7.470e-03  3.605e-01  -0.021 0.983467    
## creatinine_phosphokinase  2.222e-04  1.779e-04   1.249 0.211684    
## diabetesYes               1.451e-01  3.512e-01   0.413 0.679380    
## ejection_fraction        -7.666e-02  1.633e-02  -4.695 2.67e-06 ***
## high_blood_pressureYes   -1.027e-01  3.587e-01  -0.286 0.774688    
## platelets                -1.200e-06  1.889e-06  -0.635 0.525404    
## serum_creatinine          6.661e-01  1.815e-01   3.670 0.000242 ***
## serum_sodium             -6.698e-02  3.974e-02  -1.686 0.091855 .
## sexmale                  -5.337e-01  4.139e-01  -1.289 0.197299
## smokingYes               -1.349e-02  4.126e-01  -0.033 0.973915
## time                     -2.104e-02  3.014e-03  -6.981 2.92e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 375.35  on 298  degrees of freedom
## Residual deviance: 219.55  on 286  degrees of freedom
## AIC: 245.55
##
## Number of Fisher Scoring iterations: 6
```

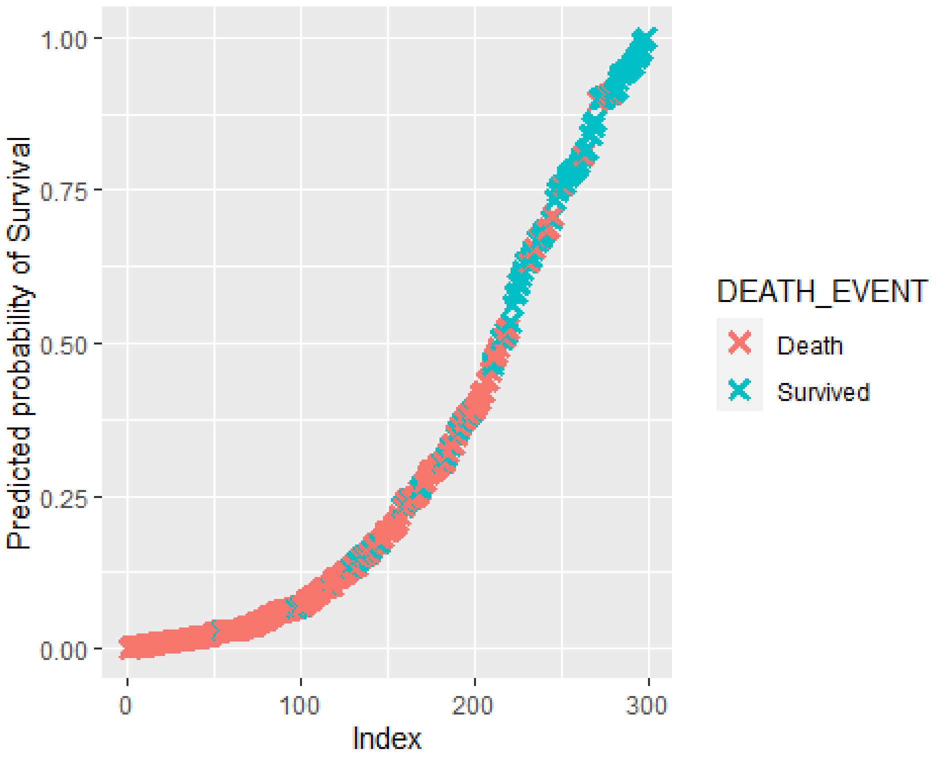
```
#Based on the summary, we can say age, ejection_fraction, serum_creatinine
and time are significant variables for predicting death event
#For every one year increase in Age the odds of survival on a log scale is
expected to increase by 0.047, holding all the other variables constant
#For every one percent increase in ejection_fraction the odds of survival on
a log scale is expected to decrease by 0.076, holding all the other variables
constant
#For every one mg/dL increase in serum_creatinine the odds of survival on a
log scale is expected to increase by 0.66, holding all the other variables
constant
#For every one day increase in follow-up period the odds of survival on a log
scale is expected to decrease by 0.021, holding all the other variables
constant

#Calculating the overall "Pseudo R-squared" and its p-value
ll.null2 <- logistic$null.deviance/-2
ll.proposed2 <- logistic$deviance/-2
## McFadden's Pseudo R^2 = [ LL(Null) - LL(Proposed) ] / LL(Null)
(ll.null2 - ll.proposed2) / ll.null2
```

```
## [1] 0.4150663
```

```
## The p-value for the R^2
1 - pchisq(2*(ll.proposed2 - ll.null2), df=(length(logistic$coefficients)-1))
```

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

```
#Plot the data
predicted.data2 <-
data.frame(probability.of.death_event=logistic$fitted.values,DEATH_EVENT=data
set$DEATH_EVENT)
predicted.data2 <-
predicted.data2[order(predicted.data2$probability.of.death_event,
decreasing=FALSE),]
predicted.data2$rank <- 1:nrow(predicted.data2)
ggplot(data=predicted.data2, aes(x=rank, y=probability.of.death_event)) +
  geom_point(aes(color=DEATH_EVENT), alpha=1, shape=4, stroke=2) +
  xlab("Index") +
  ylab("Predicted probability of Survival")
```



```
#Confusion Matrix
confusion_matrix(logistic)

##                   Predicted Death Predicted Survived Total
## Actual Death                  187                 16   203
## Actual Survived                27                 69    96
## Total                         214                 85   299

