

Stats 101C Homework 3

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Due 10/22/2021

Problem 1

Preparing for Problem 1

```
# set birthday seed
set.seed(0213)
# make wine data
wine = read.csv("Wine Fall 2021.csv")
dim(wine)
```

```
## [1] 10000    14
```

```
# make wine.color numbers to ensure compatibility
wine$Wine.Color = replace(wine$Wine.Color, wine$Wine.Color == "W", 0) # white is 0
wine$Wine.Color = replace(wine$Wine.Color, wine$Wine.Color == "R", 1) # red is 1
# split data
library(caTools)
wine_split = sample.split(wine[,14], SplitRatio = 0.70)
wine_train = wine[wine_split == TRUE,]
wine_test = wine[wine_split == FALSE,]
dim(wine_train)
```

```
## [1] 7000    14
```

```
dim(wine_test)
```

```
## [1] 3000    14
```

Part A

Make Logistic Model

```
library(caret)
```

```
## Loading required package: ggplot2
```

```
## Loading required package: lattice
```

```
wine_glm = glm(as.factor(Class) ~ Wine.Color + fixed.acidity + volatile.acidity + citric.acid + residual.sugar,
               family = binomial,
               data = wine_train)
```

Test Logistic Model With Training Data

```
# training conf matrix
wine_glm_pred = predict(wine_glm, newdata = wine_train, type = "response")
wine_glm_vec = rep("Good", 7000)
wine_glm_vec[wine_glm_pred < 0.5] = "Bad"
confusionMatrix(as.factor(wine_glm_vec), as.factor(wine_train[, 14]))
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction   Bad Good
##          Bad  2372 1323
##          Good 1174 2131
##
##              Accuracy : 0.6433
##              95% CI : (0.6319, 0.6545)
##          No Information Rate : 0.5066
##          P-Value [Acc > NIR] : < 2.2e-16
##
##              Kappa : 0.286
##
##  Mcnemar's Test P-Value : 0.003059
##
##              Sensitivity : 0.6689
##              Specificity : 0.6170
##          Pos Pred Value : 0.6419
##          Neg Pred Value : 0.6448
##              Prevalence : 0.5066
##          Detection Rate : 0.3389
##          Detection Prevalence : 0.5279
##          Balanced Accuracy : 0.6429
##
##          'Positive' Class : Bad
##
```

Test Logistic Model With Testing Data

```
# testing conf matrix
wine_glm_pred = predict(wine_glm, newdata = wine_test, type = "response")
wine_glm_vec = rep("Good", 3000)
wine_glm_vec[wine_glm_pred < 0.5] = "Bad"
confusionMatrix(as.factor(wine_glm_vec), as.factor(wine_test[, 14]))
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction   Bad Good
```

```
##      Bad  1005  579
##      Good  515  901
##
##              Accuracy : 0.6353
##              95% CI : (0.6178, 0.6526)
##      No Information Rate : 0.5067
##      P-Value [Acc > NIR] : < 2e-16
##
##              Kappa : 0.2701
##
##      McNemar's Test P-Value : 0.05682
##
##              Sensitivity : 0.6612
##              Specificity : 0.6088
##      Pos Pred Value : 0.6345
##      Neg Pred Value : 0.6363
##              Prevalence : 0.5067
##      Detection Rate : 0.3350
##      Detection Prevalence : 0.5280
##      Balanced Accuracy : 0.6350
##
##      'Positive' Class : Bad
##
```

Part B

Make LDA Model

```
library(MASS)
wine_lda = lda(as.factor(Class) ~ Wine.Color + fixed.acidity + volatile.acidity + citric.acid + residual.sugar,
               data = wine_train)
```

Test LDA Model with Training Data

```
# training conf matrix
wine_lda_pred = predict(wine_lda, newdata = wine_train)
confusionMatrix(as.factor(wine_lda_pred$class), as.factor(wine_train[, 14]))
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction  Bad Good
##      Bad   2384 1331
##      Good  1162 2123
##
##              Accuracy : 0.6439
##              95% CI : (0.6325, 0.6551)
##      No Information Rate : 0.5066
##      P-Value [Acc > NIR] : < 2.2e-16
##
##              Kappa : 0.2871
##
```

```
## McNemar's Test P-Value : 0.0007662
##
##      Sensitivity : 0.6723
##      Specificity : 0.6146
##      Pos Pred Value : 0.6417
##      Neg Pred Value : 0.6463
##      Prevalence : 0.5066
##      Detection Rate : 0.3406
##      Detection Prevalence : 0.5307
##      Balanced Accuracy : 0.6435
##
##      'Positive' Class : Bad
##
```

Test LDA Model with Testing Data

```
# testing conf matrix
wine_lda_pred = predict(wine_lda, newdata = wine_test)
confusionMatrix(as.factor(wine_lda_pred$class), as.factor(wine_test[, 14]))
```

```
## Confusion Matrix and Statistics
##
##      Reference
## Prediction  Bad Good
##      Bad   1008  581
##      Good    512  899
##
##      Accuracy : 0.6357
##      95% CI : (0.6182, 0.6529)
##      No Information Rate : 0.5067
##      P-Value [Acc > NIR] : <2e-16
##
##      Kappa : 0.2708
##
## McNemar's Test P-Value : 0.0397
##
##      Sensitivity : 0.6632
##      Specificity : 0.6074
##      Pos Pred Value : 0.6344
##      Neg Pred Value : 0.6371
##      Prevalence : 0.5067
##      Detection Rate : 0.3360
##      Detection Prevalence : 0.5297
##      Balanced Accuracy : 0.6353
##
##      'Positive' Class : Bad
##
```

Part C

Make QDA Model

```
wine_qda = qda(as.factor(Class) ~ Wine.Color + fixed.acidity + volatile.acidity + citric.acid + residual.sugar,
               data = wine_train)
```

Test QDA Model with Training Data

```
# training conf matrix
wine_qda_pred = predict(wine_qda, newdata = wine_train)
confusionMatrix(as.factor(wine_qda_pred$class), as.factor(wine_train[, 14]))
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction   Bad Good
##          Bad  1859  888
##          Good 1687 2566
##
##              Accuracy : 0.6321
##              95% CI : (0.6207, 0.6435)
##          No Information Rate : 0.5066
##          P-Value [Acc > NIR] : < 2.2e-16
##
##              Kappa : 0.2664
##
##  Mcnemar's Test P-Value : < 2.2e-16
##
##              Sensitivity : 0.5243
##              Specificity : 0.7429
##              Pos Pred Value : 0.6767
##              Neg Pred Value : 0.6033
##              Prevalence : 0.5066
##              Detection Rate : 0.2656
##          Detection Prevalence : 0.3924
##          Balanced Accuracy : 0.6336
##
##          'Positive' Class : Bad
##
```

Test QDA Model with Testing Data

```
# testing conf matrix
wine_qda_pred = predict(wine_qda, newdata = wine_test)
confusionMatrix(as.factor(wine_qda_pred$class), as.factor(wine_test[, 14]))
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction   Bad Good
##          Bad   802  387
##          Good  718 1093
##
##              Accuracy : 0.6317
##              95% CI : (0.6141, 0.649)
```

```
##      No Information Rate : 0.5067
##      P-Value [Acc > NIR] : < 2.2e-16
##
##              Kappa : 0.2654
##
##      McNemar's Test P-Value : < 2.2e-16
##
##              Sensitivity : 0.5276
##              Specificity : 0.7385
##              Pos Pred Value : 0.6745
##              Neg Pred Value : 0.6035
##              Prevalence : 0.5067
##              Detection Rate : 0.2673
##      Detection Prevalence : 0.3963
##      Balanced Accuracy : 0.6331
##
##      'Positive' Class : Bad
##
```

Part D

Make KNN Model

```
library(class)
# recreate x_train but scale everything except non numeric arguments
wine_scaled_train = data.frame(X = wine_train$X, Wine.Color = wine_train$Wine.Color, scale(wine_train[,
wine_scaled_test = data.frame(X = wine_test$X, Wine.Color = wine_test$Wine.Color, scale(wine_test[, c(-
# make knn model
wine_knn_train = knn(wine_scaled_train[, c(-1, -2, -14)], wine_scaled_train[, c(-1, -2, -14)], wine_sca
wine_knn_test = knn(wine_scaled_train[, c(-1, -2, -14)], wine_scaled_test[, c(-1, -2, -14)], wine_scaled
```

Test KNN Model with Training Data

```
# training conf matrix
confusionMatrix(as.factor(wine_knn_train), as.factor(wine_train[, 14]))
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction  Bad Good
##      Bad   2447 1115
##      Good  1099 2339
##
##              Accuracy : 0.6837
##              95% CI : (0.6727, 0.6946)
##      No Information Rate : 0.5066
##      P-Value [Acc > NIR] : <2e-16
##
##              Kappa : 0.3673
##
##      McNemar's Test P-Value : 0.7499
##
##              Sensitivity : 0.6901
```

```
##           Specificity : 0.6772
##           Pos Pred Value : 0.6870
##           Neg Pred Value : 0.6803
##           Prevalence : 0.5066
##           Detection Rate : 0.3496
##           Detection Prevalence : 0.5089
##           Balanced Accuracy : 0.6836
##
##           'Positive' Class : Bad
##
```

Test KNN Model with Testing Data

```
# testing conf matrix
confusionMatrix(as.factor(wine_knn_test), as.factor(wine_test[, 14]))
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  Bad Good
##           Bad 1001  510
##           Good  519  970
##
##           Accuracy : 0.657
##           95% CI : (0.6397, 0.674)
##           No Information Rate : 0.5067
##           P-Value [Acc > NIR] : <2e-16
##
##           Kappa : 0.3139
##
##           Mcnemar's Test P-Value : 0.8031
##
##           Sensitivity : 0.6586
##           Specificity : 0.6554
##           Pos Pred Value : 0.6625
##           Neg Pred Value : 0.6514
##           Prevalence : 0.5067
##           Detection Rate : 0.3337
##           Detection Prevalence : 0.5037
##           Balanced Accuracy : 0.6570
##
##           'Positive' Class : Bad
##
```

