Machine learning - Assignment 6

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## Setup

Loading the necessary packages for data cleaning, modeling, partitioning, nhanes interface, and classification.

Comparison between Classification Trees, SVM and Logistic Regression

The posted article by Yu et al utilized NHANES data from 1999-2004 to predict diabetes and pre-diabetes using Support Vector Machines. You will conduct a similar analysis using data within the NHANES package in R. For this exercise, you will try to predict Diabetes using similar (although not all) variables. The available data is also slightly different, so you likely won’t get the same answers.

## Number 1: Loading NHANES, Restricting and Partitioning

Restrict the NHANES data to the list of 12 variables below. Partition the data into training and testing using a 70/30 split.

“Age”, “Gender”, “Race1”, “Education”, “HHIncome” (DEMO), “Weight”, “Height” (BMXBMI), “Pulse” (BPX), “Diabetes” (DIQ), “BMI” (BMXBMI), “PhysActive”, “Smoke100” (SMQ)

# Loading  
demo\_99 = nhanes\_load\_data("DEMO", "1999-2000")

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.  
## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.  
## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Downloading DEMO.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/DEMO.XPT

demo\_01 = nhanes\_load\_data("DEMO", "2001-2002")

## Downloading DEMO\_B.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/DEMO\_B.XPT

demo\_03 = nhanes\_load\_data("DEMO", "2003-2004")

## Downloading DEMO\_C.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/DEMO\_C.XPT

bmx\_99 = nhanes\_load\_data("BMX", "1999-2000")

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

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## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Downloading BMX.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/BMX.XPT

bmx\_01 = nhanes\_load\_data("BMX", "2001-2002")

## Downloading BMX\_B.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/BMX\_B.XPT

bmx\_03 = nhanes\_load\_data("BMX", "2003-2004")

## Downloading BMX\_C.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/BMX\_C.XPT

bpx\_99 = nhanes\_load\_data("BPX", "1999-2000")

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.  
## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Downloading BPX.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/BPX.XPT

bpx\_01 = nhanes\_load\_data("BPX", "2001-2002")

## Downloading BPX\_B.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/BPX\_B.XPT

bpx\_03 = nhanes\_load\_data("BPX", "2003-2004")

## Downloading BPX\_C.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/BPX\_C.XPT

paq\_99 = nhanes\_load\_data("PAQ", "1999-2000")

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.  
## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Downloading PAQ.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/PAQ.XPT

paq\_01 = nhanes\_load\_data("PAQ", "2001-2002")

## Downloading PAQ\_B.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/PAQ\_B.XPT

paq\_03 = nhanes\_load\_data("PAQ", "2003-2004")

## Downloading PAQ\_C.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/PAQ\_C.XPT

diq\_99 = nhanes\_load\_data("DIQ", "1999-2000")

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.  
## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Downloading DIQ.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/DIQ.XPT

diq\_01 = nhanes\_load\_data("DIQ", "2001-2002")

## Downloading DIQ\_B.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/DIQ\_B.XPT

diq\_03 = nhanes\_load\_data("DIQ", "2003-2004")

## Downloading DIQ\_C.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/DIQ\_C.XPT

smq\_99 = nhanes\_load\_data("SMQ", "1999-2000")

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.  
## Cycle 1999-2000 doesn't always follow the normal naming conventions, so skipping the file suffix check.

## Downloading SMQ.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/SMQ.XPT

smq\_01 = nhanes\_load\_data("SMQ", "2001-2002")

## Downloading SMQ\_B.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/SMQ\_B.XPT

smq\_03 = nhanes\_load\_data("SMQ", "2003-2004")

## Downloading SMQ\_C.XPT to /var/folders/5j/2zqbq7jx49g71545t3lq5bfh0000gn/T//RtmpOMOu3p/SMQ\_C.XPT

# Joining  
data\_99 =   
 left\_join(demo\_99, bmx\_99, by = "SEQN") %>%   
 left\_join(bpx\_99, by = "SEQN") %>%   
 left\_join(paq\_99, by = "SEQN") %>%   
 left\_join(diq\_99, by = "SEQN") %>%   
 left\_join(smq\_99, by = "SEQN") %>%   
 select("SEQN", "RIDAGEYR", "RIAGENDR", "RIDRETH1", "DMDEDUC2", "INDHHINC", "BMXBMI", "BMXHT", "BMXWT", "BPXPLS", "DIQ010", "PAQ180", "SMQ020")   
  
data\_01 =   
 left\_join(demo\_01, bmx\_01, by = "SEQN") %>%   
 left\_join(bpx\_01, by = "SEQN") %>%   
 left\_join(paq\_01, by = "SEQN") %>%   
 left\_join(diq\_01, by = "SEQN") %>%   
 left\_join(smq\_01, by = "SEQN") %>%   
 select("SEQN", "RIDAGEYR", "RIAGENDR", "RIDRETH1", "DMDEDUC2", "INDHHINC", "BMXBMI", "BMXHT", "BMXWT", "BPXPLS", "DIQ010", "PAQ180", "SMQ020")   
  
data\_03 =   
 left\_join(demo\_03, bmx\_03, by = "SEQN") %>%   
 left\_join(bpx\_03, by = "SEQN") %>%   
 left\_join(paq\_03, by = "SEQN") %>%   
 left\_join(diq\_03, by = "SEQN") %>%   
 left\_join(smq\_03, by = "SEQN") %>%   
 select("SEQN", "RIDAGEYR", "RIAGENDR", "RIDRETH1", "DMDEDUC2", "INDHHINC", "BMXBMI", "BMXHT", "BMXWT", "BPXPLS", "DIQ010", "PAQ180", "SMQ020")   
  
final\_data = bind\_rows(data\_99, data\_01, data\_03) %>%   
 janitor::clean\_names() %>%   
 filter(diq010 %in% c(1,2)) %>%   
 mutate(diq010 = as.factor(diq010),   
 riagendr = as.factor(riagendr),   
 ridreth1 = as.factor(ridreth1),   
 dmdeduc2 = as.factor(dmdeduc2),   
 indhhinc = as.factor(indhhinc),   
 paq180 = as.factor(paq180),   
 smq020 = as.factor(smq020)) %>%   
 drop\_na()

Partitioning:

training\_data = final\_data$diq010 %>% createDataPartition(p = 0.7, list = F)  
train\_data = final\_data[training\_data, ]  
test\_data = final\_data[-training\_data, ]

## Number 2: Prediction Models

Construct three prediction models to predict diabetes using the 11 features from NHANES. You will use the following three algorithms to create your prediction models:

1. Classification Tree
2. Support Vector Classifier (i.e. Support Vector Machine with a linear classifier)
3. Logistic regression.

