

# P8106\_group2recovery\_primaryanalysis

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## Import and data manipulation

```
# Load recovery.RData environment
load("./recovery.Rdata")

dat %>% na.omit()

# dat1 draw a random sample of 2000 participants Uni:3307
set.seed(3307)

dat1 = dat[sample(1:10000, 2000),]

dat1 =
  dat1[, -1] %>%
  mutate(
    gender = as.factor(gender),
    race = as.factor(race),
    smoking = as.factor(smoking),
```

```

hypertension = as.factor(hypertension),
diabetes = as.factor(diabetes),
vaccine = as.factor(vaccine),
severity = as.factor(severity),
study = as.factor(
  case_when(study == "A" ~ 1, study == "B" ~ 2, study == "C" ~ 3)
)
)

# dat2 draw a random sample of 2000 participants Uni:2493
set.seed(2493)

dat2 = dat[sample(1:10000, 2000),]

dat2 =
  dat2[, -1] %>%
  mutate(
    gender = as.factor(gender),
    race = as.factor(race),
    smoking = as.factor(smoking),
    hypertension = as.factor(hypertension),
    diabetes = as.factor(diabetes),
    vaccine = as.factor(vaccine),
    severity = as.factor(severity),
    study = as.factor(
      case_when(study == "A" ~ 1, study == "B" ~ 2, study == "C" ~ 3)
    )
  )

# Merged dataset with unique observation
covid_dat = rbind(dat1, dat2) %>%
  unique()

covid_dat2 = model.matrix(recovery_time ~ ., covid_dat)[, -1]

# Partition dataset into two parts: training data (70%) and test data (30%)
rowTrain = createDataPartition(y = covid_dat$recovery_time, p = 0.7, list = FALSE)

trainData = covid_dat[rowTrain, ]
testData = covid_dat[-rowTrain, ]

ctrl1 = trainControl(method = "repeatedcv", number = 10, repeats = 5)

```

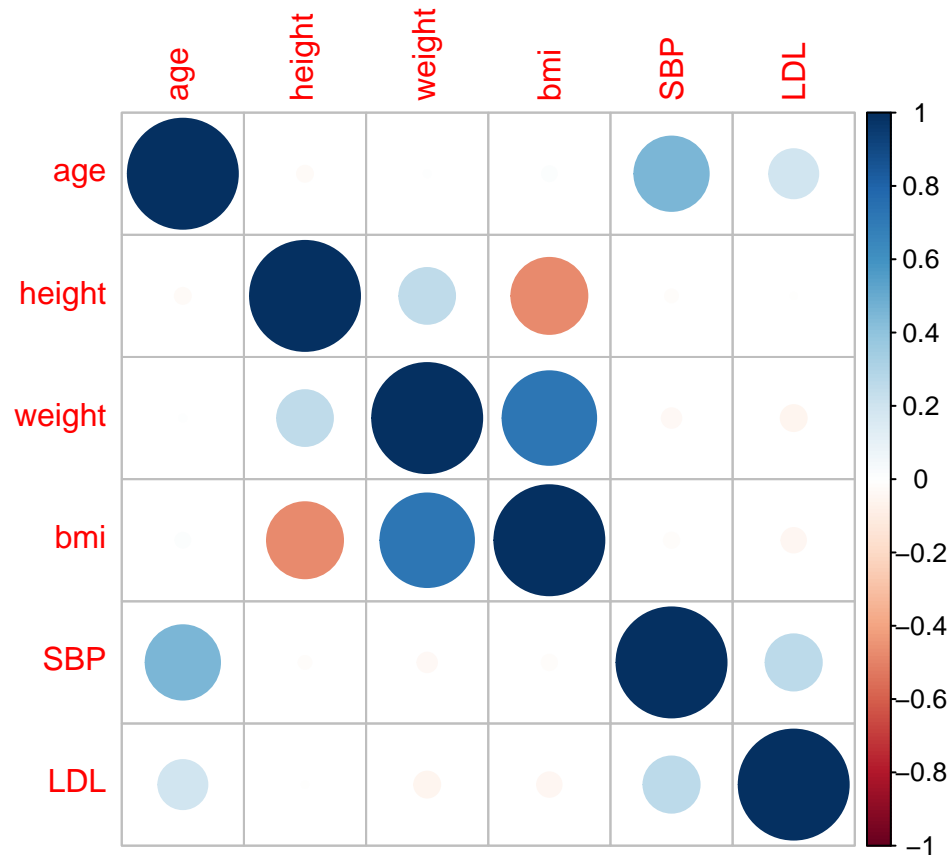
## Data visualization

### Correlation plot

```

corr_dat = covid_dat[rowTrain,] %>%
  dplyr::select('age', 'height', 'weight', 'bmi', 'SBP', 'LDL')
corrplot(cor(corr_dat), method = "circle", type = "full")