Part E

```
wine_log_train_acc = (2372 + 2131)/7000
wine_log_test_acc = (1005 + 901)/3000
wine_lda_train_acc = (2384 + 2123)/7000
wine_lda_test_acc = (1008 + 899)/3000
wine_qda_train_acc = (1859 + 2566)/7000
```

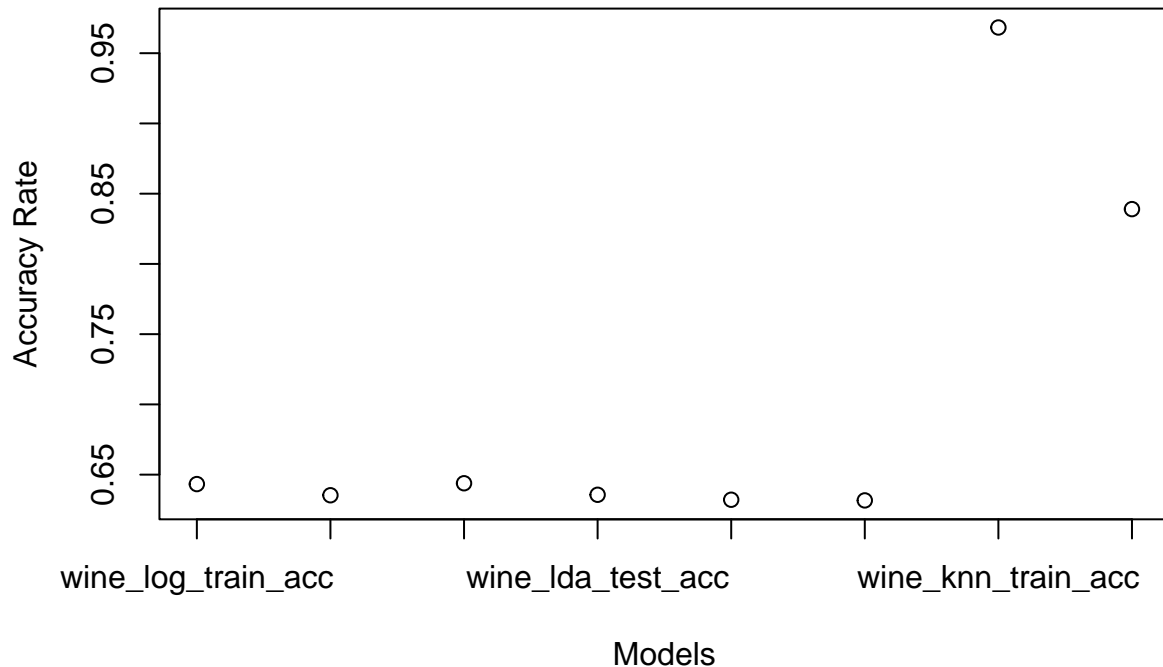
```

wine_qda_test_acc = (802 + 1093)/3000
wine_knn_train_acc = (3435 + 3343)/7000
wine_knn_test_acc = (1289 + 1228)/3000

# plot accuracies so it is easier to see
model_num = c(wine_log_train_acc, wine_log_test_acc, wine_lda_train_acc, wine_lda_test_acc, wine_qda_train_acc, wine_qda_test_acc, wine_knn_train_acc, wine_knn_test_acc)

plot(model_num, xlab = "Models", ylab = "Accuracy Rate", xaxt = "n")
axis(1, at = 1:8, labels = c("wine_log_train_acc", "wine_log_test_acc", "wine_lda_train_acc", "wine_lda_test_acc", "wine_qda_train_acc", "wine_qda_test_acc", "wine_knn_train_acc", "wine_knn_test_acc"))

```



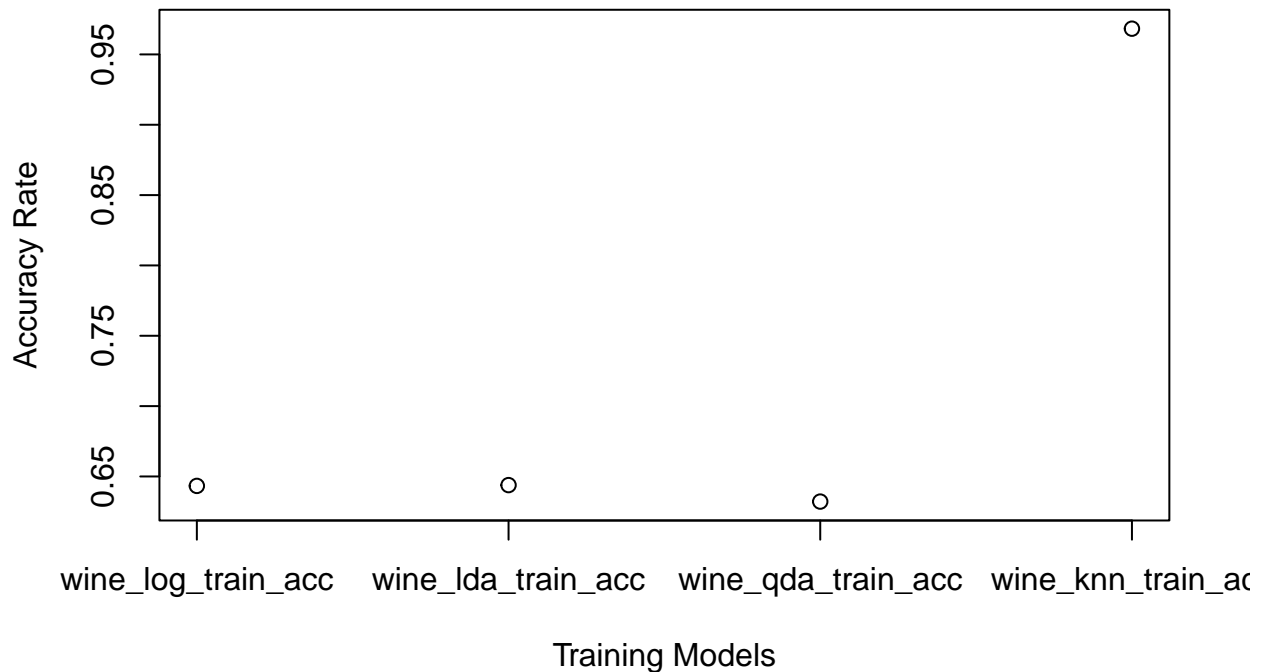
Looking at the accuracy points, it is clear that the KNN model does the best out of the rest. Whereas the training and testing data for the logistic, lda, and qda models all hover below 70%, the KNN training model has an accuracy above 95% (and its testing model having an accuracy of a little less than 85%). This shows that on average, the dataset is very complicated and that the KNN performs the best when trying to predict whether a wine bottle is “Good” or “Bad.”

```

# plot only training accuracies
model_num = c(wine_log_train_acc, wine_lda_train_acc, wine_qda_train_acc, wine_knn_train_acc)

plot(model_num, xlab = "Training Models", ylab = "Accuracy Rate", xaxt = "n")
axis(1, at = 1:4, labels = c("wine_log_train_acc", "wine_lda_train_acc", "wine_qda_train_acc", "wine_knn_train_acc"))

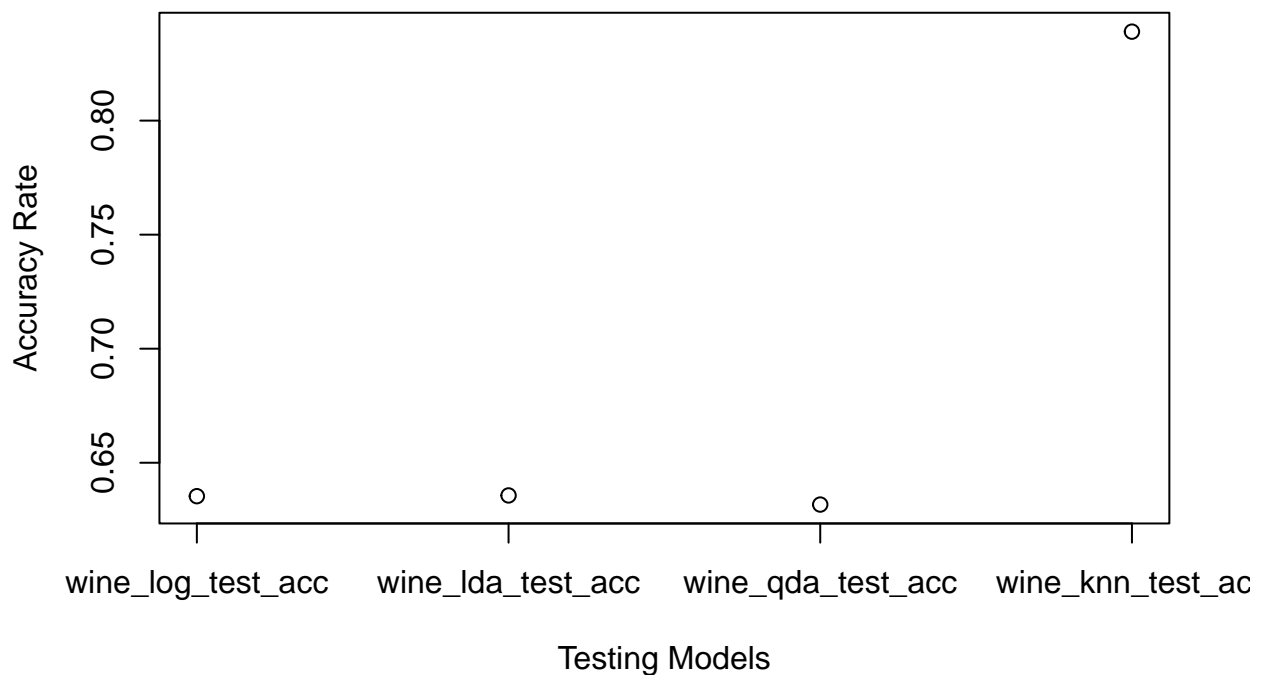
```

Looking more closely at just the training data, we see what was touched on previously even more pronounced. Whereas the training data for the logistic, LDA, and QDA models are around 65%, the KNN model has an accuracy rate 30% more than its competitors.

```
# plot only testing accuracies
model_num = c(wine_log_test_acc, wine_lda_test_acc, wine_qda_test_acc, wine_knn_test_acc)

plot(model_num, xlab = "Testing Models", ylab = "Accuracy Rate", xaxt = "n")
axis(1, at = 1:4, labels = c("wine_log_test_acc", "wine_lda_test_acc", "wine_qda_test_acc", "wine_knn_test_acc"))
```



Looking at the most important data sets (the testing data set), we see that the KNN model does the best

out of the other three models.