### Classification Tree

train\_control = trainControl(method = "cv", number = 10)  
grid\_2 = expand.grid(cp = seq(0.0001, 0.011, by = 0.0001))  
tree\_diabetes = train(diq010 ~., data = train\_data, method = "rpart", trControl = train\_control, tuneGrid = grid\_2)  
tree\_diabetes$bestTune

## cp  
## 50 0.005

tree\_diabetes

## CART   
##   
## 8244 samples  
## 12 predictor  
## 2 classes: '1', '2'   
##   
## No pre-processing  
## Resampling: Cross-Validated (10 fold)   
## Summary of sample sizes: 7419, 7420, 7419, 7420, 7420, 7420, ...   
## Resampling results across tuning parameters:  
##   
## cp Accuracy Kappa   
## 0.0001 0.8719045 0.129358789  
## 0.0002 0.8725110 0.129250554  
## 0.0003 0.8749381 0.131635211  
## 0.0004 0.8767579 0.128640004  
## 0.0005 0.8779710 0.126481540  
## 0.0006 0.8782137 0.125711774  
## 0.0007 0.8811250 0.123194316  
## 0.0008 0.8812462 0.123473025  
## 0.0009 0.8829450 0.121868547  
## 0.0010 0.8835512 0.118323034  
## 0.0011 0.8846434 0.114038328  
## 0.0012 0.8857348 0.110915167  
## 0.0013 0.8857348 0.110915167  
## 0.0014 0.8877977 0.099048039  
## 0.0015 0.8877977 0.099048039  
## 0.0016 0.8884045 0.097555903  
## 0.0017 0.8892535 0.096272218  
## 0.0018 0.8926489 0.096503698  
## 0.0019 0.8942252 0.092504471  
## 0.0020 0.8942252 0.092504471  
## 0.0021 0.8954387 0.076045889  
## 0.0022 0.8958023 0.073665649  
## 0.0023 0.8958023 0.067966404  
## 0.0024 0.8958023 0.059820934  
## 0.0025 0.8976227 0.054988793  
## 0.0026 0.8976227 0.054988793  
## 0.0027 0.8976227 0.054988793  
## 0.0028 0.8983508 0.044258150  
## 0.0029 0.8985936 0.037610679  
## 0.0030 0.8993217 0.030190110  
## 0.0031 0.9006552 0.023417352  
## 0.0032 0.9006552 0.021662320  
## 0.0033 0.9006552 0.021662320  
## 0.0034 0.9006552 0.021662320  
## 0.0035 0.9011403 0.010259039  
## 0.0036 0.9011403 0.010259039  
## 0.0037 0.9011403 0.004640633  
## 0.0038 0.9011403 0.004640633  
## 0.0039 0.9011403 0.004640633  
## 0.0040 0.9011403 0.004640633  
## 0.0041 0.9011403 0.004640633  
## 0.0042 0.9016252 0.001862278  
## 0.0043 0.9016252 0.001862278  
## 0.0044 0.9016252 0.001862278  
## 0.0045 0.9016252 0.001862278  
## 0.0046 0.9016252 0.001862278  
## 0.0047 0.9023533 0.003341726  
## 0.0048 0.9023533 0.003341726  
## 0.0049 0.9027174 0.004146543  
## 0.0050 0.9027174 0.004146543  
## 0.0051 0.9025961 0.000000000  
## 0.0052 0.9025961 0.000000000  
## 0.0053 0.9025961 0.000000000  
## 0.0054 0.9025961 0.000000000  
## 0.0055 0.9025961 0.000000000  
## 0.0056 0.9025961 0.000000000  
## 0.0057 0.9025961 0.000000000  
## 0.0058 0.9025961 0.000000000  
## 0.0059 0.9025961 0.000000000  
## 0.0060 0.9025961 0.000000000  
## 0.0061 0.9025961 0.000000000  
## 0.0062 0.9025961 0.000000000  
## 0.0063 0.9025961 0.000000000  
## 0.0064 0.9025961 0.000000000  
## 0.0065 0.9025961 0.000000000  
## 0.0066 0.9025961 0.000000000  
## 0.0067 0.9025961 0.000000000  
## 0.0068 0.9025961 0.000000000  
## 0.0069 0.9025961 0.000000000  
## 0.0070 0.9025961 0.000000000  
## 0.0071 0.9025961 0.000000000  
## 0.0072 0.9025961 0.000000000  
## 0.0073 0.9025961 0.000000000  
## 0.0074 0.9025961 0.000000000  
## 0.0075 0.9025961 0.000000000  
## 0.0076 0.9025961 0.000000000  
## 0.0077 0.9025961 0.000000000  
## 0.0078 0.9025961 0.000000000  
## 0.0079 0.9025961 0.000000000  
## 0.0080 0.9025961 0.000000000  
## 0.0081 0.9025961 0.000000000  
## 0.0082 0.9025961 0.000000000  
## 0.0083 0.9025961 0.000000000  
## 0.0084 0.9025961 0.000000000  
## 0.0085 0.9025961 0.000000000  
## 0.0086 0.9025961 0.000000000  
## 0.0087 0.9025961 0.000000000  
## 0.0088 0.9025961 0.000000000  
## 0.0089 0.9025961 0.000000000  
## 0.0090 0.9025961 0.000000000  
## 0.0091 0.9025961 0.000000000  
## 0.0092 0.9025961 0.000000000  
## 0.0093 0.9025961 0.000000000  
## 0.0094 0.9025961 0.000000000  
## 0.0095 0.9025961 0.000000000  
## 0.0096 0.9025961 0.000000000  
## 0.0097 0.9025961 0.000000000  
## 0.0098 0.9025961 0.000000000  
## 0.0099 0.9025961 0.000000000  
## 0.0100 0.9025961 0.000000000  
## 0.0101 0.9025961 0.000000000  
## 0.0102 0.9025961 0.000000000  
## 0.0103 0.9025961 0.000000000  
## 0.0104 0.9025961 0.000000000  
## 0.0105 0.9025961 0.000000000  
## 0.0106 0.9025961 0.000000000  
## 0.0107 0.9025961 0.000000000  
## 0.0108 0.9025961 0.000000000  
## 0.0109 0.9025961 0.000000000  
## 0.0110 0.9025961 0.000000000  
##   
## Accuracy was used to select the optimal model using the largest value.  
## The final value used for the model was cp = 0.005.

