

Model Building

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```
knitr::opts_chunk$set(echo = TRUE, message = FALSE, warning = FALSE)
library(tidyverse)

## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.4
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.4.4     v tibble    3.2.1
## v lubridate 1.9.2     v tidyr    1.3.0
## v purrr    1.0.2
## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()   masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
library(dplyr)
library(MASS)

##
## Attaching package: 'MASS'
##
## The following object is masked from 'package:dplyr':
##
##     select
library(ggplot2)
library(corrplot)

## corrplot 0.92 loaded
library(leaps)
library(glmnet)

## Loading required package: Matrix
##
## Attaching package: 'Matrix'
##
## The following objects are masked from 'package:tidyverse':
##
##     expand, pack, unpack
##
## Loaded glmnet 4.1-8
library(igraph)

##
## Attaching package: 'igraph'
```

```

##  

## The following objects are masked from 'package:lubridate':  

##  

##      %--%, union  

##  

## The following objects are masked from 'package:dplyr':  

##  

##      as_data_frame, groups, union  

##  

## The following objects are masked from 'package:purrr':  

##  

##      compose, simplify  

##  

## The following object is masked from 'package:tidyr':  

##  

##      crossing  

##  

## The following object is masked from 'package:tibble':  

##  

##      as_data_frame  

##  

## The following objects are masked from 'package:stats':  

##  

##      decompose, spectrum  

##  

## The following object is masked from 'package:base':  

##  

##      union  

library(arules)

##  

## Attaching package: 'arules'  

##  

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

##  

##      recode  

##  

## The following objects are masked from 'package:base':  

##  

##      abbreviate, write  

library(caret)

## Loading required package: lattice
##  

## Attaching package: 'caret'  

##  

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

##  

##      lift  

library(pROC)

## Type 'citation("pROC")' for a citation.
##

```

```

## Attaching package: 'pROC'
##
## The following objects are masked from 'package:stats':
##
##     cov, smooth, var
library(performance) # vif
library(ggpubr)
library(vcd)

```

```

## Loading required package: grid

```

Data Cleaning

```

# import data
breastcancer = read_csv("./data/Project_2_data.csv")

#Data Cleaning
breastcancer_1 = breastcancer |>
  janitor::clean_names() |>
  mutate(
    race = as_factor(race),
    marital_status = factor(marital_status, levels = c("Single", "Married", "Divorced", "Separated", "Widowed")),
    t_stage = factor(t_stage, levels = c("T1", "T2", "T3", "T4")),
    n_stage = factor(n_stage, levels = c("N1", "N2", "N3")),
    x6th_stage = factor(x6th_stage, levels = c("IIA", "IIB", "IIIA", "IIIB", "IIIC")),
    differentiate = factor(differentiate, levels = c("Moderately differentiated", "Poorly differentiated")),
    grade = factor(grade, levels = c("1", "2", "3", "anaplastic; Grade IV")),
    a_stage = factor(a_stage, levels = c("Distant", "Regional")),
    estrogen_status = as_factor(estrogen_status),
    progesterone_status = as_factor(progesterone_status),
    status = ifelse(status == "Dead", 1, 0),
    status = as_factor(status))

breastcancer_clean = breastcancer_1 |>
  mutate(node_positive_prop = reginol_node_positive / regional_node_examined,
         node_positive_prop = round(node_positive_prop, 4))

breastcancer_clean

## # A tibble: 4,024 x 17
##       age race  marital_status t_stage n_stage x6th_stage differentiate      grade
##   <dbl> <fct> <fct>        <fct>  <fct>    <fct>        <fct>        <fct>
## 1     68 White Married      T1      N1      IIA Poorly different~ 3
## 2     50 White Married      T2      N2      IIIA Moderately diffe~ 2
## 3     58 White Divorced    T3      N3      IIIC Moderately diffe~ 2
## 4     58 White Married      T1      N1      IIA Poorly different~ 3
## 5     47 White Married      T2      N1      IIB Poorly different~ 3
## 6     51 White Single      T1      N1      IIA Moderately diffe~ 2
## 7     51 White Married      T1      N1      IIA Well differentia~ 1
## 8     40 White Married      T2      N1      IIB Moderately diffe~ 2
## 9     40 White Divorced    T4      N3      IIIC Poorly different~ 3
## 10    69 White Married      T4      N3      IIIC Well differentia~ 1
## # i 4,014 more rows

```

```

## # i 9 more variables: a_stage <fct>, tumor_size <dbl>, estrogen_status <fct>,
## #   progesterone_status <fct>, regional_node_examined <dbl>,
## #   reginol_node_positive <dbl>, survival_months <dbl>, status <fct>,
## #   node_positive_prop <dbl>

```

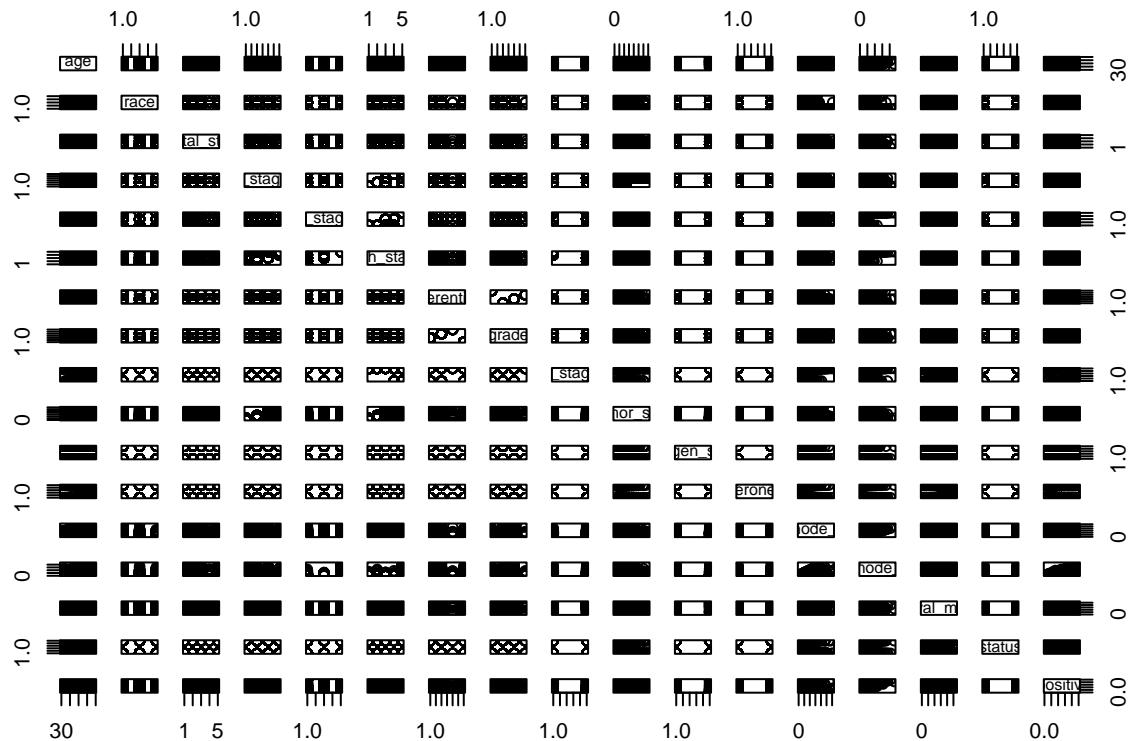
Exploratory Analysis

Checking Association Between Numerical Variables

```

# exploratory
pairs(breastcancer_clean)

```

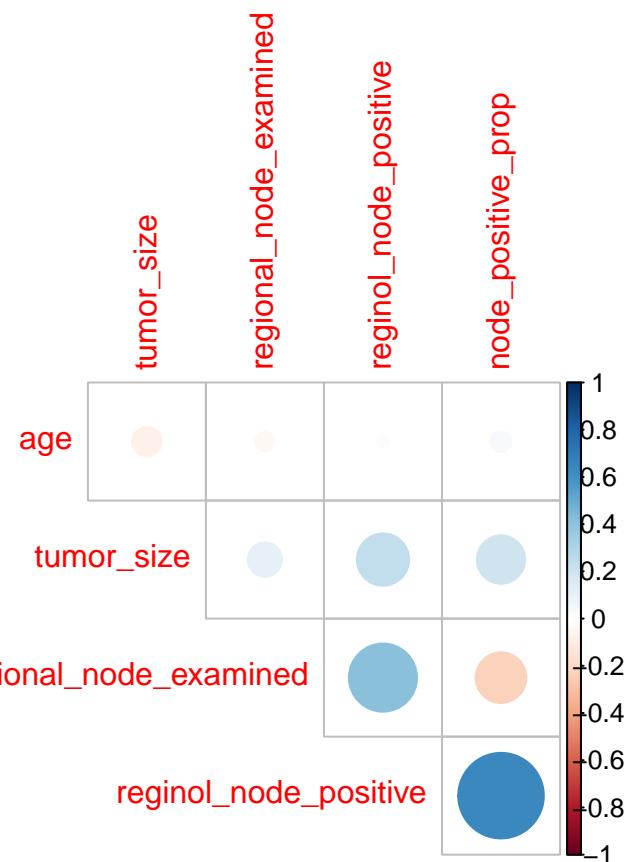


```

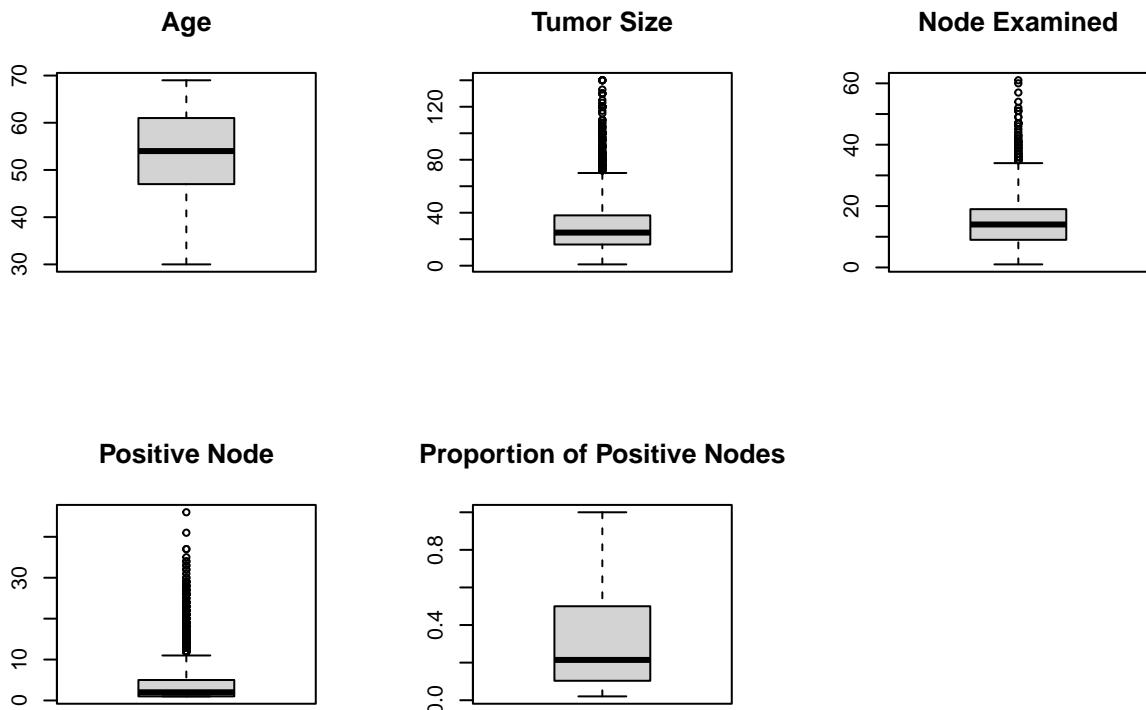
# correlation plot
breastcancer_num = breastcancer_clean |>
  dplyr::select(age, tumor_size, regional_node_examined, reginol_node_positive, node_positive_prop)

corrplot(cor(breastcancer_num), type = "upper", diag = FALSE)

```



```
# Boxplots for each variable
par(mfrow=c(2,3))
boxplot(breastcancer_clean$age, main='Age')
boxplot(breastcancer_clean$tumor_size, main='Tumor Size')
boxplot(breastcancer_clean$regional_node_examined,main='Node Examined' )
boxplot(breastcancer_clean$reginol_node_positive, main='Positive Node')
boxplot(breastcancer_clean$node_positive_prop, main='Proportion of Positive Nodes')
```



- tumor_size has substantial amounts of outliers.
- reginol_node_positive and node_positive_prop are highly correlated.

Checking Association Between Categorical Variables

```

breastcancer_cag = breastcancer_clean |>
  dplyr::select(-age, -tumor_size, -regional_node_examined, -reginol_node_positive, -node_positive_prop)

rules <- apriori(breastcancer_cag, parameter = list(supp = 0.001, conf = 0.8))

## Apriori
##
## Parameter specification:
##   confidence minval smax arem aval originalSupport maxtime support minlen
##       0.8      0.1     1 none FALSE             TRUE      5    0.001      1
##   maxlen target ext
##       10    rules TRUE
##
## Algorithmic control:
##   filter tree heap memopt load sort verbose
##       0.1 TRUE TRUE FALSE TRUE    2    TRUE
##
## Absolute minimum support count: 4
##
## set item appearances ...[0 item(s)] done [0.00s].
## set transactions ...[36 item(s), 4024 transaction(s)] done [0.00s].

```

```

## sorting and recoding items ... [36 item(s)] done [0.00s].
## creating transaction tree ... done [0.00s].
## checking subsets of size 1 2 3 4 5 6 7 8 9 10 done [0.06s].
## writing ... [424628 rule(s)] done [0.08s].
## creating S4 object ... done [0.12s].
# Inspect the top 5 rules
inspect(head(sort(rules, by = "confidence"), 5))

```

lhs	rhs	support	confidence	cov
## [1] {grade=anaplastic; Grade IV} => {differentiate=Undifferentiated}	0.00472167	1	0.00472167	
## [2] {differentiate=Undifferentiated} => {grade=anaplastic; Grade IV}	0.00472167	1	0.00472167	
## [3] {grade=anaplastic; Grade IV} => {a_stage=Regional}	0.00472167	1	0.00472167	
## [4] {differentiate=Undifferentiated} => {a_stage=Regional}	0.00472167	1	0.00472167	
## [5] {x6th_stage=IIIB} => {t_stage=T4}	0.01665010	1	0.01665010	

Checking Logistic Regression Assumption

Fitting Model

Training Data and Test Data

```

#split the data
set.seed(123)
breastcancer_test = breastcancer_clean |>
  dplyr::select(-survival_months)
split <- createDataPartition(breastcancer_test$status, p = .7, list = FALSE)
train_data <- breastcancer_test[split, ]
test_data <- breastcancer_test[-split, ]
test_data1 = test_data |> dplyr::select(-status)

```

Backward Selection

```

breastcancer_clean1 <- breastcancer_test |>
  drop_na()

full_model <- glm(status ~ ., data = breastcancer_test, family = binomial())

summary(full_model)

##
## Call:
## glm(formula = status ~ ., family = binomial(), data = breastcancer_test)
##
## Coefficients: (4 not defined because of singularities)
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)           -3.926e+00  4.609e-01 -8.518   < 2e-16 ***
## age                  2.384e-02  5.624e-03  4.239  2.24e-05 ***
## raceBlack             5.147e-01  1.621e-01  3.174  0.001502 **
## raceOther             -4.164e-01  2.025e-01 -2.056  0.039752 *
## marital_statusMarried -1.322e-01  1.350e-01 -0.980  0.327175
## marital_statusDivorced  8.189e-02  1.754e-01  0.467  0.640527
## marital_statusSeparated 7.206e-01  3.829e-01  1.882  0.059817 .

```

```

## marital_statusWidowed          9.846e-02  2.190e-01  0.450  0.652946
## t_stageT2                      2.790e-01  1.954e-01  1.428  0.153259
## t_stageT3                      5.423e-01  3.139e-01  1.728  0.084036 .
## t_stageT4                      9.489e-01  4.502e-01  2.108  0.035058 *
## n_stagen2                      5.623e-01  2.412e-01  2.331  0.019744 *
## n_stagen3                      5.862e-01  3.052e-01  1.921  0.054735 .
## x6th_stageIIB                  2.160e-01  2.319e-01  0.931  0.351696
## x6th_stageIIIA                 -1.006e-01 2.953e-01 -0.341  0.733307
## x6th_stageIIIB                 5.262e-02  5.291e-01  0.099  0.920772
## x6th_stageIIIC                 NA          NA          NA          NA
## differentiatePoorly differentiated 3.907e-01  1.050e-01  3.721  0.000199 ***
## differentiateUndifferentiated   1.364e+00  5.352e-01  2.548  0.010831 *
## differentiateWell differentiated -5.326e-01 1.843e-01 -2.890  0.003857 **
## grade2                          NA          NA          NA          NA
## grade3                          NA          NA          NA          NA
## gradeanaplastic; Grade IV      NA          NA          NA          NA
## a_stageRegional                 -6.039e-02 2.662e-01 -0.227  0.820532
## tumor_size                      -3.839e-05 3.975e-03 -0.010  0.992295
## estrogen_statusNegative         7.373e-01  1.781e-01  4.141  3.46e-05 ***
## progesterone_statusNegative     5.885e-01  1.278e-01  4.604  4.14e-06 ***
## regional_node_examined          -2.072e-02 1.071e-02 -1.936  0.052924 .
## reginol_node_positive           5.455e-02  2.011e-02  2.712  0.006682 **
## node_positive_prop              5.896e-01  3.157e-01  1.868  0.061807 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 3444.7 on 4023 degrees of freedom
## Residual deviance: 2948.6 on 3998 degrees of freedom
## AIC: 3000.6
##
## Number of Fisher Scoring iterations: 5
backward_model <- step(full_model, direction = "backward")

## Start:  AIC=3000.61
## status ~ age + race + marital_status + t_stage + n_stage + x6th_stage +
##       differentiate + grade + a_stage + tumor_size + estrogen_status +
##       progesterone_status + regional_node_examined + reginol_node_positive +
##       node_positive_prop
##
##
## Step:  AIC=3000.61
## status ~ age + race + marital_status + t_stage + n_stage + x6th_stage +
##       differentiate + a_stage + tumor_size + estrogen_status +
##       progesterone_status + regional_node_examined + reginol_node_positive +
##       node_positive_prop
##
##                               Df Deviance    AIC
## - x6th_stage               3   2950.4 2996.4
## - tumor_size                1   2948.6 2998.6
## - a_stage                   1   2948.7 2998.7
## - t_stage                   3   2953.8 2999.8
## - marital_status             4   2956.3 3000.3

```

```

## <none>                      2948.6 3000.6
## - node_positive_prop         1   2952.0 3002.0
## - regional_node_examined    1   2952.5 3002.5
## - n_stage                     1   2954.2 3004.2
## - reginol_node_positive      1   2956.1 3006.1
## - race                        2   2963.9 3011.9
## - estrogen_status              1   2965.6 3015.6
## - age                          1   2966.9 3016.9
## - progesterone_status          1   2968.7 3018.7
## - differentiate                3   2982.5 3028.5
##
## Step: AIC=2996.45
## status ~ age + race + marital_status + t_stage + n_stage + differentiate +
##       a_stage + tumor_size + estrogen_status + progesterone_status +
##       regional_node_examined + reginol_node_positive + node_positive_prop
##
##                               Df Deviance     AIC
## - tumor_size                  1   2950.4 2994.4
## - a_stage                     1   2950.5 2994.5
## - marital_status                4   2958.1 2996.1
## <none>                         2950.4 2996.4
## - node_positive_prop           1   2953.7 2997.7
## - regional_node_examined      1   2954.5 2998.5
## - n_stage                      2   2958.2 3000.2
## - reginol_node_positive        1   2958.3 3002.3
## - t_stage                      3   2964.9 3004.9
## - race                         2   2966.2 3008.2
## - estrogen_status               1   2967.7 3011.7
## - age                          1   2968.2 3012.2
## - progesterone_status          1   2970.4 3014.4
## - differentiate                 3   2984.0 3024.0
##
## Step: AIC=2994.45
## status ~ age + race + marital_status + t_stage + n_stage + differentiate +
##       a_stage + estrogen_status + progesterone_status + regional_node_examined +
##       reginol_node_positive + node_positive_prop
##
##                               Df Deviance     AIC
## - a_stage                     1   2950.5 2992.5
## - marital_status                4   2958.1 2994.1
## <none>                         2950.4 2994.4
## - node_positive_prop           1   2953.8 2995.8
## - regional_node_examined      1   2954.5 2996.5
## - n_stage                      2   2958.2 2998.2
## - reginol_node_positive        1   2958.3 3000.3
## - race                         2   2966.2 3006.2
## - estrogen_status               1   2967.7 3009.7
## - age                          1   2968.2 3010.2
## - progesterone_status          1   2970.5 3012.5
## - t_stage                      3   2975.9 3013.9
## - differentiate                 3   2984.0 3022.0
##
## Step: AIC=2992.5
## status ~ age + race + marital_status + t_stage + n_stage + differentiate +

```

```

##      estrogen_status + progesterone_status + regional_node_examined +
##      reginol_node_positive + node_positive_prop
##
##                                Df Deviance    AIC
## - marital_status          4   2958.2 2992.2
## <none>                      2950.5 2992.5
## - node_positive_prop      1   2953.8 2993.8
## - regional_node_examined  1   2954.6 2994.6
## - n_stage                  2   2958.4 2996.4
## - reginol_node_positive   1   2958.3 2998.3
## - race                     2   2966.2 3004.2
## - estrogen_status          1   2967.8 3007.8
## - age                      1   2968.3 3008.3
## - progesterone_status      1   2970.5 3010.5
## - t_stage                  3   2977.9 3013.9
## - differentiate            3   2984.0 3020.0
##
## Step:  AIC=2992.23
## status ~ age + race + t_stage + n_stage + differentiate + estrogen_status +
##         progesterone_status + regional_node_examined + reginol_node_positive +
##         node_positive_prop
##
##                                Df Deviance    AIC
## <none>                      2958.2 2992.2
## - node_positive_prop          1   2961.8 2993.8
## - regional_node_examined     1   2962.1 2994.1
## - n_stage                    2   2965.8 2995.8
## - reginol_node_positive      1   2966.2 2998.2
## - race                       2   2977.0 3007.0
## - estrogen_status             1   2975.3 3007.3
## - age                        1   2978.1 3010.1
## - progesterone_status        1   2979.1 3011.1
## - t_stage                    3   2986.5 3014.5
## - differentiate              3   2991.6 3019.6
summary(backward_model)