These three plots indicate that it is very difficult to determine whether a wine bottle is “Good” or “Bad” (i.e. the predictors did not do an extremely good job of determining whether or not a bottle of wine was “Good” or “Bad”). This is because the most complicated model (the KNN model) performed the best on all fronts. Furthermore, an accuracy rate of around 65% (as shown by the logistic, QDA, and LDA models) for both the three models of both testing and training data sets further exemplify this conclusion.

Problem 2

```
# create a smaller wine data set because wine is too large to function with
new_wine = wine[sample(nrow(wine), 3000),]
```

Part A

```
# create wine glm model for loocv to work
wine_glm = glm(as.factor(Class) ~ Wine.Color + fixed.acidity + volatile.acidity + citric.acid + residual.sugar,
               family = binomial,
               data = new_wine)
library(boot)
```

```
##
## Attaching package: 'boot'

## The following object is masked from 'package:lattice':
##
##      melanoma
```

```
wine_cv_glm = cv.glm(new_wine, wine_glm)
wine_cv_glm$delta
```

```
## [1] 0.2272358 0.2272355
```

Part B

```
# leave one out cv for LDA
wine_cv_lda = lda(as.factor(Class) ~ Wine.Color + fixed.acidity + volatile.acidity + citric.acid + residual.sugar,
                  data = new_wine,
                  CV = TRUE)
confusionMatrix(as.factor(wine_cv_lda$class), as.factor(new_wine[, 14]))
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction Bad Good
##      Bad  947  553
##      Good 553  947
```

```
##
##           Accuracy : 0.6313
##           95% CI : (0.6138, 0.6486)
##      No Information Rate : 0.5
##      P-Value [Acc > NIR] : <2e-16
##
##           Kappa : 0.2627
##
##  Mcnemar's Test P-Value : 1
##
##           Sensitivity : 0.6313
##           Specificity : 0.6313
##      Pos Pred Value : 0.6313
##      Neg Pred Value : 0.6313
##           Prevalence : 0.5000
##      Detection Rate : 0.3157
##      Detection Prevalence : 0.5000
##      Balanced Accuracy : 0.6313
##
##      'Positive' Class : Bad
##
```

Part C

```
wine_cv_qda = qda(as.factor(Class) ~ Wine.Color + fixed.acidity + volatile.acidity + citric.acid + resis
                  data = new_wine,
                  CV = TRUE)
confusionMatrix(as.factor(wine_cv_qda$class), as.factor(new_wine[, 14]))
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  Bad Good
##      Bad    784  399
##      Good    716 1101
##
##           Accuracy : 0.6283
##           95% CI : (0.6108, 0.6457)
##      No Information Rate : 0.5
##      P-Value [Acc > NIR] : < 2.2e-16
##
##           Kappa : 0.2567
##
##  Mcnemar's Test P-Value : < 2.2e-16
##
##           Sensitivity : 0.5227
##           Specificity : 0.7340
##      Pos Pred Value : 0.6627
##      Neg Pred Value : 0.6059
##           Prevalence : 0.5000
##      Detection Rate : 0.2613
##      Detection Prevalence : 0.3943
```

```
##          Balanced Accuracy : 0.6283
##
##          'Positive' Class : Bad
##
```

Part D

```
# scale non-numeric arguments
new_wine_scaled = data.frame(X = new_wine$X, Wine.Color = new_wine$Wine.Color, scale(new_wine[, c(-1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32, -33, -34, -35, -36, -37, -38, -39, -40, -41, -42, -43, -44, -45, -46, -47, -48, -49, -50, -51, -52, -53, -54, -55, -56, -57, -58, -59, -60, -61, -62, -63, -64, -65, -66, -67, -68, -69, -70, -71, -72, -73, -74, -75, -76, -77, -78, -79, -80, -81, -82, -83, -84, -85, -86, -87, -88, -89, -90, -91, -92, -93, -94, -95, -96, -97, -98, -99, -100)], as.factor(new_wine_scaled[, 14]))

# make knn model
wine_knn_cv = knn.cv(train = new_wine_scaled[, c(-1, -2, -14)], cl = new_wine_scaled[, 14], k = 25)

confusionMatrix(as.factor(wine_knn_cv), as.factor(new_wine_scaled[, 14]))
```

```
## Confusion Matrix and Statistics
##
##          Reference
## Prediction Bad Good
##          Bad  980  536
##          Good 520  964
##
##          Accuracy : 0.648
##          95% CI : (0.6306, 0.6651)
##          No Information Rate : 0.5
##          P-Value [Acc > NIR] : <2e-16
##
##          Kappa : 0.296
##
##          Mcnemar's Test P-Value : 0.6444
##
##          Sensitivity : 0.6533
##          Specificity : 0.6427
##          Pos Pred Value : 0.6464
##          Neg Pred Value : 0.6496
##          Prevalence : 0.5000
##          Detection Rate : 0.3267
##          Detection Prevalence : 0.5053
##          Balanced Accuracy : 0.6480
##
##          'Positive' Class : Bad
##
```

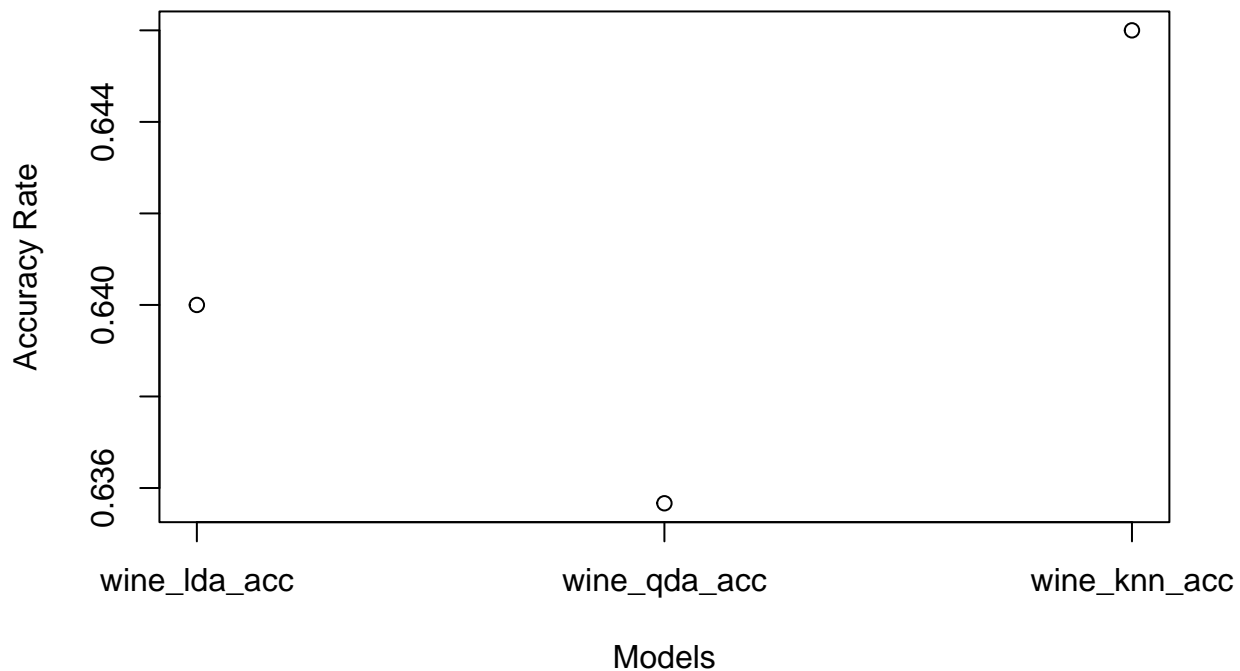
Part E

```
wine_glm_mse = wine_cv_glm$delta
wine_lda_acc = (956 + 964)/3000
wine_qda_acc = (841 + 1066)/3000
wine_knn_acc = (952 + 986)/3000
```

```
# plot accuracies so it is easier to see
model_num = c(wine_lda_acc, wine_qda_acc, wine_knn_acc)
wine_glm_mse
```

```
## [1] 0.2272358 0.2272355
```

```
plot(model_num, xlab = "Models", ylab = "Accuracy Rate", xaxt = "n")
axis(1, at = 1:3, labels = c("wine_lda_acc", "wine_qda_acc", "wine_knn_acc"))
```



Looking at the plot (which disregards the MSE from the LOOCV logistics model), we can see that the accuracy rates for the three classification models are poor (like number 1, they hover around 65% or less). This shows that leave-one-out cross validation did not help the model perform better. In the case of KNN, it made the model perform worse (KNN now has an accuracy rate of a bit over 65%, as opposed to its near 85% when tested on the testing data set in number 1). Looking at the MSE for the logistic cross validation method, we see an MSE of 0.2267057 and 0.2265990, which is also very poor. This shows that the LOOCV method for all methods (logistic, LDA, QDA, and KNN) performs badly. This may be because the wine data set predictors do not serve as good predictors for determining whether a wine is “Good” or “Bad.”