```

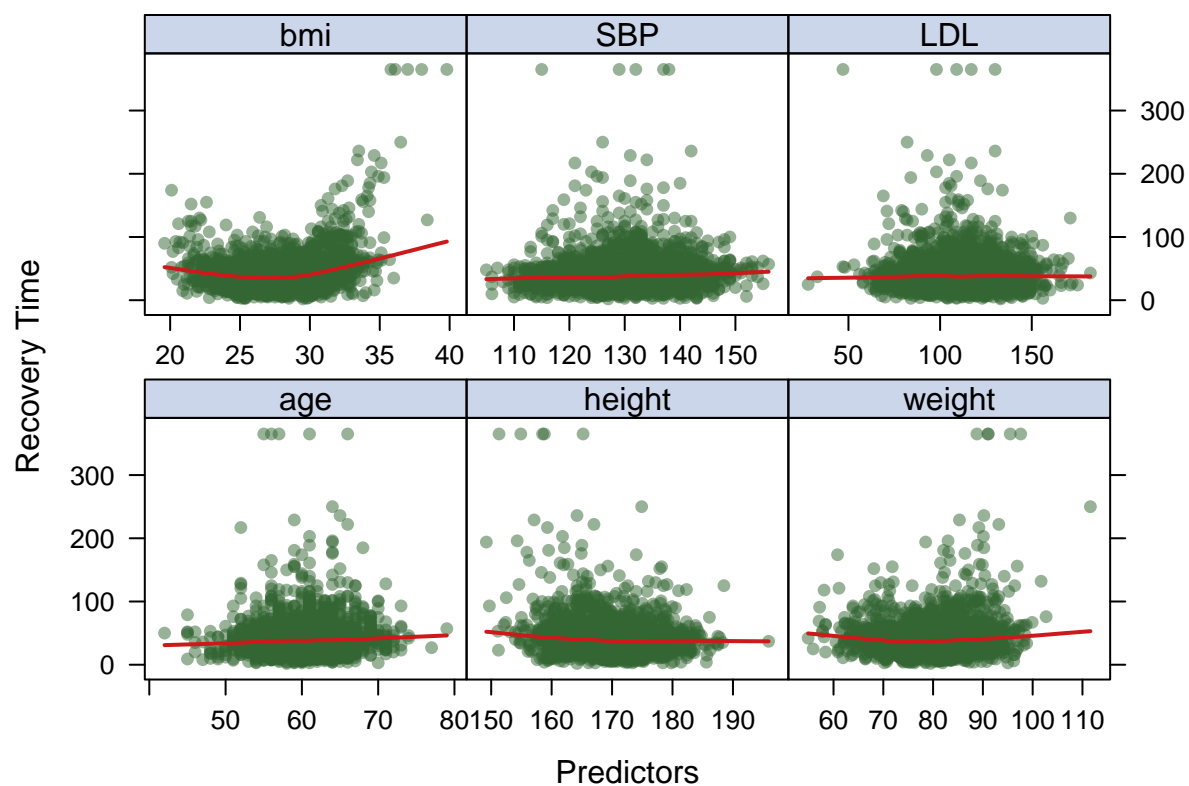


## Feature plot

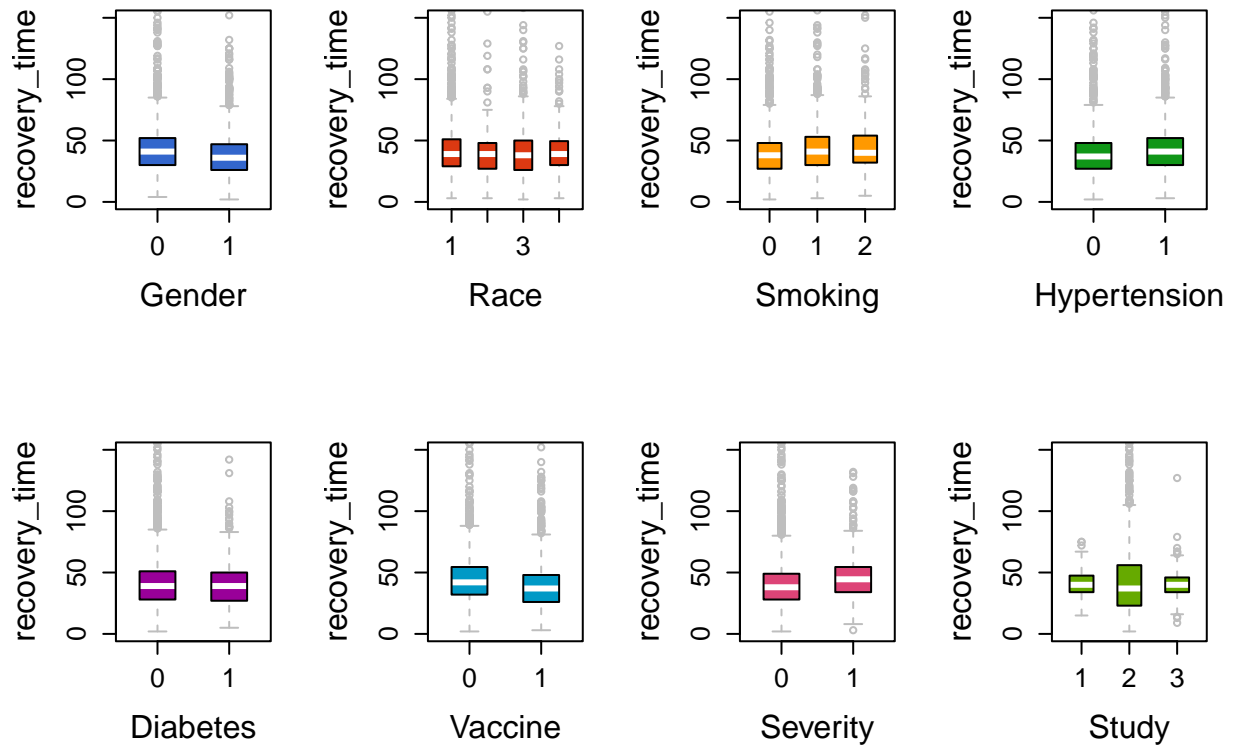
```
vis_trdat = trainData %>%
  dplyr::select('age', 'height', 'weight', 'bmi', 'SBP', 'LDL', 'recovery_time')

theme1 <- trellis.par.get()
theme1$plot.symbol$col <- rgb(.2, .4, .2, .5)
theme1$plot.symbol$pch <- 16
theme1$plot.line$col <- rgb(.8, .1, .1, 1)
theme1$plot.line$lwd <- 2
theme1$strip.background$col <- rgb(.0, .2, .6, .2)
trellis.par.set(theme1)

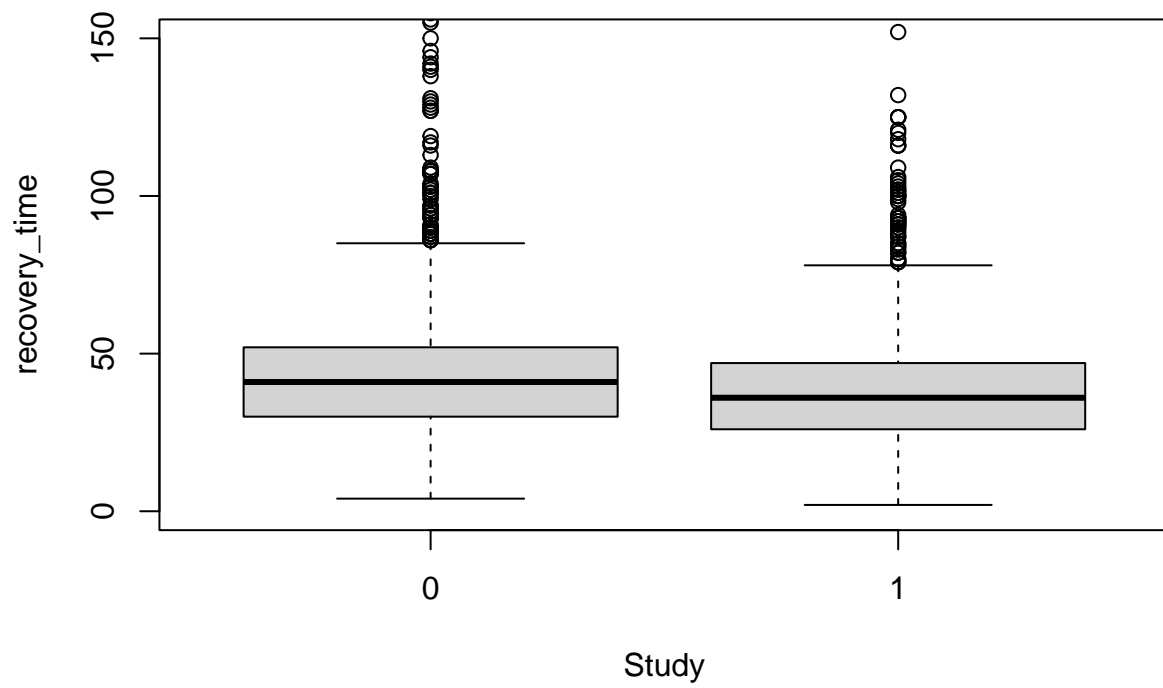
featurePlot(x = vis_trdat[, 1:6],
            y = vis_trdat[, 7],
            plot = "scatter",
            span = 0.5,
            labels = c("Predictors", "Recovery Time"),
            type = c("p", "smooth"))
```



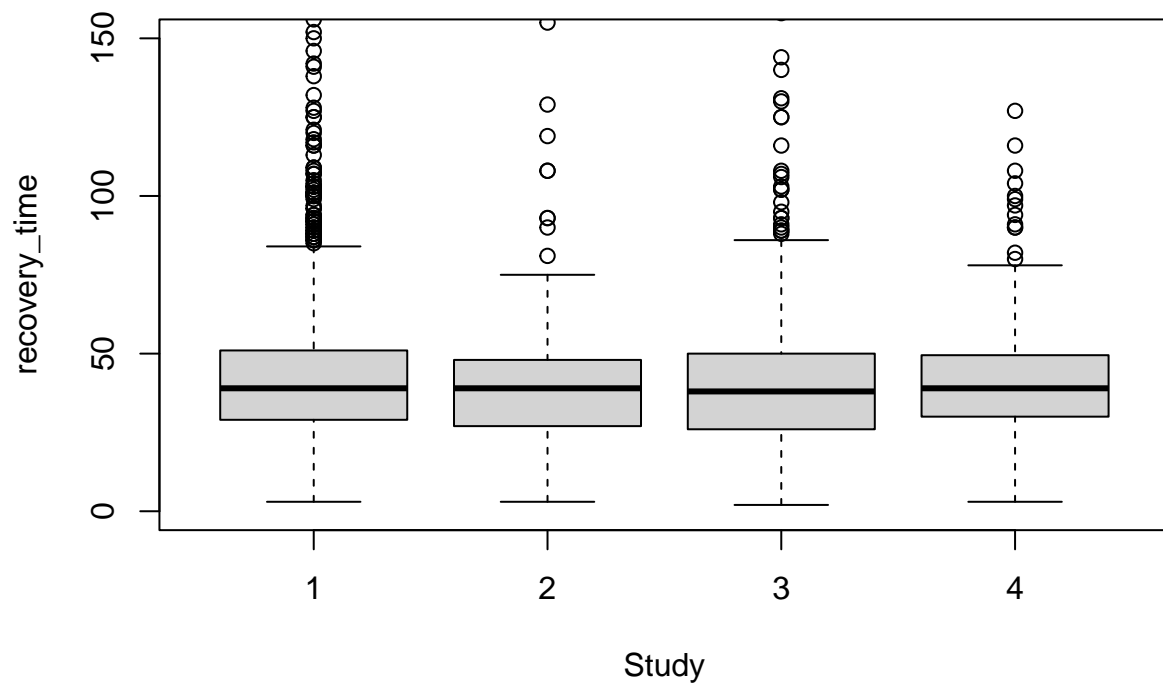
## Boxplot



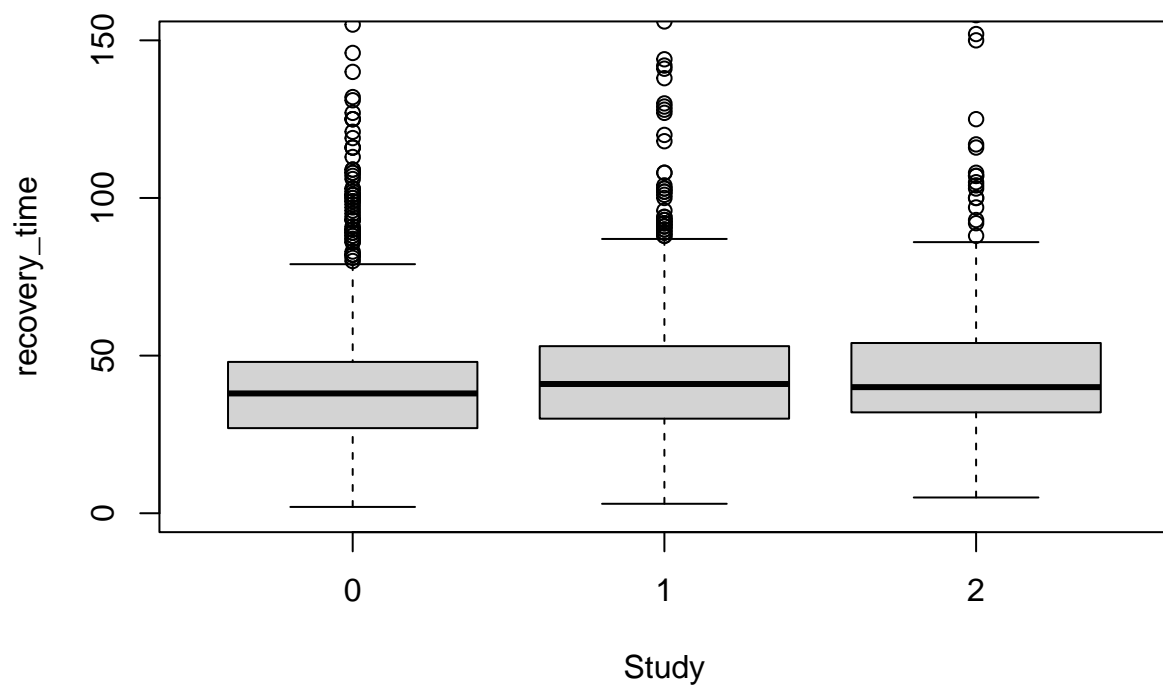
```
bp_gender = boxplot(recovery_time ~ gender, data = trainData, xlab = "Study", ylim = c(0, 150))
```



```
bp_race = boxplot(recovery_time ~ race, data = trainData, xlab = "Study", ylim = c(0, 150))
```