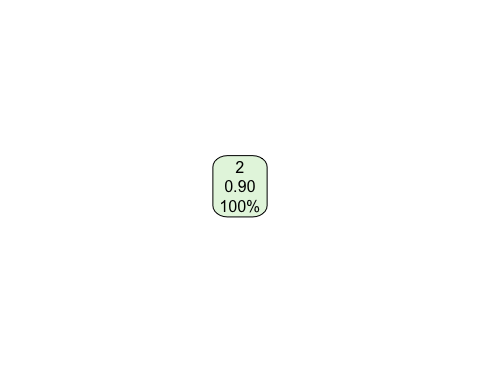
varImp(tree\_diabetes)

## rpart variable importance

## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
## -Inf  
  
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
## -Inf  
  
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## -Inf  
  
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
## -Inf  
  
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
## -Inf

## only 20 most important variables shown (out of 39)  
##   
## Overall  
## dmdeduc29 NaN  
## indhhinc4 NaN  
## indhhinc2 NaN  
## smq0209 NaN  
## paq1802 NaN  
## bmxwt NaN  
## paq1809 NaN  
## bmxbmi NaN  
## indhhinc9 NaN  
## indhhinc99 NaN  
## smq0202 NaN  
## dmdeduc22 NaN  
## ridreth15 NaN  
## riagendr2 NaN  
## indhhinc10 NaN  
## paq1804 NaN  
## indhhinc8 NaN  
## dmdeduc25 NaN  
## ridreth12 NaN  
## bpxpls NaN

rpart.plot(tree\_diabetes$finalModel)



The optimal Cp was 0.0047.

### Support Vector Classifier

svm\_diabetes = svm(diq010 ~ ., data = train\_data, kernel="linear", cost = 0.1, scale = TRUE)  
print(svm\_diabetes)

##   
## Call:  
## svm(formula = diq010 ~ ., data = train\_data, kernel = "linear",   
## cost = 0.1, scale = TRUE)  
##   
##   
## Parameters:  
## SVM-Type: C-classification   
## SVM-Kernel: linear   
## cost: 0.1   
##   
## Number of Support Vectors: 1738

new\_data = train\_data[-11]  
  
svm\_pred = predict(svm\_diabetes, new\_data)  
table(svm\_pred, train\_data$diq010)

##   
## svm\_pred 1 2  
## 1 0 0  
## 2 803 7441

misClasificError = mean(svm\_pred != train\_data$diq010, na.rm = T)  
print(paste('Accuracy Model 1',1 - misClasificError))

## [1] "Accuracy Model 1 0.902595827268316"

features = new\_data  
outcome = train\_data$diq010  
  
svm\_tune = tune(svm, diq010 ~ ., data = train\_data, kernel="linear", range=list(cost=10^(-1:1)))  
  
summary(svm\_tune)

##   
## Parameter tuning of 'svm':  
##   
## - sampling method: 10-fold cross validation   
##   
## - best parameters:  
## cost  
## 0.1  
##   
## - best performance: 0.09740644   
##   
## - Detailed performance results:  
## cost error dispersion  
## 1 0.1 0.09740644 0.01439658  
## 2 1.0 0.09740644 0.01439658  
## 3 10.0 0.09740644 0.01439658

Accuracy of the SVM model was also 0.90.

### Logistic Regression

log\_model = glm(diq010 ~ ., data = train\_data, family = binomial(link = "logit"))   
log\_model

##   
## Call: glm(formula = diq010 ~ ., family = binomial(link = "logit"),   
## data = train\_data)  
##   
## Coefficients:  
## (Intercept) seqn ridageyr riagendr2 ridreth12   
## 8.448e+00 -8.354e-06 -5.604e-02 1.392e-01 2.703e-01   
## ridreth13 ridreth14 ridreth15 dmdeduc22 dmdeduc23   
## 9.212e-01 2.393e-01 -1.796e-01 1.345e-01 2.722e-01   
## dmdeduc24 dmdeduc25 dmdeduc27 dmdeduc29 indhhinc2   
## 1.192e-01 5.045e-01 1.299e+01 1.285e+01 -5.649e-01   
## indhhinc3 indhhinc4 indhhinc5 indhhinc6 indhhinc7   
## -5.187e-01 -2.441e-01 -4.176e-01 -2.227e-01 -1.953e-01   
## indhhinc8 indhhinc9 indhhinc10 indhhinc11 indhhinc12   
## -4.786e-01 -1.398e-01 -5.150e-03 8.129e-02 -1.451e-01   
## indhhinc13 indhhinc77 indhhinc99 bmxbmi bmxht   
## 3.391e-01 -8.367e-01 1.265e+00 -4.545e-02 1.987e-03   
## bmxwt bpxpls paq1802 paq1803 paq1804   
## -1.174e-02 -2.418e-02 3.613e-01 5.132e-01 6.708e-01   
## paq1807 paq1809 smq0202 smq0207 smq0209   
## 1.289e+01 1.261e+01 9.186e-02 -1.260e+01 1.244e+01   
##   
## Degrees of Freedom: 8243 Total (i.e. Null); 8204 Residual  
## Null Deviance: 5265   
## Residual Deviance: 4263 AIC: 4343