##
## Call:
## glm(formula = status ~ age + race + t_stage + n_stage + differentiate +
##       estrogen_status + progesterone_status + regional_node_examined +
##       reginol_node_positive + node_positive_prop, family = binomial(),
##       data = breastcancer_test)
##
## Coefficients:
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)           -4.043002  0.364319 -11.097 < 2e-16 ***
## age                   0.024037  0.005446  4.414 1.01e-05 ***
## raceBlack             0.571314  0.158713  3.600 0.000319 ***
## raceOther              -0.436020  0.202095 -2.157 0.030967 *
## t_stageT2              0.414742  0.112950  3.672 0.000241 ***
## t_stageT3              0.536668  0.148743  3.608 0.000309 ***
## t_stageT4              1.080665  0.243415  4.440 9.01e-06 ***
## n_stagen2              0.359193  0.133273  2.695 0.007035 **
## n_stagen3              0.483083  0.238891  2.022 0.043156 *

```

```

## differentiatePoorly differentiated 0.390119  0.104692  3.726 0.000194 ***
## differentiateUndifferentiated     1.342852  0.527454  2.546 0.010899 *
## differentiateWell differentiated   -0.514237  0.183185 -2.807 0.004997 **
## estrogen_statusNegative          0.736776  0.177100  4.160 3.18e-05 ***
## progesterone_statusNegative      0.598155  0.127456  4.693 2.69e-06 ***
## regional_node_examined          -0.020698  0.010690 -1.936 0.052845 .
## reginol_node_positive           0.055765  0.020031  2.784 0.005370 **
## node_positive_prop              0.603430  0.313593  1.924 0.054324 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 3444.7 on 4023 degrees of freedom
## Residual deviance: 2958.2 on 4007 degrees of freedom
## AIC: 2992.2
##
## Number of Fisher Scoring iterations: 5

```

Backward Model Predictions

```

predictions_backward <- predict(backward_model, newdata = test_data1)

# Viewing predictions
print(predictions_backward)

```

	1	2	3	4	5	6
##	-1.226793547	-3.011097529	-2.471941006	-2.041982813	-2.904755034	-1.643671648
##	7	8	9	10	11	12
##	-1.647522277	-3.642448561	-0.628895418	-2.727396465	-1.187120305	-1.333928129
##	13	14	15	16	17	18
##	-2.816951541	-2.150158044	-2.443708643	-3.189127293	-3.055596600	-2.869741517
##	19	20	21	22	23	24
##	-2.361291743	-2.847547901	-0.380991845	-2.159364245	-2.327152677	-3.498244406
##	25	26	27	28	29	30
##	-3.464231882	-1.192074207	-2.555026771	-2.869635853	-1.870905050	-2.371486024
##	31	32	33	34	35	36
##	-2.444720893	-2.248477836	-2.367945823	-2.392953302	-1.561106604	-4.031314759
##	37	38	39	40	41	42
##	-2.755545636	-1.441729973	-2.646010497	-2.352520081	-2.111914428	-0.477897358
##	43	44	45	46	47	48
##	-2.368026076	-2.658274961	-2.376443876	-1.295212515	-2.172569404	-2.109775117
##	49	50	51	52	53	54
##	-2.449018901	-2.134397367	-0.660707582	-1.402658246	-1.866293130	-2.647798221
##	55	56	57	58	59	60
##	-0.899538530	-2.415725827	-2.637868316	-2.474017052	-2.326111442	-3.128211515
##	61	62	63	64	65	66
##	-1.683165996	-2.114834351	-2.008104141	-1.219884391	-3.138784689	-2.400332355
##	67	68	69	70	71	72
##	-3.134022512	-3.419531740	-1.874713438	1.019363304	-0.923701688	-2.450575818
##	73	74	75	76	77	78
##	-2.640202592	-2.867623557	-1.185186674	1.710076194	-3.034252791	-0.926214176
##	79	80	81	82	83	84
##	-1.493744745	-2.741378632	-2.162104858	-1.271578284	-2.586021476	-1.723869609

	85	86	87	88	89	90
##	-3.555735209	-2.385275774	-2.480277275	-0.956744653	-2.603189900	-1.806634847
##	91	92	93	94	95	96
##	-0.631738721	1.058790189	-2.129373002	-3.511817438	-0.434692855	-2.462651884
##	97	98	99	100	101	102
##	-0.665994884	-1.727521459	0.176418460	-2.501489804	-0.255138829	-3.633437713
##	103	104	105	106	107	108
##	-2.266714340	-2.872529183	-2.254488662	-1.903834708	-0.908095976	-2.738152945
##	109	110	111	112	113	114
##	-2.875013938	-1.489229010	-1.499286378	-2.587230164	-2.406924080	-3.354524141
##	115	116	117	118	119	120
##	-2.442544791	-1.884630224	-1.886856283	-3.686750539	-1.890854532	-1.728792179
##	121	122	123	124	125	126
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##	169	170	171	172	173	174
##	-2.737704313	-1.385954670	-2.676471265	-2.210495805	-2.322872984	-2.728612273
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##	-2.626338048	-1.928419854	-2.715959350	-0.580864071	-2.550313713	-2.024569332
##	889	890	891	892	893	894
##	-3.268692167	0.090910275	-2.897738062	-1.312306455	-2.683433527	-2.683663944

##	895	896	897	898	899	900
##	-2.867512575	-1.710232605	-2.589380619	-1.126957663	-2.496593104	-2.116415489
##	901	902	903	904	905	906
##	-1.788698352	-1.426720960	-1.051050614	-0.564223442	-2.161731244	-3.209759750
##	907	908	909	910	911	912
##	-3.271932926	-1.909602235	-2.443708643	-1.883416262	-2.535348873	-2.106016293
##	913	914	915	916	917	918
##	-1.492145751	-2.566198507	-1.153776049	-0.521627876	-2.197160142	-2.057814075
##	919	920	921	922	923	924
##	-1.198345892	-2.028344395	-2.094162877	-2.328954017	-1.576818802	-2.298787003
##	925	926	927	928	929	930
##	-0.727229033	-2.640854941	-0.395757306	-1.609776739	-2.090554818	-3.067475221
##	931	932	933	934	935	936
##	-1.806255407	-1.691746387	-1.887096581	-2.970772661	-2.420693003	-3.258720695
##	937	938	939	940	941	942
##	-2.097499526	-1.029877145	-2.269420546	-1.250575455	-0.012589542	-2.578151094
##	943	944	945	946	947	948
##	-2.689452547	-2.543458165	0.914542475	-0.642095987	-1.449191570	-2.731853607
##	949	950	951	952	953	954
##	-1.100756140	0.467725559	-1.907595008	-3.475550015	-3.056119468	-1.022176369
##	955	956	957	958	959	960
##	-2.597901294	-2.774876753	-1.636632449	-1.908667594	-2.252601377	-2.308669779
##	961	962	963	964	965	966
##	-1.841117942	-2.839260117	0.829688555	-3.232063176	-1.131611681	-1.943823023
##	967	968	969	970	971	972
##	-2.278383642	-2.479031999	-3.248743028	-3.080660790	-2.881838861	-1.251408685
##	973	974	975	976	977	978
##	-2.733169327	-0.448663459	-1.808685211	-1.336445106	-1.476077606	-1.341061447
##	979	980	981	982	983	984
##	-3.215038206	-2.009628065	-1.747474346	-1.002656530	-2.333712687	-1.665120119
##	985	986	987	988	989	990
##	-1.207999800	-1.344995614	-0.878064114	-0.193253545	-2.787037777	-2.911875189
##	991	992	993	994	995	996
##	-2.689452547	-2.804269186	-2.372766922	-1.845898046	-1.118185832	-2.473917717
##	997	998	999	1000	1001	1002
##	-2.724637480	-2.933259509	-3.254235250	0.616747384	-2.613546280	-3.197564639
##	1003	1004	1005	1006	1007	1008
##	-2.379436176	-1.771544419	-1.359429167	-2.210048135	-3.354524141	-1.947657989
##	1009	1010	1011	1012	1013	1014
##	-1.848506555	-1.910743000	-0.986028014	-1.300133806	-1.879469261	-1.909426597
##	1015	1016	1017	1018	1019	1020
##	-1.050775688	-2.009461259	-2.341532654	-1.510935180	-1.475231730	-2.776571115
##	1021	1022	1023	1024	1025	1026
##	-2.769014012	-3.058137989	-1.316033869	-2.106859920	-0.713336759	-2.298661379
##	1027	1028	1029	1030	1031	1032
##	-2.492795632	-2.203191385	-1.291119189	-1.810086519	1.176188840	-2.179187068
##	1033	1034	1035	1036	1037	1038
##	-2.148260061	-2.755340693	-2.379597300	-1.820465793	-3.806059583	-1.943150836
##	1039	1040	1041	1042	1043	1044
##	-1.942047525	-2.670945014	-0.905388721	-0.443902916	-3.844943332	-2.528477080
##	1045	1046	1047	1048	1049	1050
##	-2.718268907	-2.322113868	-1.319300857	-2.645622372	-2.857060610	-2.520742711
##	1051	1052	1053	1054	1055	1056
##	-0.199492657	-2.120113685	-1.675354364	-3.001133512	-1.439980618	-2.356314029

```

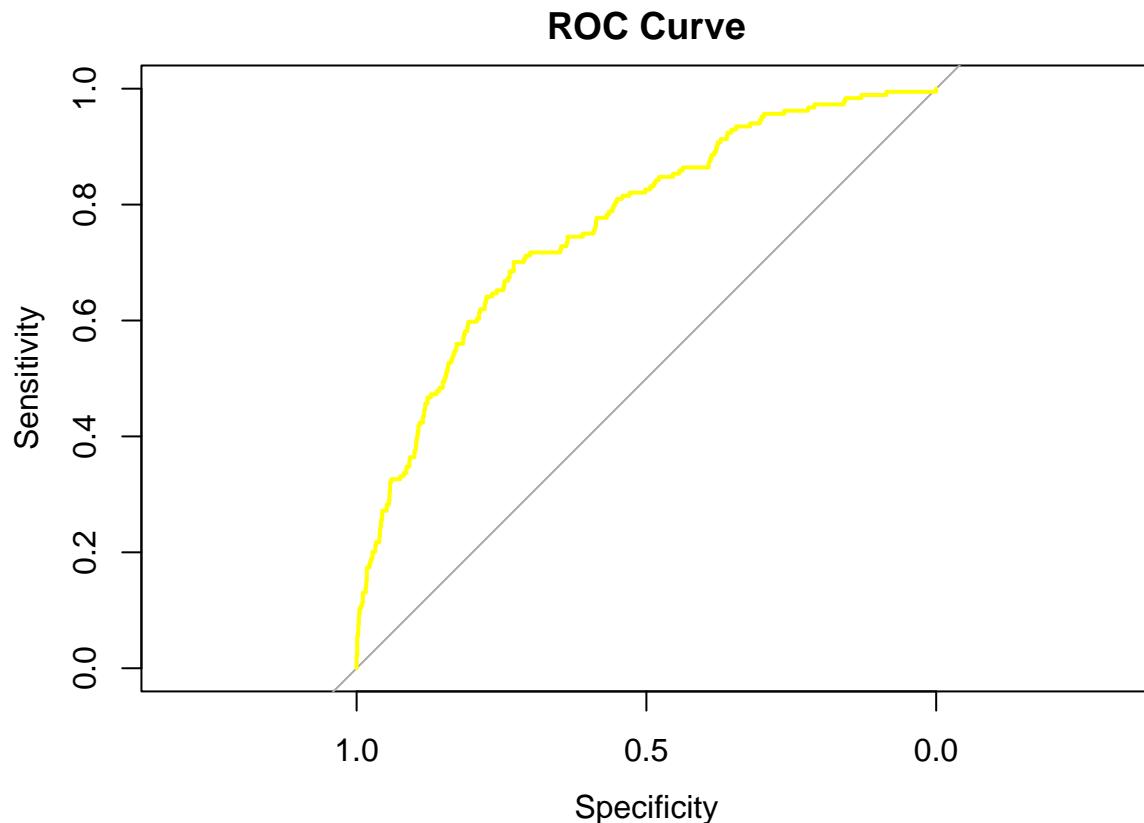
##      1057      1058      1059      1060      1061      1062
## -1.244971847 -0.755501225 -1.783356168 -1.037806640 -2.938606771 -2.788927841
##      1063      1064      1065      1066      1067      1068
## -1.817605390 -1.583271739 -3.000904512 -2.159591506 -3.621061811 -2.057580664
##      1069      1070      1071      1072      1073      1074
## -2.471941006 -1.154289601 -1.318532739 -2.884016308 -1.523432006 -0.006538615
##      1075      1076      1077      1078      1079      1080
## -3.104174145 -1.871038728 -1.019608116 -2.890930901 -3.319345331 -2.084621636
##      1081      1082      1083      1084      1085      1086
## -2.580776224 -0.534624503 -1.942002859 -1.961939102 -2.472925621 -3.271932926
##      1087      1088      1089      1090      1091      1092
## -2.515464059 -2.616668681 -1.092174147 -3.033657842 -2.789938238 -2.497153591
##      1093      1094      1095      1096      1097      1098
##  0.357955929 -2.644051959 -2.768876802 -2.944506487 -2.249488233 -2.494862358
##      1099      1100      1101      1102      1103      1104
## -1.334573116 -1.405650546 -2.542486433 -2.573125510 -1.467422923 -2.325050431
##      1105      1106      1107      1108      1109      1110
## -0.236238209 -1.198829495 -2.772858351 -2.935912558 -3.184856235 -3.094153629
##      1111      1112      1113      1114      1115      1116
## -1.280131820 -1.050973515 -3.126904189  0.439956722 -1.105427721 -1.118553606
##      1117      1118      1119      1120      1121      1122
##  0.600555719 -3.024048824 -3.151256895 -2.857769189 -3.374842097 -0.543247323
##      1123      1124      1125      1126      1127      1128
## -1.899372189 -3.005371618 -1.377414927 -2.076189217 -3.545992582 -3.409135698
##      1129      1130      1131      1132      1133      1134
## -2.733604837 -2.049209596 -3.078132537 -1.942711320 -1.306115666 -1.845853380
##      1135      1136      1137      1138      1139      1140
## -3.193203468 -2.544800647 -2.130525417 -2.510420723 -1.638447115 -1.858340156
##      1141      1142      1143      1144      1145      1146
## -0.145832719 -2.664223334 -3.008175177 -1.201760925 -1.733191041 -1.806493679
##      1147      1148      1149      1150      1151      1152
##  0.376902776 -3.170290639 -3.239020659 -2.201927021 -2.578849667 -2.469798862
##      1153      1154      1155      1156      1157      1158
## -2.974857044 -3.176286254 -2.350460677 -0.767598138 -2.803416838 -2.761564656
##      1159      1160      1161      1162      1163      1164
## -2.861386889 -2.417356340 -2.375689810 -1.548799528 -3.028240525 -2.113037836
##      1165      1166      1167      1168      1169      1170
## -1.786298764 -2.393245766 -2.454041974 -0.367457689 -1.808780791 -1.828930090
##      1171      1172      1173      1174      1175      1176
## -2.394225977 -0.875707855 -1.912194010 -1.959015805 -1.623258096 -3.165276346
##      1177      1178      1179      1180      1181      1182
## -3.039672571 -0.740767898 -2.350638141 -2.030999623 -2.161345746 -2.006690755
##      1183      1184      1185      1186      1187      1188
## -3.727211903 -2.842226684 -0.080895175 -1.404061611 -0.381437584 -1.536808825
##      1189      1190      1191      1192      1193      1194
## -2.085737747 -1.377942880 -2.018911438 -2.112773203 -0.851858497 -2.256759834
##      1195      1196      1197      1198      1199      1200
##  0.262058510 -1.129468364 -0.092214539 -2.555482989 -0.130947548 -3.039764220
##      1201      1202      1203      1204      1205      1206
## -3.114150446 -1.487582525 -3.333196587 -0.618300863 -1.951862033 -0.962943140

roc_curve_backward <- roc(response = as.matrix(test_data$status), predictor = as.numeric(predictions_back)
auc(roc_curve_backward)

## Area under the curve: 0.7649

```

```
#plot the roc curve
plot(roc_curve_backward, main = "ROC Curve", col = "yellow")
```



Forward Selection

```
null_model <- glm(status ~ 1, data = breastcancer_test, family = binomial())
forward_model <- step(null_model, scope = list(lower = null_model, upper = full_model), direction = "forw")

## Start: AIC=3446.68
## status ~ 1
##
##                                     Df Deviance   AIC
## + x6th_stage                  4   3197.4 3207.4
## + n_stage                      2   3214.0 3220.0
## + reginol_node_positive        1   3236.8 3240.8
## + node_positive_prop           1   3237.8 3241.8
## + progesterone_status          1   3335.1 3339.1
## + estrogen_status               1   3338.7 3342.7
## + differentiate                3   3337.3 3345.3
## + grade                         3   3337.3 3345.3
## + t_stage                       3   3349.2 3357.2
## + tumor_size                    1   3380.1 3384.1
## + a_stage                        1   3415.7 3419.7
## + race                          2   3418.9 3424.9
## + marital_status                 4   3419.2 3429.2
```

```

## + age                      1  3432.0 3436.0
## + regional_node_examined   1  3439.9 3443.9
## <none>                     3444.7 3446.7
##
## Step: AIC=3207.4
## status ~ x6th_stage
##
##                                     Df Deviance    AIC
## + progesterone_status          1  3114.6 3126.6
## + estrogen_status              1  3120.1 3132.1
## + differentiate               3  3137.0 3153.0
## + grade                       3  3137.0 3153.0
## + node_positive_prop          1  3153.6 3165.6
## + race                        2  3173.1 3187.1
## + age                         1  3182.6 3194.6
## + reginol_node_positive       1  3182.9 3194.9
## + regional_node_examined      1  3184.6 3196.6
## + marital_status              4  3178.9 3196.9
## + n_stage                     1  3187.3 3199.3
## + t_stage                     3  3189.9 3205.9
## <none>                      3197.4 3207.4
## + tumor_size                  1  3195.7 3207.7
## + a_stage                     1  3197.2 3209.2
##
## Step: AIC=3126.58
## status ~ x6th_stage + progesterone_status
##
##                                     Df Deviance    AIC
## + node_positive_prop          1  3071.2 3085.2
## + differentiate               3  3074.8 3092.8
## + grade                       3  3074.8 3092.8
## + estrogen_status              1  3092.9 3106.9
## + race                        2  3091.9 3107.9
## + reginol_node_positive       1  3098.1 3112.1
## + age                         1  3101.0 3115.0
## + regional_node_examined      1  3103.1 3117.1
## + n_stage                     1  3104.1 3118.1
## + marital_status              4  3098.7 3118.7
## + t_stage                     3  3106.5 3124.5
## <none>                      3114.6 3126.6
## + tumor_size                  1  3113.4 3127.4
## + a_stage                     1  3114.3 3128.3
##
## Step: AIC=3085.18
## status ~ x6th_stage + progesterone_status + node_positive_prop
##
##                                     Df Deviance    AIC
## + differentiate               3  3028.9 3048.9
## + grade                       3  3028.9 3048.9
## + estrogen_status              1  3048.4 3064.4
## + race                        2  3048.3 3066.3
## + age                         1  3059.8 3075.8
## + marital_status              4  3057.5 3079.5
## + n_stage                     1  3066.9 3082.9

```

```

## + reginol_node_positive 1 3067.3 3083.3
## + t_stage 3 3063.7 3083.7
## <none> 3071.2 3085.2
## + tumor_size 1 3069.6 3085.6
## + a_stage 1 3070.8 3086.8
## + regional_node_examined 1 3071.1 3087.1
##
## Step: AIC=3048.86
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate
##
##                               Df Deviance   AIC
## + race 2 3009.6 3033.6
## + age 1 3012.6 3034.6
## + estrogen_status 1 3014.6 3036.6
## + marital_status 4 3015.6 3043.6
## + reginol_node_positive 1 3024.5 3046.5
## + n_stage 1 3024.7 3046.7
## <none> 3028.9 3048.9
## + t_stage 3 3023.6 3049.6
## + tumor_size 1 3027.8 3049.8
## + a_stage 1 3028.3 3050.3
## + regional_node_examined 1 3028.8 3050.8
##
## Step: AIC=3033.6
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race
##
##                               Df Deviance   AIC
## + age 1 2993.7 3019.7
## + estrogen_status 1 2995.7 3021.7
## + reginol_node_positive 1 3004.8 3030.8
## + marital_status 4 2999.8 3031.8
## + n_stage 1 3005.9 3031.9
## <none> 3009.6 3033.6
## + t_stage 3 3004.2 3034.2
## + tumor_size 1 3008.5 3034.5
## + a_stage 1 3009.0 3035.0
## + regional_node_examined 1 3009.5 3035.5
##
## Step: AIC=3019.65
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age
##
##                               Df Deviance   AIC
## + estrogen_status 1 2976.8 3004.8
## + reginol_node_positive 1 2989.0 3017.0
## + n_stage 1 2989.8 3017.8
## + marital_status 4 2985.6 3019.6
## <none> 2993.7 3019.7
## + t_stage 3 2987.8 3019.8
## + tumor_size 1 2991.9 3019.9
## + a_stage 1 2992.8 3020.8
## + regional_node_examined 1 2993.6 3021.6

```