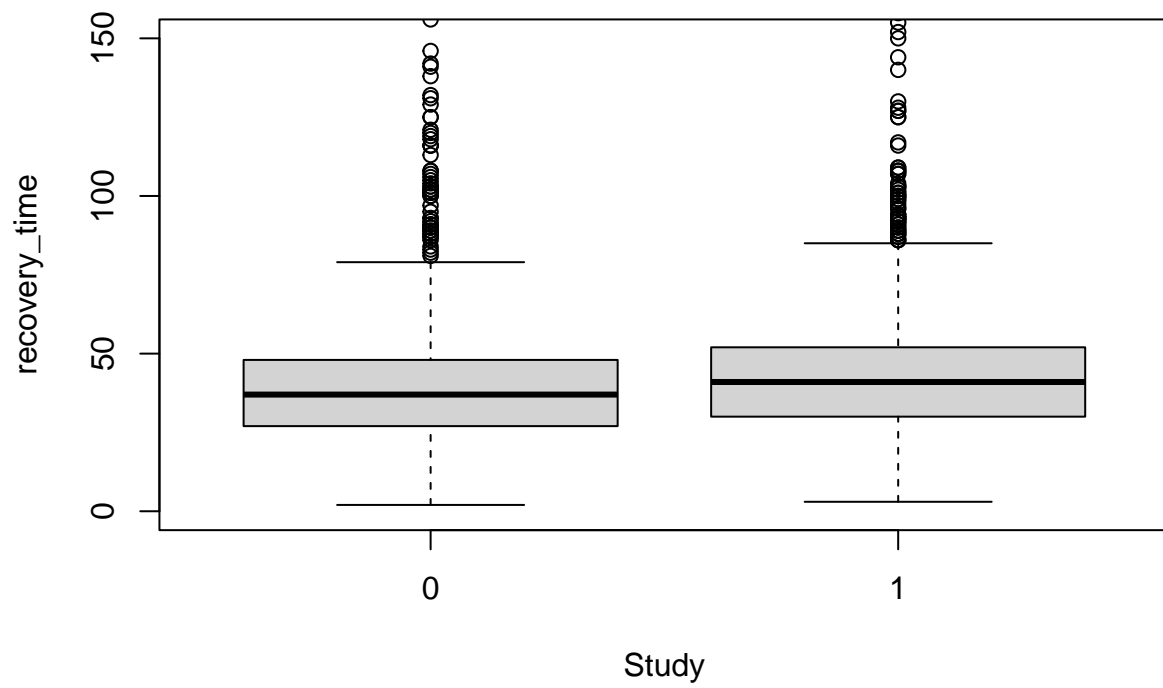


```
bp_smoking = boxplot(recovery_time ~ smoking, data = trainData, xlab = "Study", ylim = c(0, 150))
```

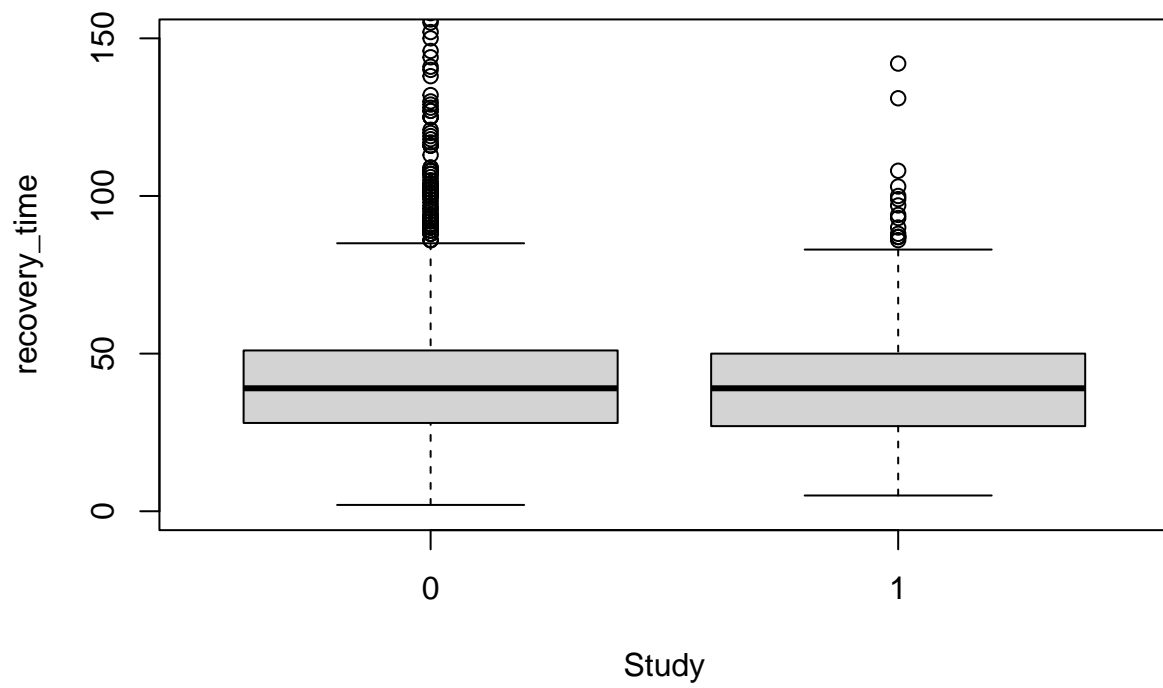


```
bp_hypertension = boxplot(recovery_time ~ hypertension, data = trainData, xlab = "Study", ylim = c(0, 150))
```

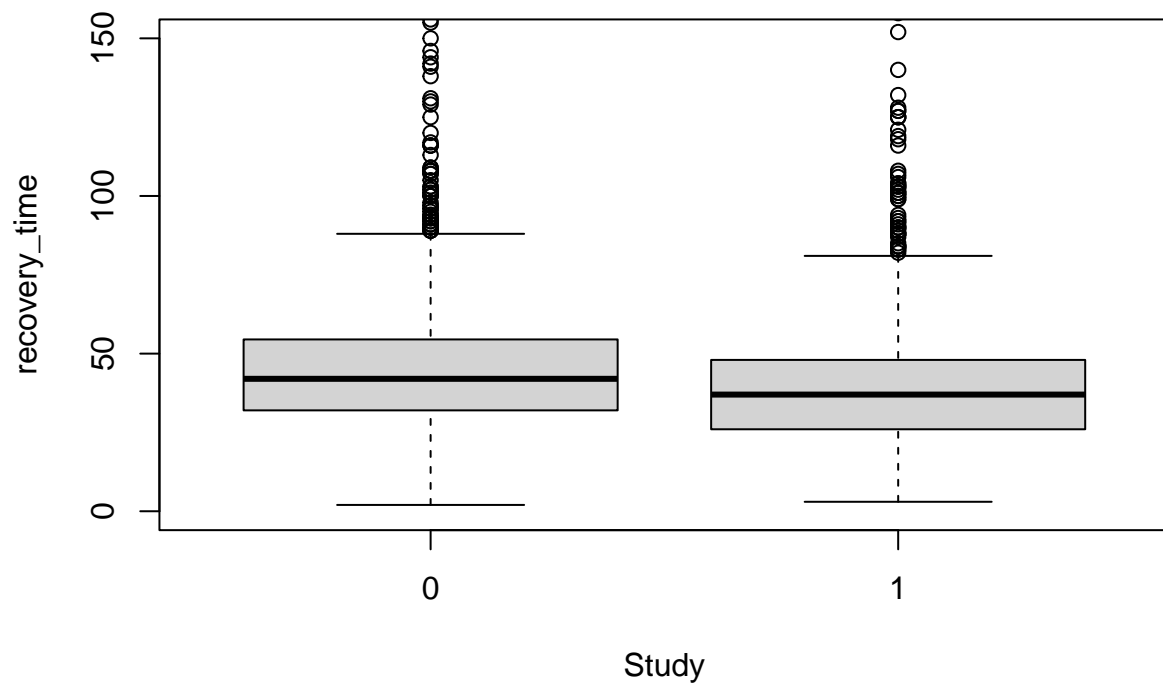




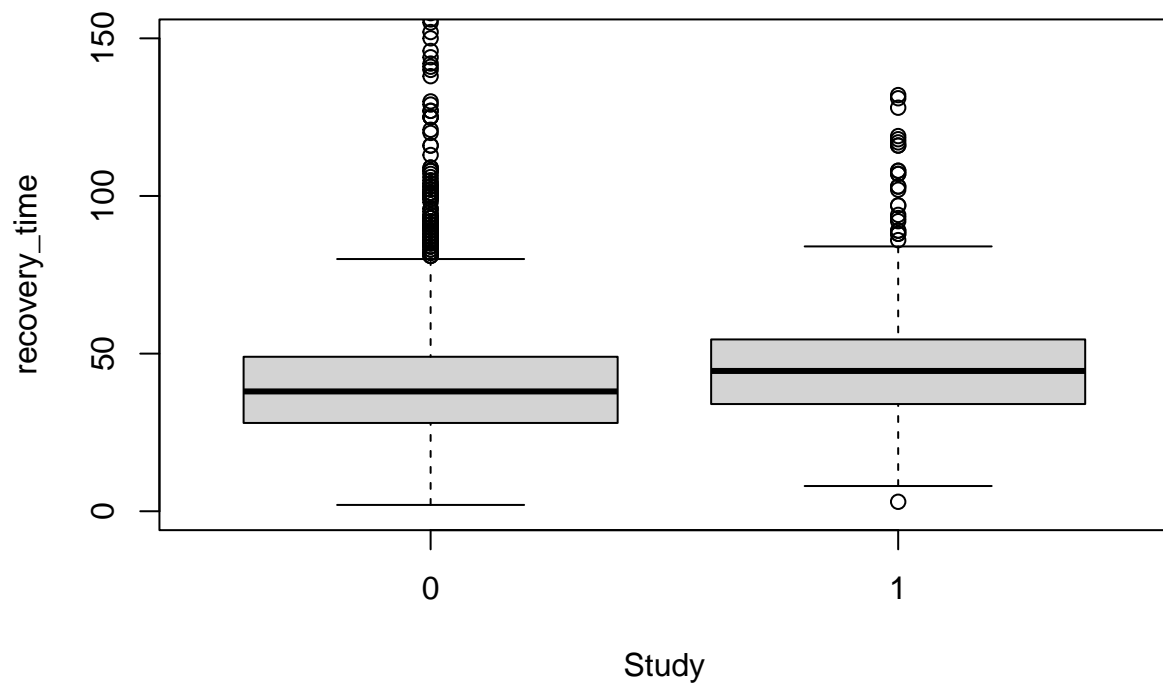
```
bp_diabetes = boxplot(recovery_time ~ diabetes, data = trainData, xlab = "Study", ylim = c(0, 150))
```