Problem 3

Part A

```
# create wine glm model for cv to work
wine_glm = glm(as.factor(Class) ~ Wine.Color + fixed.acidity + volatile.acidity + citric.acid + residual,
               family = binomial,
               data = new_wine)
library(boot)

wine_cv10_glm = cv.glm(new_wine, wine_glm, K = 10)
wine_cv10_glm$delta
```

```
## [1] 0.2271660 0.2270694
```

Part B

```
# function "train" from caret library can do lda and qda with a number of folds
library(caret)
wine_cv10_lda = train(as.factor(Class) ~ Wine.Color + fixed.acidity + volatile.acidity + citric.acid + 
                      data = new_wine,
                      method = "lda",
                      trControl = trainControl(method = "cv", number = 10),
                      metric = "Accuracy")
wine_cv10_lda_pred = predict(wine_cv10_lda, new_wine[, c(-1, -14)])
confusionMatrix(as.factor(wine_cv10_lda_pred), as.factor(new_wine[, 14]))
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction Bad Good
##      Bad  954  546
##      Good 546  954
##
##              Accuracy : 0.636
##              95% CI : (0.6185, 0.6532)
##      No Information Rate : 0.5
##      P-Value [Acc > NIR] : <2e-16
##
##              Kappa : 0.272
##
##  Mcnemar's Test P-Value : 1
##
##              Sensitivity : 0.636
##              Specificity : 0.636
##              Pos Pred Value : 0.636
##              Neg Pred Value : 0.636
##              Prevalence : 0.500
##              Detection Rate : 0.318
##      Detection Prevalence : 0.500
##              Balanced Accuracy : 0.636
##
##              'Positive' Class : Bad
##
```

Part C

```
# train function from library caret can do qda with multiple folds
wine_cv10_qda = train(as.factor(Class) ~ Wine.Color + fixed.acidity + volatile.acidity + citric.acid + 
                      data = new_wine,
                      method = "qda",
                      trControl = trainControl(method = "cv", number = 10),
                      metric = "Accuracy")
```

```
wine_cv10_qda_pred = predict.train(wine_cv10_qda, new_wine[, c(-1, -14)])
confusionMatrix(as.factor(wine_cv10_qda_pred), as.factor(new_wine[, 14]))
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  Bad Good
##      Bad    802  384
##      Good    698 1116
##
##           Accuracy : 0.6393
##           95% CI : (0.6219, 0.6565)
##      No Information Rate : 0.5
##      P-Value [Acc > NIR] : < 2.2e-16
##
##           Kappa : 0.2787
##
##  Mcnemar's Test P-Value : < 2.2e-16
##
##           Sensitivity : 0.5347
##           Specificity : 0.7440
##      Pos Pred Value : 0.6762
##      Neg Pred Value : 0.6152
##           Prevalence : 0.5000
##      Detection Rate : 0.2673
##      Detection Prevalence : 0.3953
##      Balanced Accuracy : 0.6393
##
##      'Positive' Class : Bad
##
```

Part D

```
wine_cv10_knn = train(x = new_wine_scaled[, c(-1, -2, -14)],
                      y = new_wine_scaled[, 14],
                      method = "knn",
                      tuneGrid = data.frame(k = 25),
                      trControl = trainControl(method = "cv", number = 10),
                      metric = "Accuracy")
wine_cv10_knn_pred = predict(wine_cv10_knn, new_wine[, c(-1, -2, -14)])
confusionMatrix(as.factor(wine_cv10_knn_pred), as.factor(new_wine[, 14]))
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  Bad Good
##      Bad   1437 1436
##      Good    63  64
##
##           Accuracy : 0.5003
##           95% CI : (0.4823, 0.5184)
```

```

##      No Information Rate : 0.5
##      P-Value [Acc > NIR] : 0.4927
##
##              Kappa : 7e-04
##
##      McNemar's Test P-Value : <2e-16
##
##              Sensitivity : 0.95800
##              Specificity : 0.04267
##              Pos Pred Value : 0.50017
##              Neg Pred Value : 0.50394
##              Prevalence : 0.50000
##              Detection Rate : 0.47900
##      Detection Prevalence : 0.95767
##      Balanced Accuracy : 0.50033
##
##      'Positive' Class : Bad
##

```

Part E

```

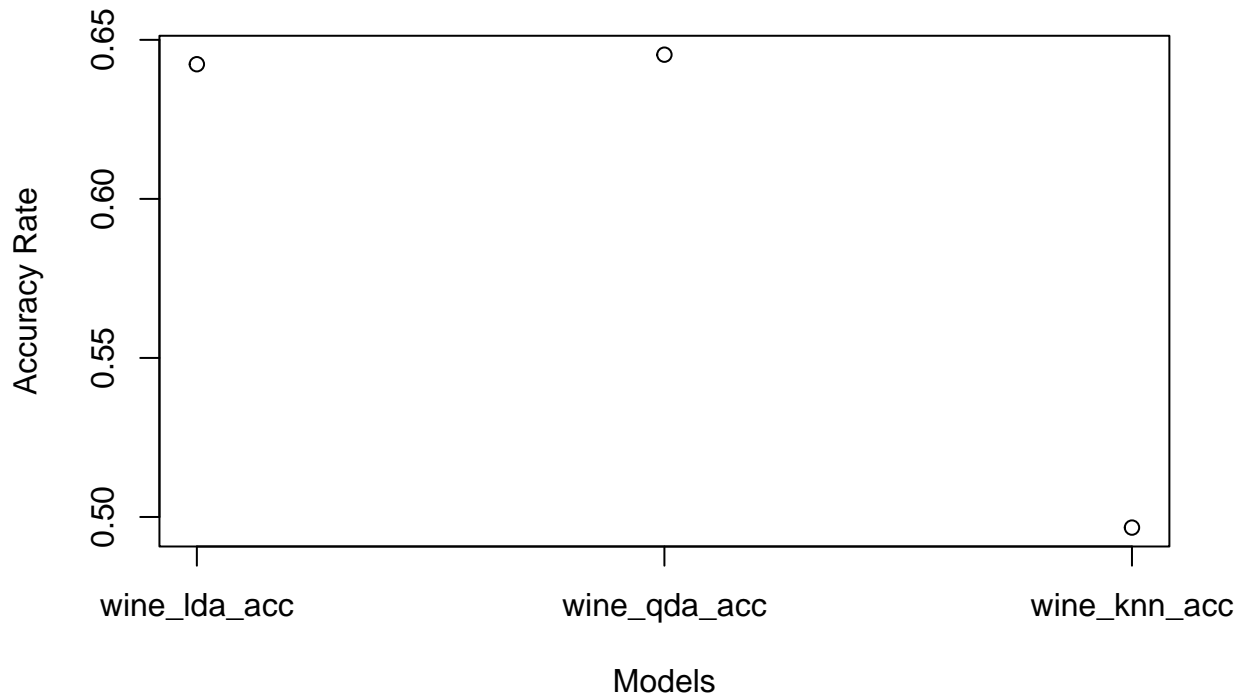
wine_glm_mse = wine_cv10_glm$delta
wine_lda_acc = (960 + 967)/3000
wine_qda_acc = (852 + 1084)/3000
wine_knn_acc = (1306 + 184)/3000

# plot accuracies so it is easier to see
model_num = c(wine_lda_acc, wine_qda_acc, wine_knn_acc)
wine_glm_mse

## [1] 0.2271660 0.2270694

plot(model_num, xlab = "Models", ylab = "Accuracy Rate", xaxt = "n")
axis(1, at = 1:3, labels = c("wine_lda_acc", "wine_qda_acc", "wine_knn_acc"))

```

Instead of LOOCV, this problem is concerned with 10-folds (rather than N-folds). Interestingly enough, the accuracy results of 10-folds is better than the LOOCV (for LDA and QDA). However, the MSE for this logistic model is 0.2267057 and 0.2265990 (the same MSE for LOOCV). For KNN, 10-Fold KNN actually did a lot worse (10%+ worse).

Problem 4

```
set.seed(1128)
births = read.csv("births 10000 0b F2021.csv")
# delete variables that will not help with predicting outcome variables
births = births[, -c(3, 4, 5, 6, 17, 18, 19)]
# omit NAs
births = na.omit(births)
# resize births so the data is more manageable
birthsNew = births[sample(nrow(births), 3000),]
names(birthsNew)[35] = "Birth.Weight"
```