pdata <- predict(logistic,newdata=dataset,type="response" )
pdata

##            1            2            3            4            5 
## 0.9793073820 0.9067149740 0.9570132585 0.8998995179 0.9953911997 
##            6            7            8            9           10 
## 0.9470249475 0.9665948236 0.3304746994 0.3889735944 0.9993527922 
##           11           12           13           14           15 
## 0.9685325921 0.7888549332 0.7021269470 0.5074851512 0.6844173509 
##           16           17           18           19           20 
## 0.7702631162 0.8179328418 0.9148003004 0.8997178303 0.7777244922 
##           21           22           23           24           25 
## 0.9066767238 0.9011333759 0.6393118753 0.1557585354 0.9550761551 
##           26           27           28           29           30 
## 0.8393907390 0.9020743771 0.6095748828 0.9747028378 0.9280890356
##         31         32         33         34         35
## 0.9385809020 0.9147338133 0.7471777699 0.7334826829 0.3581656449
##         36         37         38         39         40
## 0.9509908151 0.7359553845 0.5993106534 0.9080717450 0.8551062002
##         41         42         43         44         45
## 0.9385259276 0.7586802972 0.5619806901 0.5094117878 0.2675407498
##         46         47         48         49         50
## 0.6188645962 0.7547723020 0.3810741199 0.9927237792 0.6318486141
##         51         52         53         54         55
## 0.7851493399 0.7842762388 0.9444024848 0.5162619559 0.8415566938
##         56         57         58         59         60
## 0.9435669099 0.8075643832 0.3328296287 0.6419562917 0.8643877667
##         61         62         63         64         65
## 0.7769259139 0.6666495055 0.3639674646 0.1735805857 0.0237291876
##         66         67         68         69         70
## 0.9478586912 0.7946040072 0.6779812327 0.7737882333 0.7608804713
##         71         72         73         74         75
## 0.1019430790 0.4080523162 0.9097212170 0.2844243526 0.8137059736
##         76         77         78         79         80
## 0.5811662333 0.1220379662 0.1576972850 0.5223566391 0.1964405102
##         81         82         83         84         85
## 0.6332520973 0.2324247683 0.9034577751 0.4772643585 0.5941891923
##         86         87         88         89         90
## 0.0569575440 0.3036732295 0.0636962347 0.1134280994 0.3919251701
##         91         92         93         94         95
## 0.2907571900 0.2908714510 0.0614628641 0.6723733875 0.2520900088
##         96         97         98         99        100
## 0.0445136022 0.6704862295 0.1734651449 0.6538056760 0.3863843064
##        101        102        103        104        105
## 0.4943149263 0.3202369931 0.6882833309 0.4191760614 0.2470874833
##        106        107        108        109        110
## 0.6319411124 0.1821007909 0.2477920851 0.3840529029 0.0981006911
##        111        112        113        114        115
## 0.2304142893 0.3026544365 0.5231874578 0.1548905226 0.4215619668
##        116        117        118        119        120
## 0.3087609160 0.0787251124 0.4831822056 0.0934640215 0.8033632326
##        121        122        123        124        125
## 0.0864589139 0.4537855903 0.2958473090 0.3740274799 0.6830300680
##        126        127        128        129        130
## 0.1151429894 0.8589178599 0.0644979297 0.2750398670 0.4376849402
##        131        132        133        134        135
## 0.0303635301 0.8967572521 0.1677982416 0.0297029145 0.7078888336
##        136        137        138        139        140
## 0.3345708565 0.0982498578 0.7591174037 0.4177665248 0.2187830430
##        141        142        143        144        145
## 0.4645497176 0.1481755844 0.3959698154 0.1802048594 0.5781942743
##        146        147        148        149        150
## 0.1296345117 0.1933096070 0.0609660520 0.6514053794 0.2707977142
##        151        152        153        154        155
## 0.5047835199 0.0315179140 0.0692556725 0.2092043894 0.3024749905
##          156          157          158          159          160 
## 0.4417145641 0.2570049451 0.2431913414 0.2902174211 0.0657354759 
##          161          162          163          164          165 
## 0.1989961836 0.0814535296 0.1168817669 0.2452025047 0.1794601269 
##          166          167          168          169          170 
## 0.5343327748 0.0192403470 0.6843262164 0.2022509509 0.2913151203 
##          171          172          173          174          175 
## 0.1373227695 0.0893313081 0.0183791751 0.1722622760 0.1343270196 
##          176          177          178          179          180 
## 0.0154090848 0.1919585844 0.0362649306 0.0159363280 0.0485935443 
##          181          182          183          184          185 
## 0.0766684346 0.2369616329 0.3031166637 0.3155436536 0.1517264800 
##          186          187          188          189          190 
## 0.1434887697 0.0285556070 0.3488701344 0.0961830070 0.0149776716 
##          191          192          193          194          195 
## 0.3492802398 0.0307853801 0.0424645873 0.1522858366 0.1628268752 
##          196          197          198          199          200 
## 0.0671893288 0.0464337149 0.1266277312 0.2023944130 0.4046519018 
##          201          202          203          204          205 
## 0.0415688917 0.0040153990 0.0106405152 0.3796646692 0.0629106092 
##          206          207          208          209          210 
## 0.0284131170 0.0165001172 0.1355694216 0.0798109326 0.0872443260 
##          211          212          213          214          215 
## 0.2454660433 0.0030820518 0.0330756155 0.1454391737 0.0520072769 
##          216          217          218          219          220 
## 0.1191573382 0.0275590066 0.4691565071 0.1037258914 0.0384074871 
##          221          222          223          224          225 
## 0.3704402368 0.0108993974 0.0135508102 0.0608954966 0.0608506722 
##          226          227          228          229          230 
## 0.0668953402 0.1150933760 0.0419386004 0.7933814662 0.2438555978 
##          231          232          233          234          235 
## 0.2615818011 0.0726026980 0.0121871592 0.0253174306 0.0123110291 
##          236          237          238          239          240 
## 0.0189728557 0.0101710435 0.1249018695 0.0646063860 0.0131484281 
##          241          242          243          244          245 
## 0.0651459275 0.0903769651 0.0137518690 0.0542663536 0.0473135723 
##          246          247          248          249          250 
## 0.0363141287 0.0691433689 0.1913641876 0.0088378852 0.0543461698 
##          251          252          253          254          255 
## 0.0372647778 0.0303225759 0.0102365430 0.1227338442 0.0026485134 
##          256          257          258          259          260 
## 0.0196392330 0.0609922401 0.0143742576 0.0263795292 0.0041658398 
##          261          262          263          264          265 
## 0.0108066400 0.0296381264 0.1324948593 0.0069219640 0.0197666677 
##          266          267          268          269          270 
## 0.0075506559 0.1029223514 0.0183755862 0.0100017625 0.0116898012 
##          271          272          273          274          275 
## 0.0294131610 0.0186204951 0.0462272307 0.0033243461 0.0302263065 
##          276          277          278          279          280 
## 0.0075890060 0.0332975887 0.0287535899 0.0301428442 0.0194953196 
##        281        282        283        284        285 
## 0.0339186983 0.0682835446 0.0981659815 0.0197277171 0.0038837855 
##        286        287        288        289        290 
## 0.0105702565 0.0184985489 0.0032980392 0.0277978553 0.0357715039 
##        291        292        293        294        295 
## 0.0020211380 0.0165845423 0.0053715227 0.0133320619 0.0067397574 
##        296        297        298        299 
## 0.0140111896 0.0008008297 0.0059965251 0.0026973899
```