```

##
## Step: AIC=3004.83
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status
##
##                                     Df Deviance    AIC
## + reginol_node_positive     1   2972.5 3002.5
## + n_stage                   1   2973.7 3003.7
## + t_stage                   3   2970.6 3004.6
## + marital_status            4   2968.6 3004.6
## <none>                      2976.8 3004.8
## + tumor_size                 1   2974.9 3004.9
## + a_stage                    1   2976.2 3006.2
## + regional_node_examined    1   2976.8 3006.8
##
## Step: AIC=3002.46
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status + reginol_node_positive
##
##                                     Df Deviance    AIC
## + t_stage                     3   2965.0 3001.0
## + regional_node_examined     1   2969.2 3001.2
## + tumor_size                  1   2969.8 3001.8
## + marital_status              4   2964.4 3002.4
## <none>                       2972.5 3002.5
## + n_stage                     1   2970.6 3002.6
## + a_stage                     1   2971.8 3003.8
##
## Step: AIC=3000.99
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status + reginol_node_positive +
##      t_stage
##
##                                     Df Deviance    AIC
## + n_stage                     1   2960.2 2998.2
## + regional_node_examined     1   2961.9 2999.9
## <none>                         2965.0 3001.0
## + marital_status              4   2957.6 3001.6
## + a_stage                     1   2964.8 3002.8
## + tumor_size                  1   2964.9 3002.9
##
## Step: AIC=2998.21
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status + reginol_node_positive +
##      t_stage + n_stage
##
##                                     Df Deviance    AIC
## + regional_node_examined    1   2956.4 2996.4
## <none>                         2960.2 2998.2
## + marital_status             4   2952.6 2998.6
## + a_stage                     1   2960.1 3000.1
## + tumor_size                  1   2960.2 3000.2
##
## Step: AIC=2996.43

```

```

## status ~ x6th_stage + progesterone_status + node_positive_prop +
##   differentiate + race + age + estrogen_status + reginol_node_positive +
##   t_stage + n_stage + regional_node_examined
##
##             Df Deviance    AIC
## <none>            2956.4 2996.4
## + marital_status  4   2948.7 2996.7
## + a_stage         1   2956.3 2998.3
## + tumor_size      1   2956.4 2998.4
summary(forward_model)

##
## Call:
## glm(formula = status ~ x6th_stage + progesterone_status + node_positive_prop +
##   differentiate + race + age + estrogen_status + reginol_node_positive +
##   t_stage + n_stage + regional_node_examined, family = binomial(),
##   data = breastcancer_test)
##
## Coefficients: (1 not defined because of singularities)
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)                 -4.100706  0.368581 -11.126 < 2e-16 ***
## x6th_stageIIB                0.216934  0.231471   0.937 0.348657
## x6th_stageIIIA              -0.094910  0.293344  -0.324 0.746282
## x6th_stageIIIB              -0.002374  0.525696  -0.005 0.996397
## x6th_stageIIIC                0.583552  0.302424   1.930 0.053658 .
## progesterone_statusNegative  0.600631  0.127583   4.708 2.50e-06 ***
## node_positive_prop            0.614358  0.314318   1.955 0.050633 .
## differentiatePoorly differentiated 0.391798  0.104770   3.740 0.000184 ***
## differentiateUndifferentiated 1.365911  0.530708   2.574 0.010060 *
## differentiateWell differentiated -0.516520  0.183377  -2.817 0.004852 **
## raceBlack                     0.566698  0.158777   3.569 0.000358 ***
## raceOther                      -0.429648  0.202132  -2.126 0.033538 *
## age                            0.024419  0.005455   4.477 7.59e-06 ***
## estrogen_statusNegative        0.732009  0.177393   4.126 3.68e-05 ***
## reginol_node_positive          0.054849  0.020068   2.733 0.006273 **
## t_stageT2                      0.289452  0.181160   1.598 0.110093
## t_stageT3                      0.539008  0.207548   2.597 0.009403 **
## t_stageT4                      1.014926  0.402742   2.520 0.011734 *
## n_stageN2                      0.551156  0.238727   2.309 0.020959 *
## n_stageN3                      NA        NA        NA        NA
## regional_node_examined         -0.020397  0.010704  -1.906 0.056709 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 3444.7 on 4023 degrees of freedom
## Residual deviance: 2956.4 on 4004 degrees of freedom
## AIC: 2996.4
##
## Number of Fisher Scoring iterations: 5
predictions_forward <- predict(forward_model, newdata = test_data1)

```

```

# Viewing predictions
print(predictions_forward)

##          1           2           3           4           5           6
## -1.156292372 -3.044543655 -2.500695946 -1.978803902 -2.933536192 -1.578054214
##          7           8           9          10          11          12
## -1.770218804 -3.680807241 -0.558492184 -2.760651603 -1.116356867 -1.273289921
##         13          14          15          16          17          18
## -2.764595490 -2.270921730 -2.380735964 -3.211220991 -3.089897000 -2.890929344
##         19          20          21          22          23          24
## -2.393456537 -2.883400233 -0.312882284 -2.111950137 -2.452224440 -3.534936635
##         25          26          27          28          29          30
## -3.505017534 -1.249382522 -2.586625255 -2.810516261 -1.810787435 -2.313897856
##         31          32          33          34          35          36
## -2.472880652 -2.191746139 -2.496137082 -2.332337127 -1.664887578 -4.058666265
##         37          38          39          40          41          42
## -2.702963346 -1.469142094 -2.670991343 -2.393984097 -2.149249404 -0.409574196
##         43          44          45          46          47          48
## -2.304830188 -2.598081499 -2.314902918 -1.234034772 -2.112431607 -2.046329269
##         49          50          51          52          53          54
## -2.376488397 -2.160918008 -0.586798893 -1.438715379 -1.925541243 -2.575879498
##         55          56          57          58          59          60
## -1.018079184 -2.449752021 -2.769111528 -2.410761270 -2.266098964 -3.164287574
##         61          62          63          64          65          66
## -1.623755071 -2.057817827 -1.947557590 -1.239621164 -3.162833651 -2.429764428
##         67          68          69          70          71          72
## -3.065580228 -3.353500714 -1.812616517  1.087297547 -0.985643607 -2.487705914
##         73          74          75          76          77          78
## -2.671627931 -2.892053509 -1.117971749  1.697663931 -3.066053323 -0.871224533
##         79          80          81          82          83          84
## -1.557185609 -2.678452915 -2.282542071 -1.202640281 -2.531524077 -1.746929995
##         85          86          87          88          89          90
## -3.580811319 -2.325191070 -2.421183271 -0.891088527 -2.546825009 -1.733391246
##         91          92          93          94          95          96
## -0.663159972  1.141611311 -2.254092005 -3.551033983 -0.491653786 -2.406033364
##         97          98          99          100         101         102
## -0.722879515 -1.672306944  0.241193666 -2.529481843 -0.257859933 -3.667278521
##        103         104         105         106         107         108
## -2.323862397 -2.817961487 -2.197689863 -1.835346530 -0.842183982 -2.771446823
##        109         110         111         112         113         114
## -2.912379134 -1.547742739 -1.559655271 -2.615057153 -2.352202372 -3.393805723
##        115         116         117         118         119         120
## -2.506281315 -1.912412648 -1.820184458 -3.708771685 -1.830888315 -1.665696743
##        121         122         123         124         125         126
## -2.710717634 -1.955265024 -0.954147097 -0.969653434 -0.448705917 -2.284142703
##        127         128         129         130         131         132
## -1.132862336 -2.118825941 -1.401183115 -0.869945126 -1.414378704 -1.651559154
##        133         134         135         136         137         138
## -0.713259206 -0.466621217 -2.051573984 -2.439257947 -1.608402220 -2.561352222
##        139         140         141         142         143         144
## -0.713000698 -1.906985098 -2.280649931 -0.961649733 -1.604246888 -3.188147597
##        145         146         147         148         149         150
## -2.376433092 -2.242834534 -3.370001423 -2.475242669 -3.247788871 -3.202143596
##        151         152         153         154         155         156

```

```

## -3.140511243 -1.966697588 -2.015040630 -2.974367164 -2.173686842 -2.701061455
##      157          158          159          160          161          162
## -1.891569355 -3.026928587 -3.231399772 -2.167198378 -2.717186887 -2.710154315
##      163          164          165          166          167          168
## -0.973071608 -3.402097013 -2.272420177 -0.129737162 -3.355346557 -0.709825126
##      169          170          171          172          173          174
## -2.773371859 -1.323358156 -2.709610694 -2.153027856 -2.263423957 -2.768469854
##      175          176          177          178          179          180
## -2.239005102 -1.444493886 -1.529694395 -2.182116311 -2.272629647 -1.909559114
##      181          182          183          184          185          186
## -2.898222610 -3.068401754 -1.355484141 -1.723471085 -2.090013034 -0.104920749
##      187          188          189          190          191          192
## -0.662592419 -1.733698969 -2.822423605 -3.126635020 -0.985146401 -2.287859747
##      193          194          195          196          197          198
## -0.270282490 -1.892093575 -1.884184240 -2.538156978 -2.236737022 -1.817733404
##      199          200          201          202          203          204
## -1.349044520 -0.917202652 -1.307708075 -2.327510447 -2.635860564 -1.931694624
##      205          206          207          208          209          210
## -3.038712479 -2.242864860 -2.255372876 -1.390031134 -1.917608689 -1.592440178
##      211          212          213          214          215          216
## -2.021053170 -2.106724295 -1.850982424 -2.890034088 -1.181097876 -2.154124116
##      217          218          219          220          221          222
## -2.863582332 -0.787886882 -1.636358105 -2.414849532 -0.528630922 -2.547821506
##      223          224          225          226          227          228
## -2.477892911 -2.728206385 -1.713488467 -2.032029841 -2.877913172 -1.697770285
##      229          230          231          232          233          234
## -0.350982102 -2.327730658 -1.434154197 -2.530495135 -3.316770453 -2.283498528
##      235          236          237          238          239          240
## -1.983807663 -2.399718999 -2.176313577 -0.509341947 -3.296744858 -2.191803581
##      241          242          243          244          245          246
## -2.868460012 -2.011283512 -2.144888919 -0.164040753 -3.141722485 -3.077661610
##      247          248          249          250          251          252
## -2.923311521 -1.751822338 -2.326171086 -1.704801666 -1.341703455 -2.798647273
##      253          254          255          256          257          258
## -2.012953741 -2.820275354 -1.854801393 -2.207619863 -1.246268980 -2.601169244
##      259          260          261          262          263          264
## -1.177233309 -1.850317705 -1.777810357 -0.364115543 -1.913508907 -3.483498904
##      265          266          267          268          269          270
## -2.501924733 -0.821170118 -2.084440892 -0.637250166 -0.844360621 -2.993355589
##      271          272          273          274          275          276
## -1.782827686 -1.717061808 -2.438907291 -0.255199161 -1.083319440 -2.976078136
##      277          278          279          280          281          282
## -2.963272389 -3.002699978 -1.640926379 -1.088061982 -2.248210792 -0.715055954
##      283          284          285          286          287          288
## -3.233220574 -2.756432038 -2.591339130 -2.197455503 -1.077599294 -2.256345440
##      289          290          291          292          293          294
## -1.182622813 -0.153167507 -2.035587155 -2.695036829 -0.670229569 -2.509062347
##      295          296          297          298          299          300
## -2.290639226 -1.519378749 -2.785611024 -3.287704303 -3.630484865 -1.382703375
##      301          302          303          304          305          306
## -2.021476442 -2.188890064 -3.003718599 -1.951453210 -3.427818067 -2.550605473
##      307          308          309          310          311          312
## -1.795907786 -1.975373608 -0.221717629 -3.062329610 -2.090013034 -0.860375935
##      313          314          315          316          317          318

```

```

## -2.896322693 -2.459971313 -2.311713363 -3.924615677  0.174171718 -3.055226488
##      319          320          321          322          323          324
##  1.626845952 -1.924444983 -2.554592289 -2.414839092 -2.901351000 -2.436435868
##      325          326          327          328          329          330
## -2.439897417 -2.151551207 -1.460072002 -0.972189941 -2.312490885 -0.796989443
##      331          332          333          334          335          336
## -2.070625572 -0.988526020 -1.904850111 -1.686075181 -0.827700954 -1.461613413
##      337          338          339          340          341          342
## -0.829459599 -1.891595552 -0.879937416 -2.266065208 -2.230954021  1.088336365
##      343          344          345          346          347          348
## -2.169608295 -2.290133407 -2.994087715 -2.136065181 -2.150291413 -2.157797555
##      349          350          351          352          353          354
## -1.138608484 -1.942732112 -2.704076541  0.449314601 -1.485459793 -1.318481557
##      355          356          357          358          359          360
## -0.963639100 -1.129909810 -2.774228418 -0.812010959 -3.459711965 -3.091031009
##      361          362          363          364          365          366
## -2.206259357 -2.871315486 -1.067692106 -1.477642509 -0.358017358 -3.102049396
##      367          368          369          370          371          372
## -1.709043154 -3.001163159  0.225293026 -3.140511243 -0.581514023 -2.918530237
##      373          374          375          376          377          378
## -0.539769035 -1.925015077 -2.531890644 -2.555070297 -2.394723922 -2.471759011
##      379          380          381          382          383          384
## -1.833415270 -2.533231424 -2.266220371 -0.155146378 -2.941821730 -1.289381027
##      385          386          387          388          389          390
## -1.455548623 -2.564550223 -3.468203969 -2.350589941 -1.128278490 -3.189348953
##      391          392          393          394          395          396
## -2.785359309 -2.442110229 -3.743082118 -3.194283908 -2.017593603 -2.125725264
##      397          398          399          400          401          402
## -0.801313559 -0.380461043 -2.606449069 -2.140419532 -1.168284403 -4.005660189
##      403          404          405          406          407          408
## -2.095166979 -2.906647174 -2.657900897 -1.491330843 -1.330335936 -2.269466254
##      409          410          411          412          413          414
## -0.580926566 -2.439503969 -2.960675611 -2.166470040 -3.182562062 -1.664344579
##      415          416          417          418          419          420
##  1.914497408 -0.643061202 -2.290484063 -3.556604477 -2.900520658 -2.521142865
##      421          422          423          424          425          426
## -2.608504355 -0.409392843 -2.922449381 -1.751309168  0.613215121 -0.901406662
##      427          428          429          430          431          432
## -2.246994574 -2.023786756 -0.889934260 -1.244160137 -1.596520355 -2.892008713
##      433          434          435          436          437          438
## -0.284125711 -1.705129583 -2.620684005 -3.287024372 -0.586701795 -1.570308718
##      439          440          441          442          443          444
## -2.883375227 -0.978889729 -2.492850207 -2.534827775 -2.321707757 -0.564258830
##      445          446          447          448          449          450
## -2.685438656 -2.574388619 -2.364510503 -3.697875723 -1.128775037 -2.292375579
##      451          452          453          454          455          456
## -2.626752594 -2.442455948 -3.459903537 -0.503380257  0.260861368 -1.372670483
##      457          458          459          460          461          462
## -2.067206076  0.819788031 -3.601251766 -2.705253941 -2.223036979 -2.877286056
##      463          464          465          466          467          468
## -2.155239101 -1.852106446 -2.205435869 -2.935239875 -1.587543275 -2.679657686
##      469          470          471          472          473          474
## -2.598371366 -2.653870142 -2.372293834 -2.007873177 -1.665601869 -3.322359158
##      475          476          477          478          479          480

```

```

##  0.065234692 -2.864882204 -1.458210242 -0.255975679 -2.330801995 -2.663266918
##      481        482        483        484        485        486
## -1.797231751 -3.422466186 -1.822679833 -2.513153982 -0.656611127 -2.337793717
##      487        488        489        490        491        492
## -0.003481132 -2.524694798 -2.527005998 -2.320687017 -2.653618352 -1.978283233
##      493        494        495        496        497        498
## -2.267229703 -2.792503328 -0.414145374 -3.652379378 -3.561063322 -3.641672841
##      499        500        501        502        503        504
## -1.961959905 -2.034264869 -1.925600487 -2.411637241 -2.501733980 -2.990630795
##      505        506        507        508        509        510
## -1.693029214 -2.202885933 -1.229078384 -1.713875421 -2.276367387 -2.321403201
##      511        512        513        514        515        516
## -1.902640439 -3.019128560 -3.123452126 -2.442110229 -1.811596503 -3.705310594
##      517        518        519        520        521        522
## -2.760942338  0.087415255 -0.453436759 -1.807697700 -2.087466609 -2.271406225
##      523        524        525        526        527        528
## -3.629394333 -1.642891123 -2.474257179 -1.961238666 -2.072305074 -3.071111956
##      529        530        531        532        533        534
## -0.326531859 -3.041059290 -2.625115267 -2.534954997 -3.160660914  0.423904041
##      535        536        537        538        539        540
## -2.348680602 -3.165019699 -2.188815639 -0.614532931 -0.528143859 -2.353505563
##      541        542        543        544        545        546
## -2.561698898 -2.681340905  0.136242014 -0.476887216 -0.654198340 -2.308310368
##      547        548        549        550        551        552
## -1.427307972 -2.338506814 -1.236912762 -2.997479356 -2.170896564 -2.083344632
##      553        554        555        556        557        558
## -2.642690996 -3.792952077 -2.339476935 -1.666949242 -2.436173704 -2.658633022
##      559        560        561        562        563        564
## -2.684941163 -3.655254377 -1.697320271 -2.093924020 -1.393097390 -3.007665761
##      565        566        567        568        569        570
## -1.568438884 -2.778900534 -2.877330020 -0.965991090 -2.529077175 -1.663695266
##      571        572        573        574        575        576
## -3.539660133 -2.125400030 -1.671998469 -2.366001382 -1.039743146 -1.868243057
##      577        578        579        580        581        582
## -2.151039780 -3.093381365 -1.920628245 -3.162802908 -1.787454114 -2.076523850
##      583        584        585        586        587        588
## -3.363446624 -1.834375808 -2.678288997 -1.890206917 -2.558530142 -1.274513479
##      589        590        591        592        593        594
## -2.164103974 -0.229248919 -2.772451885 -2.995705946 -0.492438656 -3.124092585
##      595        596        597        598        599        600
## -2.899280102 -2.558530142 -2.326912444 -1.116167350 -1.812351185 -2.922553031
##      601        602        603        604        605        606
## -1.459166000 -3.013450880 -1.386118267 -2.540554370  0.991716874 -1.377398815
##      607        608        609        610        611        612
## -3.188706429 -0.779955270 -2.379057476 -1.142485079 -1.521078945 -2.479819889
##      613        614        615        616        617        618
## -2.141346618 -3.564143396 -3.310200852 -1.230646333 -2.614429208 -2.769810634
##      619        620        621        622        623        624
## -1.338230356 -1.331426642 -2.822882482 -2.219649803 -2.955703035 -3.119173577
##      625        626        627        628        629        630
## -1.055064614 -2.176624646 -2.427357429 -1.703303599 -3.333650771 -2.559091467
##      631        632        633        634        635        636
## -2.194718741 -1.239929340 -1.132778704 -2.476512299 -2.536323044 -2.769269923
##      637        638        639        640        641        642

```

```

## -1.946196386  1.903225012 -1.898183311 -2.675994973 -3.197144084  0.342235809
##      643       644       645       646       647       648
## -2.646112816 -1.646144535 -1.719894296 -2.066290970 -1.431478509 -2.217227498
##      649       650       651       652       653       654
## -2.484884382 -2.485273578 -1.807954915 -2.610955327 -2.450497636 -0.974116758
##      655       656       657       658       659       660
## -0.855292938 -2.960682254 -3.225959209 -2.163269599 -2.310499216 -2.941120076
##      661       662       663       664       665       666
## -2.226734181 -3.041097040 -1.915855684 -3.593695951 -2.091202739 -3.608282801
##      667       668       669       670       671       672
## -2.303375435 -2.557563411 -2.501176018 -2.228418718 -0.740836713 -1.973719222
##      673       674       675       676       677       678
## -2.458774796 -0.955378536 -1.363255131 -1.740709268 -1.783739642  0.372280552
##      679       680       681       682       683       684
## -2.084734985 -3.026422768 -2.707470732 -2.551882087 -1.888398286 -1.745188742
##      685       686       687       688       689       690
## -1.873811567 -1.781381741 -1.463741830 -2.756427989 -0.776405836 -2.498837486
##      691       692       693       694       695       696
## -2.342752692  0.602249322 -2.118547016 -2.430452219 -2.000290919 -1.256776555
##      697       698       699       700       701       702
## -0.284147054 -2.508320521 -2.697854540 -2.279214102 -0.846305365 -1.718479527
##      703       704       705       706       707       708
## -3.245015063 -3.210174207  0.921909235 -3.507300059 -1.608740128 -2.135641909
##      709       710       711       712       713       714
## -2.667109851 -2.177446711 -3.930361812 -2.732305528 -2.377467151 -2.625931273
##      715       716       717       718       719       720
## -1.997899495 -3.027522899 -2.912334178 -0.712974583 -1.088836623 -2.714035107
##      721       722       723       724       725       726
## -2.167828463 -1.342363097 -2.468618762 -1.623747462 -3.691840700 -2.764785271
##      727       728       729       730       731       732
##  0.421461845 -1.123028307 -2.848928172 -0.872336393 -1.969890413 -2.569434431
##      733       734       735       736       737       738
## -2.771010697 -3.307459145 -2.372368639  0.156154382 -2.550040939 -2.813622981
##      739       740       741       742       743       744
## -2.571115612 -2.438374095 -3.054596543 -1.635876491 -1.902444885 -2.924939513
##      745       746       747       748       749       750
## -2.704076541 -1.485748439 -2.736232748 -3.004131102 -1.723681360 -0.856997193
##      751       752       753       754       755       756
## -1.588594350 -2.437031353 -2.507612506 -2.696554069 -2.662330373 -0.616319125
##      757       758       759       760       761       762
## -2.084440892 -2.205716067 -1.825174024 -2.048712191 -3.607023969 -1.831316688
##      763       764       765       766       767       768
## -2.007592368 -2.708766985 -3.118757342 -1.709791479 -1.190877767 -2.349227933
##      769       770       771       772       773       774
## -1.923377750 -1.794465731 -2.104379928 -2.978141260 -2.300728285 -1.526985854
##      775       776       777       778       779       780
## -2.927371660 -2.660876177 -1.920599327 -0.387804539 -0.816397698 -1.678184758
##      781       782       783       784       785       786
## -3.033502146 -1.848407226 -1.618054382 -2.886879546 -1.035972319 -2.502292519
##      787       788       789       790       791       792
## -2.132554662 -1.833728533 -2.948842626 -1.786357855 -1.392684836 -2.928741746
##      793       794       795       796       797       798
## -1.856792625 -2.637216548 -1.961010397 -2.410534458 -1.958113505 -2.646932756
##      799       800       801       802       803       804

```