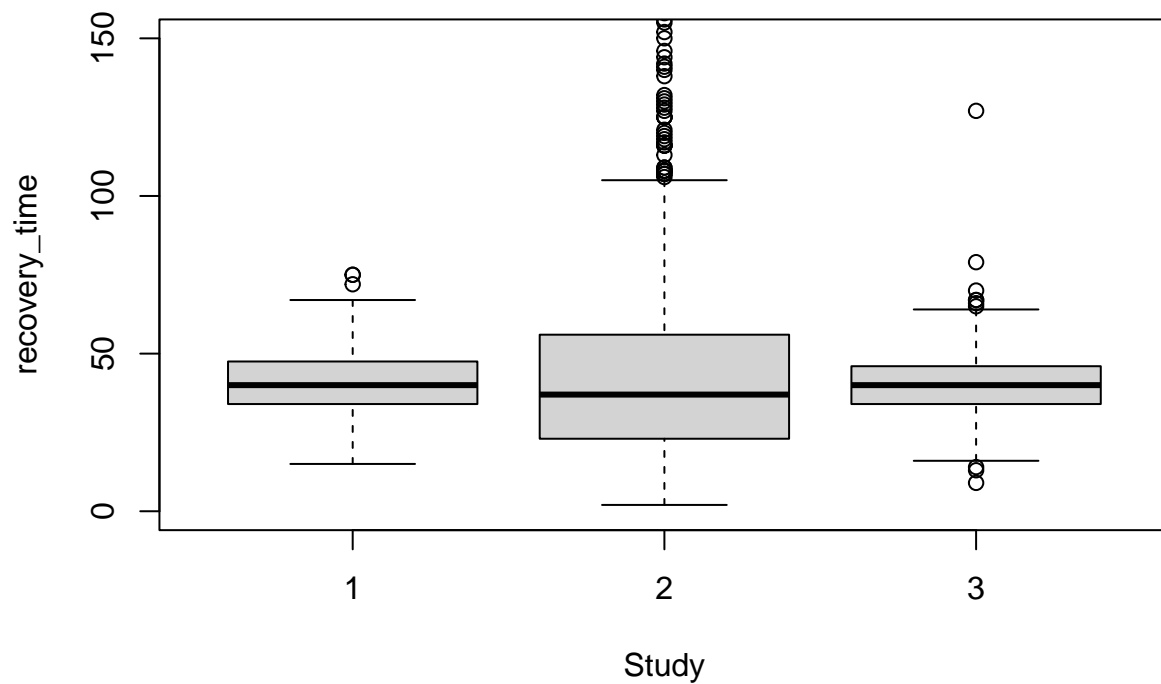
```
bp_vaccine = boxplot(recovery_time ~ vaccine, data = trainData, xlab = "Study", ylim = c(0, 150))
```



```
bp_severity = boxplot(recovery_time ~ severity, data = trainData, xlab = "Study", ylim = c(0, 150))
```



```
bp_study = boxplot(recovery_time ~ study, data = trainData, xlab = "Study", ylim = c(0, 150))
```



## Model training

### GAM

```
set.seed(2)
gam.fit = train(x = covid_dat2[rowTrain,],
                y = covid_dat$recovery_time[rowTrain],
                method = "gam",
                tuneGrid = data.frame(method = "GCV.Cp", select = c(TRUE,FALSE)),
                trControl = ctrl1)
```

```
gam.fit$bestTune
```

```
## select method
## 2 TRUE GCV.Cp
```

```
gam.fit$finalModel
```

```
##
## Family: gaussian
## Link function: identity
##
```

```
## Formula:
## .outcome ~ gender1 + race2 + race3 + race4 + smoking1 + smoking2 +
##      hypertension1 + diabetes1 + vaccine1 + severity1 + study2 +
##      study3 + s(age) + s(SBP) + s(LDL) + s(bmi) + s(height) +
##      s(weight)
##
## Estimated degrees of freedom:
## 0.765 0.000 0.000 7.872 4.491 0.430  total = 26.56
##
## GCV score: 495.0358
```

```
# test error
pred.gam = predict(gam.fit, newdata = covid_dat2[-rowTrain,])
gam.RMSE = mean((pred.gam - covid_dat$recovery_time[-rowTrain])^2)
gam.RMSE
```

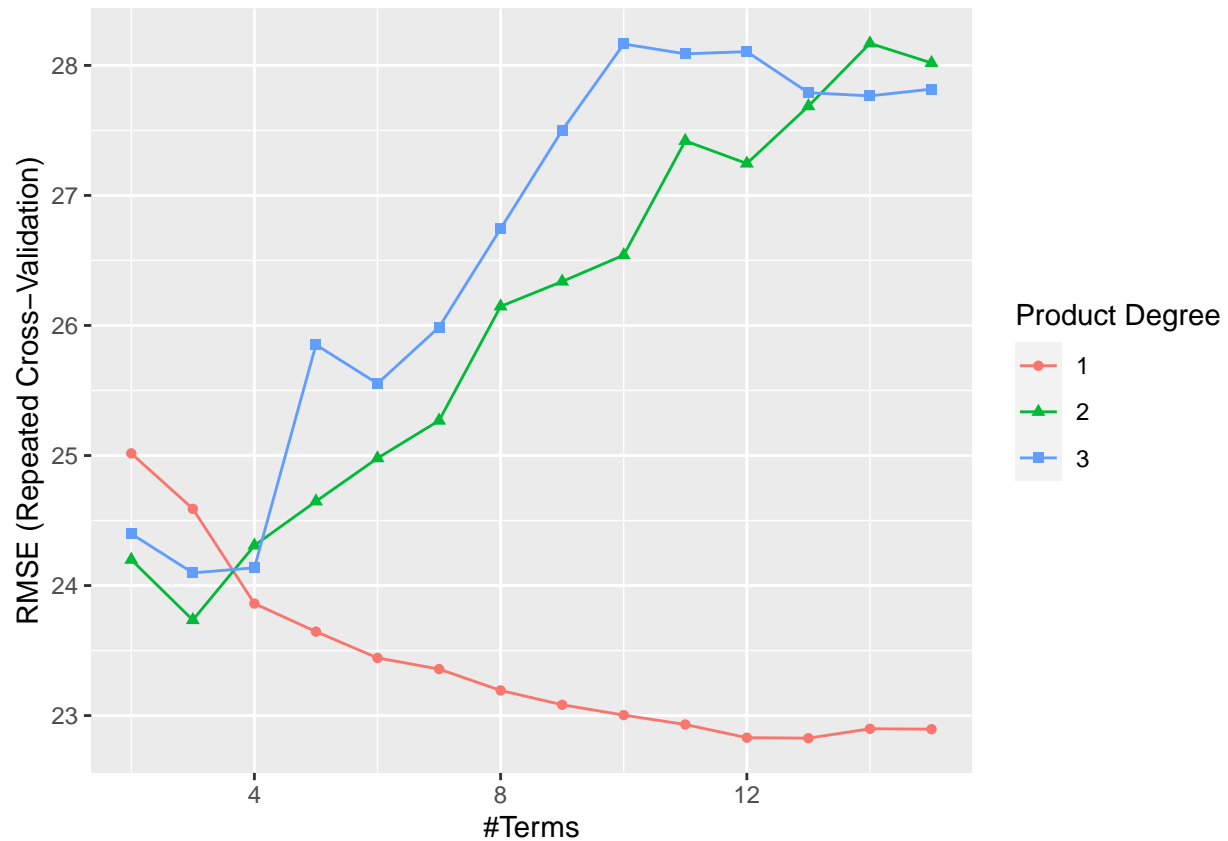
```
## [1] 502.8183
```

## MARS

```
mars_grid = expand.grid(degree = 1:3,
                        nprune = 2:15)

set.seed(2)
mars.fit = train(x = covid_dat2[rowTrain,],
                 y = covid_dat$recovery_time[rowTrain],
                 method = "earth",
                 tuneGrid = mars_grid,
                 trControl = ctrl1)

ggplot(mars.fit)
```



```
mars.fit$bestTune
```

```
##      nprune degree
## 12      13      1
```

```
mars.fit$finalModel
```

```
## Selected 12 of 20 terms, and 8 of 18 predictors (nprune=13)
## Termination condition: RSq changed by less than 0.001 at 20 terms
## Importance: bmi, vaccine1, severity1, gender1, hypertension1, study2, ...
## Number of terms at each degree of interaction: 1 11 (additive model)
## GCV 500.9977    RSS 1236067    GRSq 0.3893063    RSq 0.3999563
```

```
# test error
```

```
pred.mars = predict(mars.fit, newdata = covid_dat2[-rowTrain,])
mars.RMSE = mean((pred.mars - covid_dat$recovery_time[-rowTrain])^2)
mars.RMSE
```

```
## [1] 505.8689
```

Regression tree

```
set.seed(2)
```

```
#Build a regression tree on the training data to predict the respons
```