Part A

```
library(car)

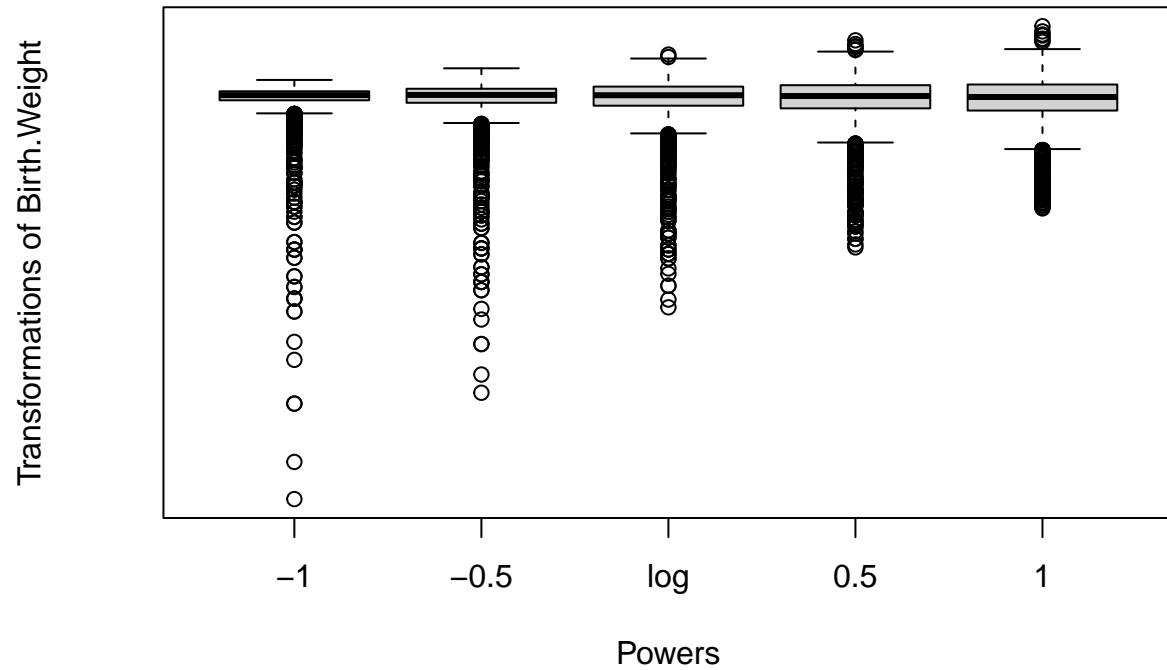
## Loading required package: carData

##
## Attaching package: 'car'

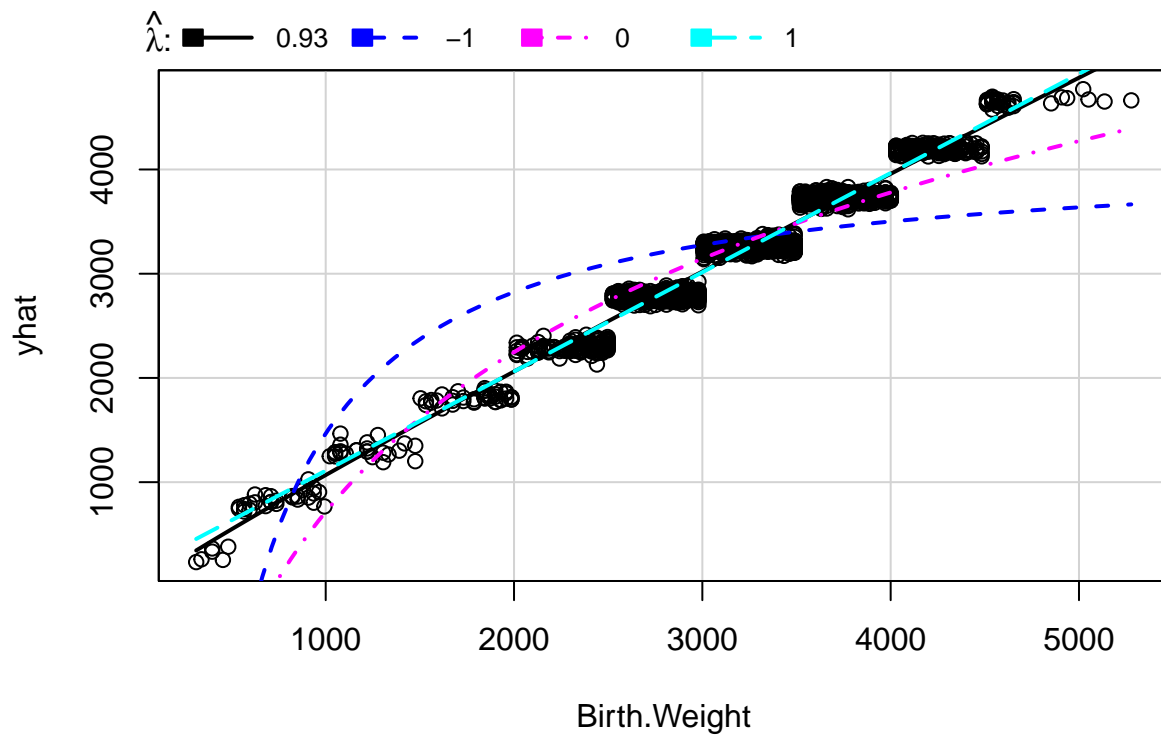
## The following object is masked from 'package:boot':
```

```
##
##      logit
```

```
symbol(~Birth.Weight, data = birthsNew)
```



```
inverseResponsePlot(lm(Birth.Weight ~ ., data = birthsNew))
```



```
##      lambda      RSS
```

```
## 1 0.9332759 53415434
## 2 -1.0000000 516424304
## 3 0.0000000 150403760
## 4 1.0000000 53744253
```

Both plots show that a lambda of 1 (i.e. keeping the response variable the same and not transforming the equation) will be best for the response variable.

Part B

Backwards Stepwise with Mallows-CP (AIC)

```
births_lm = lm(Birth.Weight ~., data = birthsNew)
library(stats)
back_reg = step(births_lm,
                direction = "backward",
                k = 2)

## Start: AIC=29613.98
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
## Education.of.mother..years. + Total.Preg + BDead + Terms +
## LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
## Birth.weight.group + Marital + Birth.Attendant + Numchild +
## Month.Term + Year.Term + Low.Birth + RaceMom + RaceDad +
## Mother.Minority + Father.Minority + HispMom + HispDad + AveCigs +
## Smoker + AveDrink + Wt.Gain
##
##
## Step: AIC=29613.98
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
## Education.of.mother..years. + Total.Preg + BDead + Terms +
## LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
## Birth.weight.group + Marital + Birth.Attendant + Numchild +
## Month.Term + Year.Term + Low.Birth + RaceMom + RaceDad +
## Father.Minority + HispMom + HispDad + AveCigs + Smoker +
## AveDrink + Wt.Gain
##
##
## Step: AIC=29613.98
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
## Education.of.mother..years. + Total.Preg + BDead + Terms +
## LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
## Birth.weight.group + Marital + Birth.Attendant + Numchild +
## Month.Term + Year.Term + Low.Birth + RaceDad + Father.Minority +
## HispMom + HispDad + AveCigs + Smoker + AveDrink + Wt.Gain
##
##
## Step: AIC=29613.98
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
```

```

## Education.of.mother..years. + Total.Preg + BDead + Terms +
## LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
## Birth.weight.group + Marital + Birth.Attendant + Month.Term +
## Year.Term + Low.Birth + RaceDad + Father.Minority + HispMom +
## HispDad + AveCigs + Smoker + AveDrink + Wt.Gain
##
##           Df Sum of Sq      RSS      AIC
## - Race           2      13930  56473087 29611
## - RaceDad         1         236  56459394 29612
## - Race.of.child   1         791  56459948 29612
## - AveDrink         1        1297  56460455 29612
## - Total.Preg       1         1813  56460970 29612
## - Father.Minority  1         2435  56461592 29612
## - AveCigs          1        2847  56462004 29612
## - Terms            1        5805  56464962 29612
## - Prenatal         1        6152  56465309 29612
## - Month.Term       1        6298  56465456 29612
## - Year.Term        1        6955  56466112 29612
## - Education.of.mother..years. 1      10817  56469974 29613
## - Low.Birth        1       11205  56470363 29613
## - Gender           1       14482  56473640 29613
## - Age.of.mother    1       17289  56476447 29613
## - Age.of.father    1       18241  56477398 29613
## - Education.of.father..years. 1      19885  56479043 29613
## - Marital          1       21654  56480811 29613
## - LOutcome         1       25512  56484669 29613
## - Trimester.Prenatal 1      28360  56487517 29613
## - Institution.type  1      32213  56491370 29614
## <none>                                56459157 29614
## - BDead            1       45734  56504891 29614
## - Smoker            1       47301  56506458 29614
## - Visits            1       52004  56511161 29615
## - HispMom           6      247777  56706934 29615
## - Birth.Attendant   1       62621  56521778 29615
## - Wt.Gain           1      108903  56568061 29618
## - HispDad           6      323559  56782716 29619
## - Plurality.of.birth 1      193610  56652767 29622
## - Weeks             1     1747615  58206773 29703
## - Birth.weight.group 1  438183442  494642600 36123
##
## Step:  AIC=29610.72
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
## Education.of.mother..years. + Total.Preg + BDead + Terms +
## LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
## Birth.weight.group + Marital + Birth.Attendant + Month.Term +
## Year.Term + Low.Birth + RaceDad + Father.Minority + HispMom +
## HispDad + AveCigs + Smoker + AveDrink + Wt.Gain
##
##           Df Sum of Sq      RSS      AIC
## - AveDrink         1        1115  56474202 29609
## - Total.Preg        1         1578  56474665 29609
## - AveCigs           1         2364  56475451 29609
## - RaceDad           1         2609  56475696 29609

```

```

## - Race.of.child          1      5987  56479074 29609
## - Month.Term             1      6147  56479234 29609
## - Terms                  1      6159  56479246 29609
## - Prenatal               1      6339  56479426 29609
## - Year.Term              1      6971  56480058 29609
## - Education.of.mother..years. 1    11190  56484277 29609
## - Low.Birth              1     11515  56484602 29609
## - Gender                 1     14273  56487360 29609
## - Age.of.mother          1     16681  56489768 29610
## - Age.of.father          1     17951  56491037 29610
## - Education.of.father..years. 1    20028  56493114 29610
## - Marital                1     22501  56495588 29610
## - LOutcome               1     25779  56498866 29610
## - Trimester.Prenatal     1     27877  56500963 29610
## - Institution.type       1     31947  56505034 29610
## <none>                   1          56473087 29611
## - BDead                  1     45723  56518810 29611
## - Smoker                 1     46821  56519908 29611
## - Visits                 1     49869  56522956 29611
## - HispMom                6    245833  56718920 29612
## - Birth.Attendant        1     66973  56540060 29612
## - Father.Minority        1     70295  56543382 29612
## - Wt.Gain                1    110902  56583989 29615
## - HispDad                6    318495  56791582 29616
## - Plurality.of.birth     1    190646  56663733 29619
## - Weeks                  1   1746280  58219367 29700
## - Birth.weight.group     1  440766277 497239364 36135
##
## Step:  AIC=29608.78
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + Total.Preg + BDead + Terms +
##   LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
##   Birth.weight.group + Marital + Birth.Attendant + Month.Term +
##   Year.Term + Low.Birth + RaceDad + Father.Minority + HispMom +
##   HispDad + AveCigs + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS   AIC
## - Total.Preg      1      1575  56475777 29607
## - AveCigs          1      2408  56476610 29607
## - RaceDad          1      2645  56476847 29607
## - Race.of.child    1      6072  56480274 29607
## - Month.Term       1      6229  56480431 29607
## - Terms            1      6273  56480475 29607
## - Prenatal         1      6508  56480710 29607
## - Year.Term        1      7032  56481234 29607
## - Education.of.mother..years. 1    11457  56485659 29607
## - Low.Birth        1     11640  56485842 29607
## - Gender           1     14373  56488575 29608
## - Age.of.mother    1     16870  56491072 29608
## - Age.of.father    1     18072  56492274 29608
## - Education.of.father..years. 1    20028  56494230 29608
## - Marital          1     22506  56496708 29608
## - LOutcome         1     25723  56499925 29608