```

## -2.488822678 -2.484306846 -1.987995113  1.160642145 -1.306146328 -2.182100284
##          805          806          807          808          809          810
## -2.644372177 -2.381787956 -1.763878534 -2.914921388 -2.013298356 -2.745391779
##          811          812          813          814          815          816
## -2.289743373 -1.251297880 -2.332980412 -1.002202139 -1.890580676 -1.014552896
##          817          818          819          820          821          822
## -2.726833897 -1.129990588 -2.004471451 -3.164372072 -2.331416020 -1.977745745
##          823          824          825          826          827          828
##  0.251550768 -2.830372897 -1.518677371 -1.958783919 -2.910486721 -0.237278487
##          829          830          831          832          833          834
## -1.690223007 -2.226474202 -1.162824023 -1.005621121 -3.501074632 -1.076726818
##          835          836          837          838          839          840
## -3.583863946 -2.469415944 -1.963048228 -1.830310780 -3.778482661 -1.341593307
##          841          842          843          844          845          846
## -1.987222738 -2.768293394 -2.967802725 -1.114818487 -1.263482277 -0.800621110
##          847          848          849          850          851          852
## -1.274046701  0.227456942 -0.934784311 -2.475126544  0.531133317 -3.476655777
##          853          854          855          856          857          858
## -2.706242799 -0.445867775  0.543404518 -2.229643132 -2.995734111 -2.476277091
##          859          860          861          862          863          864
## -0.040520943  0.642169868  0.328689419 -3.201418738 -2.866978770 -2.069412961
##          865          866          867          868          869          870
## -2.455044521 -2.771628397 -2.536449145 -1.978886900 -0.766974637 -1.040562850
##          871          872          873          874          875          876
## -1.546129823 -1.775768361 -3.627645966 -1.796710773 -1.847395891 -1.184872994
##          877          878          879          880          881          882
## -2.291956915 -2.790508664 -3.187563018 -2.725480310 -1.187921252  0.513118072
##          883          884          885          886          887          888
## -2.651200804 -1.868945022 -2.660279419 -0.608701189 -2.574841552 -1.966620442
##          889          890          891          892          893          894
## -3.399083445  0.034820677 -2.845133081 -1.246696687 -2.629706781 -2.634033401
##          895          896          897          898          899          900
## -2.904070369 -1.832335300 -2.534321956 -1.062278427 -2.527863119 -2.143409608
##          901          902          903          904          905          906
## -1.726424136 -1.461589242 -1.108787599 -0.491727763 -2.091089597 -3.235223637
##          907          908          909          910          911          912
## -3.309666694 -1.858498753 -2.380735964 -1.822281024 -2.569459813 -2.141944760
##          913          914          915          916          917          918
## -1.550393065 -2.508809023 -1.085429030 -0.453769067 -2.318644413 -1.997057587
##          919          920          921          922          923          924
## -1.321029870 -2.053210798 -2.133267039 -2.356235092 -1.639024968 -2.328629441
##          925          926          927          928          929          930
## -0.781112046 -2.583510322 -0.452845557 -1.548377720 -2.120445550 -3.096701839
##          931          932          933          934          935          936
## -1.744506380 -1.626891924 -1.822929216 -2.998721611 -2.357480232 -3.279932993
##          937          938          939          940          941          942
## -2.033572891 -1.087635610 -2.297785283 -1.198254661 -0.075204499 -2.613136630
##          943          944          945          946          947          948
## -2.634124565 -2.487053410  0.996823995 -0.693832092 -1.506616426 -2.660517475
##          949          950          951          952          953          954
## -1.043842928  0.397109796 -1.840000736 -3.511729023 -3.091673533 -1.028705604
##          955          956          957          958          959          960
## -2.632259236 -2.806442405 -1.574281066 -1.936831503 -2.194700159 -2.337793717
##          961          962          963          964          965          966

```

```

## -1.777819086 -2.871993440  0.772876288 -3.265771204 -1.060459685 -1.883336048
##      967         968         969         970         971         972
## -2.214037943 -2.507603241 -3.190028883 -3.121474606 -2.916323764 -1.277329724
##      973         974         975         976         977         978
## -2.765906912 -0.355961488 -1.748014503 -1.394836419 -1.416209456 -1.394640838
##      979         980         981         982         983         984
## -3.249102593 -1.947796605 -1.681379169 -1.060114916 -2.367503260 -1.726490824
##      985         986         987         988         989         990
## -1.144673321 -1.281296790 -0.938498485 -0.245897668 -2.811311781 -2.944517879
##      991         992         993         994         995         996
## -2.634124565 -2.747018789 -2.403822250 -1.783536060 -1.179031664 -2.419024233
##      997         998         999        1000        1001        1002
## -2.659493882 -2.877619043 -3.278868793  0.683303898 -2.646199119 -3.136386417
##     1003        1004        1005        1006        1007        1008
## -2.318415449 -1.704286973 -1.295036957 -2.146958709 -3.393805723 -1.977150141
##     1009        1010        1011        1012        1013        1014
## -1.784130877 -1.974833247 -0.914278138 -1.230877705 -1.941958834 -1.977481756
##     1015        1016        1017        1018        1019        1020
## -1.111650355 -1.950778138 -2.371041847 -1.572115100 -1.533292919 -2.717628742
##     1021        1022        1023        1024        1025        1026
## -2.799858516 -3.000913381 -1.337296584 -2.038680545 -0.803282099 -2.330992748
##     1027        1028        1029        1030        1031        1032
## -2.521718362 -2.257666295 -1.228052685 -1.735549950  1.114619522 -2.118547016
##     1033        1034        1035        1036        1037        1038
## -2.209097716 -2.789204126 -2.316091099 -1.838065508 -3.840627402 -1.881927968
##     1039        1040        1041        1042        1043        1044
## -1.881211480 -2.611302234 -0.842431508 -0.371749520 -3.783159155 -2.452457161
##     1045        1046        1047        1048        1049        1050
## -2.746591842 -2.265241720 -1.249512842 -2.593287053 -2.788450459 -2.460981269
##     1051        1052        1053        1054        1055        1056
## -0.261187976 -2.145960664 -1.737759514 -2.933212705 -1.374337661 -2.381190864
##     1057        1058        1059        1060        1061        1062
## -1.183119423 -0.813439916 -1.723138334 -0.958516179 -2.970702949 -2.821323351
##     1063        1064        1065        1066        1067        1068
## -1.879083860 -1.529204941 -3.031211611 -2.286718637 -3.656442557 -2.000582579
##     1069        1070        1071        1072        1073        1074
## -2.500695946 -1.085210123 -1.443124144 -2.913719914 -1.460235638 -0.006893748
##     1075        1076        1077        1078        1079        1080
## -3.139868719 -1.808671403 -1.078461629 -2.921225770 -3.349688975 -2.015249686
##     1081        1082        1083        1084        1085        1086
## -2.518362527 -0.462963898 -1.880244749 -2.028408441 -2.416337098 -3.309666694
##     1087        1088        1089        1090        1091        1092
## -2.456754354 -2.649534122 -1.212990429 -2.979154222 -2.822508103 -2.438773725
##     1093        1094        1095        1096        1097        1098
##  0.350911861 -2.586410547 -2.715757780 -2.882806433 -2.192930891 -2.441878413
##     1099        1100        1101        1102        1103        1104
## -1.382175694 -1.442227910 -2.481504734 -2.607367852 -1.402956596 -2.260820107
##     1105        1106        1107        1108        1109        1110
## -0.294815100 -1.261167666 -2.809778164 -2.968936734 -3.215575659 -3.034428453
##     1111        1112        1113        1114        1115        1116
## -1.339326616 -0.999140705 -3.161712376  0.384603729 -1.039211208 -1.059469827
##     1117        1118        1119        1120        1121        1122
##  0.660678529 -3.148332623 -3.184751159 -2.972211593 -3.407949417 -0.487620865
##     1123        1124        1125        1126        1127        1128

```

```

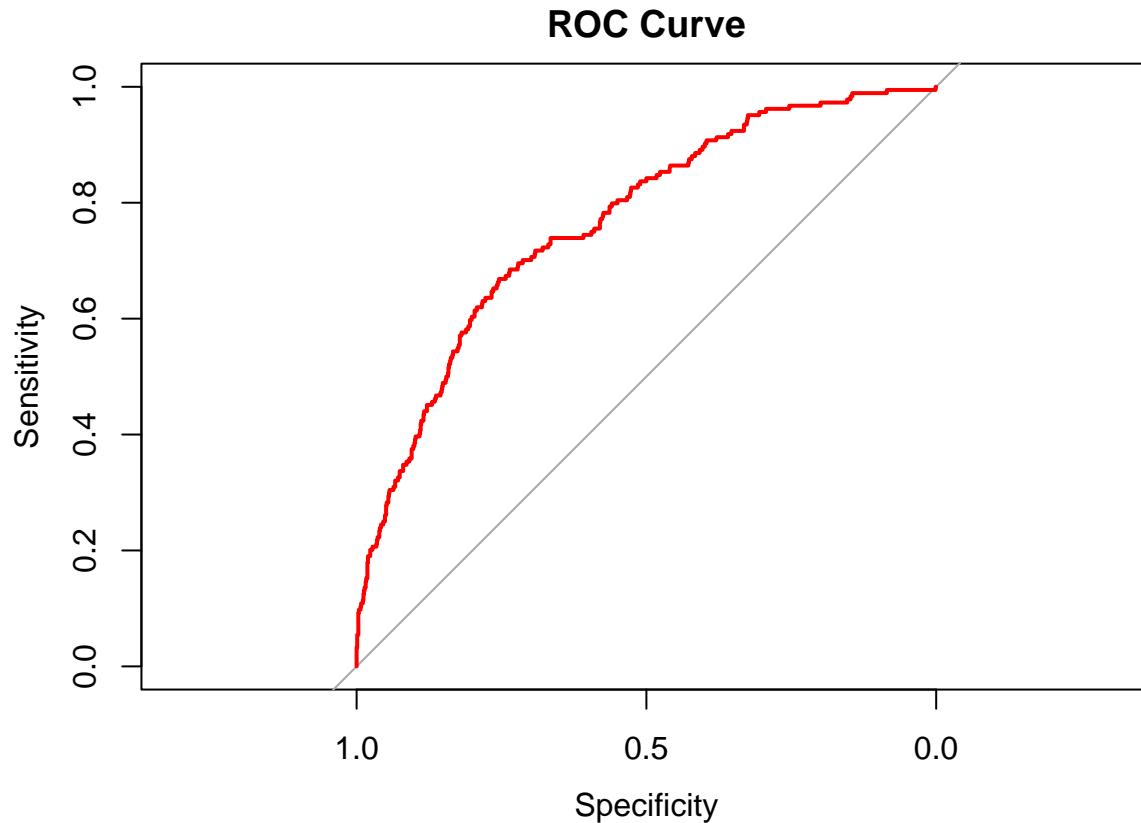
## -1.958713974 -2.950875608 -1.313944141 -2.012887847 -3.583907910 -3.437768468
##      1129          1130          1131          1132          1133          1134
## -2.680835086 -2.113053622 -3.019349906 -1.875199961 -1.242672263 -1.782569329
##      1135          1136          1137          1138          1139          1140
## -3.226562451 -2.478288654 -2.157697457 -2.633404036 -1.664872705 -1.957512091
##      1141          1142          1143          1144          1145          1146
## -0.203577921 -2.595625566 -2.950400449 -1.133395908 -1.792377296 -1.931233446
##      1147          1148          1149          1150          1151          1152
##  0.378357042 -3.195758336 -3.277460121 -2.143147445 -2.510931940 -2.408154939
##      1153          1154          1155          1156          1157          1158
## -2.997849352 -3.213125284 -2.292872169 -0.703909054 -2.834853504 -2.707381130
##      1159          1160          1161          1162          1163          1164
## -2.891356605 -2.364110750 -2.323583389 -1.579262507 -3.060233044 -2.173625554
##      1165          1166          1167          1168          1169          1170
## -1.849643266 -2.521063220 -2.485990065 -0.428347745 -1.738300392 -1.758807985
##      1171          1172          1173          1174          1175          1176
## -2.338498284 -0.815937140 -1.968041953 -1.985793776 -1.557953151 -3.095945982
##      1177          1178          1179          1180          1181          1182
## -2.987712445 -0.683052927 -2.295365283 -1.971592033 -2.094644267 -2.067156812
##      1183          1184          1185          1186          1187          1188
## -3.760138232 -2.782445547 -0.138199539 -1.460486739 -0.408840416 -1.593491349
##      1189          1190          1191          1192          1193          1194
## -2.021910414 -1.409421054 -2.142779523 -2.044061712 -0.783277433 -2.193942652
##      1195          1196          1197          1198          1199          1200
##  0.258881696 -1.066773820 -0.163098763 -2.581348637 -0.186045277 -3.070420365
##      1201          1202          1203          1204          1205          1206
## -3.149617174 -1.421279236 -3.365254266 -0.559601316 -2.008765711 -1.015617728

roc_curve_forward <- roc(response = as.matrix(test_data$status), predictor = as.numeric(predictions_for
auc(roc_curve_forward)

## Area under the curve: 0.7668

#plot the roc curve
plot(roc_curve_forward, main = "ROC Curve", col = "red")

```



```
check_collinearity(forward_model)
```

```
## # Check for Multicollinearity
##
## Low Correlation
##
##           Term   VIF      VIF 95% CI Increased SE Tolerance
## progesterone_status 1.43 [ 1.38,  1.49]      1.20      0.70
## node_positive_prop 4.39 [ 4.16,  4.64]      2.10      0.23
## differentiate       1.12 [ 1.09,  1.16]      1.06      0.89
## race                1.02 [ 1.01,  1.09]      1.01      0.98
## age                 1.05 [ 1.02,  1.10]      1.02      0.96
## estrogen_status     1.48 [ 1.42,  1.54]      1.22      0.68
## n_stage              4.99 [ 4.72,  5.27]      2.23      0.20
## regional_node_examined 3.43 [ 3.26,  3.62]      1.85      0.29
## Tolerance 95% CI
## [0.67, 0.73]
## [0.22, 0.24]
## [0.86, 0.92]
## [0.91, 0.99]
## [0.91, 0.98]
## [0.65, 0.70]
## [0.19, 0.21]
## [0.28, 0.31]
##
## Moderate Correlation
```

```

##          Term      VIF      VIF 95% CI Increased SE Tolerance
##  reginol_node_positive 7.36 [ 6.96,    7.80]           2.71     0.14
##  Tolerance 95% CI
##          [0.13, 0.14]
##
##  High Correlation
##
##          Term      VIF      VIF 95% CI Increased SE Tolerance Tolerance 95% CI
##  x6th_stage 156.64 [147.33, 166.53]        12.52 6.38e-03 [0.01, 0.01]
##  t_stage    11.79 [ 11.12, 12.51]           3.43     0.08 [0.08, 0.09]
breastcancer_for = breastcancer_test|>
  dplyr::select(-t_stage)

null_model_1 <- glm(status ~ 1, data = breastcancer_for, family = binomial())
full_model_1 <- glm(status ~ ., data = breastcancer_for, family = binomial())
forward_model_1 <- step(null_model_1, scope = list(lower = null_model_1, upper = full_model_1), direction = "forward")

## Start: AIC=3446.68
## status ~ 1
##
##          Df Deviance   AIC
## + x6th_stage      4 3197.4 3207.4
## + n_stage         2 3214.0 3220.0
## + reginol_node_positive 1 3236.8 3240.8
## + node_positive_prop 1 3237.8 3241.8
## + progesterone_status 1 3335.1 3339.1
## + estrogen_status   1 3338.7 3342.7
## + differentiate     3 3337.3 3345.3
## + grade            3 3337.3 3345.3
## + tumor_size        1 3380.1 3384.1
## + a_stage           1 3415.7 3419.7
## + race              2 3418.9 3424.9
## + marital_status    4 3419.2 3429.2
## + age               1 3432.0 3436.0
## + regional_node_examined 1 3439.9 3443.9
## <none>             3444.7 3446.7
##
## Step: AIC=3207.4
## status ~ x6th_stage
##
##          Df Deviance   AIC
## + progesterone_status 1 3114.6 3126.6
## + estrogen_status     1 3120.1 3132.1
## + differentiate       3 3137.0 3153.0
## + grade              3 3137.0 3153.0
## + node_positive_prop 1 3153.6 3165.6
## + race               2 3173.1 3187.1
## + age                1 3182.6 3194.6
## + reginol_node_positive 1 3182.9 3194.9
## + regional_node_examined 1 3184.6 3196.6
## + marital_status      4 3178.9 3196.9
## + n_stage             1 3187.3 3199.3
## <none>               3197.4 3207.4

```

```

## + tumor_size          1  3195.7 3207.7
## + a_stage              1  3197.2 3209.2
##
## Step: AIC=3126.58
## status ~ x6th_stage + progesterone_status
##
##                                     Df Deviance   AIC
## + node_positive_prop      1  3071.2 3085.2
## + differentiate            3  3074.8 3092.8
## + grade                   3  3074.8 3092.8
## + estrogen_status          1  3092.9 3106.9
## + race                     2  3091.9 3107.9
## + reginol_node_positive    1  3098.1 3112.1
## + age                      1  3101.0 3115.0
## + regional_node_examined   1  3103.1 3117.1
## + n_stage                  1  3104.1 3118.1
## + marital_status           4  3098.7 3118.7
## <none>                    3114.6 3126.6
## + tumor_size                1  3113.4 3127.4
## + a_stage                  1  3114.3 3128.3
##
## Step: AIC=3085.18
## status ~ x6th_stage + progesterone_status + node_positive_prop
##
##                                     Df Deviance   AIC
## + differentiate            3  3028.9 3048.9
## + grade                   3  3028.9 3048.9
## + estrogen_status          1  3048.4 3064.4
## + race                     2  3048.3 3066.3
## + age                      1  3059.8 3075.8
## + marital_status           4  3057.5 3079.5
## + n_stage                  1  3066.9 3082.9
## + reginol_node_positive    1  3067.3 3083.3
## <none>                    3071.2 3085.2
## + tumor_size                1  3069.6 3085.6
## + a_stage                  1  3070.8 3086.8
## + regional_node_examined   1  3071.1 3087.1
##
## Step: AIC=3048.86
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##       differentiate
##
##                                     Df Deviance   AIC
## + race                     2  3009.6 3033.6
## + age                      1  3012.6 3034.6
## + estrogen_status           1  3014.6 3036.6
## + marital_status            4  3015.6 3043.6
## + reginol_node_positive    1  3024.5 3046.5
## + n_stage                  1  3024.7 3046.7
## <none>                    3028.9 3048.9
## + tumor_size                1  3027.8 3049.8
## + a_stage                  1  3028.3 3050.3
## + regional_node_examined   1  3028.8 3050.8
##

```

```

## Step: AIC=3033.6
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race
##
##                                     Df Deviance    AIC
## + age                         1  2993.7 3019.7
## + estrogen_status              1  2995.7 3021.7
## + reginol_node_positive       1  3004.8 3030.8
## + marital_status               4  2999.8 3031.8
## + n_stage                      1  3005.9 3031.9
## <none>                        3009.6 3033.6
## + tumor_size                   1  3008.5 3034.5
## + a_stage                       1  3009.0 3035.0
## + regional_node_examined      1  3009.5 3035.5
##
## Step: AIC=3019.65
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age
##
##                                     Df Deviance    AIC
## + estrogen_status              1  2976.8 3004.8
## + reginol_node_positive       1  2989.0 3017.0
## + n_stage                      1  2989.8 3017.8
## + marital_status               4  2985.6 3019.6
## <none>                        2993.7 3019.7
## + tumor_size                   1  2991.9 3019.9
## + a_stage                       1  2992.8 3020.8
## + regional_node_examined      1  2993.6 3021.6
##
## Step: AIC=3004.83
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status
##
##                                     Df Deviance    AIC
## + reginol_node_positive       1  2972.5 3002.5
## + n_stage                      1  2973.7 3003.7
## + marital_status               4  2968.6 3004.6
## <none>                        2976.8 3004.8
## + tumor_size                   1  2974.9 3004.9
## + a_stage                       1  2976.2 3006.2
## + regional_node_examined      1  2976.8 3006.8
##
## Step: AIC=3002.46
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status + reginol_node_positive
##
##                                     Df Deviance    AIC
## + regional_node_examined      1  2969.2 3001.2
## + tumor_size                   1  2969.8 3001.8
## + marital_status               4  2964.4 3002.4
## <none>                        2972.5 3002.5
## + n_stage                      1  2970.6 3002.6
## + a_stage                       1  2971.8 3003.8
##

```