```
dataset$DEATH_EVENT
```

```
##   [1] Survived Survived Survived Survived Survived Survived Survived
##   [8] Survived Survived Survived Survived Survived Survived Survived
##  [15] Death    Survived Survived Survived Survived Survived Death   
##  [22] Survived Survived Death    Survived Survived Survived Survived
##  [29] Survived Survived Survived Survived Survived Death    Survived
##  [36] Survived Survived Survived Death    Survived Survived Survived
##  [43] Survived Death    Survived Survived Survived Survived Survived
##  [50] Survived Survived Survived Survived Survived Survived Survived
##  [57] Death    Death    Survived Survived Survived Survived Death   
##  [64] Survived Death    Survived Survived Survived Survived Survived
##  [71] Death    Death    Survived Death    Survived Survived Death   
##  [78] Death    Death    Death    Death    Death    Survived Death   
##  [85] Survived Death    Death    Death    Death    Death    Death   
##  [92] Death    Death    Survived Death    Death    Death    Death   
##  [99] Death    Death    Death    Death    Death    Death    Death   
## [106] Survived Death    Death    Death    Death    Survived Death   
## [113] Death    Survived Death    Death    Death    Death    Death   
## [120] Survived Death    Death    Death    Death    Survived Death   
## [127] Survived Death    Death    Death    Death    Death    Death   
## [134] Death    Death    Death    Death    Death    Death    Death   
## [141] Survived Death    Death    Death    Survived Death    Death   
## [148] Death    Survived Death    Survived Death    Death    Death   
## [155] Death    Death    Death    Death    Death    Death    Death   
## [162] Death    Death    Survived Survived Survived Death    Survived
## [169] Death    Death    Death    Death    Death    Death    Death   
## [176] Death    Death    Death    Death    Death    Death    Survived
## [183] Survived Survived Survived Survived Survived Survived Death   
## [190] Death    Death    Death    Death    Death    Survived Survived
## [197] Death    Death    Death    Death    Death    Death    Death   
## [204] Death    Death    Death    Death    Death    Death    Death   
## [211] Death    Death    Death    Survived Death    Death    Death   
## [218] Survived Death    Death    Survived Death    Death    Death   
## [225] Death    Death    Death    Death    Death    Death    Survived
## [232] Death    Death    Death    Death    Death    Death    Death   
## [239] Death    Death    Death    Death    Death    Death    Death   
## [246] Death    Survived Death    Death    Death    Death    Death   
## [253] Death    Death    Death    Death    Death    Death    Death   
## [260] Death    Death    Death    Survived Death    Death    Death   
## [267] Survived Death    Death    Death    Death    Death    Death
## [274] Death    Death    Death    Death    Death    Death    Death
## [281] Death    Death    Death    Death    Death    Death    Death
## [288] Death    Death    Death    Death    Death    Death    Death
## [295] Death    Death    Death    Death    Death
## Levels: Death Survived
```

```
pdataF <- as.factor(ifelse(test=as.numeric(pdata>0.5) == 0, yes="Death",
no="Survived"))

confusionMatrix(pdataF, dataset$DEATH_EVENT)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction Death Survived
##   Death      187       27
##   Survived    16       69
##
##                Accuracy : 0.8562
##                  95% CI : (0.8112, 0.8939)
##     No Information Rate : 0.6789
##     P-Value [Acc > NIR] : 1.627e-12
##
##                   Kappa : 0.6599
##
##  Mcnemar's Test P-Value : 0.1273
##
##             Sensitivity : 0.9212
##             Specificity : 0.7188
##          Pos Pred Value : 0.8738
##          Neg Pred Value : 0.8118
##              Prevalence : 0.6789
##          Detection Rate : 0.6254
##    Detection Prevalence : 0.7157
##       Balanced Accuracy : 0.8200
##
##        'Positive' Class : Death
##
```

```
#ROC curve
roc(dataset$DEATH_EVENT,logistic$fitted.values,plot=TRUE)
```

```
## Setting levels: control = Death, case = Survived
```

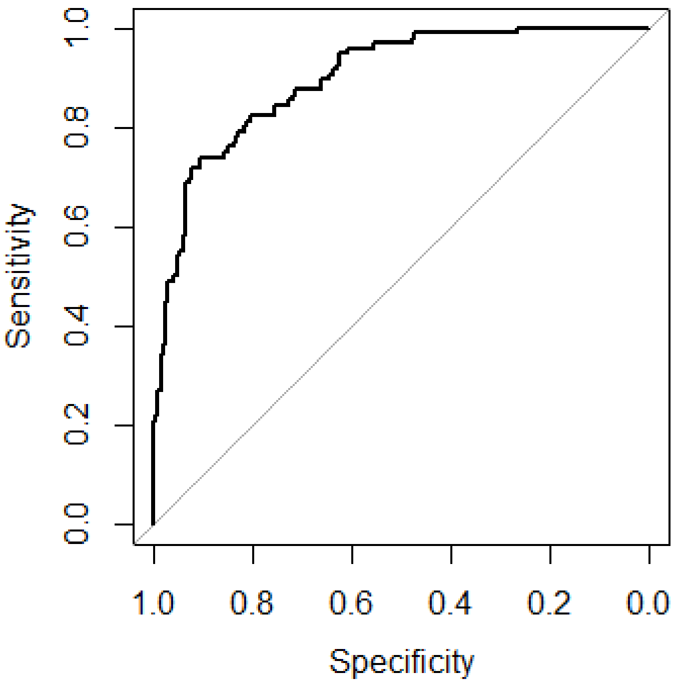
```
## Setting direction: controls < cases
```

```
##
## Call:
## roc.default(response = dataset$DEATH_EVENT, predictor =
logistic$fitted.values,     plot = TRUE)
##
```

```
## Data: logistic$fitted.values in 203 controls (dataset$DEATH_EVENT Death) <
96 cases (dataset$DEATH_EVENT Survived).
## Area under the curve: 0.8972
```