```

```

## - Trimester.Prenatal      1      28085  56502287 29608
## - Institution.type        1      31911  56506113 29608
## <none>                    56474202 29609
## - BDead                   1      45672  56519874 29609
## - Smoker                   1      46614  56520816 29609
## - Visits                   1      49844  56524046 29609
## - HispMom                  6     246438  56720640 29610
## - Birth.Attendant         1      66698  56540900 29610
## - Father.Minority         1      70436  56544638 29611
## - Wt.Gain                  1     110627  56584828 29613
## - HispDad                  6     317398  56791600 29614
## - Plurality.of.birth      1     190691  56664893 29617
## - Weeks                    1     1747125  58221327 29698
## - Birth.weight.group      1  440848042  497322244 36133
##
## Step:  AIC=29606.86
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##      Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
##      Education.of.mother..years. + BDead + Terms + LOutcome +
##      Weeks + Prenatal + Trimester.Prenatal + Visits + Birth.weight.group +
##      Marital + Birth.Attendant + Month.Term + Year.Term + Low.Birth +
##      RaceDad + Father.Minority + HispMom + HispDad + AveCigs +
##      Smoker + Wt.Gain
##
##
##      Df Sum of Sq      RSS      AIC
## - AveCigs      1      2439  56478216 29605
## - RaceDad      1      2571  56478347 29605
## - Race.of.child 1      6177  56481953 29605
## - Prenatal     1      6315  56482092 29605
## - Month.Term   1      6509  56482285 29605
## - Year.Term    1      7730  56483506 29605
## - Low.Birth    1     11519  56487296 29605
## - Education.of.mother..years. 1  13637  56489413 29606
## - Gender       1     14168  56489945 29606
## - Age.of.father 1     17684  56493461 29606
## - Terms        1     17755  56493532 29606
## - Age.of.mother 1     19882  56495658 29606
## - Education.of.father..years. 1  20099  56495875 29606
## - Marital      1     22755  56498531 29606
## - Trimester.Prenatal 1  28207  56503984 29606
## - Institution.type 1  32227  56508004 29607
## <none>                    56475777 29607
## - Smoker       1     46247  56522024 29607
## - Visits       1     49179  56524955 29607
## - BDead        1     49514  56525290 29607
## - LOutcome     1     49988  56525765 29608
## - HispMom      6    246444  56722220 29608
## - Birth.Attendant 1     68323  56544100 29608
## - Father.Minority 1     69079  56544856 29609
## - Wt.Gain      1    109586  56585362 29611
## - HispDad      6    316783  56792560 29612
## - Plurality.of.birth 1    189255  56665032 29615
## - Weeks        1    1745875  58221651 29696
## - Birth.weight.group 1  443626863  500102640 36148

```

```

##
## Step: AIC=29604.99
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
## Education.of.mother..years. + BDead + Terms + LOutcome +
## Weeks + Prenatal + Trimester.Prenatal + Visits + Birth.weight.group +
## Marital + Birth.Attendant + Month.Term + Year.Term + Low.Birth +
## RaceDad + Father.Minority + HispMom + HispDad + Smoker +
## Wt.Gain
##
##
## Df Sum of Sq RSS AIC
## - RaceDad 1 2486 56480701 29603
## - Race.of.child 1 6018 56484234 29603
## - Month.Term 1 6515 56484730 29603
## - Prenatal 1 6584 56484799 29603
## - Year.Term 1 7622 56485838 29603
## - Low.Birth 1 11877 56490093 29604
## - Education.of.mother..years. 1 13358 56491574 29604
## - Gender 1 14327 56492543 29604
## - Terms 1 17747 56495963 29604
## - Age.of.father 1 18068 56496283 29604
## - Age.of.mother 1 19714 56497930 29604
## - Education.of.father..years. 1 20404 56498620 29604
## - Marital 1 22555 56500771 29604
## - Trimester.Prenatal 1 28605 56506821 29605
## - Institution.type 1 32264 56510480 29605
## <none> 56478216 29605
## - Visits 1 48734 56526950 29606
## - BDead 1 49556 56527772 29606
## - LOutcome 1 49703 56527919 29606
## - HispMom 6 245993 56724209 29606
## - Father.Minority 1 68233 56546449 29607
## - Birth.Attendant 1 69232 56547448 29607
## - Wt.Gain 1 109148 56587364 29609
## - HispDad 6 316640 56794856 29610
## - Plurality.of.birth 1 188212 56666428 29613
## - Smoker 1 199693 56677908 29614
## - Weeks 1 1747951 58226167 29694
## - Birth.weight.group 1 443624584 500102800 36146
##
## Step: AIC=29603.13
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
## Education.of.mother..years. + BDead + Terms + LOutcome +
## Weeks + Prenatal + Trimester.Prenatal + Visits + Birth.weight.group +
## Marital + Birth.Attendant + Month.Term + Year.Term + Low.Birth +
## Father.Minority + HispMom + HispDad + Smoker + Wt.Gain
##
##
## Df Sum of Sq RSS AIC
## - Race.of.child 1 3536 56484237 29601
## - Prenatal 1 6523 56487225 29601
## - Month.Term 1 6705 56487407 29601
## - Year.Term 1 7651 56488352 29602
## - Low.Birth 1 12017 56492719 29602

```

```

## - Education.of.mother..years. 1 13409 56494110 29602
## - Gender 1 14394 56495096 29602
## - Terms 1 17605 56498306 29602
## - Age.of.father 1 18179 56498880 29602
## - Age.of.mother 1 19559 56500261 29602
## - Education.of.father..years. 1 21201 56501902 29602
## - Marital 1 24326 56505028 29602
## - Trimester.Prenatal 1 28381 56509083 29603
## - Institution.type 1 32042 56512744 29603
## <none> 56480701 29603
## - Visits 1 48415 56529116 29604
## - LOutcome 1 49307 56530008 29604
## - BDead 1 49522 56530223 29604
## - HispMom 6 245262 56725964 29604
## - Birth.Attendant 1 69625 56550326 29605
## - Father.Minority 1 71915 56552616 29605
## - Wt.Gain 1 109904 56590605 29607
## - HispDad 6 317081 56797782 29608
## - Plurality.of.birth 1 187721 56668422 29611
## - Smoker 1 198454 56679156 29612
## - Weeks 1 1761303 58242004 29693
## - Birth.weight.group 1 443636935 500117636 36144
##
## Step: AIC=29601.31
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Age.of.father + Age.of.mother + Education.of.father..years. +
## Education.of.mother..years. + BDead + Terms + LOutcome +
## Weeks + Prenatal + Trimester.Prenatal + Visits + Birth.weight.group +
## Marital + Birth.Attendant + Month.Term + Year.Term + Low.Birth +
## Father.Minority + HispMom + HispDad + Smoker + Wt.Gain
##
## Df Sum of Sq RSS AIC
## - Month.Term 1 6641 56490878 29600
## - Prenatal 1 6700 56490937 29600
## - Year.Term 1 7702 56491939 29600
## - Low.Birth 1 11566 56495803 29600
## - Education.of.mother..years. 1 13570 56497808 29600
## - Gender 1 14637 56498874 29600
## - Terms 1 17876 56502114 29600
## - Age.of.father 1 19233 56503470 29600
## - Age.of.mother 1 19733 56503971 29600
## - Education.of.father..years. 1 20854 56505091 29600
## - Marital 1 22624 56506861 29601
## - Trimester.Prenatal 1 28561 56512798 29601
## - Institution.type 1 31657 56515895 29601
## <none> 56484237 29601
## - Visits 1 48662 56532899 29602
## - BDead 1 49734 56533971 29602
## - LOutcome 1 49994 56534232 29602
## - HispMom 6 244886 56729124 29602
## - Birth.Attendant 1 69642 56553880 29603
## - Wt.Gain 1 109877 56594114 29605
## - Father.Minority 1 112309 56596547 29605
## - HispDad 6 317662 56801900 29606

```



```

## - Plurality.of.birth          1    186468  56670705 29609
## - Smoker                      1    197509  56681747 29610
## - Weeks                      1   1758923  58243160 29691
## - Birth.weight.group         1  444986856 501471093 36150
##
## Step: AIC=29599.67
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + BDead + Terms + LOutcome +
##   Weeks + Prenatal + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Year.Term + Low.Birth + Father.Minority +
##   HispMom + HispDad + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS    AIC
## - Prenatal      1      6599  56497477 29598
## - Low.Birth     1     11479  56502357 29598
## - Education.of.mother..years. 1     13378  56504256 29598
## - Gender        1     14631  56505509 29598
## - Age.of.father  1     18905  56509783 29599
## - Terms         1     19589  56510467 29599
## - Age.of.mother  1     20257  56511135 29599
## - Education.of.father..years. 1     20960  56511838 29599
## - Marital       1     21618  56512496 29599
## - Year.Term     1     24299  56515177 29599
## - Trimester.Prenatal 1     28508  56519386 29599
## - Institution.type 1     31614  56522492 29599
## <none>                                56490878 29600
## - Visits        1     48020  56538898 29600
## - BDead         1     48112  56538991 29600
## - LOutcome      1     49928  56540806 29600
## - HispMom       6    243374  56734252 29601
## - Birth.Attendant 1     70690  56561568 29601
## - Wt.Gain       1    109187  56600065 29603
## - Father.Minority 1    111740  56602618 29604
## - HispDad       6    319454  56810333 29605
## - Plurality.of.birth 1    186587  56677465 29608
## - Smoker        1    194620  56685498 29608
## - Weeks         1   1759194  58250072 29690
## - Birth.weight.group 1  445077780 501568658 36149
##
## Step: AIC=29598.02
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + BDead + Terms + LOutcome +
##   Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Year.Term + Low.Birth + Father.Minority +
##   HispMom + HispDad + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS    AIC
## - Low.Birth     1     11750  56509227 29597
## - Education.of.mother..years. 1     13425  56510902 29597
## - Gender        1     14579  56512056 29597
## - Age.of.father  1     19274  56516750 29597
## - Terms         1     19639  56517116 29597