# Make predictions  
log\_model %>% predict(test\_data)

## 12 23 38 43 60   
## 4.202484e+00 2.931306e+00 2.644263e+00 3.210666e+00 3.243414e+00   
## 75 77 118 150 154   
## 4.440972e+00 1.423576e+00 2.759528e+00 3.952570e+00 1.101669e+00   
## 157 163 166 176 181   
## 2.747676e+00 2.725548e+00 2.981155e+00 1.736960e+00 4.226834e+00   
## 184 188 195 200 244   
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## 2.136124e+00 4.967044e+00 2.862913e+00 2.459643e+00 8.348653e-01   
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## 1.508942e+00 3.035977e+00 4.688547e+00 3.290515e+00 3.934458e+00   
## 24464 24470 24472 24481 24493   
## 4.073254e+00 4.984563e+00 4.217690e+00 3.212082e+00 2.998295e+00   
## 24504 24505 24515 24523 24524   
## 1.242205e+00 2.579424e+00 1.060918e+00 4.113850e+00 2.284317e+00   
## 24537 24550 24552 24558 24566   
## 3.612545e+00 1.880277e+00 3.482892e+00 1.977899e+00 1.505134e+00   
## 24576 24578 24580 24592 24593   
## 7.928454e-01 1.943890e+00 3.642589e+00 3.688830e+00 3.766270e+00   
## 24597 24613 24627 24630 24635   
## 9.660052e-01 4.916630e+00 4.209449e+00 1.281956e+00 2.120696e+00   
## 24643 24647 24659 24662 24673   
## 3.054659e+00 2.869675e+00 3.588103e+00 1.897380e+00 2.523011e+00   
## 24674 24683 24719 24726 24729   
## 3.194516e+00 1.312776e+00 1.770822e+00 1.021349e+00 2.319784e+00   
## 24742 24759 24760 24765 24770   
## 1.850992e+00 2.208521e+00 3.741477e+00 -2.040948e-01 6.195498e-01   
## 24794 24795 24799 24800 24802   
## 2.190942e+00 2.512965e+00 2.998188e+00 4.331875e+00 7.115230e-01   
## 24803 24818 24823 24842 24844   
## 1.741420e+00 4.807451e+00 2.887040e+00 2.466401e+00 3.494500e+00   
## 24848 24850 24866 24873 24881   
## 4.983699e-01 4.326761e+00 4.133476e+00 4.765743e+00 2.242135e+00   
## 24900 24905 24919 24930 24933   
## 2.692365e+00 5.505991e+00 1.755817e+00 1.982150e+00 3.371209e+00   
## 24935 24942 24981 25003 25006   
## 2.220246e+00 4.761685e+00 2.181155e+00 1.953800e+00 4.932547e+00   
## 25021 25061 25063 25065 25066   
## 5.346882e+00 1.833921e-01 2.781053e+00 4.673237e+00 5.727167e+00   
## 25073 25097 25108 25112 25116   
## 5.146731e+00 1.426429e+00 2.433615e+00 3.454971e+00 3.492283e+00   
## 25124 25128 25134 25137 25139   
## 1.063493e+00 2.265391e+00 2.030645e-01 2.970888e+00 1.529455e+00   
## 25141 25146 25166 25173 25176   
## 2.366947e+00 2.384721e+00 2.476345e+00 4.988377e+00 3.761099e+00   
## 25179 25187 25190 25192 25214   
## 4.828590e+00 5.517905e+00 6.068434e-01 3.863399e+00 5.333885e+00   
## 25222 25224 25260 25264 25269   
## 2.467072e+00 3.302981e+00 3.630467e+00 2.054966e+00 3.467688e+00   
## 25271 25283 25287 25305 25306   
## 3.138846e+00 5.420826e-01 2.424026e+00 5.100588e+00 2.501694e+00   
## 25339 25357 25360 25363 25370   
## 2.905161e+00 4.109821e+00 1.211461e+00 8.658633e-01 1.704477e+00   
## 25379 25439 25443 25454 25465   
## 4.327918e+00 2.095032e+00 2.898107e+00 3.031819e+00 3.434210e+00   
## 25471 25478 25487 25491 25494   
## 1.986487e+00 3.683842e+00 3.548500e+00 9.940342e-01 1.365040e+00   
## 25498 25503 25547 25602 25603   
## 2.231022e+00 1.806800e+00 2.379967e+00 5.860861e-01 1.912887e+00   
## 25611 25614 25617 25624 25628   
## -1.047210e-01 2.528878e+00 -3.395469e-01 1.931763e+00 1.215669e+00   
## 25632 25637 25649 25660 25665   
## 4.632299e+00 -1.000716e-03 4.907820e+00 3.511356e+00 1.644014e+00   
## 25672 25679 25688 25689 25710   
## 3.075570e+00 3.670373e+00 1.087480e+00 9.727235e-01 3.006285e+00   
## 25715 25719 25724 25729 25746   
## 3.073050e+00 1.741791e+00 3.288960e+00 2.834807e+00 2.388558e+00   
## 25747 25756 25760 25765 25779   
## 4.761257e-01 2.955125e+00 3.601969e+00 3.461505e+00 3.773558e-01   
## 25783 25793 25807 25819 25827   
## 5.364146e+00 3.216896e+00 3.693143e+00 1.628181e+00 4.366109e+00   
## 25846 25853 25858 25860 25861   
## 3.373082e+00 1.778745e+00 1.291322e+00 1.671231e+00 2.353087e+00   
## 25866 25868 25876 25884 25890   
## 2.638467e+00 1.988525e+00 3.310919e+00 4.262162e+00 4.048177e+00   
## 25899 25903 25905 25912 25913   
## 1.174289e+00 1.332097e+00 2.791249e+00 2.794427e+00 3.464820e+00   
## 25920 25922 25930 25946 25967   
## 1.577203e+00 1.642530e+00 1.578672e+00 3.641728e+00 1.842949e+00   
## 25982 25983 25989 25991 26005   
## 3.343876e+00 4.607223e+00 4.002478e+00 -1.134378e+00 1.381088e+00   
## 26007 26015 26018 26020 26029   
## -1.073475e-01 2.679306e+00 3.862513e+00 1.836814e+00 1.638087e+00   
## 26046 26048 26078 26079 26083   
## 7.026954e-01 3.181466e+00 1.446405e+00 1.698450e+00 4.836662e+00   