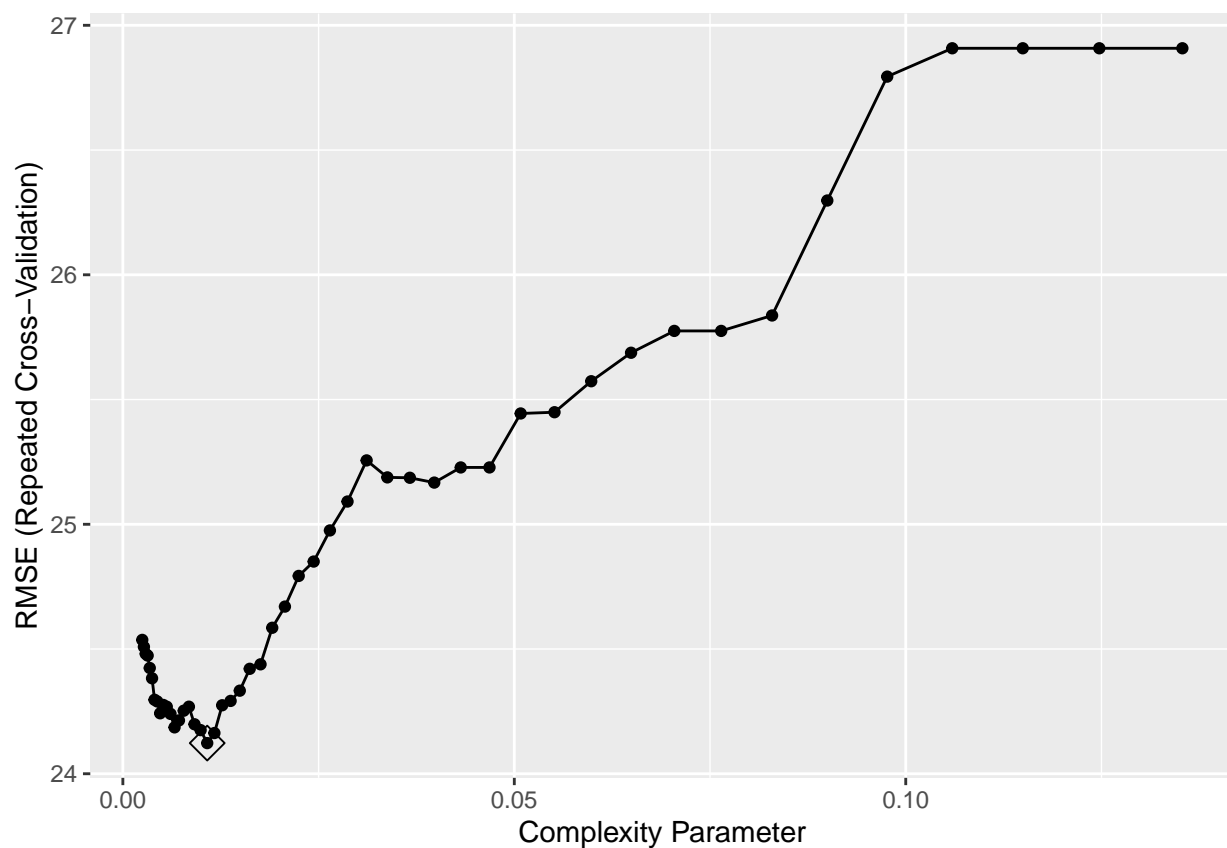
```
rpart.fit = train(recovery_time ~ . ,  
                  covid_dat[rowTrain,],  
                  method = "rpart",  
                  tuneGrid = data.frame(cp = exp(seq(-6,-2, length = 50))),  
                  trControl = ctrl1,  
                  preProcess = c("center", "scale"))
```

```
rpart.fit$bestTune
```

```
##           cp  
## 19 0.01077408
```

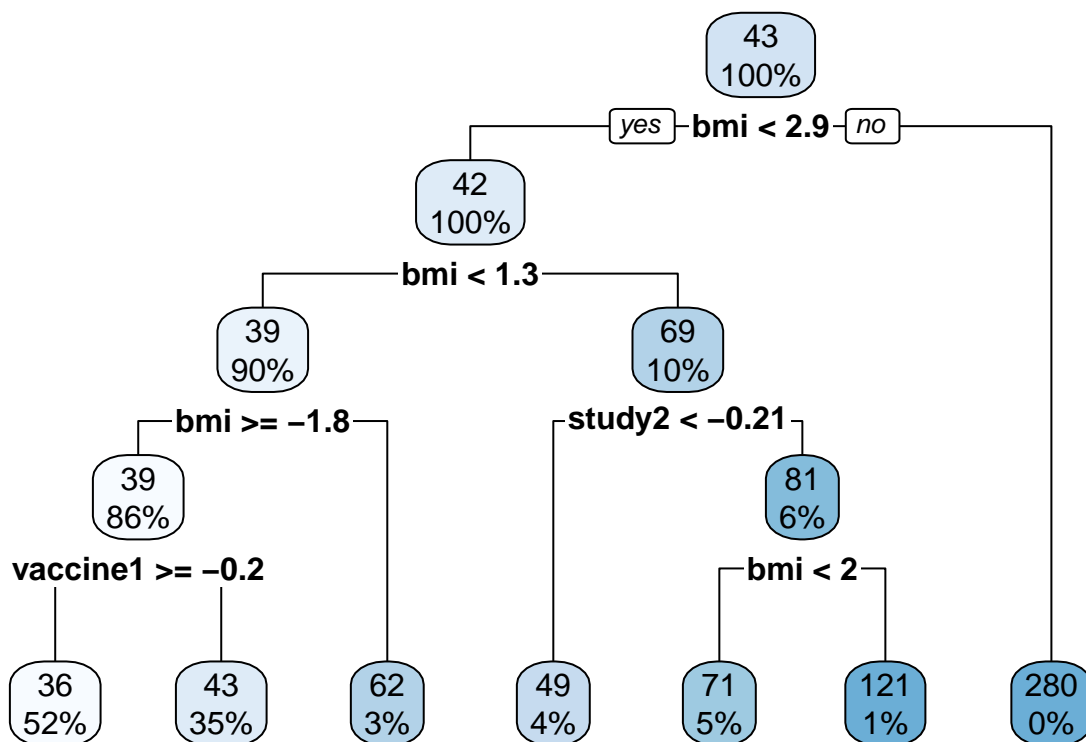
```
#plot of the tree
```

```
ggplot(rpart.fit, highlight = TRUE)
```



```
rpart.plot(rpart.fit$finalModel)
```





*# Report the variable importance*

```
summary(rpart.fit$finalModel, las = 2, cBars = 19, cex.names = 0.6)
```

## Call:

```
## (function (formula, data, weights, subset, na.action = na.rpart,
##   method, model = FALSE, x = FALSE, y = TRUE, parms, control,
##   cost, ...)
## {
```

```
##   Call <- match.call()
##   if (is.data.frame(model)) {
##     m <- model
##     model <- FALSE
##   }
##   else {
```

```
##     indx <- match(c("formula", "data", "weights", "subset"),
##       names(Call), nomatch = 0)
##     if (indx[1] == 0)
##       stop("a 'formula' argument is required")
##     temp <- Call[c(1, indx)]
##     temp$na.action <- na.action
##     temp[[1]] <- quote(stats::model.frame)
##     m <- eval.parent(temp)
##   }
##   Terms <- attr(m, "terms")
##   if (any(attr(Terms, "order") > 1))
##     stop("Trees cannot handle interaction terms")
```

```

##      Y <- model.response(m)
##      wt <- model.weights(m)
##      if (any(wt < 0))
##          stop("negative weights not allowed")
##      if (!length(wt))
##          wt <- rep(1, nrow(m))
##      offset <- model.offset(m)
##      X <- rpart.matrix(m)
##      nobs <- nrow(X)
##      nvar <- ncol(X)
##      if (missing(method)) {
##          method <- if (is.factor(Y) || is.character(Y))
##              "class"
##          else if (inherits(Y, "Surv"))
##              "exp"
##          else if (is.matrix(Y))
##              "poisson"
##          else "anova"
##      }
##      if (is.list(method)) {
##          mlist <- method
##          method <- "user"
##          init <- if (missing(parms))
##              mlist$init(Y, offset, wt = wt)
##          else mlist$init(Y, offset, parms, wt)
##          keep <- rpartcallback(mlist, nobs, init)
##          method.int <- 4
##          parms <- init$parms
##      }
##      else {
##          method.int <- pmatch(method, c("anova", "poisson", "class",
##              "exp"))
##          if (is.na(method.int))
##              stop("Invalid method")
##          method <- c("anova", "poisson", "class", "exp")[method.int]
##          if (method.int == 4)
##              method.int <- 2
##          init <- if (missing(parms))
##              get(paste("rpart", method, sep = "."), envir = environment())(Y,
##                  offset, , wt)
##          else get(paste("rpart", method, sep = "."), envir = environment())(Y,
##                  offset, parms, wt)
##          ns <- asNamespace("rpart")
##          if (!is.null(init$print))
##              environment(init$print) <- ns
##          if (!is.null(init$summary))
##              environment(init$summary) <- ns
##          if (!is.null(init$text))
##              environment(init$text) <- ns
##      }
##      Y <- init$y
##      xlevels <- .getXlevels(Terms, m)
##      cats <- rep(0, ncol(X))
##      if (!is.null(xlevels)) {

```

```

##      indx <- match(names(xlevels), colnames(X), nomatch = 0)
##      cats[indx] <- (unlist(lapply(xlevels, length)))[indx >
##      0]
##  }
##  extraArgs <- list(...)
##  if (length(extraArgs)) {
##      controlargs <- names(formals(rpart.control))
##      indx <- match(names(extraArgs), controlargs, nomatch = 0)
##      if (any(indx == 0))
##          stop(gettextf("Argument %s not matched", names(extraArgs)[indx ==
##          0]), domain = NA)
##  }
##  controls <- rpart.control(...)
##  if (!missing(control))
##      controls[names(control)] <- control
##  xval <- controls$xval
##  if (is.null(xval) || (length(xval) == 1 && xval == 0) ||
##      method == "user") {
##      xgroups <- 0
##      xval <- 0
##  }
##  else if (length(xval) == 1) {
##      xgroups <- sample(rep(1:xval, length.out = nobs), nobs,
##          replace = FALSE)
##  }
##  else if (length(xval) == nobs) {
##      xgroups <- xval
##      xval <- length(unique(xgroups))
##  }
##  else {
##      if (!is.null(attr(m, "na.action"))) {
##          temp <- as.integer(attr(m, "na.action"))
##          xval <- xval[-temp]
##          if (length(xval) == nobs) {
##              xgroups <- xval
##              xval <- length(unique(xgroups))
##          }
##          else stop("Wrong length for 'xval'")
##      }
##      else stop("Wrong length for 'xval'")
##  }
##  if (missing(cost))
##      cost <- rep(1, nvar)
##  else {
##      if (length(cost) != nvar)
##          stop("Cost vector is the wrong length")
##      if (any(cost <= 0))
##          stop("Cost vector must be positive")
##  }
##  tfun <- function(x) if (is.matrix(x))
##      rep(is.ordered(x), ncol(x))
##  else is.ordered(x)
##  labs <- sub("^'(.*)'$", "\\1", attr(Terms, "term.labels"))
##  isord <- unlist(lapply(m[labs], tfun))