```

## Step: AIC=3001.23
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status + reginol_node_positive +
##      regional_node_examined
##
##          Df Deviance    AIC
## + tumor_size     1  2966.7 3000.7
## + n_stage        1  2966.8 3000.8
## + marital_status 4  2961.0 3001.0
## <none>           2969.2 3001.2
## + a_stage        1  2968.7 3002.7
##
## Step: AIC=3000.7
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status + reginol_node_positive +
##      regional_node_examined + tumor_size
##
##          Df Deviance    AIC
## + n_stage        1  2962.2 2998.2
## + marital_status 4  2958.6 3000.6
## <none>           2966.7 3000.7
## + a_stage        1  2966.2 3002.2
##
## Step: AIC=2998.19
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status + reginol_node_positive +
##      regional_node_examined + tumor_size + n_stage
##
##          Df Deviance    AIC
## + marital_status 4  2954.1 2998.1
## <none>           2962.2 2998.2
## + a_stage        1  2961.7 2999.7
##
## Step: AIC=2998.09
## status ~ x6th_stage + progesterone_status + node_positive_prop +
##      differentiate + race + age + estrogen_status + reginol_node_positive +
##      regional_node_examined + tumor_size + n_stage + marital_status
##
##          Df Deviance    AIC
## <none>           2954.1 2998.1
## + a_stage        1  2953.8 2999.8
predictions_forward_1 <- predict(forward_model_1, newdata = test_data1)

# Viewing predictions
print(predictions_forward_1)

##          1         2         3         4         5
## -1.0641490669 -2.9220290751 -2.3366806143 -1.8867015533 -2.9692777827
##          6         7         8         9        10
## -1.4380247488 -1.8357447531 -3.7344717238 -0.5213000393 -2.8679302803
##         11        12        13        14        15
## -1.3824418581 -1.1317522216 -2.7191553719 -2.3375540490 -2.4852311699
##         16        17        18        19        20
## -3.2763434331 -3.1364960216 -2.9501189263 -2.4487475717 -2.9301275131

```

```

##      21      22      23      24      25
## -0.1761759030 -2.2323677876 -2.5836631357 -3.4546337130 -3.5437799190
##      26      27      28      29      30
## -1.3425550469 -2.4478006646 -2.9376771079 -1.8965149878 -2.2797622963
##      31      32      33      34      35
## -2.5104687698 -2.1779043150 -2.5103535589 -2.4119940127 -1.5465464350
##      36      37      38      39      40
## -4.1327583148 -2.7919037597 -1.5219970688 -2.7227578581 -2.3496062447
##      41      42      43      44      45
## -2.1370850469 -0.5942192597 -2.1149836114 -2.6489238841 -2.1739436109
##      46      47      48      49      50
## -1.3767150054 -2.2212507589 -2.1783625872 -2.2862574106 -1.9908153165
##      51      52      53      54      55
## -0.3816596580 -1.4903374138 -2.0417224575 -2.3738656115 -0.8689204816
##      56      57      58      59      60
## -2.5142066727 -2.8884024890 -2.4929325009 -2.1533063940 -3.2074516002
##      61      62      63      64      65
## -1.5272251842 -2.1516216282 -2.0478215475 -1.3555177797 -3.0014600402
##      66      67      68      69      70
## -2.2758471906 -2.9796171596 -3.4959596794 -1.9283205680  0.9696544615
##      71      72      73      74      75
## -0.9269284352 -2.4511406310 -2.4979657298 -2.9623466723 -1.2922566609
##      76      77      78      79      80
##  1.3349511557 -3.0336930474 -0.9717076859 -1.5741733523 -2.6480894058
##      81      82      83      84      85
## -2.1342583449 -1.3439192747 -2.6365438064 -1.8492155883 -3.4622344062
##      86      87      88      89      90
## -2.3057628791 -2.5630583065 -0.8053353908 -2.3770579710 -1.6502056536
##      91      92      93      94      95
## -0.5712674079  1.3078228560 -2.3844523170 -3.4597587219 -0.5905714520
##      96      97      98      99      100
## -1.6635570850 -0.7663621405 -1.7916251287  0.5307647235 -2.5736328080
##     101     102     103     104     105
## -0.8687101317 -3.7662413323 -2.4091010640 -2.9348341441 -2.2665947810
##     106     107     108     109     110
## -1.7573475358 -1.0119664486 -2.8292704697 -2.8769152801 -1.7070080845
##     111     112     113     114     115
## -1.4952261148 -2.4875563894 -2.3907666892 -3.3209107492 -2.4177009899
##     116     117     118     119     120
## -1.9928981598 -1.9489950791 -3.7898325321 -1.9309510254 -1.7576067637
##     121     122     123     124     125
## -2.5308627022 -1.9514805274 -1.0034721017 -1.0788923655 -0.8257300371
##     126     127     128     129     130
## -2.3503852683 -1.1990713602 -2.1956374778 -1.4086689771 -0.9760738409
##     131     132     133     134     135
## -1.5121555269 -1.8236419496 -0.6671366334 -0.2585520368 -2.1747075539
##     136     137     138     139     140
## -2.3691237793 -1.7274955717 -2.5033040632 -0.4556695339 -1.9261312674
##     141     142     143     144     145
## -2.4239131191 -1.1056781216 -1.7810523585 -3.2575289452 -2.4892321342
##     146     147     148     149     150
## -2.1328447681 -2.5336287900 -2.6055958932 -3.0988857536 -3.2240547426
##     151     152     153     154     155
## -2.9614534108 -2.0695917550 -2.1382596200 -2.8392071718 -2.2572158039

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##      156      157      158      159      160
## -2.6086188958 -1.7767241965 -3.1395867510 -3.3007754795 -2.2218347860
##      161      162      163      164      165
## -2.8780426877 -2.8989008087 -1.0946813740 -3.4367491793 -2.1056035953
##      166      167      168      169      170
## -0.3674735423 -3.2908869934 -0.5808787110 -2.7765853367 -1.4741646847
##      171      172      173      174      175
## -2.7839846466 -2.2242713186 -2.3875667164 -2.9392699803 -1.4974929089
##      176      177      178      179      180
## -1.3688687871 -1.3333638760 -2.2357706446 -2.2325599203 -1.7934246577
##      181      182      183      184      185
## -2.9832173508 -3.1954816344 -1.2968345880 -1.7984593140 -2.0084828380
##      186      187      188      189      190
## -0.1319340217 -0.8187627904 -1.8247822400 -2.8976946793 -3.1928357610
##      191      192      193      194      195
## -0.9492093396 -2.0926311182 -0.2465841516 -2.0194420289 -1.7727273355
##      196      197      198      199      200
## -2.6534566225 -2.2077629391 -1.9111110726 -1.1740196648 -0.8865613998
##      201      202      203      204      205
## -1.1602469616 -2.2429853179 -2.7310506591 -1.9894323186 -2.9508233846
##      206      207      208      209      210
## -2.1094846161 -2.1904582377 -1.4624043172 -2.1162766154 -1.5651057963
##      211      212      213      214      215
## -2.1394630778 -2.2061994088 -1.8734252981 -2.7990929759 -1.3163625455
##      216      217      218      219      220
## -2.2815057437 -2.9153811442 -0.8659858061 -0.9060299928 -2.2444211314
##      221      222      223      224      225
## -0.6780741699 -2.1986415954 -2.6372028287 -2.7577708835 -1.7986607676
##      226      227      228      229      230
## -2.1473254598 -2.9603046989 -1.8430401997 -0.4002517250 -2.2101177568
##      231      232      233      234      235
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##      236      237      238      239      240
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##      241      242      243      244      245
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##      246      247      248      249      250
## -3.0713236513 -2.8044312491 -1.6250448454 -2.4468502289 -1.8349512516
##      251      252      253      254      255
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##      256      257      258      259      260
## -2.1817147076 -1.3621757421 -2.6313814415 -1.2998627056 -1.9842465672
##      261      262      263      264      265
## -1.8844913717 -0.6246633643 -1.9756753078 -3.3773300351 -2.5178608504
##      266      267      268      269      270
## -0.8401522476 -2.2156477991 -0.5296725552 -0.9916961415 -2.8625770634
##      271      272      273      274      275
## -1.9119850494 -1.5818315769 -2.5382513411 -0.3664734725 -1.0732609039
##      276      277      278      279      280
## -2.9743647535 -3.0991429752 -3.1152174910 -1.6967907688 -1.1014263521
##      281      282      283      284      285
## -2.0721025826 -0.4534616242 -3.2721306533 -2.7885542219 -2.4931453008
##      286      287      288      289      290
## -2.2425699407 -0.8446279041 -2.3060927745 -1.3497957793 -0.4204729537

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##      296      297      298      299      300
## -1.5637789801 -2.7568905794 -3.2772560951 -3.7294044850 -1.3765055503
##      301      302      303      304      305
## -1.9984128500 -2.0691156130 -3.1092026308 -2.0789387899 -3.5098992096
##      306      307      308      309      310
## -2.6566501468 -1.9253408717 -2.0281751404 -0.3747057733 -3.1088293115
##      311      312      313      314      315
## -2.0503211541 -0.9904516834 -2.7721597978 -2.3745757227 -2.1996183205
##      316      317      318      319      320
## -3.7936489986  0.0672157256 -2.9530893164  1.7080556510 -2.0163982941
##      321      322      323      324      325
## -2.6192080795 -2.4829997551 -2.9867424813 -2.4671450989 -2.5878582097
##      326      327      328      329      330
## -2.0597257272 -1.5198835799 -1.0511210658 -2.2159664996 -0.5268572144
##      331      332      333      334      335
## -1.9170937990 -1.0383624215 -1.9213215063 -1.5841165528 -0.8107905409
##      336      337      338      339      340
## -1.5282053921 -0.6958013810 -1.8170486626 -0.8426570320 -2.3698333953
##      341      342      343      344      345
## -2.2830607058  1.1489148976 -2.2721808942 -2.3612644581 -2.8764041324
##      346      347      348      349      350
## -2.0441654650 -2.1674279895 -2.1500527350 -1.2530242722 -1.8706358651
##      351      352      353      354      355
## -2.5830326259  0.4597816935 -1.5620344634 -1.2333321270 -0.9742207064
##      356      357      358      359      360
## -1.2136548190 -2.6120963286 -0.6525650226 -3.5405913162 -3.1311981314
##      361      362      363      364      365
## -2.1880878556 -2.9162983566 -0.9784623833 -1.4139577355 -0.5001275551
##      366      367      368      369      370
## -3.1746704985 -1.5956861012 -2.9605095228  0.3122614343 -2.9720901647
##      371      372      373      374      375
## -0.6964713025 -2.7590376440 -0.7055319840 -1.9951080270 -2.5837644136
##      376      377      378      379      380
## -2.6304642058 -2.4411974812 -2.5094031425 -1.7261419291 -2.5977059166
##      381      382      383      384      385
## -2.3335693058 -0.2186063269 -3.0387523606 -1.3521343903 -1.4112455784
##      386      387      388      389      390
## -2.5486218148 -3.5200147220 -2.3170191223 -1.3443411240 -3.2519233177
##      391      392      393      394      395
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##      396      397      398      399      400
## -2.3071800912 -0.7422533997 -0.3367885852 -2.6120576131 -2.1753009669
##      401      402      403      404      405
## -1.2416020147 -3.9453644273 -2.0980116021 -2.7325789951 -2.6949906026
##      406      407      408      409      410
## -1.6184845037 -1.3801254575 -2.3575512552 -0.5127775734 -2.4323680894
##      411      412      413      414      415
## -3.0860447499 -2.2081437056 -3.0156239495 -0.7539060272  1.2717963534
##      416      417      418      419      420
## -0.5357702072 -2.3987968029 -3.7025822072 -2.9903372671 -2.4111982198
##      421      422      423      424      425
## -2.7007247405 -1.1445964537 -2.9519616823 -1.5448729296  1.3318189258

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##      426      427      428      429      430
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##      431      432      433      434      435
## -1.7721150127 -2.9429725670 -0.3892492212 -1.7587610605 -2.5315641267
##      436      437      438      439      440
## -3.3252299325 -0.7791729547 -1.7751221602 -2.9520115891 -0.7653972660
##      441      442      443      444      445
## -2.3414937341 -2.6255749042 -2.3342074918 -0.7467699140 -2.6879128914
##      446      447      448      449      450
## -2.6360696508 -2.4217353478 -3.7373143056 -0.9362030486 -2.3944128986
##      451      452      453      454      455
## -2.6754557617 -2.5208090695 -3.5269643385 -0.4759004899  0.2108476369
##      456      457      458      459      460
## -1.3735740285 -1.8007158929  0.8394558568 -3.6646393722 -2.7366380939
##      461      462      463      464      465
## -2.3482871827 -2.9739586474 -2.1536939682 -1.8749448466 -2.3111721367
##      466      467      468      469      470
## -2.7295884408 -1.6278674976 -2.5806611031 -2.6436185990 -2.7067905212
##      471      472      473      474      475
## -2.2878368825 -2.0983185349 -1.8388207227 -3.3475280289 -0.0686928259
##      476      477      478      479      480
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##      481      482      483      484      485
## -1.7092113200 -3.5796748557 -1.1260364898 -2.6375197938 -0.7011543298
##      486      487      488      489      490
## -2.4403354501 -0.0470576025 -2.3910413532 -2.4830324967 -2.4511707106
##      491      492      493      494      495
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##      496      497      498      499      500
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##      501      502      503      504      505
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##      531      532      533      534      535
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##      546      547      548      549      550
## -2.4041846974 -1.3074223988 -2.4532148026 -1.2903570139 -2.8876555470
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## -2.0620523302 -2.1477766202 -2.4955590343 -3.9222931716 -2.3991860207
##      556      557      558      559      560
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## -2.7075445600 -2.9038029775 -1.1468502056 -2.5808756393 -1.5239200196
##      571      572      573      574      575
## -3.3899744159 -2.2183016233 -1.5458164776 -2.3931626784 -1.0148325813
##      576      577      578      579      580
## -2.0007555835 -2.3184718725 -3.1174768966 -2.1163365132 -2.9692659384
##      581      582      583      584      585
## -1.5405456797 -2.1798251144 -3.4293118373 -1.9734253714 -2.5929145454
##      586      587      588      589      590
## -1.9424188663 -2.6438723982 -1.1866726550 -2.1798730343 -0.2005095064
##      591      592      593      594      595
## -2.8291106236 -3.0494886588 -0.3938763441 -3.1507656360 -2.8888462656
##      596      597      598      599      600
## -2.6385540213 -2.4123679934 -1.1771145064 -1.9571212659 -2.9346833161
##      601      602      603      604      605
## -1.4105533871 -3.0593253778 -1.2421316906 -2.6363998902  1.3298031151
##      606      607      608      609      610
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##      611      612      613      614      615
## -1.3895754001 -2.3496024254 -2.1833040263 -3.6172304091 -3.3629034720
##      616      617      618      619      620
## -1.2536471176 -2.7159334256 -2.8415255677 -1.2556241184 -1.4716563743
##      621      622      623      624      625
## -2.8584833600 -2.3030690191 -2.8738444095 -3.2119095274 -0.9353205374
##      626      627      628      629      630
## -2.1399353650 -2.5625289047 -1.7015352802 -3.2730686587 -2.5950716165
##      631      632      633      634      635
## -2.3124377888 -1.2606927974 -1.2254945047 -2.5385036532 -2.5579379410
##      636      637      638      639      640
## -2.7463381341 -2.1211513811  2.1520853211 -1.8007549283 -2.7580500071
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##      646      647      648      649      650
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##      651      652      653      654      655
## -1.6464628719 -2.5137441913 -2.3132678284 -1.1407029609 -0.6561179962
##      656      657      658      659      660
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##      661      662      663      664      665
## -2.1874774112 -3.1011309222 -2.2495042687 -3.6382361573 -1.9805633616
##      666      667      668      669      670
## -3.6887091541 -2.4468345224 -2.6159120872 -2.5960280507 -2.1152368326
##      671      672      673      674      675
## -0.5024633177 -1.8384361925 -2.5714085844 -0.8056139524 -1.2795139523
##      676      677      678      679      680
## -1.5889383663 -1.7772746402  0.5144775363 -1.9884720574 -3.1117266111
##      681      682      683      684      685
## -2.7993634476 -2.4678286805 -1.9181862158 -1.8332349951 -1.7476875191
##      686      687      688      689      690
## -1.8545186330 -1.5564472950 -2.4802357262 -0.0464091059 -2.3914985166
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##       696       697       698       699       700
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##       701       702       703       704       705
## -0.7144989960 -1.6115941741 -3.3456760636 -3.0984290902  0.7968537385
##       706       707       708       709       710
## -3.5739418458 -1.7529716289 -2.1631853912 -2.5716791349 -2.2638714800
##       711       712       713       714       715
## -4.0178814065 -2.6972558141 -2.4142941356 -2.7091140908 -1.9272207043
##       716       717       718       719       720
## -3.1037562963 -2.8629171865 -0.8718879760 -1.3000030053 -2.6363982944
##       721       722       723       724       725
## -2.2336416468 -1.3854077297 -2.5337874947 -1.5599715253 -3.5344837699
##       726       727       728       729       730
## -2.8303721484  0.3452140539 -1.2398160286 -2.7563289332 -0.8607169223
##       731       732       733       734       735
## -2.0607978407 -2.5036908971 -2.8500715774 -3.4148295269 -2.2516832576
##       736       737       738       739       740
##  0.2482876082 -2.6127651614 -2.7135493186 -2.5920045961 -2.3111449214
##       741       742       743       744       745
## -2.9603236335 -1.3648962662 -1.7949479918 -3.0246190516 -2.7524638939
##       746       747       748       749       750
## -1.5084015265 -2.7698279727 -3.1305059682 -1.6386496591 -0.7109765473
##       751       752       753       754       755
## -1.4770009808 -2.5158801597 -2.3223350306 -2.7439985912 -2.7299772990
##       756       757       758       759       760
## -0.7421937979 -2.1784191606 -2.3257210547 -2.0532059555 -2.1641938088
##       761       762       763       764       765
## -3.7016902653 -1.7898894217 -2.1025213853 -2.8321721934 -3.0337436227
##       766       767       768       769       770
## -1.7245675646 -1.1561978453 -2.3212801096 -1.9385154167 -1.9028991792
##       771       772       773       774       775
## -2.1772689122 -2.9392562923 -2.4247035013 -1.5397010472 -2.8281376986
##       776       777       778       779       780
## -2.7529680561 -1.9272756086 -0.4957792383 -0.8358614201 -1.7745778891
##       781       782       783       784       785
## -3.1874419186 -1.7621631357 -1.7072276795 -2.9592340554 -1.2478267020
##       786       787       788       789       790
## -2.4840325091 -2.0038245178 -1.7066588366 -3.0013598055 -1.4567193700
##       791       792       793       794       795
## -1.2903991356 -2.9456502603 -1.9635246635 -2.6514263872 -2.0318767744
##       796       797       798       799       800
## -2.4587785423 -2.0069326188 -2.4226345390 -2.5876237993 -2.5396586184
##       801       802       803       804       805
## -2.1360134335  1.3439730752 -1.3006293963 -2.3034698715 -2.7320785881
##       806       807       808       809       810
## -2.4627150956 -1.6804817443 -2.7834889239 -1.9250599843 -2.6750411538
##       811       812       813       814       815
## -1.9404628736 -1.3960784592 -2.2229256847 -1.0835584373 -1.5597924068
##       816       817       818       819       820
## -1.0643049235 -2.8234901789 -1.2318998161 -1.8457857641 -3.0827928592
##       821       822       823       824       825
## -2.3708467163 -1.9618589115  0.3126564717 -2.9634287917 -1.7003804186
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##      836      837      838      839      840
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##      841      842      843      844      845
## -1.6902727618 -2.8150059725 -3.0820913917 -1.0087276691 -1.2266804873
##      846      847      848      849      850
## -0.9249135922 -1.3799934404  0.2559894363 -0.9586348593 -2.4177789709
##      851      852      853      854      855
##  0.4406652181 -3.5571892708 -2.8002503245 -0.7358939172  0.1212308042
##      856      857      858      859      860
## -2.2052569527 -3.0431393267 -2.2758069452  0.9512005997  0.7303479477
##      861      862      863      864      865
##  0.2978823486 -3.2251287670 -2.8877588050 -2.1998632548 -2.5070583028
##      866      867      868      869      870
## -2.8032803506 -2.4129144370 -2.0445211780 -0.7091628504 -0.9986660100
##      871      872      873      874      875
## -1.4687914326 -1.8723702312 -3.7128358854 -1.7158213059 -1.7761217458
##      876      877      878      879      880
## -1.3795561291 -2.4284806561 -2.6366846564 -3.2963150283 -2.7804216867
##      881      882      883      884      885
## -1.2655363351  0.5008027110 -2.7898935540 -1.7631289723 -2.6961935434
##      886      887      888      889      890
## -0.8201639157 -2.6377196167 -1.9845933473 -3.4222068503  0.2390740787
##      891      892      893      894      895
## -2.7185435792 -1.1114897795 -2.7209686679 -2.7932194493 -2.7392309318
##      896      897      898      899      900
## -1.8370072696 -2.6243066489 -1.1059194101 -2.5640576169 -1.3648413470
##      901      902      903      904      905
## -1.6097118822 -1.3716535302 -1.0393850047 -0.4839627059 -2.2068223740
##      906      907      908      909      910
## -3.3237241130 -3.3758931818 -1.8749874568 -2.5065046776 -1.8031910857
##      911      912      913      914      915
## -2.3737735216 -2.1048492302 -1.6914445059 -2.5859786749 -0.9889271630
##      916      917      918      919      920
## -0.6213164706 -2.2367914842 -2.0279515887 -1.4499699202 -1.9366927021
##      921      922      923      924      925
## -2.0063884977 -2.3858658089 -1.7683099957 -2.3882775821 -0.7299921615
##      926      927      928      929      930
## -2.6240350240 -0.4164922988 -1.5577073246 -2.1590960163 -3.1333557108
##      931      932      933      934      935
## -1.8651802446 -1.7504768628 -1.8894484442 -2.8233541309 -2.2584820532
##      936      937      938      939      940
## -3.3706598743 -2.2623751238 -1.1005515294 -2.1295217323 -1.2516547021
##      941      942      943      944      945
##  0.6282748103 -2.6465702581 -2.5971982680 -2.5955214230  0.9925105636
##      946      947      948      949      950
## -0.7471923264 -1.6608705450 -2.5566705363 -1.2025424874  0.3661741759
##      951      952      953      954      955
## -1.9331507870 -3.6217865436 -3.1520248184 -0.8389135378 -2.6881542180
##      956      957      958      959      960
## -2.8629317927 -1.6030380347 -1.8949773148 -2.0194242920 -2.3818333039
##      961      962      963      964      965
## -1.7728270091 -2.9116551165  0.9897288133 -3.3719603534 -1.1710264109

```