```r
par(pty = "s")
roc(dataset$DEATH_EVENT,logistic$fitted.values,plot=TRUE)
```

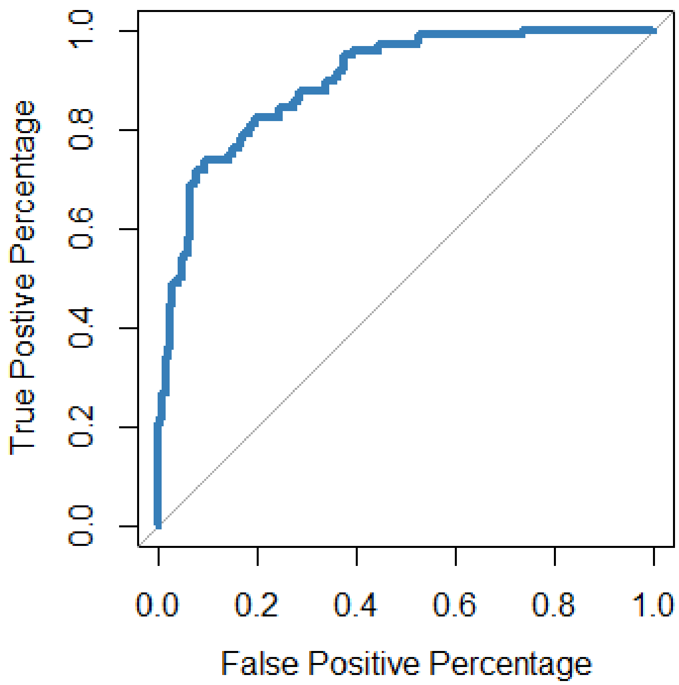
```
## Setting levels: control = Death, case = Survived
## Setting direction: controls < cases
```



```
##
## Call:
## roc.default(response = dataset$DEATH_EVENT, predictor =
logistic$fitted.values,     plot = TRUE)
##
## Data: logistic$fitted.values in 203 controls (dataset$DEATH_EVENT Death) <
96 cases (dataset$DEATH_EVENT Survived).
## Area under the curve: 0.8972
```

```r
roc(dataset$DEATH_EVENT,logistic$fitted.values,plot=TRUE, legacy.axes=TRUE,
xlab="False Positive Percentage", ylab="True Postive Percentage",
col="#377eb8", lwd=4)
```

```
## Setting levels: control = Death, case = Survived
## Setting direction: controls < cases
```



```
##
## Call:
## roc.default(response = dataset$DEATH_EVENT, predictor =
logistic$fitted.values,     plot = TRUE, legacy.axes = TRUE, xlab = "False
Positive Percentage",     ylab = "True Postive Percentage", col = "#377eb8",
lwd = 4)
##
## Data: logistic$fitted.values in 203 controls (dataset$DEATH_EVENT Death) <
96 cases (dataset$DEATH_EVENT Survived).
## Area under the curve: 0.8972
```

```
roc.info <- roc(dataset$DEATH_EVENT, logistic$fitted.values,
legacy.axes=TRUE)
```

```
## Setting levels: control = Death, case = Survived
## Setting direction: controls < cases
```

```
str(roc.info)
```

```
## List of 15
##  $ percent            : logi FALSE
##  $ sensitivities      : num [1:300] 1 1 1 1 1 1 1 1 1 1 ...
##  $ specificities      : num [1:300] 0 0.00493 0.00985 0.01478 0.0197 ...
##  $ thresholds         : num [1:300] -Inf 0.00141 0.00233 0.00267 0.00289
...
##  $ direction          : chr "<"
##  $ cases              : Named num [1:96] 0.979 0.907 0.957 0.9 0.995 ...
##   ..- attr(*, "names")= chr [1:96] "1" "2" "3" "4" ...
##  $ controls          : Named num [1:203] 0.684 0.907 0.156 0.733 0.908 ...
##   ..- attr(*, "names")= chr [1:203] "15" "21" "24" "34" ...
##  $ fun.sesp          :function (thresholds, controls, cases, direction)
##  $ auc               : 'auc' num 0.897
##   ..- attr(*, "partial.auc")= logi FALSE
##   ..- attr(*, "percent")= logi FALSE
##   ..- attr(*, "roc")=List of 15
##   .. ..$ percent           : logi FALSE
##   .. ..$ sensitivities     : num [1:300] 1 1 1 1 1 1 1 1 1 1 ...
##   .. ..$ specificities     : num [1:300] 0 0.00493 0.00985 0.01478 0.0197
...
##   .. ..$ thresholds        : num [1:300] -Inf 0.00141 0.00233 0.00267
0.00289 ...
##   .. ..$ direction         : chr "<"
##   .. ..$ cases             : Named num [1:96] 0.979 0.907 0.957 0.9 0.995
...
##   .. .. ..- attr(*, "names")= chr [1:96] "1" "2" "3" "4" ...
##   .. ..$ controls          : Named num [1:203] 0.684 0.907 0.156 0.733
0.908 ...
##   .. .. ..- attr(*, "names")= chr [1:203] "15" "21" "24" "34" ...
##   .. ..$ fun.sesp          :function (thresholds, controls, cases,
direction)
##   .. ..$ auc               : 'auc' num 0.897
##   .. .. ..- attr(*, "partial.auc")= logi FALSE
##   .. .. ..- attr(*, "percent")= logi FALSE
##   .. .. ..- attr(*, "roc")=List of 8
##   .. .. .. ..$ percent      : logi FALSE
##   .. .. .. ..$ sensitivities: num [1:300] 1 1 1 1 1 1 1 1 1 1 ...
##   .. .. .. ..$ specificities: num [1:300] 0 0.00493 0.00985 0.01478 0.0197
...
##   .. .. .. ..$ thresholds   : num [1:300] -Inf 0.00141 0.00233 0.00267
0.00289 ...
##   .. .. .. ..$ direction    : chr "<"
##   .. .. .. ..$ cases        : Named num [1:96] 0.979 0.907 0.957 0.9 0.995
...
##   .. .. .. .. ..- attr(*, "names")= chr [1:96] "1" "2" "3" "4" ...
##   .. .. .. ..$ controls     : Named num [1:203] 0.684 0.907 0.156 0.733
0.908 ...
##   .. .. .. .. ..- attr(*, "names")= chr [1:203] "15" "21" "24" "34" ...
##   .. .. .. ..$ fun.sesp     :function (thresholds, controls, cases,
direction)
##   .. .. .. ..- attr(*, "class")= chr "roc"
##   .. ..$ call              : language roc.default(response =
dataset$DEATH_EVENT, predictor = logistic$fitted.values,      legacy.axes =
TRUE)
##   .. ..$ original.predictor: Named num [1:299] 0.979 0.907 0.957 0.9 0.995
...
##   .. .. ..- attr(*, "names")= chr [1:299] "1" "2" "3" "4" ...
##   .. ..$ original.response : Factor w/ 2 levels "Death","Survived": 2 2 2
```