## 26087 26091 26092 26095 26108   
## 1.471949e+00 2.460631e+00 1.275522e+00 2.239982e+00 2.106991e+00   
## 26112 26116 26124 26132 26136   
## 1.837906e+00 2.149434e-01 4.857191e+00 1.944090e+00 2.038175e+00   
## 26150 26157 26160 26165 26169   
## 4.610430e+00 4.640370e+00 1.584931e-01 1.881590e+00 5.158031e+00   
## 26172 26184 26185 26187 26201   
## 6.255352e-01 3.802146e+00 5.207832e+00 2.792212e+00 4.673629e+00   
## 26209 26213 26235 26252 26262   
## 2.051287e+00 2.899415e+00 1.190762e+00 3.411459e+00 1.101560e+00   
## 26263 26273 26276 26277 26294   
## 2.880133e+00 5.116977e+00 7.970616e-01 4.423468e+00 3.291596e+00   
## 26297 26303 26313 26341 26346   
## 3.382905e+00 2.322757e+00 4.304988e+00 5.524442e+00 2.576305e+00   
## 26349 26354 26358 26359 26363   
## 2.274243e+00 3.011898e+00 2.484070e+00 1.518406e+00 4.184963e+00   
## 26376 26377 26404 26407 26408   
## 2.942074e+00 1.637357e+00 4.563418e+00 2.489357e+00 2.506767e+00   
## 26426 26429 26430 26438 26442   
## 2.689050e+00 6.429008e-01 3.646778e+00 1.741655e+00 1.696888e+00   
## 26452 26472 26491 26495 26511   
## 3.076806e+00 1.218792e+00 4.309118e-01 5.456403e+00 4.232900e+00   
## 26529 26550 26560 26573 26599   
## 2.739427e+00 2.984411e+00 9.399346e-01 2.336615e+00 4.345487e+00   
## 26616 26639 26641 26647 26648   
## 4.232104e+00 2.671353e+00 3.477965e+00 3.606370e+00 1.465380e+00   
## 26652 26679 26708 26710 26711   
## 2.763556e+00 4.005914e+00 7.346008e-01 3.155014e+00 2.061078e+00   
## 26712 26727 26739 26746 26753   
## 4.852812e+00 2.170556e-01 1.349777e+00 1.665170e+00 4.095115e+00   
## 26761 26764 26777 26786 26793   
## 4.835658e+00 3.615730e+00 2.312957e+00 9.656107e-01 4.077980e+00   
## 26804 26808 26816 26836 26845   
## 2.834045e+00 2.957212e+00 5.178783e+00 5.488570e+00 3.835367e+00   
## 26858 26860 26861 26871 26873   
## 3.232185e+00 4.505539e-01 2.606445e+00 2.042914e+00 4.219317e+00   
## 26880 26884 26896 26897 26921   
## 3.513334e+00 4.284904e+00 3.448975e+00 1.575195e+00 2.216258e+00   
## 26924 26927 26935 26937 26950   
## 8.387172e-01 7.679628e-01 3.396420e+00 2.054727e+00 2.148491e+00   
## 26954 26961 26968 26974 26989   
## 4.293460e+00 1.446715e+00 4.235580e-01 2.403238e+00 9.872941e-01   
## 26990 26991 26995 26996 27002   
## 3.938375e+00 2.181449e+00 1.695127e+00 2.625526e+00 2.219868e+00   
## 27003 27022 27023 27032 27033   
## 6.028069e+00 3.399289e+00 2.214426e+00 4.319853e+00 5.167578e+00   
## 27035 27039 27043 27047 27061   
## 2.485284e+00 1.965321e+00 2.326874e+00 8.793837e-01 9.458713e-01   
## 27062 27065 27070 27073 27088   
## 3.669827e+00 3.312086e+00 1.877478e+00 3.031481e+00 1.495385e+00   
## 27091 27094 27104 27105 27123   
## 3.661658e+00 5.338006e+00 3.207298e+00 3.148994e+00 2.967637e+00   
## 27131 27132 27136 27142 27143   
## 4.822379e+00 2.242561e+00 3.396936e+00 2.408458e+00 1.130281e+00   
## 27145 27150 27153 27154 27156   
## 2.271083e+00 3.440115e+00 3.654422e+00 5.250942e+00 1.908820e+00   
## 27161 27184 27199 27207 27218   
## 7.204060e-01 1.659361e+00 1.990939e+00 3.833024e+00 3.713530e+00   
## 27224 27230 27231 27246 27250   
## 1.975491e+00 4.650342e+00 2.698996e+00 8.252411e-01 1.789290e+00   
## 27263 27265 27275 27282 27288   
## 7.552657e-01 1.899051e+00 2.174199e+00 4.672262e+00 2.455701e+00   
## 27291 27296 27302 27312 27320   
## 2.312833e+00 3.084155e+00 3.110581e+00 1.610188e+00 8.328163e-01   
## 27329 27337 27349 27366 27377   
## 8.643655e-02 2.339378e+00 2.899390e+00 5.353779e+00 2.305155e+00   
## 27384 27387 27389 27406 27408   
## 2.254229e+00 1.361557e+00 4.990485e+00 6.688961e-01 3.210627e+00   
## 27410 27427 27432 27436 27444   
## 2.823081e+00 2.200784e+00 -1.002461e-01 1.531336e+00 2.852658e+00   
## 27455 27468 27479 27494 27503   
## 2.378646e+00 2.563311e+00 4.566791e+00 4.035176e+00 2.096545e+00   
## 27506 27512 27537 27543 27548   
## 3.716092e+00 3.326210e+00 2.395066e+00 3.837869e+00 3.931808e+00   
## 27552 27564 27575 27577 27596   
## 3.521964e+00 2.153539e+00 2.380651e+00 2.122032e+00 2.717630e+00   
## 27606 27608 27619 27621 27642   
## -1.654201e-01 4.431875e+00 2.992825e+00 3.803555e+00 2.415181e+00   
## 27663 27675 27680 27684 27699   
## 1.274730e+00 3.180931e+00 1.678365e+00 4.424760e+00 8.845077e-01   
## 27701 27710 27761 27783 27808   
## 1.792346e+00 4.101831e+00 4.319893e+00 2.163961e+00 3.524232e+00   
## 27810 27816 27824 27826 27827   
## 9.883442e-01 3.702084e+00 4.756582e+00 2.394733e+00 1.349087e+00   
## 27831 27841 27842 27863 27868   
## 3.981393e+00 3.045713e+00 3.464120e+00 