```

##      966      967      968      969      970
## -2.1166223440 -2.2950342744 -2.5907174670 -3.2351029482 -2.2801596535
##      971      972      973      974      975
## -2.9887141283 -1.3373235172 -2.8154826449 -0.2477771505 -1.6332261077
##      976      977      978      979      980
## -1.5212229357 -1.4785856169 -1.2898389643 -3.3138215755 -2.0632096090
##      981      982      983      984      985
## -1.7847932510 -0.9586488235 -2.4102742043 -1.8180478438 -1.0423078234
##      986      987      988      989      990
## -1.1781327417 -0.9511352214 -0.0008004456 -2.6428316829 -2.9840095708
##      991      992      993      994      995
## -2.4961491063 -2.8611801368 -2.4788919719 -1.9085447024 -1.3000434139
##      996      997      998      999      1000
## -2.1676658497 -2.6845065536 -2.8503724484 -3.1224575144  0.7850907060
##     1001     1002     1003     1004     1005
## -2.4855112354 -3.2385591424 -2.2907058378 -1.7077285266 -0.8944115930
##     1006     1007     1008     1009     1010
## -1.9549113788 -3.4850236402 -2.0224304295 -1.6817053806 -1.9385698159
##     1011     1012     1013     1014     1015
## -0.8208004649 -1.1444821328 -1.9313327456 -2.1333357265 -1.2474756359
##     1016     1017     1018     1019     1020
## -2.0756733133 -2.4340881940 -1.7276603285 -1.7092296455 -2.8189688107
##     1021     1022     1023     1024     1025
## -2.8577407827 -3.1093462406 -1.4500979021 -1.9231266886 -1.0250069790
##     1026     1027     1028     1029     1030
## -2.2148246297 -2.5843507156 -2.3933216923 -1.1160922078 -1.8590329751
##     1031     1032     1033     1034     1035
##  1.1061837882 -1.9572630494 -2.3565780205 -2.8433804252 -2.2250533676
##     1036     1037     1038     1039     1040
## -1.9310342823 -3.9148956720 -1.8230859627 -1.7705817330 -2.7310345984
##     1041     1042     1043     1044     1045
## -0.6729283076 -0.3030621845 -3.7994020219 -2.3529091451 -2.7945162852
##     1046     1047     1048     1049     1050
## -2.3546398762 -1.1858348419 -2.6252963616 -2.5464811656 -2.6072737315
##     1051     1052     1053     1054     1055
## -0.3000285081 -2.0074323802 -1.8637999836 -3.0105835415 -1.4984677412
##     1056     1057     1058     1059     1060
## -2.2590026388 -1.0550169619 -0.7828716849 -1.7213644205 -1.0014932957
##     1061     1062     1063     1064     1065
## -2.7999204602 -2.7123487535 -1.8259498976 -1.5156429708 -2.8685434519
##     1066     1067     1068     1069     1070
## -2.2345735958 -3.7512792093 -1.9336270253 -2.5703119843 -1.0774848808
##     1071     1072     1073     1074     1075
## -1.3554599961 -2.9851220747 -1.3750201803 -0.5217190873 -3.0090569247
##     1076     1077     1078     1079     1080
## -1.5879898853 -1.0583925441 -2.7522809070 -3.2435931026 -1.8195780229
##     1081     1082     1083     1084     1085
## -2.6203704867 -0.4723696366 -1.7798500605 -1.9455043840 -2.4908587438
##     1086     1087     1088     1089     1090
## -3.3280277894 -2.4717467621 -2.6744184437 -1.3483211798 -2.7535792305
##     1091     1092     1093     1094     1095
## -2.8520547984 -2.5455590295 -0.2018367440 -2.7190916395 -2.7827944324
##     1096     1097     1098     1099     1100
## -2.7732582341 -2.1436175088 -2.5296369718 -1.4751180714 -1.4809240875

```

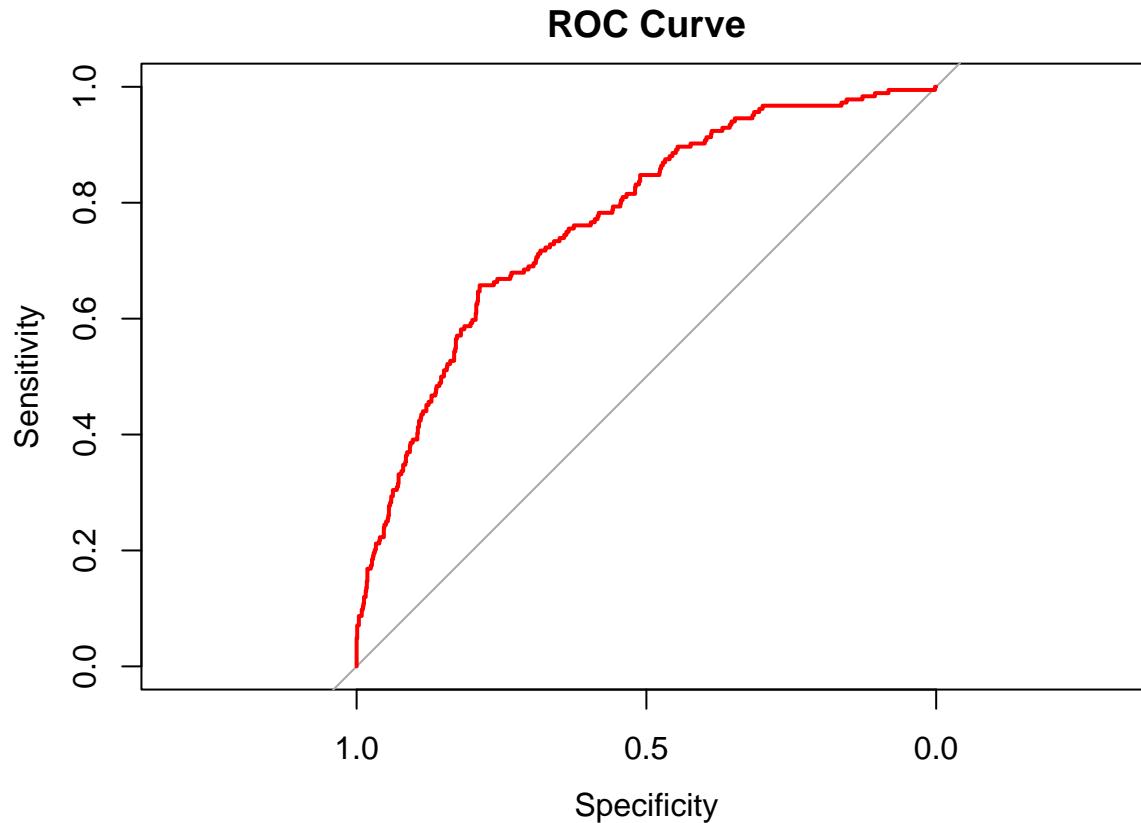
```

##          1101          1102          1103          1104          1105
## -2.6720902678 -2.7017992133 -1.3064289760 -2.2350601087 -0.2810542730
##          1106          1107          1108          1109          1110
## -1.2479615255 -2.8583048977 -2.8860887258 -3.2521211691 -2.9857039227
##          1111          1112          1113          1114          1115
## -1.1806078195 -1.0341977368 -2.9745754677  0.5598102098 -0.9424803435
##          1116          1117          1118          1119          1120
## -1.1055897345  1.0269092944 -3.2780354004 -3.0526081927 -3.1121870812
##          1121          1122          1123          1124          1125
## -3.4395085242 -0.4908496040 -2.0950994081 -3.0641469235 -1.1797987848
##          1126          1127          1128          1129          1130
## -1.9846938400 -3.5052528396 -3.4485938355 -2.7342665710 -2.2517335981
##          1131          1132          1133          1134          1135
## -3.14111132004 -1.7692119733 -1.2999176424 -1.9071762760 -3.1261338976
##          1136          1137          1138          1139          1140
## -2.4332710915 -1.3563335909 -2.7731295483 -1.7843177099 -1.9009357465
##          1141          1142          1143          1144          1145
## -0.3289608081 -2.5171910253 -3.0487948649 -1.2505191678 -1.9612993083
##          1146          1147          1148          1149          1150
## -2.0498646693 -0.2599799034 -3.2237937984 -3.1845588229 -2.2151412154
##          1151          1152          1153          1154          1155
## -2.4770598898 -1.6543942528 -3.0437719823 -3.0328353234 -2.4076372837
##          1156          1157          1158          1159          1160
## -0.7434568043 -2.7633920959 -2.5890664052 -2.9464186016 -2.4042281781
##          1161          1162          1163          1164          1165
## -2.3771054999 -1.5138231990 -2.9362874827 -2.3058952997 -1.7857164498
##          1166          1167          1168          1169          1170
## -2.5185249516 -2.5570113352 -0.4327428768 -1.6701790174 -1.7509023793
##          1171          1172          1173          1174          1175
## -2.2986907155 -0.7114030292 -2.0187028529 -1.8324079992 -1.6584232347
##          1176          1177          1178          1179          1180
## -3.1740863251 -2.9710276028 -0.4265097573 -2.1275435335 -1.8910338903
##          1181          1182          1183          1184          1185
## -2.1533476145 -2.1771531858 -3.8105178807 -2.7209396494 -0.0133381976
##          1186          1187          1188          1189          1190
## -1.3707399810 -0.2803025292 -1.4968601205 -2.0802602796 -1.3376800785
##          1191          1192          1193          1194          1195
## -1.9816017943 -1.7436250350 -0.9730732470 -2.1241691453 -0.6032876908
##          1196          1197          1198          1199          1200
## -1.0136871211 -0.2653070530 -2.6311543635 -0.1632163458 -2.9183467551
##          1201          1202          1203          1204          1205
## -3.0053934884 -1.4725356971 -3.2817845226 -0.6085871858 -1.9214420122
##          1206
## -1.1000212149

roc_curve_forward_1 <- roc(response = as.matrix(test_data$status), predictor = as.numeric(predictions_f
auc(roc_curve_forward_1)

## Area under the curve: 0.7703
#plot the roc curve
plot(roc_curve_forward_1, main = "ROC Curve", col = "red")

```



```
check_collinearity(forward_model_1)
```

```
## # Check for Multicollinearity
##
## Low Correlation
##
##           Term   VIF      VIF 95% CI Increased SE Tolerance
## progesterone_status 1.43 [ 1.38,  1.49]      1.20      0.70
## node_positive_prop 4.42 [ 4.19,  4.67]      2.10      0.23
##          differentiate 1.12 [ 1.09,  1.16]      1.06      0.89
##             race 1.06 [ 1.04,  1.11]      1.03      0.94
##              age 1.11 [ 1.08,  1.15]      1.05      0.90
## estrogen_status 1.48 [ 1.42,  1.54]      1.22      0.68
## regional_node_examined 3.43 [ 3.26,  3.62]      1.85      0.29
##          tumor_size 1.48 [ 1.43,  1.55]      1.22      0.67
##            n_stage 4.34 [ 4.11,  4.58]      2.08      0.23
## marital_status 1.13 [ 1.10,  1.18]      1.06      0.88
## Tolerance 95% CI
## [0.67, 0.73]
## [0.21, 0.24]
## [0.86, 0.92]
## [0.90, 0.97]
## [0.87, 0.93]
## [0.65, 0.70]
## [0.28, 0.31]
## [0.65, 0.70]
```

```

##      [0.22, 0.24]
##      [0.85, 0.91]
##
## Moderate Correlation
##
##           Term   VIF     VIF 95% CI Increased SE Tolerance
## reginol_node_positive 7.34 [ 6.94,  7.78]          2.71      0.14
## Tolerance 95% CI
##      [0.13, 0.14]
##
## High Correlation
##
##           Term   VIF     VIF 95% CI Increased SE Tolerance Tolerance 95% CI
## x6th_stage 20.14 [18.97, 21.39]          4.49      0.05      [0.05, 0.05]
breastcancer_for1 = breastcancer_for1>
  dplyr::select(-x6th_stage)

null_model_2 <- glm(status ~ 1, data = breastcancer_for1, family = binomial())
full_model_2 <- glm(status ~ ., data = breastcancer_for1, family = binomial())
forward_model_2 <- step(null_model_2, scope = list(lower = null_model_2, upper = full_model_2), direction = "forward")

## Start: AIC=3446.68
## status ~ 1
##
##           Df Deviance   AIC
## + n_stage       2  3214.0 3220.0
## + reginol_node_positive 1  3236.8 3240.8
## + node_positive_prop 1  3237.8 3241.8
## + progesterone_status 1  3335.1 3339.1
## + estrogen_status    1  3338.7 3342.7
## + differentiate      3  3337.3 3345.3
## + grade             3  3337.3 3345.3
## + tumor_size         1  3380.1 3384.1
## + a_stage            1  3415.7 3419.7
## + race               2  3418.9 3424.9
## + marital_status     4  3419.2 3429.2
## + age                1  3432.0 3436.0
## + regional_node_examined 1  3439.9 3443.9
## <none>              3444.7 3446.7
##
## Step: AIC=3220.03
## status ~ n_stage
##
##           Df Deviance   AIC
## + progesterone_status 1  3128.7 3136.7
## + estrogen_status      1  3134.1 3142.1
## + differentiate        3  3148.4 3160.4
## + grade               3  3148.4 3160.4
## + node_positive_prop   1  3173.8 3181.8
## + race                2  3191.0 3201.0
## + tumor_size           1  3197.6 3205.6
## + regional_node_examined 1  3200.9 3208.9
## + age                 1  3201.0 3209.0
## + marital_status       4  3196.0 3210.0

```

```

## + reginol_node_positive 1 3202.6 3210.6
## <none>                  3214.0 3220.0
## + a_stage                1 3212.4 3220.4
##
## Step: AIC=3136.66
## status ~ n_stage + progesterone_status
##
##                                     Df Deviance   AIC
## + differentiate               3  3085.0 3099.0
## + grade                      3  3085.0 3099.0
## + node_positive_prop          1  3089.4 3099.4
## + estrogen_status              1  3106.4 3116.4
## + race                        2  3107.2 3119.2
## + tumor_size                  1  3114.6 3124.6
## + reginol_node_positive       1  3115.8 3125.8
## + age                         1  3116.4 3126.4
## + regional_node_examined     1  3116.8 3126.8
## + marital_status              4  3112.8 3128.8
## <none>                      3128.7 3136.7
## + a_stage                     1  3126.8 3136.8
##
## Step: AIC=3099.03
## status ~ n_stage + progesterone_status + differentiate
##
##                                     Df Deviance   AIC
## + node_positive_prop          1  3043.6 3059.6
## + age                         1  3067.3 3083.3
## + race                        2  3066.5 3084.5
## + reginol_node_positive       1  3071.1 3087.1
## + estrogen_status              1  3071.5 3087.5
## + regional_node_examined     1  3071.7 3087.7
## + tumor_size                  1  3073.9 3089.9
## + marital_status              4  3069.6 3091.6
## + a_stage                     1  3082.9 3098.9
## <none>                      3085.0 3099.0
##
## Step: AIC=3059.61
## status ~ n_stage + progesterone_status + differentiate + node_positive_prop
##
##                                     Df Deviance   AIC
## + race                        2  3024.9 3044.9
## + age                         1  3028.4 3046.4
## + estrogen_status              1  3029.2 3047.2
## + tumor_size                  1  3034.9 3052.9
## + marital_status              4  3030.0 3054.0
## + reginol_node_positive       1  3040.0 3058.0
## + a_stage                     1  3041.3 3059.3
## <none>                      3043.6 3059.6
## + regional_node_examined     1  3043.6 3061.6
##
## Step: AIC=3044.86
## status ~ n_stage + progesterone_status + differentiate + node_positive_prop +
##      race
##

```

```

##                                     Df Deviance   AIC
## + age                           1  3010.0 3032.0
## + estrogen_status                1  3010.9 3032.9
## + tumor_size                     1  3016.0 3038.0
## + reginol_node_positive          1  3020.6 3042.6
## + marital_status                 4  3014.8 3042.8
## + a_stage                        1  3022.5 3044.5
## <none>                          3024.9 3044.9
## + regional_node_examined         1  3024.8 3046.8
##
## Step:  AIC=3032
## status ~ n_stage + progesterone_status + differentiate + node_positive_prop +
##       race + age
##
##                                     Df Deviance   AIC
## + estrogen_status                1  2993.3 3017.3
## + tumor_size                     1  2999.1 3023.1
## + reginol_node_positive          1  3005.9 3029.9
## + a_stage                        1  3007.2 3031.2
## + marital_status                 4  3001.6 3031.6
## <none>                          3010.0 3032.0
## + regional_node_examined         1  3010.0 3034.0
##
## Step:  AIC=3017.33
## status ~ n_stage + progesterone_status + differentiate + node_positive_prop +
##       race + age + estrogen_status
##
##                                     Df Deviance   AIC
## + tumor_size                     1  2982.1 3008.1
## + reginol_node_positive          1  2989.3 3015.3
## + marital_status                 4  2984.8 3016.8
## + a_stage                        1  2991.1 3017.1
## <none>                          2993.3 3017.3
## + regional_node_examined         1  2993.3 3019.3
##
## Step:  AIC=3008.05
## status ~ n_stage + progesterone_status + differentiate + node_positive_prop +
##       race + age + estrogen_status + tumor_size
##
##                                     Df Deviance   AIC
## + reginol_node_positive          1  2978.0 3006.0
## + marital_status                 4  2973.8 3007.8
## <none>                          2982.1 3008.1
## + a_stage                        1  2980.4 3008.4
## + regional_node_examined         1  2982.1 3010.1
##
## Step:  AIC=3005.98
## status ~ n_stage + progesterone_status + differentiate + node_positive_prop +
##       race + age + estrogen_status + tumor_size + reginol_node_positive
##
##                                     Df Deviance   AIC
## + regional_node_examined         1  2974.6 3004.6
## + marital_status                 4  2969.9 3005.9
## <none>                          2978.0 3006.0

```

```

## + a_stage           1  2976.2 3006.2
##
## Step: AIC=3004.62
## status ~ n_stage + progesterone_status + differentiate + node_positive_prop +
##          race + age + estrogen_status + tumor_size + reginol_node_positive +
##          regional_node_examined
##
##              Df Deviance    AIC
## + marital_status   4  2966.3 3004.3
## <none>            2974.6 3004.6
## + a_stage          1  2973.0 3005.0
##
## Step: AIC=3004.34
## status ~ n_stage + progesterone_status + differentiate + node_positive_prop +
##          race + age + estrogen_status + tumor_size + reginol_node_positive +
##          regional_node_examined + marital_status
##
##              Df Deviance    AIC
## <none>            2966.3 3004.3
## + a_stage          1  2964.9 3004.9
summary(forward_model_2)

##
## Call:
## glm(formula = status ~ n_stage + progesterone_status + differentiate +
##      node_positive_prop + race + age + estrogen_status + tumor_size +
##      reginol_node_positive + regional_node_examined + marital_status,
##      family = binomial(), data = breastcancer_for1)
##
## Coefficients:
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)             -3.872300  0.379440 -10.205 < 2e-16 ***
## n_stagen2                0.394485  0.133626   2.952 0.003156 **
## n_stagen3                0.529137  0.240428   2.201 0.027749 *
## progesterone_statusNegative  0.574828  0.127502   4.508 6.53e-06 ***
## differentiatePoorly differentiated  0.406757  0.104537   3.891 9.98e-05 ***
## differentiateUndifferentiated  1.346819  0.525271   2.564 0.010346 *
## differentiateWell differentiated -0.539183  0.183546  -2.938 0.003308 **
## node_positive_prop        0.611458  0.313106   1.953 0.050834 .
## raceBlack                 0.501780  0.161775   3.102 0.001924 **
## raceOther                 -0.430230  0.202427  -2.125 0.033556 *
## age                       0.023390  0.005595   4.180 2.91e-05 ***
## estrogen_statusNegative   0.749046  0.177620   4.217 2.47e-05 ***
## tumor_size                 0.007255  0.002101   3.453 0.000554 ***
## reginol_node_positive     0.053869  0.020040   2.688 0.007188 **
## regional_node_examined   -0.019721  0.010629  -1.855 0.063528 .
## marital_statusMarried    -0.153098  0.134179  -1.141 0.253873
## marital_statusDivorced   0.072347  0.174876   0.414 0.679093
## marital_statusSeparated  0.711835  0.379622   1.875 0.060777 .
## marital_statusWidowed    0.071174  0.217782   0.327 0.743810
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)

```

```

## Null deviance: 3444.7 on 4023 degrees of freedom
## Residual deviance: 2966.3 on 4005 degrees of freedom
## AIC: 3004.3
##
## Number of Fisher Scoring iterations: 5
predictions_forward_2 <- predict(forward_model_2, newdata = test_data1)