```
2 2 2 2 2 2 2 ...
##   .. ..$ predictor         : Named num [1:299] 0.979 0.907 0.957 0.9 0.995
...
##   .. .. ..- attr(*, "names")= chr [1:299] "1" "2" "3" "4" ...
##   .. ..$ response          : Factor w/ 2 levels "Death","Survived": 2 2 2
2 2 2 2 2 2 2 ...
##   .. ..$ levels            : chr [1:2] "Death" "Survived"
##   .. ..- attr(*, "class")= chr "roc"
##  $ call               : language roc.default(response =
dataset$DEATH_EVENT, predictor = logistic$fitted.values,      legacy.axes =
TRUE)
##  $ original.predictor: Named num [1:299] 0.979 0.907 0.957 0.9 0.995 ...
##   ..- attr(*, "names")= chr [1:299] "1" "2" "3" "4" ...
##  $ original.response : Factor w/ 2 levels "Death","Survived": 2 2 2 2 2 2
2 2 2 2 ...
##  $ predictor         : Named num [1:299] 0.979 0.907 0.957 0.9 0.995 ...
##   ..- attr(*, "names")= chr [1:299] "1" "2" "3" "4" ...
##  $ response          : Factor w/ 2 levels "Death","Survived": 2 2 2 2 2 2
2 2 2 2 ...
##  $ levels            : chr [1:2] "Death" "Survived"
##  - attr(*, "class")= chr "roc"
```

```
roc.df <- data.frame(tpp=roc.info$sensitivities*100, ## tpp = true positive
percentage
                     fpp=(1 - roc.info$specificities)*100, ## fpp = false
positive precentage
                     thresholds=roc.info$thresholds)
roc.df
```