1.140696e+00 2.416110e+00   
## 27873 27874 27888 27893 27896   
## 3.264949e+00 4.756383e+00 3.966926e+00 2.616899e+00 4.050363e+00   
## 27902 27903 27916 27918 27920   
## 6.971814e-01 2.074771e+00 5.197673e+00 3.994665e+00 3.378845e+00   
## 27922 27940 27945 27948 27951   
## 3.641778e+00 2.735733e+00 1.065735e+00 2.429559e+00 1.409439e+00   
## 27956 27961 27964 27966 27974   
## 2.207394e+00 1.169520e+00 3.034917e+00 1.527065e+00 5.069677e+00   
## 27989 28026 28049 28076 28087   
## 4.640470e+00 1.257379e+00 2.115639e+00 3.479305e+00 1.253401e+00   
## 28093 28108 28114 28123 28131   
## 1.003475e+00 2.737485e+00 1.424279e+00 1.837459e+00 2.786146e+00   
## 28141 28146 28154 28172 28174   
## 4.328004e+00 2.473022e+00 4.213844e+00 4.260273e+00 2.843913e+00   
## 28175 28190 28191 28198 28205   
## 1.750773e+00 2.649167e+00 6.582669e-01 3.135798e+00 4.599290e+00   
## 28215 28216 28222 28244 28251   
## 1.972935e+00 4.213362e+00 4.028542e+00 1.663479e-01 4.267515e+00   
## 28272 28281 28283 28287 28290   
## 3.610536e+00 3.321766e+00 3.693210e+00 1.433173e+00 1.728652e+00   
## 28296 28298 28302 28303 28308   
## 4.831911e+00 1.261412e+00 2.949804e+00 3.673276e+00 8.082034e-01   
## 28309 28315 28320 28344 28352   
## 2.971685e+00 1.556154e+00 3.354296e+00 2.614693e+00 9.140546e-01   
## 28356 28358 28367 28386 28387   
## 3.949372e+00 1.775963e+00 1.573436e+00 3.936934e+00 8.019065e-01   
## 28393 28409 28419 28424 28441   
## 3.922929e-01 4.433703e+00 2.801653e+00 1.404218e+01 1.865389e+00   
## 28451 28460 28461 28467 28468   
## 2.369774e+00 3.709990e+00 -3.383856e-01 1.659868e+00 1.796881e+00   
## 28486 28496 28497 28501 28504   
## 1.806098e+00 1.414025e+00 1.984562e+00 2.272831e+00 2.285194e+00   
## 28516 28517 28525 28532 28534   
## 2.110680e+00 2.507620e+00 -8.757174e-02 3.164044e+00 2.622435e+00   
## 28537 28548 28556 28565 28577   
## 1.703288e+00 2.287750e+00 4.536980e+00 3.263961e+00 2.191098e+00   
## 28583 28584 28591 28592 28593   
## 1.094407e+00 7.909252e-01 2.018361e+00 7.657201e-02 3.148031e+00   
## 28594 28598 28600 28612 28617   
## 1.904684e+00 2.942227e+00 3.680872e+00 4.387955e+00 4.523195e+00   
## 28629 28636 28637 28645 28656   
## 8.856748e-02 3.600653e+00 3.223016e+00 2.555316e+00 4.237015e+00   
## 28671 28677 28688 28698 28700   
## 4.664237e+00 2.398897e+00 2.207642e+00 2.364748e+00 9.042824e-01   
## 28710 28714 28716 28742 28747   
## 1.824065e+00 1.061078e+00 4.519326e+00 7.349047e-01 3.273371e+00   
## 28752 28753 28755 28756 28764   
## 4.716844e-01 2.842879e+00 4.884790e+00 5.346295e+00 2.313908e+00   
## 28768 28774 28781 28785 28792   
## 2.241842e+00 4.756585e-01 3.345723e+00 9.492308e-01 5.058490e+00   
## 28799 28800 28807 28809 28811   
## 3.454940e+00 2.639461e+00 1.233998e+00 3.055693e+00 2.935333e+00   
## 28812 28813 28815 28833 28836   
## 1.017827e+00 3.463195e+00 4.158349e+00 3.495746e+00 4.809483e+00   
## 28848 28874 28877 28888 28898   
## 3.607484e+00 6.338702e-01 2.865489e+00 4.585732e+00 7.682671e-01   
## 28899 28902 28908 28912 28914   
## 3.017956e+00 9.861665e-01 2.507655e+00 1.826026e+00 5.061378e+00   
## 28921 28925 28926 28935 28955   
## 2.303936e+00 4.121113e+00 1.010918e+00 2.915658e+00 4.521538e+00   
## 28956 28957 28959 28963 28971   
## 3.974969e+00 2.268112e+00 1.723716e+00 4.748896e+00 3.618526e+00   
## 28986 29002 29005 29010 29014   
## 2.057752e+00 4.440017e+00 1.194540e+00 3.188595e+00 4.433164e+00   
## 29017 29018 29021 29026 29034   
## 3.238311e+00 4.906338e+00 2.122458e+00 1.375255e+00 1.075954e+00   
## 29038 29039 29041 29051 29053   
## 1.442483e+00 3.145151e+00 4.211525e+00 7.456772e-01 1.328858e+00   
## 29056 29061 29065 29076 29080   
## 1.807531e+00 2.283796e+00 2.890711e+00 1.915797e+00 2.282883e+00   
## 29081 29091 29099 29107 29118   
## 3.405325e+00 3.145322e+00 3.110995e+00 1.375005e+00 1.837131e+00   
## 29129 29131 29141 29145 29147   
## 2.262461e+00 4.228247e+00 1.784700e+00 3.629096e+00 7.411499e-01   
## 29171 29173 29178 29186 29190   
## 2.831943e+00 2.688520e+00 3.168357e+00 2.993525e+00 3.350298e+00   
## 29194 29201 29233 29239 29255   
## 3.978720e+00 3.372990e+00 1.905314e+00 5.581094e+00 2.420145e+00   
## 29261 29277 29292 29306 29309   
## 3.808664e+00 2.225103e+00 2.461034e+00 6.283236e-01 -5.955523e-01   
## 29310 29317 29326 29331 29334   
## 4.299779e+00 5.184619e+00 3.827417e+00 7.627481e-01 2.391389e+00   
## 29341 29342 29353 29357 29363   
## 2.203077e+00 -6.799551e-01 3.103570e+00 1.679902e+00 3.498441e+00   
## 29372 29373   
## 2.706116e+00 1.851275e+00