```

```

## - Age.of.mother      1      20358  56517835 29597
## - Marital            1      22855  56520332 29597
## - Education.of.father..years. 1      23498  56520975 29597
## - Year.Term          1      24608  56522085 29597
## - Trimester.Prenatal 1      29214  56526690 29598
## - Institution.type    1      34087  56531563 29598
## <none>                56497477 29598
## - BDead              1      48279  56545756 29599
## - LOutcome           1      49713  56547190 29599
## - HispMom            6     241476  56738953 29599
## - Visits             1      58047  56555524 29599
## - Birth.Attendant    1      69070  56566547 29600
## - Wt.Gain            1     108572  56606049 29602
## - Father.Minority    1     113934  56611411 29602
## - HispDad            6     318357  56815834 29603
## - Plurality.of.birth 1     188303  56685779 29606
## - Smoker             1     196008  56693485 29606
## - Weeks              1     1754561  58252038 29688
## - Birth.weight.group 1  445130333 501627810 36147
##
## Step: AIC=29596.64
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + BDead + Terms + LOutcome +
##   Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Year.Term + Father.Minority +
##   HispMom + HispDad + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Education.of.mother..years.  1      12432  56521659 29595
## - Gender                      1      13801  56523028 29595
## - Terms                       1      18989  56528215 29596
## - Age.of.mother               1      19806  56529033 29596
## - Age.of.father               1      19817  56529044 29596
## - Education.of.father..years.  1     22423  56531649 29596
## - Marital                    1     23918  56533145 29596
## - Year.Term                   1     23998  56533224 29596
## - Trimester.Prenatal          1     29875  56539101 29596
## - Institution.type            1     34983  56544209 29596
## <none>                        56509227 29597
## - BDead                      1     47767  56556994 29597
## - LOutcome                   1     50233  56559460 29597
## - HispMom                    6    242618  56751845 29597
## - Visits                     1     59295  56568521 29598
## - Birth.Attendant            1     68880  56578107 29598
## - Wt.Gain                    1    107031  56616258 29600
## - Father.Minority            1    113323  56622549 29601
## - HispDad                    6    322814  56832041 29602
## - Smoker                     1    193228  56702454 29605
## - Plurality.of.birth         1    218908  56728134 29606
## - Weeks                      1    1853720  58362946 29691
## - Birth.weight.group         1  599897030 656406257 36952
##
## Step: AIC=29595.3

```

```
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Age.of.father + Age.of.mother + Education.of.father..years. +
##   BDead + Terms + LOutcome + Weeks + Trimester.Prenatal + Visits +
##   Birth.weight.group + Marital + Birth.Attendant + Year.Term +
##   Father.Minority + HispMom + HispDad + Smoker + Wt.Gain
```

	Df	Sum of Sq	RSS	AIC
## - Education.of.father..years.	1	11300	56532959	29594
## - Gender	1	14292	56535951	29594
## - Age.of.mother	1	15020	56536678	29594
## - Age.of.father	1	19037	56540696	29594
## - Terms	1	20433	56542092	29594
## - Marital	1	20821	56542480	29594
## - Year.Term	1	25801	56547460	29595
## - Trimester.Prenatal	1	30593	56552251	29595
## - Institution.type	1	36520	56558179	29595
## <none>			56521659	29595
## - HispMom	6	235679	56757338	29596
## - BDead	1	47440	56569099	29596
## - Visits	1	57164	56578823	29596
## - LOutcome	1	58888	56580547	29596
## - Birth.Attendant	1	71744	56593403	29597
## - Wt.Gain	1	104101	56625760	29599
## - Father.Minority	1	112401	56634059	29599
## - HispDad	6	325037	56846695	29601
## - Smoker	1	185455	56707114	29603
## - Plurality.of.birth	1	219860	56741519	29605
## - Weeks	1	1850887	58372545	29690
## - Birth.weight.group	1	599904276	656425935	36950

```
## Step: AIC=29593.9
```

```
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Age.of.father + Age.of.mother + BDead + Terms + LOutcome +
##   Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Year.Term + Father.Minority +
##   HispMom + HispDad + Smoker + Wt.Gain
```

	Df	Sum of Sq	RSS	AIC
## - Gender	1	14649	56547609	29593
## - Age.of.father	1	17722	56550682	29593
## - Terms	1	20124	56553084	29593
## - Age.of.mother	1	21191	56554151	29593
## - Year.Term	1	24972	56557931	29593
## - Marital	1	25443	56558402	29593
## - Trimester.Prenatal	1	28571	56561530	29593
## - Institution.type	1	35008	56567967	29594
## <none>			56532959	29594
## - BDead	1	46854	56579813	29594
## - HispMom	6	242607	56775566	29595
## - LOutcome	1	54354	56587313	29595
## - Visits	1	60669	56593628	29595
## - Birth.Attendant	1	72486	56605446	29596
## - Wt.Gain	1	107778	56640737	29598
## - Father.Minority	1	112599	56645559	29598

```

## - HispDad          6      319376  56852336 29599
## - Smoker           1      204088  56737048 29603
## - Plurality.of.birth 1      218336  56751296 29603
## - Weeks            1     1860799  58393759 29689
## - Birth.weight.group 1 599947560 656480519 36948
##
## Step:  AIC=29592.68
## Birth.Weight ~ Institution.type + Plurality.of.birth + Age.of.father +
##   Age.of.mother + BDead + Terms + LOutcome + Weeks + Trimester.Prenatal +
##   Visits + Birth.weight.group + Marital + Birth.Attendant +
##   Year.Term + Father.Minority + HispMom + HispDad + Smoker +
##   Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Age.of.father      1      19103  56566712 29592
## - Terms              1      20124  56567733 29592
## - Age.of.mother      1      23120  56570728 29592
## - Year.Term          1      24133  56571741 29592
## - Marital            1      24756  56572365 29592
## - Trimester.Prenatal 1      28481  56576090 29592
## - Institution.type   1      33716  56581325 29592
## <none>                56547609 29593
## - BDead              1      48592  56596201 29593
## - LOutcome           1      53264  56600873 29594
## - HispMom            6     243675  56791284 29594
## - Visits             1      59344  56606953 29594
## - Birth.Attendant    1      70794  56618403 29594
## - Wt.Gain            1     107454  56655062 29596
## - Father.Minority    1     113760  56661368 29597
## - HispDad            6     318631  56866239 29598
## - Smoker             1     201379  56748987 29601
## - Plurality.of.birth 1     215112  56762721 29602
## - Weeks              1     1846423  58394032 29687
## - Birth.weight.group 1 612012585 668560194 37001
##
## Step:  AIC=29591.69
## Birth.Weight ~ Institution.type + Plurality.of.birth + Age.of.mother +
##   BDead + Terms + LOutcome + Weeks + Trimester.Prenatal + Visits +
##   Birth.weight.group + Marital + Birth.Attendant + Year.Term +
##   Father.Minority + HispMom + HispDad + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Age.of.mother      1       6151  56572862 29590
## - Terms              1      19846  56586558 29591
## - Marital            1      23670  56590382 29591
## - Year.Term          1      23921  56590633 29591
## - Trimester.Prenatal 1      27756  56594468 29591
## - Institution.type   1      33621  56600333 29591
## <none>                56566712 29592
## - BDead              1      48448  56615160 29592
## - LOutcome           1      50454  56617166 29592
## - Visits             1      58113  56624825 29593
## - HispMom            6     247890  56814602 29593
## - Birth.Attendant    1      71847  56638559 29593

```

```

## - Wt.Gain          1      106300  56673012 29595
## - Father.Minority  1      115679  56682391 29596
## - HispDad          6      314657  56881368 29596
## - Smoker           1      207863  56774575 29601
## - Plurality.of.birth 1      215575  56782287 29601
## - Weeks            1     1839979  58406691 29686
## - Birth.weight.group 1 612648904 669215616 37002
##
## Step: AIC=29590.02
## Birth.Weight ~ Institution.type + Plurality.of.birth + BDead +
##   Terms + LOutcome + Weeks + Trimester.Prenatal + Visits +
##   Birth.weight.group + Marital + Birth.Attendant + Year.Term +
##   Father.Minority + HispMom + HispDad + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Terms          1      22161  56595023 29589
## - Year.Term       1      24017  56596879 29589
## - Trimester.Prenatal 1      26824  56599687 29589
## - Institution.type 1      33075  56605938 29590
## - Marital         1      34767  56607629 29590
## <none>              56572862 29590
## - BDead           1      47777  56620640 29591
## - HispMom          6     245753  56818616 29591
## - Visits           1      59516  56632378 29591
## - LOutcome         1      64021  56636884 29591
## - Birth.Attendant  1      69929  56642792 29592
## - Wt.Gain          1     103853  56676715 29594
## - Father.Minority  1     119124  56691987 29594
## - HispDad          6     312040  56884902 29595
## - Plurality.of.birth 1     213290  56786153 29599
## - Smoker           1     222693  56795555 29600
## - Weeks            1     1834200  58407063 29684
## - Birth.weight.group 1 614961681 671534543 37010
##
## Step: AIC=29589.19
## Birth.Weight ~ Institution.type + Plurality.of.birth + BDead +
##   LOutcome + Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Year.Term + Father.Minority +
##   HispMom + HispDad + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Year.Term       1       4983  56600006 29587
## - Trimester.Prenatal 1      27700  56622723 29589
## - Institution.type 1      30254  56625277 29589
## - Marital         1      34026  56629049 29589
## <none>              56595023 29589
## - BDead           1      48815  56643839 29590
## - HispMom          6     250382  56845405 29590
## - Visits           1      64103  56659127 29591
## - LOutcome         1      66280  56661303 29591
## - Birth.Attendant  1      70967  56665990 29591
## - Wt.Gain          1     103767  56698791 29593
## - Father.Minority  1     116859  56711882 29593
## - HispDad          6     311024  56906047 29594