# Viewing predictions
print(predictions_forward_2)

```

```

##          1         2         3         4         5         6
## -1.050431407 -2.713632226 -2.171992086 -1.883058955 -2.770758054 -1.583136159
##          7         8         9        10        11        12
## -1.680374244 -3.543885515 -0.480865825 -2.700714407 -1.339319820 -1.231293425
##         13        14        15        16        17        18
## -2.905745694 -2.183106594 -2.682527578 -3.050492131 -2.948248062 -2.755019229
##         19        20        21        22        23        24
## -2.266206233 -2.715323816  0.041870035 -2.397584910 -2.472032868 -3.265264063
##         25        26        27        28        29        30
## -3.353130662 -1.372189705 -2.255077136 -3.135433664 -2.086339256 -2.472620542
##         31        32        33        34        35        36
## -2.316776892 -2.320609563 -2.360221632 -2.599155817 -2.145432140 -3.938980695
##         37        38        39        40        41        42
## -2.986417565 -1.327463879 -2.527383171 -2.141034193 -1.954319260 -0.489644052
##         43        44        45        46        47        48
## -2.287518020 -2.825663445 -2.356691723 -1.262120308 -2.417668830 -2.386907265
##         49        50        51        52        53        54
## -2.313938834 -1.776470961 -0.255451630 -1.273276879 -2.036905104 -2.552802694
##         55        56        57        58        59        60
## -0.726719506 -2.319366733 -2.774877700 -2.673624984 -2.342952223 -3.019212307
##         61        62        63        64        65        66
## -1.733791283 -2.335978250 -2.231809133 -1.174174185 -2.830099455 -2.116730624
##         67        68        69        70        71        72
## -3.154486608 -3.706184357 -1.836772403  1.035165994 -0.910541449 -2.221350557
##         73        74        75        76        77        78
## -2.305528672 -2.768663472 -1.256111233  1.526923597 -2.865403177 -1.130532497
##         79        80        81        82        83        84
## -1.516227504 -2.813565450 -1.909597571 -1.535372419 -2.845546257 -1.657316553
##         85        86        87        88        89        90
## -3.279048109 -2.511265411 -2.780173405 -0.877423643 -2.538155173 -1.655153749
##         91        92        93        94        95        96
## -0.372415604  1.361312372 -2.262101839 -3.262593951 -0.640377202 -1.865607459
##         97        98        99       100       101       102
## -0.721040271 -1.967681509  0.497970080 -2.388393196 -0.835840958 -3.583543047
##        103       104       105       106       107       108
## -2.376275128 -3.126309758 -2.463629461 -1.784898510 -0.982860965 -2.636977673
##        109       110       111       112       113       114
## -2.689824100 -1.711255426 -1.463402278 -2.292967798 -2.557177692 -3.140291980
##        115       116       117       118       119       120
## -2.403897113 -1.786652609 -2.142895445 -3.605461789 -2.118009441 -1.935113805
##        121       122       123       124       125       126
## -2.316167452 -1.960730948 -1.158729209 -1.134916848 -0.709924384 -2.522008667
##        127       128       129       130       131       132

```

```

## -1.065481493 -2.373788343 -1.406440211 -1.169222020 -1.336699844 -1.819464483
##          133          134          135          136          137          138
## -1.291071472 -0.247328185 -1.992092646 -2.546973837 -1.596047397 -2.685687889
##          139          140          141          142          143          144
## -0.435629402 -2.097518557 -2.315253244 -1.307657802 -1.706311329 -3.077410787
##          145          146          147          148          149          150
## -2.675294957 -2.315794457 -2.313578916 -2.791249755 -2.919627432 -3.020791648
##          151          152          153          154          155          156
## -2.763428843 -2.254214987 -2.340498174 -2.639883265 -2.084717098 -2.421767977
##          157          158          159          160          161          162
## -1.946584208 -2.974815377 -3.132517240 -2.087575506 -2.800391289 -2.911014877
##          163          164          165          166          167          168
## -0.997584876 -3.240843050 -1.897243569 -0.294375227 -3.083969973 -0.631844842
##          169          170          171          172          173          174
## -2.576251669 -1.367306393 -2.605022420 -2.390793259 -2.594419654 -2.758406893
##          175          176          177          178          179          180
## -1.698842804 -1.384755634 -1.343142481 -2.032930685 -2.388214611 -2.017166032
##          181          182          183          184          185          186
## -3.190937169 -3.065273849 -1.463765766 -1.960132452 -1.887895127 -0.066852779
##          187          188          189          190          191          192
## -0.786163905 -1.786227569 -2.720773853 -2.994002426 -1.545045054 -1.880587666
##          193          194          195          196          197          198
## -0.175420158 -1.826020642 -1.788148775 -2.852219979 -2.017904147 -1.886655268
##          199          200          201          202          203          204
## -1.109894781 -1.049423388 -1.199843383 -2.424382321 -2.923708732 -2.168259404
##          205          206          207          208          209          210
## -2.756852638 -2.323846242 -1.993532166 -1.611856573 -1.961733556 -1.748121191
##          211          212          213          214          215          216
## -2.354757421 -2.026021950 -2.033454996 -2.792918811 -1.504956020 -2.481351578
##          217          218          219          220          221          222
## -2.727289270 -0.794091199 -0.744732196 -2.041513462 -0.682400780 -2.201806605
##          223          224          225          226          227          228
## -2.524756205 -2.919653932 -1.969775707 -2.342637526 -3.152929696 -1.852123603
##          229          230          231          232          233          234
## -0.404704152 -2.184248272 -1.284676803 -2.627135059 -2.938097888 -2.457586661
##          235          236          237          238          239          240
## -2.589945553 -2.345342057 -1.988283597 -0.372878727 -3.166380684 -2.443474602
##          241          242          243          244          245          246
## -3.202868502 -1.767518849 -2.174514725 -0.322010123 -3.017166285 -2.890796267
##          247          248          249          250          251          252
## -2.816580889 -1.783984288 -2.649279727 -2.044954241 -1.526255127 -2.654160012
##          253          254          255          256          257          258
## -2.326367866 -3.030996026 -1.660160554 -1.990158036 -1.354499716 -2.442157204
##          259          260          261          262          263          264
## -1.288038137 -1.960705214 -2.078446058 -1.241909016 -1.775642180 -3.205592394
##          265          266          267          268          269          270
## -2.313358344 -0.872825198 -2.040939976 -0.737669201 -0.865463297 -2.680823456
##          271          272          273          274          275          276
## -2.098665619 -1.366834610 -2.734326940 -0.401542933 -1.193520140 -3.141968438
##          277          278          279          280          281          282
## -2.905720561 -2.923092060 -1.487829276 -1.263973680 -2.248204229 -0.948794159
##          283          284          285          286          287          288
## -3.078825842 -2.593333765 -2.508929875 -2.028513642 -0.888351559 -2.112351545
##          289          290          291          292          293          294

```

```

## -1.254059232 -0.339226311 -2.082484761 -2.527745124 -0.480239297 -2.487582708
##          295          296          297          298          299          300
## -2.181594109 -1.340661453 -2.944620327 -3.463767890 -3.559586304 -1.570135100
##          301          302          303          304          305          306
## -2.147843390 -2.073336000 -2.921976868 -2.081295996 -3.335498308 -2.455722335
##          307          308          309          310          311          312
## -1.903107625 -1.827949285 -0.356738948 -2.926975405 -1.923967176 -0.911425188
##          313          314          315          316          317          318
## -2.572857162 -2.544490690 -2.390459782 -3.580702347  0.058433791 -2.738809385
##          319          320          321          322          323          324
## 1.700997918 -1.989876248 -2.432638220 -2.662171726 -2.788474837 -2.273701716
##          325          326          327          328          329          330
## -2.807635904 -2.064160727 -1.319195217 -1.209680013 -2.232574985 -0.579288963
##          331          332          333          334          335          336
## -1.702503560 -1.048380257 -1.844344808 -1.776032927 -1.451008769 -1.682588484
##          337          338          339          340          341          342
## -0.760122378 -1.584057879 -0.852490557 -2.571630724 -2.079710413  1.213793629
##          343          344          345          346          347          348
## -2.477948007 -2.556727011 -2.680681614 -1.834655915 -2.315186621 -2.334083948
##          349          350          351          352          353          354
## -1.144626440 -2.037089205 -2.390335902  0.549240839 -1.364578969 -1.423736993
##          355          356          357          358          359          360
## -0.990159331 -1.392140732 -2.419835793 -0.779427898 -3.346305354 -2.941787805
##          361          362          363          364          365          366
## -2.019386772 -2.716227238 -0.993066336 -1.440681695 -0.503403030 -2.984496930
##          367          368          369          370          371          372
## -1.669251518 -2.785728556  0.531948817 -2.777938664 -0.699112948 -2.583743158
##          373          374          375          376          377          378
## -0.708067115 -2.167091297 -2.730629306 -2.431707680 -2.628497411 -2.324513353
##          379          380          381          382          383          384
## -1.719824460 -2.784289383 -2.158204245 -0.373060456 -2.853106863 -1.515468607
##          385          386          387          388          389          390
## -1.578066798 -2.707126186 -3.326663520 -2.512317106 -1.334104849 -3.071927300
##          391          392          393          394          395          396
## -2.611156825 -2.269813303 -3.597874362 -2.966099233 -2.098467549 -2.926679638
##          397          398          399          400          401          402
## -0.653474079 -0.347189686 -2.787838345 -2.016359284 -1.183833338 -4.127714884
##          403          404          405          406          407          408
## -2.259569141 -2.525770941 -2.874114097 -2.246343286 -1.174457198 -2.214113365
##          409          410          411          412          413          414
## -0.517338405 -2.248909750 -3.298264952 -2.382773555 -2.831273693 -0.830259135
##          415          416          417          418          419          420
## 1.234259526 -0.670511182 -2.602275499 -3.577132253 -3.181497959 -2.207286352
##          421          422          423          424          425          426
## -2.898417537 -1.175532418 -2.749780480 -1.726742951  1.323929616 -0.707284056
##          427          428          429          430          431          432
## -2.160044599 -2.351209072 -0.850294298 -1.360093237 -1.771362612 -2.742019554
##          433          434          435          436          437          438
## -0.412066097 -1.716596652 -2.329998207 -3.136467114 -0.898261540 -1.715151055
##          439          440          441          442          443          444
## -2.758411190 -0.741172351 -2.139125957 -2.459022213 -2.478893198 -0.719527973
##          445          446          447          448          449          450
## -2.829889451 -2.816973244 -2.597251908 -3.533274076 -0.941328016 -2.577385138
##          451          452          453          454          455          456

```

```

## -2.470288778 -2.713510345 -3.339836995 -0.380615907  0.220062402 -1.566632057
##      457          458          459          460          461          462
## -1.791295004  0.867112653 -3.481864288 -2.918080148 -2.217454902 -2.812245810
##      463          464          465          466          467          468
## -2.311432826 -1.829433890 -2.196020142 -2.865496125 -1.424247105 -2.395965680
##      469          470          471          472          473          474
## -2.460803257 -2.513950736 -2.468497803 -2.294570029 -1.850604001 -3.132587063
##      475          476          477          478          479          480
## -0.090635998 -2.711756220 -1.466295254  0.055542305 -2.530679711 -2.830018258
##      481          482          483          484          485          486
## -1.738811082 -3.429259439 -1.321745174 -2.848785854 -0.860472543 -2.279644442
##      487          488          489          490          491          492
## -0.020134280 -2.558343912 -2.687617921 -2.344014943 -2.795632635 -2.005353388
##      493          494          495          496          497          498
## -2.394255217 -2.920436287 -0.322636577 -3.630824315 -3.442187381 -3.492193170
##      499          500          501          502          503          504
## -2.094826345 -1.340538320 -1.859417552 -2.244259664 -2.658134206 -2.915923597
##      505          506          507          508          509          510
## -1.668190259 -2.018420728 -1.226807664 -1.862393965 -2.040144745 -2.227552370
##      511          512          513          514          515          516
## -1.970738373 -2.851219195 -3.334314757 -2.306087856 -1.925361482 -3.435024621
##      517          518          519          520          521          522
## -2.662603438  0.021293571 -0.534976968 -1.980010891 -2.136214481 -2.132858944
##      523          524          525          526          527          528
## -3.473446019 -1.770241812 -2.319638401 -2.238663275 -2.111132812 -2.796958942
##      529          530          531          532          533          534
## -0.330002527 -2.733860939 -2.506356162 -2.175108223 -2.793252890  0.620346834
##      535          536          537          538          539          540
## -2.659559322 -3.041037700 -1.805498017 -0.836601233 -0.628421382 -2.064586314
##      541          542          543          544          545          546
## -2.424340573 -2.380969628 -0.022692511 -0.375503904 -0.483642991 -2.212637902
##      547          548          549          550          551          552
## -1.492388605 -2.322614298 -1.253211331 -2.903890662 -1.911275279 -1.935871836
##      553          554          555          556          557          558
## -2.313582599 -3.741753590 -2.221118927 -1.809596264 -2.745130200 -2.910449310
##      559          560          561          562          563          564
## -2.510772740 -3.570485371 -1.618609421 -2.118105376 -1.322668181 -3.292756389
##      565          566          567          568          569          570
## -1.850059775 -2.518441190 -2.708788916 -1.145411043 -2.376729322 -1.475844760
##      571          572          573          574          575          576
## -3.208472693 -2.417291165 -1.718328455 -2.557352714 -1.188393237 -2.205534921
##      577          578          579          580          581          582
## -2.324419026 -2.913509528 -2.048424893 -2.769189722 -1.577327873 -2.040841165
##      583          584          585          586          587          588
## -3.246154278 -1.973429244 -2.398752846 -1.892316306 -2.470455052 -1.135834726
##      589          590          591          592          593          594
## -2.334222082 -0.196430022 -2.644179830 -2.856224625 -0.566756841 -2.963272909
##      595          596          597          598          599          600
## -2.764035759 -2.463200141 -2.280333921 -1.317671179 -2.160717697 -3.095604710
##      601          602          603          604          605          606
## -1.190510811 -2.868317066 -1.423429794 -2.821177129  1.290184911 -1.330477156
##      607          608          609          610          611          612
## -2.782056262 -0.796297286 -2.198480956 -1.368541887 -1.546059369 -2.137885376
##      613          614          615          616          617          618

```

```

## -1.987457390 -3.431353102 -3.167971675 -1.413187327 -2.907316462 -2.659713849
##       619          620          621          622          623          624
## -1.202426524 -1.275610513 -2.633360451 -2.283740260 -2.669920892 -3.034938283
##       625          626          627          628          629          630
## -0.981351569 -2.294824273 -2.506648244 -1.538118362 -3.088819182 -2.772505077
##       631          632          633          634          635          636
## -2.514938120 -1.293552650 -1.401029352 -2.328912054 -2.403379446 -2.613086953
##       637          638          639          640          641          642
## -2.118788758  2.128221060 -1.824967045 -2.586771664 -3.133842311  0.556682471
##       643          644          645          646          647          648
## -2.372750750 -1.538205693 -1.612563006 -2.149400452 -1.320643288 -2.524850996
##       649          650          651          652          653          654
## -2.110125766 -2.182096194 -1.822484561 -2.704078256 -2.498762088 -1.119527253
##       655          656          657          658          659          660
## -0.506115344 -2.781401479 -2.855949284 -2.074685238 -2.118157789 -2.828819276
##       661          662          663          664          665          666
## -2.372617574 -2.906018506 -2.955187524 -3.417117105 -2.146890387 -3.510051136
##       667          668          669          670          671          672
## -2.314187199 -2.439368845 -2.781190057 -1.964069130 -0.402746478 -2.012324553
##       673          674          675          676          677          678
## -2.774283656 -0.856298407 -1.430514049 -1.377557042 -1.780600662  0.547882669
##       679          680          681          682          683          684
## -1.986855278 -3.306418816 -3.000758502 -2.336921197 -1.761074253 -1.658840869
##       685          686          687          688          689          690
## -1.900542452 -1.655189817 -1.736672024 -2.498651130 -0.004626382 -2.210991169
##       691          692          693          694          695          696
## -1.971362282  0.641864035 -2.373305010 -2.499465580 -2.149840456 -1.189226153
##       697          698          699          700          701          702
## -0.912723930 -2.312239973 -2.468821333 -2.242511383 -0.761426073 -2.156698468
##       703          704          705          706          707          708
## -3.178555474 -2.888264704  0.861969290 -3.385516341 -1.591160868 -1.962510383
##       709          710          711          712          713          714
## -2.387554333 -2.435947855 -3.828746606 -2.876317359 -2.205539776 -2.527392930
##       715          716          717          718          719          720
## -1.956379662 -2.928031772 -3.068644156 -0.844194607 -1.225382016 -2.460636766
##       721          722          723          724          725          726
## -2.052687764 -1.215735081 -2.722544357 -1.610836269 -3.303653767 -2.655976096
##       727          728          729          730          731          732
##  0.320380948 -1.184216175 -2.933853930 -0.728144797 -2.264049921 -2.330269430
##       733          734          735          736          737          738
## -2.672099089 -3.592751872 -2.052414029  0.246339401 -2.427440341 -2.527893518
##       739          740          741          742          743          744
## -2.756543111 -2.486589341 -2.757312311 -1.364352370 -1.967947652 -3.219397644
##       745          746          747          748          749          750
## -2.572453119 -1.517209848 -2.575755795 -3.336932490 -2.270507603 -1.292863232
##       751          752          753          754          755          756
## -1.494310152 -2.324739088 -2.486795550 -2.553269704 -2.544909658 -0.883035238
##       757          758          759          760          761          762
## -1.990155602 -2.533732322 -1.995266470 -2.364988216 -3.512226553 -1.584997344
##       763          764          765          766          767          768
## -2.079492858 -2.666045030 -3.055543519 -1.671752047 -1.028457512 -2.366774707
##       769          770          771          772          773          774
## -2.116099755 -2.091509167 -1.991930732 -2.766600640 -2.621260068 -1.599400753
##       775          776          777          778          779          780

```

```

## -2.843685414 -2.894224478 -2.078008102 -0.526019835 -0.862854899 -1.729430526
##      781      782      783      784      785      786
## -2.995974370 -1.929246760 -1.677450857 -2.787435237 -1.174260693 -2.285720959
##      787      788      789      790      791      792
## -1.839551297 -1.919156177 -2.815079092 -1.450495002 -1.290106486 -2.754389265
##      793      794      795      796      797      798
## -2.167257571 -2.464066361 -1.972565858 -2.628250815 -1.813771751 -2.274966906
##      799      800      801      802      803      804
## -2.782513264 -2.361944342 -2.138166285  1.468831484 -1.853984797 -2.512389497
##      805      806      807      808      809      810
## -2.921026540 -2.274492176 -1.690687844 -2.605071396 -1.866010553 -2.490481321
##      811      812      813      814      815      816
## -1.969098562 -1.236700847 -2.379416268 -0.868183117 -1.547089255 -1.225629500
##      817      818      819      820      821      822
## -3.020786558 -1.276397901 -1.626987490 -2.901471371 -2.160362580 -1.884520864
##      823      824      825      826      827      828
##  0.302974162 -2.832496682 -1.615857553 -2.073955711 -3.058749046  0.005627584
##      829      830      831      832      833      834
## -1.035962647 -2.145154605 -1.215360504 -0.918915663 -3.405667900 -1.061968611
##      835      836      837      838      839      840
## -3.544700556 -2.253824933 -1.913136861 -2.102027197 -3.702739165 -1.248396890
##      841      842      843      844      845      846
## -1.713738353 -2.626934358 -2.918357668 -0.983366940 -1.246880775 -1.092612617
##      847      848      849      850      851      852
## -1.363773260  0.270120498 -0.842547994 -2.610950649  0.474975214 -3.382278036
##      853      854      855      856      857      858
## -2.971328980 -1.421085416  0.202768475 -2.119277572 -2.848663743 -2.097817848
##      859      860      861      862      863      864
##  0.908974642  0.811360039  0.401582984 -3.050334152 -2.696327030 -2.204228850
##      865      866      867      868      869      870
## -2.308387216 -2.617675704 -2.604575192 -2.233422517 -0.685913899 -1.027482416
##      871      872      873      874      875      876
## -1.253687432 -2.066575015 -3.530079192 -1.937392009 -1.792848656 -1.360811309
##      877      878      879      880      881      882
## -2.290881108 -2.671810455 -3.160099933 -2.598255415 -1.245397774  0.573872351
##      883      884      885      886      887      888
## -2.601890068 -1.927075386 -2.867294581 -0.649127521 -2.436934645 -2.144712774
##      889      890      891      892      893      894
## -3.258217901  0.246122206 -2.901173338 -1.179439280 -2.916247973 -2.971801325
##      895      896      897      898      899      900
## -2.537380637 -1.661844314 -2.826900205 -1.050452772 -2.365490706 -1.186130555
##      901      902      903      904      905      906
## -1.789093083 -1.162602580 -1.036760395 -0.456841553 -2.417623682 -3.127865486
##      907      908      909      910      911      912
## -3.195031391 -2.064468137 -2.711547220 -1.953348402 -2.152373138 -1.895712440
##      913      914      915      916      917      918
## -1.672138175 -2.766132724 -0.990661786 -0.613320519 -2.079448723 -2.197002632
##      919      920      921      922      923      924
## -1.314429930 -1.750259217 -1.786103165 -2.177758554 -1.764545600 -2.187779690
##      925      926      927      928      929      930
## -0.764407060 -2.803149852 -0.383960249 -1.678248638 -1.952678266 -2.917554465
##      931      932      933      934      935      936
## -2.066975722 -1.942621493 -2.044589609 -2.638644890 -2.281726351 -3.165039718
##      937      938      939      940      941      942

```