## Number 3

In the classification tree, the optimal hyperparameter Cp for highest was 0.0047.

train\_control = trainControl(method = "cv", number = 10)  
grid\_2 = expand.grid(cp = seq(0.0001, 0.011, by = 0.0001))  
tree\_diabetes = train(diq010 ~., data = train\_data, method = "rpart", trControl = train\_control, tuneGrid = grid\_2)  
tree\_diabetes$bestTune

## cp  
## 48 0.0048

tree\_diabetes

## CART   
##   
## 8244 samples  
## 12 predictor  
## 2 classes: '1', '2'   
##   
## No pre-processing  
## Resampling: Cross-Validated (10 fold)   
## Summary of sample sizes: 7420, 7420, 7420, 7419, 7420, 7418, ...   
## Resampling results across tuning parameters:  
##   
## cp Accuracy Kappa   
## 0.0001 0.8702108 0.138438720  
## 0.0002 0.8702108 0.138438720  
## 0.0003 0.8719091 0.139735100  
## 0.0004 0.8740920 0.141803440  
## 0.0005 0.8762746 0.139070614  
## 0.0006 0.8774861 0.135100249  
## 0.0007 0.8801547 0.135704661  
## 0.0008 0.8808823 0.133631230  
## 0.0009 0.8813677 0.133448132  
## 0.0010 0.8844017 0.138545180  
## 0.0011 0.8846443 0.136572740  
## 0.0012 0.8862219 0.134622794  
## 0.0013 0.8863433 0.133728999  
## 0.0014 0.8908317 0.118327219  
## 0.0015 0.8908317 0.118327219  
## 0.0016 0.8908317 0.118327219  
## 0.0017 0.8914382 0.114069618  
## 0.0018 0.8920448 0.103005671  
## 0.0019 0.8930151 0.102268543  
## 0.0020 0.8947130 0.097983871  
## 0.0021 0.8954395 0.081045437  
## 0.0022 0.8954395 0.081045437  
## 0.0023 0.8965312 0.069855875  
## 0.0024 0.8981088 0.056125867  
## 0.0025 0.8983515 0.056697026  
## 0.0026 0.8983515 0.056697026  
## 0.0027 0.8994438 0.044160055  
## 0.0028 0.9016266 0.016651015  
## 0.0029 0.9016266 0.016651015  
## 0.0030 0.9016266 0.016651015  
## 0.0031 0.9018690 0.011585092  
## 0.0032 0.9018690 0.011585092  
## 0.0033 0.9018690 0.011585092  
## 0.0034 0.9018690 0.011585092  
## 0.0035 0.9021112 0.006517103  
## 0.0036 0.9021112 0.006517103  
## 0.0037 0.9024748 0.007338279  
## 0.0038 0.9024748 0.007338279  
## 0.0039 0.9024748 0.007338279  
## 0.0040 0.9024748 0.007338279  
## 0.0041 0.9024748 0.007338279  
## 0.0042 0.9027172 0.006086647  
## 0.0043 0.9027172 0.006086647  
## 0.0044 0.9027172 0.006086647  
## 0.0045 0.9027172 0.006086647  
## 0.0046 0.9027172 0.006086647  
## 0.0047 0.9027172 0.006086647  
## 0.0048 0.9027172 0.006086647  
## 0.0049 0.9024748 0.001719873  
## 0.0050 0.9024748 0.001719873  
## 0.0051 0.9024748 0.001719873  
## 0.0052 0.9024748 0.001719873  
## 0.0053 0.9024748 0.001719873  
## 0.0054 0.9024748 0.001719873  
## 0.0055 0.9024748 0.001719873  
## 0.0056 0.9025962 0.000000000  
## 0.0057 0.9025962 0.000000000  
## 0.0058 0.9025962 0.000000000  
## 0.0059 0.9025962 0.000000000  
## 0.0060 0.9025962 0.000000000  
## 0.0061 0.9025962 0.000000000  
## 0.0062 0.9025962 0.000000000  
## 0.0063 0.9025962 0.000000000  
## 0.0064 0.9025962 0.000000000  
## 0.0065 0.9025962 0.000000000  
## 0.0066 0.9025962 0.000000000  
## 0.0067 0.9025962 0.000000000  
## 0.0068 0.9025962 0.000000000  
## 0.0069 0.9025962 0.000000000  
## 0.0070 0.9025962 0.000000000  
## 0.0071 0.9025962 0.000000000  
## 0.0072 0.9025962 0.000000000  
## 0.0073 0.9025962 0.000000000  
## 0.0074 0.9025962 0.000000000  
## 0.0075 0.9025962 0.000000000  
## 0.0076 0.9025962 0.000000000  
## 0.0077 0.9025962 0.000000000  
## 0.0078 0.9025962 0.000000000  
## 0.0079 0.9025962 0.000000000  
## 0.0080 0.9025962 0.000000000  
## 0.0081 0.9025962 0.000000000  
## 0.0082 0.9025962 0.000000000  
## 0.0083 0.9025962 0.000000000  
## 0.0084 0.9025962 0.000000000  
## 0.0085 0.9025962 0.000000000  
## 0.0086 0.9025962 0.000000000  
## 0.0087 0.9025962 0.000000000  
## 0.0088 0.9025962 0.000000000  
## 0.0089 0.9025962 0.000000000  
## 0.0090 0.9025962 0.000000000  
## 0.0091 0.9025962 0.000000000  
## 0.0092 0.9025962 0.000000000  
## 0.0093 0.9025962 0.000000000  
## 0.0094 0.9025962 0.000000000  
## 0.0095 0.9025962 0.000000000  
## 0.0096 0.9025962 0.000000000  
## 0.0097 0.9025962 0.000000000  
## 0.0098 0.9025962 0.000000000  
## 0.0099 0.9025962 0.000000000  
## 0.0100 0.9025962 0.000000000  
## 0.0101 0.9025962 0.000000000  
## 0.0102 0.9025962 0.000000000  
## 0.0103 0.9025962 0.000000000  
## 0.0104 0.9025962 0.000000000  
## 0.0105 0.9025962 0.000000000  
## 0.0106 0.9025962 0.000000000  
## 0.0107 0.9025962 0.000000000  
## 0.0108 0.9025962 0.000000000  
## 0.0109 0.9025962 0.000000000  
## 0.0110 0.9025962 0.000000000  
##   
## Accuracy was used to select the optimal model using the largest value.  
## The final value used for the model was cp = 0.0048.