```
##            tpp         fpp  thresholds
## 1   100.000000 100.0000000        -Inf
## 2   100.000000  99.5073892 0.001410984
## 3   100.000000  99.0147783 0.002334826
## 4   100.000000  98.5221675 0.002672952
## 5   100.000000  98.0295567 0.002889721
## 6   100.000000  97.5369458 0.003190045
## 7   100.000000  97.0443350 0.003311193
## 8   100.000000  96.5517241 0.003604066
## 9   100.000000  96.0591133 0.003949592
## 10  100.000000  95.5665025 0.004090619
## 11  100.000000  95.0738916 0.004768681
## 12  100.000000  94.5812808 0.005684024
## 13  100.000000  94.0886700 0.006368141
## 14  100.000000  93.5960591 0.006830861
## 15  100.000000  93.1034483 0.007236310
## 16  100.000000  92.6108374 0.007569831
## 17  100.000000  92.1182266 0.008213446
## 18  100.000000  91.6256158 0.009419824
## 19  100.000000  91.1330049 0.010086403
## 20  100.000000  90.6403941 0.010203793
## 21  100.000000  90.1477833 0.010403400
## 22  100.000000  89.6551724 0.010605386
## 23  100.000000  89.1625616 0.010723578
## 24  100.000000  88.6699507 0.010853019
## 25  100.000000  88.1773399 0.011294599
## 26  100.000000  87.6847291 0.011938480
## 27  100.000000  87.1921182 0.012249094
## 28  100.000000  86.6995074 0.012729729
## 29  100.000000  86.2068966 0.013240245
## 30  100.000000  85.7142857 0.013441436
## 31  100.000000  85.2216749 0.013651340
## 32  100.000000  84.7290640 0.013881529
## 33  100.000000  84.2364532 0.014192724
## 34  100.000000  83.7438424 0.014675965
## 35  100.000000  83.2512315 0.015193378
## 36  100.000000  82.7586207 0.015672706
## 37  100.000000  82.2660099 0.016218223
## 38  100.000000  81.7733990 0.016542330
## 39  100.000000  81.2807882 0.017480064
## 40  100.000000  80.7881773 0.018377381
## 41  100.000000  80.2955665 0.018438862
## 42  100.000000  79.8029557 0.018559522
## 43  100.000000  79.3103448 0.018796675
## 44  100.000000  78.8177340 0.019106601
## 45  100.000000  78.3251232 0.019367833
## 46  100.000000  77.8325123 0.019567276
## 47  100.000000  77.3399015 0.019683475
## 48  100.000000  76.8472906 0.019747192
## 49  100.000000  76.3546798 0.021747928
## 50  100.000000  75.8620690 0.024523309
## 51  100.000000  75.3694581 0.025848480
## 52  100.000000  74.8768473 0.026969268
## 53  100.000000  74.3842365 0.027678431
## 54  100.000000  73.8916256 0.028105486
## 55  100.000000  73.3990148 0.028484362
## 56   98.958333  73.3990148 0.028654598
## 57   98.958333  72.9064039 0.029083375
## 58   98.958333  72.4137931 0.029525644
## 59   98.958333  71.9211823 0.029670520
## 60   98.958333  71.4285714 0.029922879
## 61   98.958333  70.9359606 0.030184575
## 62   98.958333  70.4433498 0.030274441
## 63   98.958333  69.9507389 0.030343053
## 64   98.958333  69.4581281 0.030574455
## 65   98.958333  68.9655172 0.031151647
## 66   98.958333  68.4729064 0.032296765
## 67   98.958333  67.9802956 0.033186602
## 68   98.958333  67.4876847 0.033608143
## 69   98.958333  66.9950739 0.034845101
## 70   98.958333  66.5024631 0.036018217
## 71   98.958333  66.0098522 0.036289530
## 72   98.958333  65.5172414 0.036789453
## 73   98.958333  65.0246305 0.037836132
## 74   98.958333  64.5320197 0.039988189
## 75   98.958333  64.0394089 0.041753746
## 76   98.958333  63.5467980 0.042201594
## 77   98.958333  63.0541872 0.043489095
## 78   98.958333  62.5615764 0.045370416
## 79   98.958333  62.0689655 0.046330473
## 80   98.958333  61.5763547 0.046873644
## 81   98.958333  61.0837438 0.047953558
## 82   98.958333  60.5911330 0.050300411
## 83   98.958333  60.0985222 0.053136815
## 84   98.958333  59.6059113 0.054306262
## 85   98.958333  59.1133005 0.055651857
## 86   98.958333  58.6206897 0.058904108
## 87   98.958333  58.1280788 0.060873084
## 88   98.958333  57.6354680 0.060930774
## 89   98.958333  57.1428571 0.060979146
## 90   98.958333  56.6502463 0.061227552
## 91   98.958333  56.1576355 0.062186737
## 92   98.958333  55.6650246 0.063303422
## 93   98.958333  55.1724138 0.064097082
## 94   98.958333  54.6798030 0.064552158
## 95   98.958333  54.1871921 0.064876157
## 96   98.958333  53.6945813 0.065440702
## 97   98.958333  53.2019704 0.066315408
## 98   98.958333  52.7093596 0.067042335
## 99   97.916667  52.7093596 0.067736437
## 100  97.916667  52.2167488 0.068713457
## 101  96.875000  52.2167488 0.069199521
## 102  96.875000  51.7241379 0.070929185
## 103  96.875000  51.2315271 0.074635566
## 104  96.875000  50.7389163 0.077696774
## 105  96.875000  50.2463054 0.079268022
## 106  96.875000  49.7536946 0.080632231
## 107  96.875000  49.2610837 0.083956222
## 108  96.875000  48.7684729 0.086851620
## 109  96.875000  48.2758621 0.088287817
## 110  96.875000  47.7832512 0.089854137
## 111  96.875000  47.2906404 0.091920493
## 112  96.875000  46.7980296 0.094823514
## 113  96.875000  46.3054187 0.097141849
## 114  96.875000  45.8128079 0.098133336
## 115  96.875000  45.3201970 0.098207920
## 116  96.875000  44.8275862 0.100096468
## 117  96.875000  44.3349754 0.102432715
## 118  95.833333  44.3349754 0.103324121
## 119  95.833333  43.8423645 0.108576995
## 120  95.833333  43.3497537 0.114260738
## 121  95.833333  42.8571429 0.115118183
## 122  95.833333  42.3645320 0.116012378
## 123  95.833333  41.8719212 0.118019553
## 124  95.833333  41.3793103 0.120597652
## 125  95.833333  40.8866995 0.122385905
## 126  95.833333  40.3940887 0.123817857
## 127  95.833333  39.9014778 0.125764800
## 128  95.833333  39.4088670 0.128131121
## 129  95.833333  38.9162562 0.131064686
## 130  94.791667  38.9162562 0.133410939
## 131  94.791667  38.4236453 0.134948221
## 132  94.791667  37.9310345 0.136446096
## 133  94.791667  37.4384236 0.140405770
## 134  93.750000  37.4384236 0.144463972
## 135  92.708333  37.4384236 0.146807379
## 136  92.708333  36.9458128 0.149951032
## 137  91.666667  36.9458128 0.152006158
## 138  91.666667  36.4532020 0.153588180
## 139  90.625000  36.4532020 0.155324529
## 140  90.625000  35.9605911 0.156727910
## 141  90.625000  35.4679803 0.160262080
## 142  89.583333  35.4679803 0.165312558
## 143  89.583333  34.9753695 0.170030259
## 144  89.583333  34.4827586 0.172863710
## 145  89.583333  33.9901478 0.173522865
## 146  88.541667  33.9901478 0.176520356
## 147  87.500000  33.9901478 0.179832493
## 148  87.500000  33.4975369 0.181152825
## 149  87.500000  33.0049261 0.186732489
## 150  87.500000  32.5123153 0.191661386
## 151  87.500000  32.0197044 0.192634096
## 152  87.500000  31.5270936 0.194875059
## 153  87.500000  31.0344828 0.197718347
## 154  87.500000  30.5418719 0.200623567
## 155  87.500000  30.0492611 0.202322682
## 156  87.500000  29.5566502 0.205799401
## 157  87.500000  29.0640394 0.213993716
## 158  87.500000  28.5714286 0.224598666
## 159  86.458333  28.5714286 0.231419529
## 160  86.458333  28.0788177 0.234693201
## 161  85.416667  28.0788177 0.240076487
## 162  85.416667  27.5862069 0.243523470
## 163  85.416667  27.0935961 0.244529051
## 164  84.375000  27.0935961 0.245334274
## 165  84.375000  26.6009852 0.246276763
## 166  84.375000  26.1083744 0.247439784
## 167  84.375000  25.6157635 0.249941047
## 168  84.375000  25.1231527 0.254547477
## 169  84.375000  24.6305419 0.259293373
## 170  83.333333  24.6305419 0.264561275
## 171  82.291667  24.6305419 0.269169232
## 172  82.291667  24.1379310 0.272918791
## 173  82.291667  23.6453202 0.279732110
## 174  82.291667  23.1527094 0.287320887
## 175  82.291667  22.6600985 0.290487306
## 176  82.291667  22.1674877 0.290814320
## 177  82.291667  21.6748768 0.291093286
## 178  82.291667  21.1822660 0.293581215
## 179  82.291667  20.6896552 0.299161150
## 180  82.291667  20.1970443 0.302564713
## 181  82.291667  19.7044335 0.302885550
## 182  81.250000  19.7044335 0.303394947
## 183  81.250000  19.2118227 0.306217073
## 184  81.250000  18.7192118 0.312152285
## 185  80.208333  18.7192118 0.317890323
## 186  80.208333  18.2266010 0.325355846
## 187  79.166667  18.2266010 0.331652164
## 188  79.166667  17.7339901 0.333700243
## 189  79.166667  17.2413793 0.341720495
## 190  78.125000  17.2413793 0.349075187
## 191  78.125000  16.7487685 0.353722942
## 192  77.083333  16.7487685 0.361066555
## 193  77.083333  16.2561576 0.367203851
## 194  76.041667  16.2561576 0.372233858
## 195  76.041667  15.7635468 0.376846075
## 196  76.041667  15.2709360 0.380369395
## 197  75.000000  15.2709360 0.382563511
## 198  75.000000  14.7783251 0.385218605
## 199  75.000000  14.2857143 0.387678950
## 200  73.958333  14.2857143 0.390449382
## 201  73.958333  13.7931034 0.393947493
## 202  73.958333  13.3004926 0.400310859
## 203  73.958333  12.8078818 0.406352109
## 204  73.958333  12.3152709 0.412909420
## 205  73.958333  11.8226601 0.418471293
## 206  73.958333  11.3300493 0.420369014
## 207  73.958333  10.8374384 0.429623454
## 208  73.958333  10.3448276 0.439699752
## 209  73.958333   9.8522167 0.447750077
## 210  73.958333   9.3596059 0.459167654
## 211  72.916667   9.3596059 0.466853112
## 212  71.875000   9.3596059 0.473210433
## 213  71.875000   8.8669951 0.480223282
## 214  71.875000   8.3743842 0.488748566
## 215  71.875000   7.8817734 0.499549223
## 216  70.833333   7.8817734 0.506134336
## 217  69.791667   7.8817734 0.508448469
## 218  69.791667   7.3891626 0.512836872
## 219  68.750000   7.3891626 0.519309297
## 220  68.750000   6.8965517 0.522772048
## 221  68.750000   6.4039409 0.528760116
## 222  67.708333   6.4039409 0.548156732
## 223  66.666667   6.4039409 0.570087482
## 224  65.625000   6.4039409 0.579680254
## 225  64.583333   6.4039409 0.587677713
## 226  63.541667   6.4039409 0.596749923
## 227  62.500000   6.4039409 0.604442768
## 228  61.458333   6.4039409 0.614219739
## 229  60.416667   6.4039409 0.625356605
## 230  59.375000   6.4039409 0.631894863
## 231  58.333333   6.4039409 0.632596605
## 232  58.333333   5.9113300 0.636281986
## 233  57.291667   5.9113300 0.640634083
## 234  56.250000   5.9113300 0.646680836
## 235  55.208333   5.9113300 0.652605528
## 236  55.208333   5.4187192 0.660227591
## 237  54.166667   5.4187192 0.668567868
## 238  54.166667   4.9261084 0.671429809
## 239  53.125000   4.9261084 0.675177310
## 240  52.083333   4.9261084 0.680505650
## 241  51.041667   4.9261084 0.683678142
## 242  50.000000   4.9261084 0.684371784
## 243  50.000000   4.4334975 0.686350341
## 244  50.000000   3.9408867 0.695205139
## 245  48.958333   3.9408867 0.705007890
## 246  48.958333   3.4482759 0.720685758
## 247  48.958333   2.9556650 0.734719034
## 248  47.916667   2.9556650 0.741566577
## 249  46.875000   2.9556650 0.750975036
## 250  45.833333   2.9556650 0.756726300
## 251  44.791667   2.9556650 0.758898850
## 252  44.791667   2.4630542 0.759998937
## 253  43.750000   2.4630542 0.765571794
## 254  42.708333   2.4630542 0.772025675
## 255  41.666667   2.4630542 0.775357074
## 256  40.625000   2.4630542 0.777325203
## 257  39.583333   2.4630542 0.781000366
## 258  38.541667   2.4630542 0.784712789
## 259  37.500000   2.4630542 0.787002137
## 260  36.458333   2.4630542 0.791118200
## 261  36.458333   1.9704433 0.793992737
## 262  35.416667   1.9704433 0.798983620
## 263  34.375000   1.9704433 0.805463808
## 264  34.375000   1.4778325 0.810635178
## 265  33.333333   1.4778325 0.815819408
## 266  32.291667   1.4778325 0.828661790
## 267  31.250000   1.4778325 0.840473716
## 268  30.208333   1.4778325 0.848331447
## 269  29.166667   1.4778325 0.857012030
## 270  28.125000   1.4778325 0.861652813
## 271  27.083333   1.4778325 0.880572509
## 272  27.083333   0.9852217 0.898237541
## 273  26.041667   0.9852217 0.899808674
## 274  25.000000   0.9852217 0.900516447
## 275  23.958333   0.9852217 0.901603877
## 276  22.916667   0.9852217 0.902766076
## 277  21.875000   0.9852217 0.905067249
## 278  21.875000   0.4926108 0.906695849
## 279  20.833333   0.4926108 0.907393360
## 280  20.833333   0.0000000 0.908896481
## 281  19.791667   0.0000000 0.912227515
## 282  18.750000   0.0000000 0.914767057
## 283  17.708333   0.0000000 0.921444668
## 284  16.666667   0.0000000 0.933307482
## 285  15.625000   0.0000000 0.938553415
## 286  14.583333   0.0000000 0.941073906
## 287  13.541667   0.0000000 0.943984697
## 288  12.500000   0.0000000 0.945713716
## 289  11.458333   0.0000000 0.947441819
## 290  10.416667   0.0000000 0.949424753
## 291   9.375000   0.0000000 0.953033485
## 292   8.333333   0.0000000 0.956044707
## 293   7.291667   0.0000000 0.961804041
## 294   6.250000   0.0000000 0.967563708
## 295   5.208333   0.0000000 0.971617715
## 296   4.166667   0.0000000 0.977005110
## 297   3.125000   0.0000000 0.986015581
## 298   2.083333   0.0000000 0.994057489
## 299   1.041667   0.0000000 0.997371996
## 300   0.000000   0.0000000         Inf
```