```

```

## storage.mode(X) <- "double"
## storage.mode(wt) <- "double"
## temp <- as.double(unlist(init$parms))
## if (!length(temp))
##   temp <- 0
## rpfit <- .Call(C_rpart, ncat = as.integer(cats * !isord),
##   method = as.integer(method.int), as.double(unlist(controls)),
##   temp, as.integer(xval), as.integer(xgroups), as.double(t(init$y)),
##   X, wt, as.integer(init$numy), as.double(cost))
## nsplit <- nrow(rpfit$split)
## ncat <- if (!is.null(rpfit$csplit))
##   nrow(rpfit$csplit)
## else 0
## if (nsplit == 0)
##   xval <- 0
## numcp <- ncol(rpfit$cptable)
## temp <- if (nrow(rpfit$cptable) == 3)
##   c("CP", "nsplit", "rel error")
## else c("CP", "nsplit", "rel error", "xerror", "xstd")
## dimnames(rpfit$cptable) <- list(temp, 1:numcp)
## tname <- c("<leaf>", colnames(X))
## splits <- matrix(c(rpfit$split[, 2:3], rpfit$dsplit), ncol = 5,
##   dimnames = list(tname[rpfit$split[, 1] + 1], c("count",
##     "ncat", "improve", "index", "adj")))
## index <- rpfit$inode[, 2]
## nadd <- sum(isord[rpfit$split[, 1]])
## if (nadd > 0) {
##   newc <- matrix(0, nadd, max(cats))
##   cvar <- rpfit$split[, 1]
##   indx <- isord[cvar]
##   cdir <- splits[indx, 2]
##   ccut <- floor(splits[indx, 4])
##   splits[indx, 2] <- cats[cvar[indx]]
##   splits[indx, 4] <- ncat + 1:nadd
##   for (i in 1:nadd) {
##     newc[i, 1:(cats[(cvar[indx])[i]])] <- -as.integer(cdir[i])
##     newc[i, 1:ccut[i]] <- as.integer(cdir[i])
##   }
##   catmat <- if (ncat == 0)
##     newc
##   else {
##     cs <- rpfit$csplit
##     ncs <- ncol(cs)
##     ncc <- ncol(newc)
##     if (ncs < ncc)
##       cs <- cbind(cs, matrix(0, nrow(cs), ncc - ncs))
##     rbind(cs, newc)
##   }
##   ncat <- ncat + nadd
## }
## else catmat <- rpfit$csplit
## if (nsplit == 0) {
##   frame <- data.frame(row.names = 1, var = "<leaf>", n = rpfit$inode[,
##     5], wt = rpfit$dnnode[, 3], dev = rpfit$dnnode[, 1],

```

```

##           yval = rpfit$dnode[, 4], complexity = rpfit$dnode[,
##           2], ncompete = 0, nsurrogate = 0)
##     }
##   else {
##     temp <- ifelse(index == 0, 1, index)
##     svar <- ifelse(index == 0, 0, rpfit$split[temp, 1])
##     frame <- data.frame(row.names = rpfit$inode[, 1], var = tname[svar +
##     1], n = rpfit$inode[, 5], wt = rpfit$dnode[, 3],
##     dev = rpfit$dnode[, 1], yval = rpfit$dnode[, 4],
##     complexity = rpfit$dnode[, 2], ncompete = pmax(0,
##     rpfit$inode[, 3] - 1), nsurrogate = rpfit$inode[,
##     4])
##   }
##   if (method.int == 3) {
##     numclass <- init$numresp - 2
##     nodeprob <- rpfit$dnode[, numclass + 5]/sum(wt)
##     temp <- pmax(1, init$counts)
##     temp <- rpfit$dnode[, 4 + (1:numclass)] %*% diag(init$parms$prior/temp)
##     yprob <- temp/rowSums(temp)
##     yval2 <- matrix(rpfit$dnode[, 4 + (0:numclass)], ncol = numclass +
##     1)
##     frame$yval2 <- cbind(yval2, yprob, nodeprob)
##   }
##   else if (init$numresp > 1)
##     frame$yval2 <- rpfit$dnode[, -(1:3), drop = FALSE]
##   if (is.null(init$summary))
##     stop("Initialization routine is missing the 'summary' function")
##   functions <- if (is.null(init$print))
##     list(summary = init$summary)
##   else list(summary = init$summary, print = init$print)
##   if (!is.null(init$text))
##     functions <- c(functions, list(text = init$text))
##   if (method == "user")
##     functions <- c(functions, mlist)
##   where <- rpfit$which
##   names(where) <- row.names(m)
##   ans <- list(frame = frame, where = where, call = Call, terms = Terms,
##   cptable = t(rpfit$cptable), method = method, parms = init$parms,
##   control = controls, functions = functions, numresp = init$numresp)
##   if (nsplit)
##     ans$splits = splits
##   if (ncat > 0)
##     ans$csplit <- catmat + 2
##   if (nsplit)
##     ans$variable.importance <- importance(ans)
##   if (model) {
##     ans$model <- m
##     if (missing(y))
##       y <- FALSE
##   }
##   if (y)
##     ans$y <- Y
##   if (x) {
##     ans$x <- X

```

```

##      ans$wt <- wt
##    }
##    ans$ordered <- isord
##    if (!is.null(attr(m, "na.action")))
##      ans$na.action <- attr(m, "na.action")
##    if (!is.null(xlevels))
##      attr(ans, "xlevels") <- xlevels
##    if (method == "class")
##      attr(ans, "ylevels") <- init$ylevels
##    class(ans) <- "rpart"
##    ans
##  }(formula = .outcome ~ ., data = list(c(-0.491180822761473,
## 0.415420284546335, -1.17113165324233, 0.642070561373287, -0.0378802691075688,
## 0.415420284546335, 0.415420284546335, 2.4552727759889, -1.85108248372319,
## -0.491180822761473, -0.717831099588425, 1.5486716686811, -0.0378802691075688,
## 0.868720838200239, 1.32202139185414, -0.944481376415377, -0.0378802691075688,
## -0.717831099588425, -1.17113165324233, -1.62443220689623, 0.188770007719383,
## -0.717831099588425, -0.0378802691075688, 0.642070561373287, 1.5486716686811,
## -0.491180822761473, -0.717831099588425, 0.415420284546335, 0.188770007719383,
## 1.32202139185414, -1.17113165324233, 0.642070561373287, 0.415420284546335,
## 0.415420284546335, -0.717831099588425, 0.868720838200239, 0.188770007719383,
## -0.0378802691075688, 1.09537111502719, -0.944481376415377, -0.491180822761473,
## 2.4552727759889, -2.30438303737709, 0.642070561373287, -1.39778193006928,
## 1.77532194550805, 0.188770007719383, 0.415420284546335, -1.39778193006928,
## -2.53103331420404, -0.264530545934521, 1.32202139185414, 1.32202139185414,
## -0.0378802691075688, -0.491180822761473, 0.415420284546335, -0.0378802691075688,
## -0.717831099588425, -0.264530545934521, -1.17113165324233, 0.415420284546335,
## -1.85108248372319, 1.09537111502719, 0.188770007719383, 1.09537111502719,
## -1.39778193006928, 0.188770007719383, 0.642070561373287, -1.17113165324233,
## -0.0378802691075688, 1.09537111502719, -1.39778193006928, -0.944481376415377,
## 1.5486716686811, -0.0378802691075688, -0.717831099588425, 0.188770007719383,
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## 48, 42, 35, 32, 21, 34, 24, 34, 250, 43, 13, 44, 53, 46, 43,
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## 20, 7, 0, 4, 5, 2, 0, 30, 0))
## n= 2513
##
##          CP nsplit rel error
## 1 0.21794422      0 1.0000000
## 2 0.09489917      1 0.7820558
## 3 0.02965163      2 0.6871566
## 4 0.02015958      4 0.6278534
## 5 0.01231462      5 0.6076938
## 6 0.01077408      6 0.5953792
##
## Variable importance
##      bmi      study2      study3 vaccine1      height      weight
##      82          7          3          3          2          2
##
## Node number 1: 2513 observations,      complexity param=0.2179442
## mean=43.10665, MSE=819.722
## left son=2 (2505 obs) right son=3 (8 obs)
## Primary splits:
##      bmi      < 2.913112      to the left, improve=0.217944200, (0 missing)
##      height < -1.850917      to the right, improve=0.045485090, (0 missing)
##      weight < 1.204033      to the left, improve=0.036833680, (0 missing)
##      vaccine1 < -0.2017165      to the right, improve=0.015906280, (0 missing)
##      LDL      < -2.711449      to the right, improve=0.007447712, (0 missing)
##
## Node number 2: 2505 observations,      complexity param=0.09489917
## mean=42.3513, MSE=595.0287
## left son=4 (2250 obs) right son=5 (255 obs)
## Primary splits:
##      bmi      < 1.278118      to the left, improve=0.13115230, (0 missing)
##      height < -0.5889625      to the right, improve=0.03068432, (0 missing)
##      vaccine1 < -0.2017165      to the right, improve=0.02439458, (0 missing)
##      weight < 0.8685148      to the left, improve=0.02245563, (0 missing)
##      gender1 < 0.02188708      to the right, improve=0.01050541, (0 missing)
## Surrogate splits:
##      height < -2.086482      to the right, agree=0.903, adj=0.043, (0 split)
##      weight < 1.979917      to the left, agree=0.901, adj=0.027, (0 split)
##
## Node number 3: 8 observations
## mean=279.625, MSE=15057.23
##
## Node number 4: 2250 observations,      complexity param=0.02015958
## mean=39.37733, MSE=366.3185
## left son=8 (2171 obs) right son=9 (79 obs)
## Primary splits:
##      bmi      < -1.846538      to the right, improve=0.05038476, (0 missing)
##      vaccine1 < -0.2017165      to the right, improve=0.03110116, (0 missing)
##      gender1 < 0.02188708      to the right, improve=0.01965444, (0 missing)
##      weight < -1.074692      to the right, improve=0.01904932, (0 missing)
##      severity1 < 1.260735      to the left, improve=0.01607559, (0 missing)
## Surrogate splits:
##      weight < -2.039305      to the right, agree=0.972, adj=0.203, (0 split)