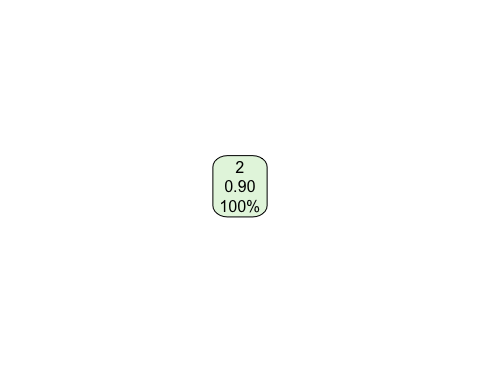
varImp(tree\_diabetes)

## rpart variable importance

## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
## -Inf  
  
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
## -Inf  
  
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
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## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
## -Inf  
  
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
## -Inf  
  
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning  
## -Inf

## only 20 most important variables shown (out of 39)  
##   
## Overall  
## indhhinc99 NaN  
## ridageyr NaN  
## paq1809 NaN  
## ridreth13 NaN  
## paq1807 NaN  
## indhhinc8 NaN  
## indhhinc10 NaN  
## ridreth14 NaN  
## bmxbmi NaN  
## indhhinc5 NaN  
## smq0202 NaN  
## dmdeduc27 NaN  
## paq1802 NaN  
## dmdeduc29 NaN  
## indhhinc77 NaN  
## indhhinc7 NaN  
## bmxht NaN  
## indhhinc4 NaN  
## bpxpls NaN  
## indhhinc13 NaN

rpart.plot(tree\_diabetes$finalModel)



The accuracy of the classification tree at a complexity parameter of 0.0047 was 90.26%. The accuracy of the support vector machine was 90.26%.

Log model accuracy:

pred\_log = predict(log\_model, train\_data)  
pred\_log\_class = ifelse(pred\_log > 0.5,1,0)  
misClasificError = mean(pred\_log\_class != train\_data$diq010, na.rm = T)  
print(paste('Accuracy Log Model',1 - misClasificError))

## [1] "Accuracy Log Model 0.0835759340126152"

The accuracy of the logistic model is only 8.35%.

## Number 4

The classification tree appears to have been the most appropriate here. The support vector machine did not work as expected. We will now calculate accuracy in the final test set for the classification tree.

pred\_diabetes<-predict(tree\_diabetes, test\_data)  
pred\_diabetes\_prob<-predict(tree\_diabetes, test\_data, type="prob")  
  
eval.results<-confusionMatrix(pred\_diabetes, test\_data$diq010, positive = "1")  
print(eval.results)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 1 2  
## 1 0 0  
## 2 344 3188  
##   
## Accuracy : 0.9026   
## 95% CI : (0.8923, 0.9122)  
## No Information Rate : 0.9026   
## P-Value [Acc > NIR] : 0.5144   
##   
## Kappa : 0   
##   
## Mcnemar's Test P-Value : <2e-16   
##   
## Sensitivity : 0.0000   
## Specificity : 1.0000   
## Pos Pred Value : NaN   
## Neg Pred Value : 0.9026   
## Prevalence : 0.0974   
## Detection Rate : 0.0000   
## Detection Prevalence : 0.0000   
## Balanced Accuracy : 0.5000   
##   
## 'Positive' Class : 1   
##

The accuracy for the classification tree is 90.26%.

## Number 5

One major limitation of classification trees is model instability. Updates to the data, which occur with every annual NHANES cycle, are likely to completely change the structure of the tree, thereby limiting its interpretability over the long term.

Another limitation of classification trees is that the algorithm is “greedy” - meaning it only looks at the current node, not downstream nodes to make a splitting decision.