```
head(roc.df)
```

```
##   tpp       fpp  thresholds
## 1 100 100.00000        -Inf
## 2 100  99.50739 0.001410984
## 3 100  99.01478 0.002334826
## 4 100  98.52217 0.002672952
## 5 100  98.02956 0.002889721
## 6 100  97.53695 0.003190045
```

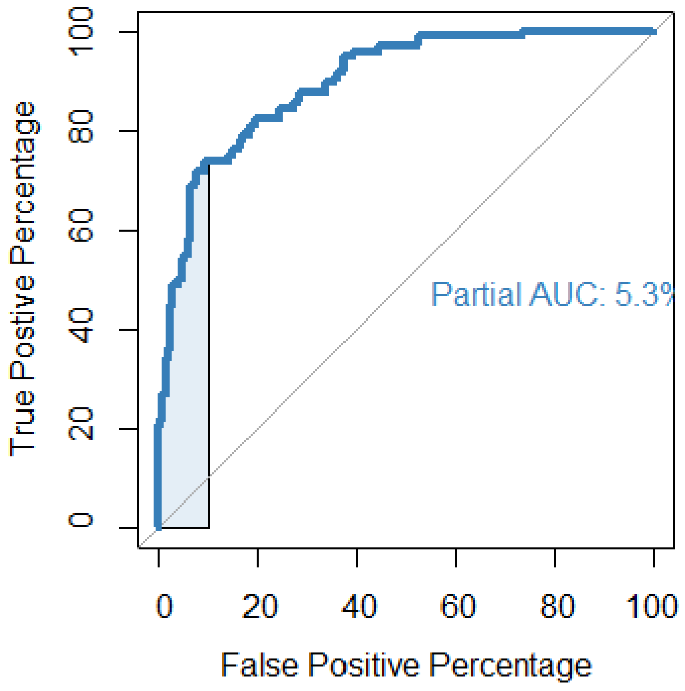
```
tail(roc.df)
```

```
##          tpp fpp thresholds
## 295 5.208333   0  0.9716177
## 296 4.166667   0  0.9770051
## 297 3.125000   0  0.9860156
## 298 2.083333   0  0.9940575
## 299 1.041667   0  0.9973720
## 300 0.000000   0        Inf
```