```

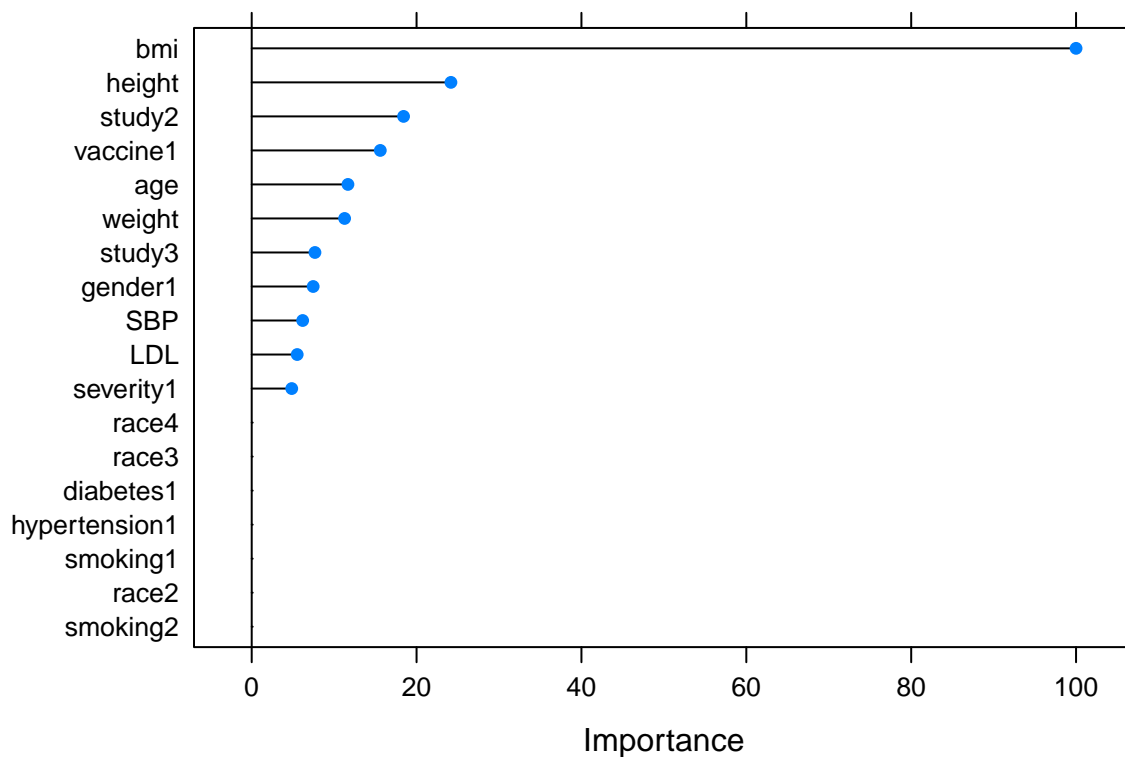
```

##
## Node number 5: 255 observations,    complexity param=0.02965163
##   mean=68.59216, MSE=1846.438
##   left son=10 (100 obs) right son=11 (155 obs)
##   Primary splits:
##     study2 < -0.205099    to the left,  improve=0.12803110, (0 missing)
##     bmi    < 2.004782     to the left,  improve=0.11038570, (0 missing)
##     study3 < 0.7173617    to the right, improve=0.05332546, (0 missing)
##     age    < 0.7553957    to the left,  improve=0.03537199, (0 missing)
##     height < -0.3533976   to the right, improve=0.02828122, (0 missing)
##   Surrogate splits:
##     study3 < 0.7173617    to the right, agree=0.804, adj=0.50, (0 split)
##     height < -0.08418054  to the right, agree=0.643, adj=0.09, (0 split)
##     weight < 2.126706     to the right, agree=0.635, adj=0.07, (0 split)
##     diabetes1 < 0.9375758 to the right, agree=0.631, adj=0.06, (0 split)
##     race4   < 1.345332    to the right, agree=0.616, adj=0.02, (0 split)
##
## Node number 8: 2171 observations,    complexity param=0.01231462
##   mean=38.55781, MSE=315.8146
##   left son=16 (1301 obs) right son=17 (870 obs)
##   Primary splits:
##     vaccine1 < -0.2017165  to the right, improve=0.03699883, (0 missing)
##     bmi      < 0.769453    to the left,  improve=0.02836350, (0 missing)
##     gender1  < 0.02188708  to the right, improve=0.02166156, (0 missing)
##     severity1 < 1.260735   to the left,  improve=0.01768035, (0 missing)
##     SBP      < 0.04158358  to the left,  improve=0.01480118, (0 missing)
##   Surrogate splits:
##     height < 2.170512     to the left,  agree=0.602, adj=0.008, (0 split)
##     LDL    < 2.163143     to the left,  agree=0.602, adj=0.006, (0 split)
##     age    < -2.644358    to the right, agree=0.601, adj=0.005, (0 split)
##     bmi    < -1.773872    to the right, agree=0.601, adj=0.005, (0 split)
##     SBP    < 2.540078     to the left,  agree=0.601, adj=0.003, (0 split)
##
## Node number 9: 79 observations
##   mean=61.89873, MSE=1228.547
##
## Node number 10: 100 observations
##   mean=49.45, MSE=157.5675
##
## Node number 11: 155 observations,    complexity param=0.02965163
##   mean=80.94194, MSE=2547.113
##   left son=22 (124 obs) right son=23 (31 obs)
##   Primary splits:
##     bmi    < 2.004782     to the left,  improve=0.15673680, (0 missing)
##     height < -2.288395    to the right, improve=0.06351868, (0 missing)
##     age    < 0.7553957    to the left,  improve=0.04577189, (0 missing)
##     LDL    < -0.008955012 to the right, improve=0.03089930, (0 missing)
##     SBP    < 1.915454     to the right, improve=0.02815939, (0 missing)
##   Surrogate splits:
##     height < -2.582851    to the right, agree=0.819, adj=0.097, (0 split)
##
## Node number 16: 1301 observations
##   mean=35.76249, MSE=254.5931
##

```

```
## Node number 17: 870 observations
##   mean=42.73793, MSE=378.2072
##
## Node number 22: 124 observations
##   mean=70.95161, MSE=1468.272
##
## Node number 23: 31 observations
##   mean=120.9032, MSE=4866.345
```

```
plot(varImp(rpart.fit, scale = TRUE))
```



```
## rpart does not have RMSE
```

## Random Forest

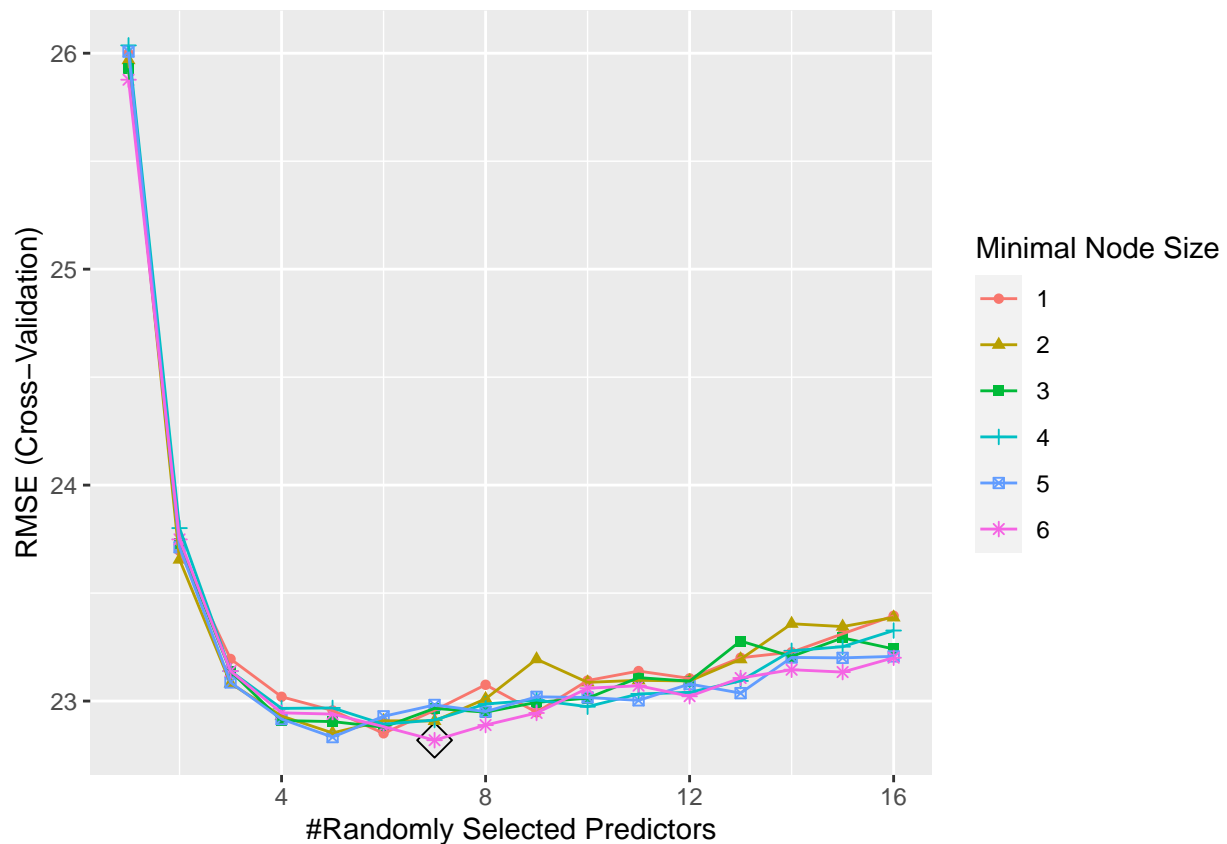
```
ctrlrnf = trainControl(method = "cv")

# Using Caret package to build random forest plot
rf.grid = expand.grid(mtry = 1:16,
                      splitrule = "variance",
                      min.node.size = 1:6)

set.seed(2)
```

```
rf.fit = train(recovery_time ~ .,
              covid_dat[rowTrain,],
              method = "ranger",
              tuneGrid = rf.grid(),
              trControl = ctrlrf)
```

```
ggplot(rf.fit, highlight = TRUE)
```



```
# Best tuning parameter
```

```
rf.fit$bestTune
```