```

## -2.200223503 -1.128666271 -1.957409778 -1.413780410  0.648532312 -2.455195103
##          943         944         945         946         947         948
## -2.799500892 -2.803780971  0.430587228 -0.701137631 -1.673607260 -2.763290476
##          949         950         951         952         953         954
## -1.389738887  0.384573327 -2.111588088 -3.445029771 -2.971112934 -0.701756458
##          955         956         957         958         959         960
## -2.480424431 -2.672545559 -1.442627460 -1.693219451 -2.171322579 -2.199840426
##          961         962         963         964         965         966
## -1.919765962 -2.724084779  1.014278282 -3.203379195 -1.072150674 -2.062672809
##          967         968         969         970         971         972
## -2.486069950 -2.406529245 -3.392717619 -2.086898538 -2.807307944 -1.119637641
##          973         974         975         976         977         978
## -2.626474903 -0.808795054 -1.812489807 -1.516137138 -1.633277987 -1.258232767
##          979         980         981         982         983         984
## -3.113201844 -2.277332919 -1.675241817 -0.951047714 -2.201372918 -1.803064073
##          985         986         987         988         989         990
## -1.109411488 -1.358600451 -0.942964810 -0.024500382 -2.427639151 -2.794193710
##          991         992         993         994         995         996
## -2.661657592 -3.062395181 -2.294558836 -2.118852710 -1.297789659 -2.168730248
##          997         998         999        1000        1001        1002
## -2.860887697 -3.045044922 -2.927620316  0.737707400 -2.291795772 -3.445437774
##          1003        1004        1005        1006        1007        1008
## -2.438267736 -1.654575685 -0.937160376 -2.113532422 -3.315154286 -1.821794514
##          1009        1010        1011        1012        1013        1014
## -1.693675117 -1.925855722 -0.639820519 -1.241302541 -1.932924669 -2.132513002
##          1015        1016        1017        1018        1019        1020
## -1.245377504 -2.277118703 -2.251850727 -1.730521744 -1.702901756 -3.012960863
##          1021        1022        1023        1024        1025        1026
## -2.667943457 -3.305712325 -1.267733641 -2.103786632 -1.682082724 -2.011041542
##          1027        1028        1029        1030        1031        1032
## -2.399831173 -2.378224162 -1.324795607 -1.750235064  1.129816359 -2.149033653
##          1033        1034        1035        1036        1037        1038
## -2.353068879 -2.664856139 -2.414983691 -1.751590188 -3.712473143 -2.020487244
##          1039        1040        1041        1042        1043        1044
## -1.965203258 -2.937810769 -0.738044018 -0.287917033 -3.959095580 -2.377815695
##          1045        1046        1047        1048        1049        1050
## -2.605179762 -2.559636420 -1.201078011 -2.809294656 -2.535320526 -2.818519690
##          1051        1052        1053        1054        1055        1056
## -0.299997419 -1.819417540 -1.848487349 -3.179003804 -1.685019425 -2.080048676
##          1057        1058        1059        1060        1061        1062
## -1.236725233 -0.784903399 -1.642374815 -1.251522220 -2.628519143 -2.512862927
##          1063        1064        1065        1066        1067        1068
## -1.855778850 -1.685086295 -2.667892976 -2.103391005 -3.563483145 -2.107573227
##          1069        1070        1071        1072        1073        1074
## -2.396263443 -0.976922967 -1.141182829 -2.802065411 -1.264935107 -0.426319184
##          1075        1076        1077        1078        1079        1080
## -2.806450316 -1.747382660 -1.030626803 -2.545551208 -3.032583653 -1.842632996
##          1081        1082        1083        1084        1085        1086
## -2.815225686 -0.411835828 -1.984901425 -1.900745002 -2.673568544 -3.129737197
##          1087        1088        1089        1090        1091        1092
## -2.613930461 -2.486216563 -1.204622949 -2.928439836 -2.661816654 -2.750969733
##          1093        1094        1095        1096        1097        1098
## -0.158399770 -2.933465267 -2.961279167 -2.781803748 -2.330231083 -2.733802654
##          1099       1100       1101       1102       1103       1104

```

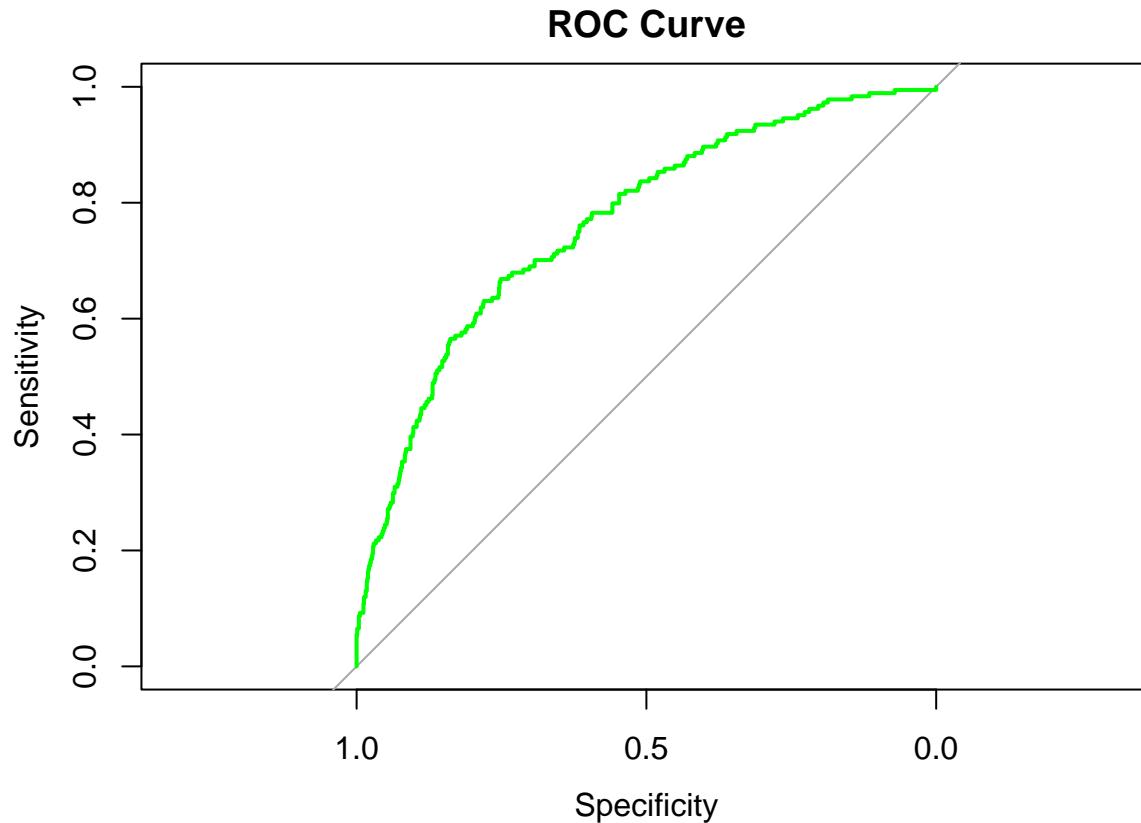
```

## -1.245580118 -1.252742195 -2.598503037 -2.531744601 -1.372660556 -2.386039627
##      1105      1106      1107      1108      1109      1110
## -0.288710671 -1.215919435 -2.670821242 -2.700760552 -3.049092410 -3.142808467
##      1111      1112      1113      1114      1115      1116
## -1.133579314 -1.225617686 -2.770108364  0.578059647 -0.911750707 -1.300121888
##      1117      1118      1119      1120      1121      1122
##  1.201460130 -3.151530615 -2.861164119 -2.989595119 -3.233582295 -0.619768592
##      1123      1124      1125      1126      1127      1128
## -2.076526173 -3.261057178 -1.196183396 -2.183740024 -3.309910819 -3.233462529
##      1129      1130      1131      1132      1133      1134
## -2.923709926 -2.242310263 -3.338659927 -1.774727364 -1.469147192 -2.124041056
##      1135      1136      1137      1138      1139      1140
## -2.927358491 -2.470371267 -1.151863655 -2.654974363 -1.622203727 -2.534291652
##      1141      1142      1143      1144      1145      1146
## -0.348272354 -2.544230645 -3.236832560 -1.184176177 -1.954314101 -1.920564928
##      1147      1148      1149      1150      1151      1152
## -0.220694455 -3.015907842 -2.988362236 -2.413667457 -2.509185521 -1.850707650
##      1153      1154      1155      1156      1157      1158
## -2.834786748 -2.833292949 -2.593057215 -0.669234444 -2.574011869 -2.782814061
##      1159      1160      1161      1162      1163      1164
## -2.758622656 -2.582166734 -2.555761669 -1.347830469 -2.731267737 -2.296763719
##      1165      1166      1167      1168      1169      1170
## -1.768073394 -2.353498845 -2.383222843 -0.450354539 -1.682934246 -1.675174100
##      1171      1172      1173      1174      1175      1176
## -2.505728080 -0.752267367 -2.076668170 -1.627750408 -1.607098359 -3.350138809
##      1177      1178      1179      1180      1181      1182
## -3.179999536 -0.285095558 -2.332917561 -2.067042170 -2.313119178 -2.181683319
##      1183      1184      1185      1186      1187      1188
## -3.593241629 -2.900870233  0.012690426 -1.371981849 -0.074778109 -1.488287029
##      1189      1190      1191      1192      1193      1194
## -2.261948654 -1.175927868 -1.838741465 -1.786747999 -0.961540462 -2.312883658
##      1195      1196      1197      1198      1199      1200
## -0.633823498 -1.193416643 -0.254615390 -2.428233192 -0.214350417 -2.725521912
##      1201      1202      1203      1204      1205      1206
## -2.819536916 -1.650846235 -3.080084113 -0.804600134 -1.931002781 -1.072325643

roc_curve_forward_2 <- roc(response = as.matrix(test_data$status), predictor = as.numeric(predictions_f
auc(roc_curve_forward_2)

## Area under the curve: 0.7643
#plot the roc curve
plot(roc_curve_forward_2, main = "ROC Curve", col = "green")

```



```
check_collinearity(forward_model_2)
```

```
## # Check for Multicollinearity
##
## Low Correlation
##
##           Term   VIF   VIF 95% CI Increased SE Tolerance
##       n_stage 4.17 [3.95, 4.40]      2.04     0.24
##   progesterone_status 1.43 [1.38, 1.49]      1.20     0.70
##           differentiate 1.11 [1.08, 1.16]      1.05     0.90
##   node_positive_prop 4.37 [4.14, 4.62]      2.09     0.23
##           race 1.06 [1.03, 1.11]      1.03     0.94
##           age 1.11 [1.07, 1.15]      1.05     0.90
##   estrogen_status 1.48 [1.42, 1.54]      1.22     0.68
##           tumor_size 1.09 [1.06, 1.14]      1.05     0.91
## regional_node_examined 3.41 [3.23, 3.59]      1.85     0.29
##           marital_status 1.13 [1.09, 1.17]      1.06     0.89
## Tolerance 95% CI
##       [0.23, 0.25]
##       [0.67, 0.73]
##       [0.86, 0.93]
##       [0.22, 0.24]
##       [0.90, 0.97]
##       [0.87, 0.93]
##       [0.65, 0.70]
##       [0.88, 0.94]
```

```

##      [0.28, 0.31]
##      [0.85, 0.91]
##
## Moderate Correlation
##
##           Term VIF   VIF 95% CI Increased SE Tolerance
## reginol_node_positive 7.32 [6.92, 7.76]          2.71     0.14
## Tolerance 95% CI
##      [0.13, 0.14]

cv_model <- train(status ~ n_stage + progesterone_status + differentiate + node_positive_prop + race + age + tumor_size + marital_statusMarried + marital_statusSeparated + reginol_node_positive, data = breast_cancer, method = "glmnet", family = "binomial")

cv_model$finalModel

##
## Call:  NULL
##
## Coefficients:
##                               (Intercept)                                n_stageN2
##                                         -3.752296                               0.406197
##                               n_stageN3                                progesterone_statusNegative
##                                         0.444508                               0.570745
## 'differentiatePoorly differentiated'                                differentiateUndifferentiated
##                                         0.422756                               1.049159
## 'differentiateWell differentiated'                                 node_positive_prop
##                                         -0.591706                               0.715977
##                               raceBlack                                raceOther
##                                         0.508269                               -0.446691
##                               age                                estrogen_statusNegative
##                                         0.020502                               0.740192
##                               tumor_size                                regional_node_examined
##                                         0.005541                               -0.014100
## marital_statusMarried                                marital_statusDivorced
##                                         -0.184001                               0.196259
## marital_statusSeparated                                marital_statusWidowed
##                                         0.413136                               -0.130717
## reginol_node_positive
##                                         0.055452

##
## Degrees of Freedom: 2817 Total (i.e. Null);  2799 Residual
## Null Deviance:      2414
## Residual Deviance: 2083  AIC: 2121

print(cv_model)

## Generalized Linear Model
##
## 2818 samples
##   11 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 2536, 2537, 2537, 2536, 2535, 2537, ...
## Resampling results:
```

```

## Accuracy Kappa
## 0.8569918 0.1948568

```

Comment

The model's performance was evaluated using 10-fold cross-validation.

```

# Calculate AUC for the "White" group
tmp1 = roc(breastcancer_clean$status[breastcancer_clean$race == "White"], predictions_forward_2[breastcancer_clean$race == "White"])
white_auc = tmp1$auc

# Calculate AUC for the "Black" group
tmp2 = roc(breastcancer_clean$status[breastcancer_clean$race == "Black"], predictions_forward_2[breastcancer_clean$race == "Black"])
black_auc = tmp2$auc

# Calculate AUC for the "Other" group
tmp3 = roc(breastcancer_clean$status[breastcancer_clean$race == "Other"], predictions_forward_2[breastcancer_clean$race == "Other"])
other_auc = tmp3$auc

# Calculate AUC for the "Positive Progesterone Status" group
tmp4 = roc(breastcancer_clean$status[breastcancer_clean$progesterone_status == "Positive"], predictions_forward_2[breastcancer_clean$progesterone_status == "Positive"])
positive_auc = tmp4$auc

# Calculate AUC for the "Negative Progesterone Status" group
tmp5 = roc(breastcancer_clean$status[breastcancer_clean$progesterone_status == "Negative"], predictions_forward_2[breastcancer_clean$progesterone_status == "Negative"])
negative_auc = tmp5$auc

```

Discussion

AIC of backward selection is 2992.2 compared to AIC = 2996.4 for forward selection. The difference in AIC is approximately 4 for the backward and forward selection models. This difference suggests less support for the model with higher AIC. The forward model is slightly more complex than the backward model. In addition, the backward selection model is a nested version of the forward selection model.

LASSO

```

#split the data
set.seed(123)
breastcancer_test = breastcancer_clean |>
  dplyr::select(-survival_months)
split <- createDataPartition(breastcancer_test$status, p = .7, list = FALSE)
train_data <- breastcancer_test[split, ]
test_data <- breastcancer_test[-split, ]

X <- as.matrix(train_data[, -which(names(train_data) == "status")])
y <- train_data$status

set.seed(123)
lasso_model <- glmnet(X, y, alpha = 1, family = "binomial")

#determine the best lambda
cv_lasso <- cv.glmnet(X, y, alpha = 1, family = "binomial", type.measure = "auc")
best_lambda <- cv_lasso$lambda.min

```

```

best_coefs <- coef(cv_lasso, s = best_lambda)

# prediction
test_data1 = test_data |> dplyr::select(-status)
predictions <- predict(cv_lasso, newx = as.matrix(test_data1), s = best_lambda, type = "response")

```

Evaluating the LASSO Model

```

library(pROC)

# For logistic regression, convert log-odds to probabilities
probabilities <- exp(predictions) / (1 + exp(predictions))

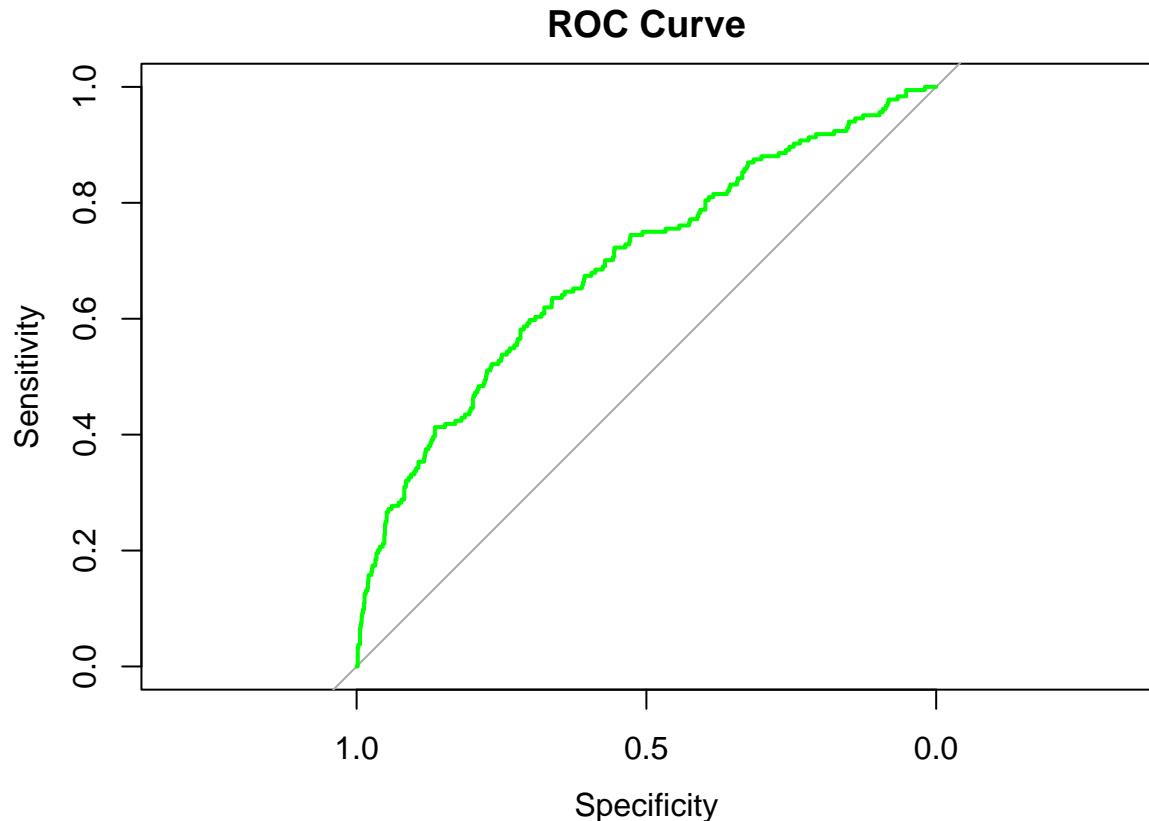
roc_curve <- roc(response = as.matrix(test_data$status), predictor = as.numeric(probabilities) )

# auc
auc(roc_curve)

## Area under the curve: 0.6916
#plot the roc curve

plot(roc_curve, main = "ROC Curve", col = "green")

```



```

### Comment
AUC = 0.6916 Only 4 predictors

```

Ridge Regression

```
set.seed(123)
ridge_model <- glmnet(X, y, alpha = 0, family = "binomial")

#determine the best lambda
cv_ridge <- cv.glmnet(X, y, alpha = 0, family = "binomial", type.measure = "auc")
best_ridge_lambda <- cv_ridge$lambda.min

best_ridge_coefs <- coef(cv_ridge, s = best_ridge_lambda)

# prediction
test_data1 = test_data|> dplyr::select(-status)
prediction_ridge <- predict(cv_ridge, newx = as.matrix(test_data1), s = best_ridge_lambda, type = "response")
```

Evaluating the Ridge Model

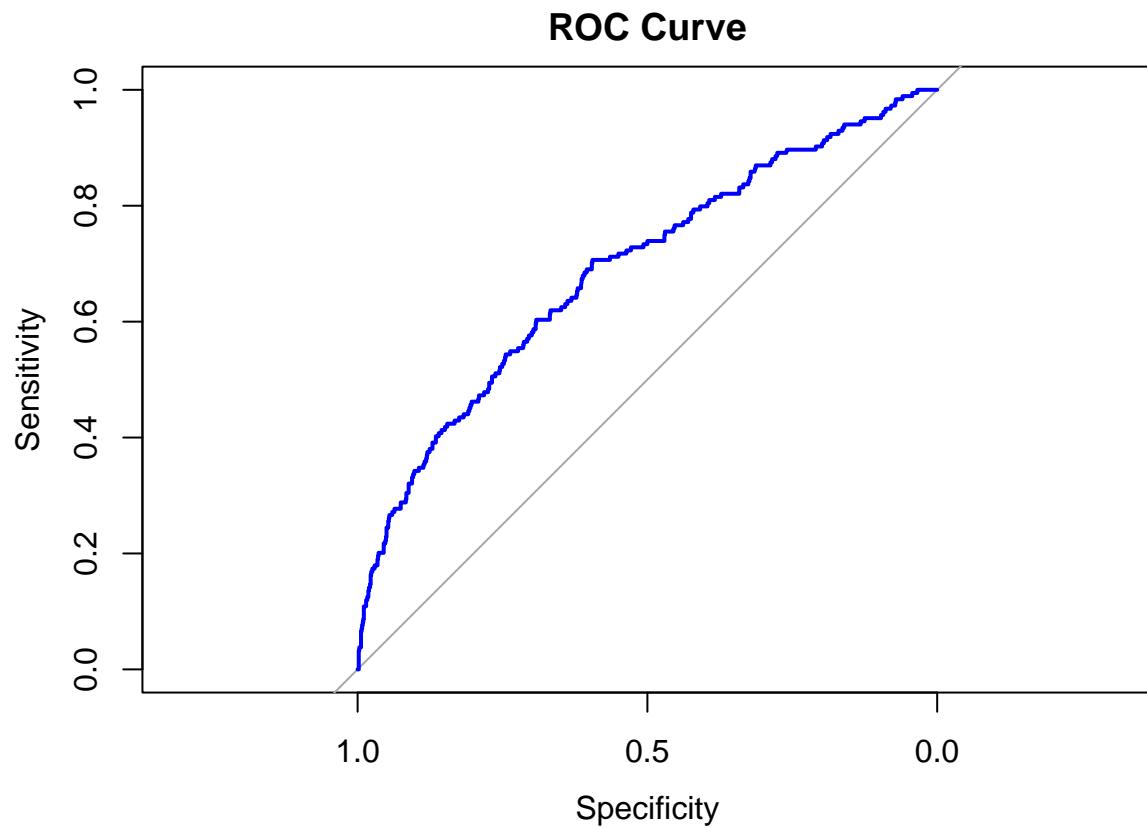
```
# For logistic regression, convert log-odds to probabilities
prob_ridge <- exp(prediction_ridge) / (1 + exp(prediction_ridge))

roc_curve_ridge <- roc(response = as.matrix(test_data$status), predictor = as.numeric(prob_ridge) )

# auc
auc(roc_curve_ridge)

## Area under the curve: 0.6897
#plot the roc curve

plot(roc_curve_ridge, main = "ROC Curve", col = "blue")
```



Comment

AUC = 0.6897 Takes 5 predictors into consideration.