```
#Setting thresholds between TPP 60% and 80%
roc.df[roc.df$tpp > 60 & roc.df$tpp < 80,]
```

```
##          tpp       fpp thresholds
## 187 79.16667 18.226601  0.3316522
## 188 79.16667 17.733990  0.3337002
## 189 79.16667 17.241379  0.3417205
## 190 78.12500 17.241379  0.3490752
## 191 78.12500 16.748768  0.3537229
## 192 77.08333 16.748768  0.3610666
## 193 77.08333 16.256158  0.3672039
## 194 76.04167 16.256158  0.3722339
## 195 76.04167 15.763547  0.3768461
## 196 76.04167 15.270936  0.3803694
## 197 75.00000 15.270936  0.3825635
## 198 75.00000 14.778325  0.3852186
## 199 75.00000 14.285714  0.3876790
## 200 73.95833 14.285714  0.3904494
## 201 73.95833 13.793103  0.3939475
## 202 73.95833 13.300493  0.4003109
## 203 73.95833 12.807882  0.4063521
## 204 73.95833 12.315271  0.4129094
## 205 73.95833 11.822660  0.4184713
## 206 73.95833 11.330049  0.4203690
## 207 73.95833 10.837438  0.4296235
## 208 73.95833 10.344828  0.4396998
## 209 73.95833  9.852217  0.4477501
## 210 73.95833  9.359606  0.4591677
## 211 72.91667  9.359606  0.4668531
## 212 71.87500  9.359606  0.4732104
## 213 71.87500  8.866995  0.4802233
## 214 71.87500  8.374384  0.4887486
## 215 71.87500  7.881773  0.4995492
## 216 70.83333  7.881773  0.5061343
## 217 69.79167  7.881773  0.5084485
## 218 69.79167  7.389163  0.5128369
## 219 68.75000  7.389163  0.5193093
## 220 68.75000  6.896552  0.5227720
## 221 68.75000  6.403941  0.5287601
## 222 67.70833  6.403941  0.5481567
## 223 66.66667  6.403941  0.5700875
## 224 65.62500  6.403941  0.5796803
## 225 64.58333  6.403941  0.5876777
## 226 63.54167  6.403941  0.5967499
## 227 62.50000  6.403941  0.6044428
## 228 61.45833  6.403941  0.6142197
## 229 60.41667  6.403941  0.6253566
```

```
roc(dataset$DEATH_EVENT,logistic$fitted.values,plot=TRUE, legacy.axes=TRUE,
xlab="False Positive Percentage", ylab="True Postive Percentage",
col="#377eb8", lwd=4, percent=TRUE, print.auc=TRUE, partial.auc=c(100, 90),
auc.polygon = TRUE, auc.polygon.col = "#377eb822", print.auc.x=45)

## Setting levels: control = Death, case = Survived
## Setting direction: controls < cases
```



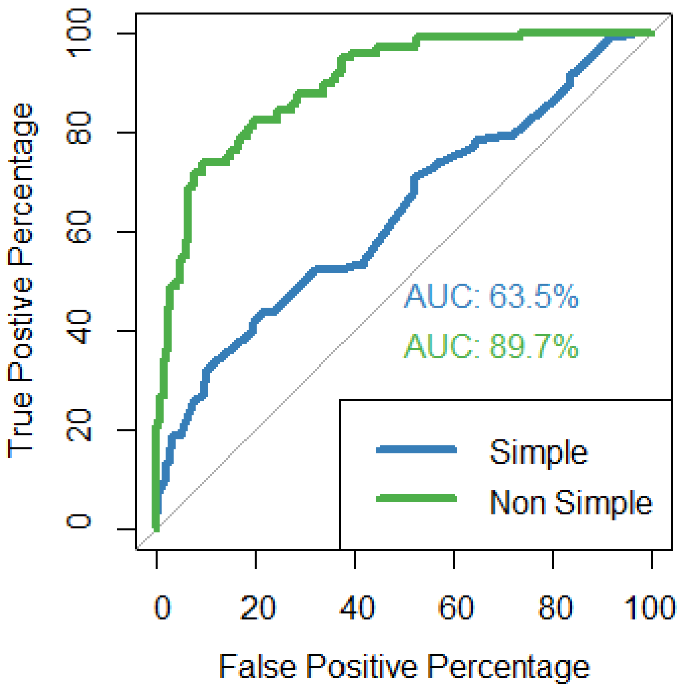
```
##
## Call:
## roc.default(response = dataset$DEATH_EVENT, predictor =
logistic$fitted.values,     percent = TRUE, plot = TRUE, legacy.axes = TRUE,
xlab = "False Positive Percentage",     ylab = "True Postive Percentage", col
= "#377eb8", lwd = 4,     print.auc = TRUE, partial.auc = c(100, 90),
auc.polygon = TRUE,     auc.polygon.col = "#377eb822", print.auc.x = 45)
##
## Data: logistic$fitted.values in 203 controls (dataset$DEATH_EVENT Death) <
96 cases (dataset$DEATH_EVENT Survived).
## Partial area under the curve (specificity 100%-90%): 5.271%

# Plotting and comparing two ROC's (one using Age as single predictor and
other using all variables as predictors)
roc(dataset$DEATH_EVENT, logistic_simple2$fitted.values, plot=TRUE,
legacy.axes=TRUE, percent=TRUE, xlab="False Positive Percentage", ylab="True
Postive Percentage", col="#377eb8", lwd=4, print.auc=TRUE)

## Setting levels: control = Death, case = Survived
## Setting direction: controls < cases
```

```
##
## Call:
## roc.default(response = dataset$DEATH_EVENT, predictor =
logistic_simple2$fitted.values,     percent = TRUE, plot = TRUE, legacy.axes
= TRUE, xlab = "False Positive Percentage",     ylab = "True Postive
Percentage", col = "#377eb8", lwd = 4,     print.auc = TRUE)
##
## Data: logistic_simple2$fitted.values in 203 controls (dataset$DEATH_EVENT
Death) < 96 cases (dataset$DEATH_EVENT Survived).
## Area under the curve: 63.46%
```

```
plot.roc(dataset$DEATH_EVENT, logistic$fitted.values, percent=TRUE,
col="#4daf4a", lwd=4, print.auc=TRUE, add=TRUE, print.auc.y=40)
```

```
## Setting levels: control = Death, case = Survived
## Setting direction: controls < cases
```

```
legend("bottomright", legend=c("Simple", "Non Simple"), col=c("#377eb8",
"#4daf4a"), lwd=4)
```



```
#Based on the plot, we can say the model using all variables as predictors is
better
```