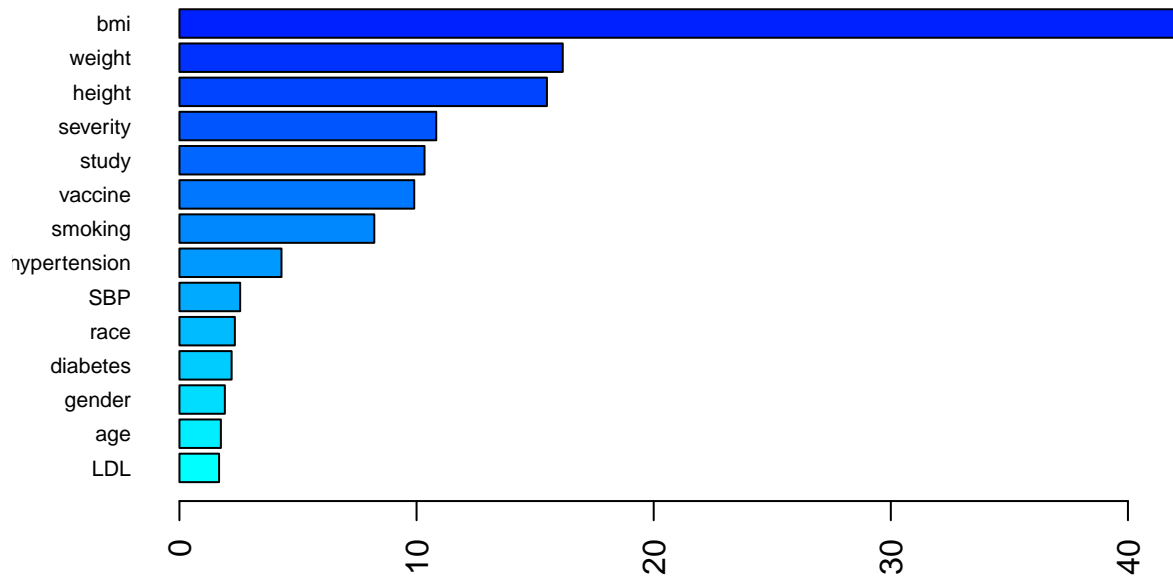
```
##      mtry splitrule min.node.size
## 42      7  variance                6
```

```
# Variable importance
```

```
rf2.final.per = ranger(recovery_time ~ .,
                      covid_dat[rowTrain,],
                      mtry = rf.fit$bestTune[[1]],
                      splitrule = "variance",
                      min.node.size = rf.fit$bestTune[[3]],
                      importance = "permutation",
                      scale.permutation.importance = TRUE)
```

```
barplot(sort(ranger::importance(rf2.final.per), decreasing = FALSE),
```

```
las = 2, horiz = TRUE, cex.names = 0.7,
col = colorRampPalette(colors = c("cyan", "blue"))(16))
```



```
# test error

set.seed(2)
rffit_pred = predict(rf.fit, newdata = covid_dat[-rowTrain,])
rffit.RMSE = RMSE(rffit_pred, covid_dat$recovery_time[-rowTrain])
rffit.RMSE
```

```
## [1] 22.80351
```

## Boosting

```
ctrlboost = trainControl(method = "cv")

gbm_grid = expand.grid(n.trees = c(100, 250, 500, 1000, 2000, 3000),
                      interaction.depth = 1:3,
                      shrinkage = c(0.0005, 0.001, 0.002),
                      n.minobsinnode = 1)

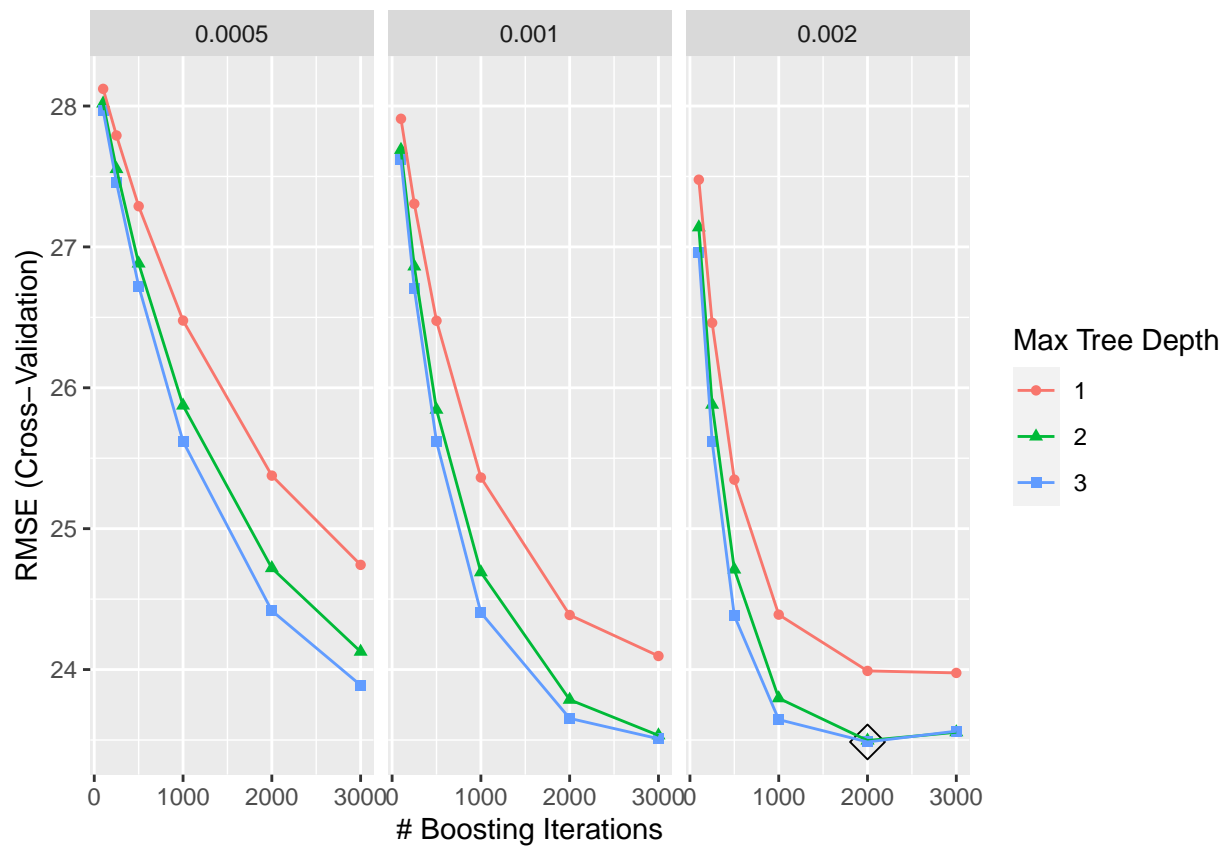
set.seed(2)
gbm.fit = train(recovery_time ~ . ,
               covid_dat[rowTrain,],
```

```
tuneGrid = gbm_grid,
trControl = ctrlboost,
method = "gbm",
verbose = FALSE)
```

```
gbm.fit$bestTune
```

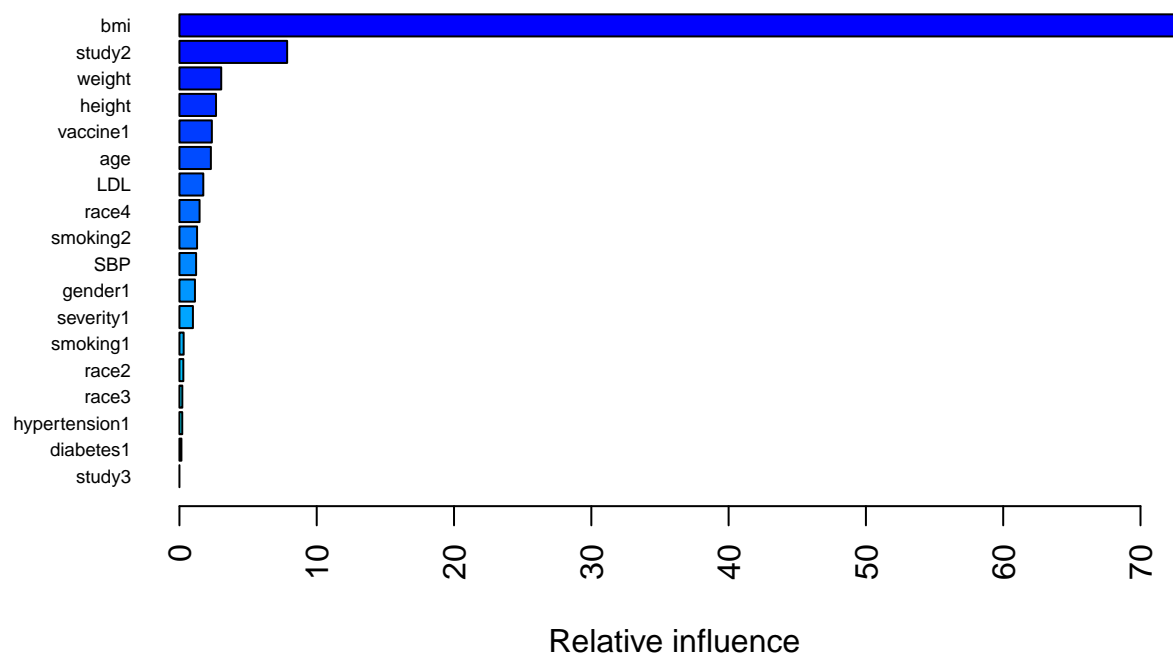
```
##      n.trees interaction.depth shrinkage n.minobsinnode
## 53      2000                3      0.002                1
```

```
ggplot(gbm.fit, highlight = TRUE)
```



```
# Report the variable importance
summary(gbm.fit$finalModel, las = 2, cBars = 19, cex.names = 0.6)
```





```
##           var    rel.inf
## bmi          bmi 72.8306899
## study2       study2  7.8446965
## weight       weight  3.0431561
## height       height  2.6654281
## vaccine1     vaccine1  2.3613918
## age          age  2.2890618
## LDL          LDL  1.7390874
## race4        race4  1.4669575
## smoking2     smoking2  1.2842068
## SBP          SBP  1.2143366
## gender1      gender1  1.1307862
## severity1    severity1  0.9822185
## smoking1     smoking1  0.3068305
## race2        race2  0.2838777
## race3        race3  0.2095629
## hypertension1 hypertension1  0.2037763
## diabetes1     diabetes1  0.1439356
## study3       study3  0.0000000
```

```
#test error
```

```
set.seed(2)
pred.gbm = predict(gbm.fit, newdata = covid_dat[-rowTrain,])
gbm.RMSE = RMSE(pred.gbm, covid_dat$recovery_time[-rowTrain])
gbm.RMSE
```

```
## [1] 22.25067
```

## Model selection