```

```

## - Plurality.of.birth 1 211236 56806259 29598
## - Smoker 1 218320 56813343 29599
## - Weeks 1 1824880 58419903 29682
## - Birth.weight.group 1 615123833 671718856 37009
##
## Step: AIC=29587.46
## Birth.Weight ~ Institution.type + Plurality.of.birth + BDead +
## LOutcome + Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
## Marital + Birth.Attendant + Father.Minority + HispMom + HispDad +
## Smoker + Wt.Gain
##
## Df Sum of Sq RSS AIC
## - Trimester.Prenatal 1 27756 56627762 29587
## - Institution.type 1 29661 56629668 29587
## - Marital 1 34338 56634344 29587
## <none> 56600006 29587
## - BDead 1 48743 56648750 29588
## - HispMom 6 248410 56848416 29589
## - LOutcome 1 61451 56661457 29589
## - Visits 1 62169 56662175 29589
## - Birth.Attendant 1 72083 56672089 29589
## - Wt.Gain 1 103216 56703222 29591
## - Father.Minority 1 117045 56717052 29592
## - HispDad 6 310371 56910377 29592
## - Plurality.of.birth 1 209067 56809074 29597
## - Smoker 1 220603 56820609 29597
## - Weeks 1 1824577 58424583 29681
## - Birth.weight.group 1 615988769 672588776 37011
##
## Step: AIC=29586.93
## Birth.Weight ~ Institution.type + Plurality.of.birth + BDead +
## LOutcome + Weeks + Visits + Birth.weight.group + Marital +
## Birth.Attendant + Father.Minority + HispMom + HispDad + Smoker +
## Wt.Gain
##
## Df Sum of Sq RSS AIC
## - Marital 1 27254 56655016 29586
## - Institution.type 1 30389 56658151 29587
## <none> 56627762 29587
## - Visits 1 41357 56669119 29587
## - BDead 1 48492 56676254 29587
## - HispMom 6 248297 56876059 29588
## - LOutcome 1 64927 56692689 29588
## - Birth.Attendant 1 72344 56700106 29589
## - Wt.Gain 1 102721 56730483 29590
## - Father.Minority 1 111913 56739675 29591
## - HispDad 6 319894 56947656 29592
## - Plurality.of.birth 1 199291 56827053 29595
## - Smoker 1 216418 56844180 29596
## - Weeks 1 1882866 58510628 29683
## - Birth.weight.group 1 615965468 672593231 37009
##
## Step: AIC=29586.37
## Birth.Weight ~ Institution.type + Plurality.of.birth + BDead +

```

```
##      LOutcome + Weeks + Visits + Birth.weight.group + Birth.Attendant +
##      Father.Minority + HispMom + HispDad + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Institution.type      1      30860  56685876 29586
## <none>                    56655016 29586
## - Visits                 1      48037  56703053 29587
## - BDead                  1      48631  56703647 29587
## - HispMom                6     249947  56904963 29588
## - Birth.Attendant        1      74442  56729458 29588
## - LOutcome               1      76371  56731387 29588
## - Wt.Gain                1     102359  56757375 29590
## - HispDad                6     313702  56968717 29591
## - Father.Minority        1     170467  56825483 29593
## - Plurality.of.birth     1     199078  56854093 29595
## - Smoker                 1     259296  56914312 29598
## - Weeks                  1     1870755  58525771 29682
## - Birth.weight.group     1  616655420  673310436 37010
##
## Step:  AIC=29586
## Birth.Weight ~ Plurality.of.birth + BDead + LOutcome + Weeks +
##      Visits + Birth.weight.group + Birth.Attendant + Father.Minority +
##      HispMom + HispDad + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## <none>                    56685876 29586
## - Visits                 1     48934  56734810 29587
## - BDead                  1     48946  56734822 29587
## - HispMom                6     249843  56935719 29587
## - Birth.Attendant        1      61357  56747233 29587
## - LOutcome               1      74324  56760200 29588
## - Wt.Gain                1     103511  56789387 29589
## - HispDad                6     313809  56999685 29591
## - Father.Minority        1     166842  56852718 29593
## - Plurality.of.birth     1     200577  56886453 29595
## - Smoker                 1     254422  56940298 29597
## - Weeks                  1     1873764  58559641 29682
## - Birth.weight.group     1  617432854  674118730 37012
```

```
back_reg$terms
```

```
## Birth.Weight ~ Plurality.of.birth + BDead + LOutcome + Weeks +
##      Visits + Birth.weight.group + Birth.Attendant + Father.Minority +
##      HispMom + HispDad + Smoker + Wt.Gain
## attr(,"variables")
## list(Birth.Weight, Plurality.of.birth, BDead, LOutcome, Weeks,
##      Visits, Birth.weight.group, Birth.Attendant, Father.Minority,
##      HispMom, HispDad, Smoker, Wt.Gain)
## attr(,"factors")
##      Plurality.of.birth BDead LOutcome Weeks Visits
## Birth.Weight           0     0         0     0     0
## Plurality.of.birth     1     0         0     0     0
## BDead                   0     1         0     0     0
## LOutcome                0     0         1     0     0
```

```

## Weeks                0      0      0      1      0
## Visits                0      0      0      0      1
## Birth.weight.group    0      0      0      0      0
## Birth.Attendant       0      0      0      0      0
## Father.Minority       0      0      0      0      0
## HispMom               0      0      0      0      0
## HispDad               0      0      0      0      0
## Smoker                0      0      0      0      0
## Wt.Gain               0      0      0      0      0
##
##      Birth.weight.group Birth.Attendant Father.Minority HispMom
## Birth.Weight           0                0                0      0
## Plurality.of.birth     0                0                0      0
## BDead                  0                0                0      0
## LOutcome               0                0                0      0
## Weeks                  0                0                0      0
## Visits                  0                0                0      0
## Birth.weight.group     1                0                0      0
## Birth.Attendant        0                1                0      0
## Father.Minority        0                0                1      0
## HispMom                0                0                0      1
## HispDad                0                0                0      0
## Smoker                  0                0                0      0
## Wt.Gain                 0                0                0      0
##
##      HispDad Smoker Wt.Gain
## Birth.Weight      0      0      0
## Plurality.of.birth 0      0      0
## BDead              0      0      0
## LOutcome           0      0      0
## Weeks              0      0      0
## Visits              0      0      0
## Birth.weight.group 0      0      0
## Birth.Attendant    0      0      0
## Father.Minority    0      0      0
## HispMom            0      0      0
## HispDad            1      0      0
## Smoker              0      1      0
## Wt.Gain             0      0      1
## attr("term.labels")
## [1] "Plurality.of.birth" "BDead"          "LOutcome"
## [4] "Weeks"              "Visits"         "Birth.weight.group"
## [7] "Birth.Attendant"    "Father.Minority" "HispMom"
## [10] "HispDad"            "Smoker"         "Wt.Gain"
## attr("order")
## [1] 1 1 1 1 1 1 1 1 1 1 1 1
## attr("intercept")
## [1] 1
## attr("response")
## [1] 1
## attr(".Environment")
## <environment: R_GlobalEnv>
## attr("predvars")
## list(Birth.Weight, Plurality.of.birth, BDead, LOutcome, Weeks,
##      Visits, Birth.weight.group, Birth.Attendant, Father.Minority,
##      HispMom, HispDad, Smoker, Wt.Gain)

```



```
## attr("dataClasses")
##      Birth.Weight Plurality.of.birth      BDead      LOutcome
##      "numeric"      "numeric"      "numeric"      "numeric"
##      Weeks      Visits Birth.weight.group      Birth.Attendant
##      "numeric"      "numeric"      "numeric"      "numeric"
##      Father.Minority      HispMom      HispDad      Smoker
##      "character"      "character"      "character"      "character"
##      Wt.Gain
##      "numeric"
```

Part C

Backwards Stepwise with BIC

```
births_lm = lm(Birth.Weight ~., data = birthsNew)
library(stats)
back_reg = step(births_lm,
  direction = "backward",
  k = log(3000))
```

```
## Start: AIC=29872.26
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##      Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
##      Education.of.mother..years. + Total.Preg + BDead + Terms +
##      LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
##      Birth.weight.group + Marital + Birth.Attendant + Numchild +
##      Month.Term + Year.Term + Low.Birth + RaceMom + RaceDad +
##      Mother.Minority + Father.Minority + HispMom + HispDad + AveCigs +
##      Smoker + AveDrink + Wt.Gain
##
##
## Step: AIC=29872.26
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##      Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
##      Education.of.mother..years. + Total.Preg + BDead + Terms +
##      LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
##      Birth.weight.group + Marital + Birth.Attendant + Numchild +
##      Month.Term + Year.Term + Low.Birth + RaceMom + RaceDad +
##      Father.Minority + HispMom + HispDad + AveCigs + Smoker +
##      AveDrink + Wt.Gain
##
##
## Step: AIC=29872.26
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##      Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
##      Education.of.mother..years. + Total.Preg + BDead + Terms +
##      LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
##      Birth.weight.group + Marital + Birth.Attendant + Numchild +
##      Month.Term + Year.Term + Low.Birth + RaceDad + Father.Minority +
##      HispMom + HispDad + AveCigs + Smoker + AveDrink + Wt.Gain
##
##
## Step: AIC=29872.26
```

```

## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + Total.Preg + BDead + Terms +
##   LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
##   Birth.weight.group + Marital + Birth.Attendant + Month.Term +
##   Year.Term + Low.Birth + RaceDad + Father.Minority + HispMom +
##   HispDad + AveCigs + Smoker + AveDrink + Wt.Gain
##
##               Df Sum of Sq      RSS   AIC
## - HispMom      6    247777 56706934 29837
## - HispDad      6    323559 56782716 29841
## - Race         2     13930 56473087 29857
## - RaceDad      1       236 56459394 29864
## - Race.of.child 1       791 56459948 29864
## - AveDrink     1     1297 56460455 29864
## - Total.Preg   1     1813 56460970 29864
## - Father.Minority 1     2435 56461592 29864
## - AveCigs      1     2847 56462004 29864
## - Terms       1     5805 56464962 29865
## - Prenatal    1     6152 56465309 29865
## - Month.Term   1     6298 56465456 29865
## - Year.Term    1     6955 56466112 29865
## - Education.of.mother..years. 1    10817 56469974 29865
## - Low.Birth    1    11205 56470363 29865
## - Gender       1    14482 56473640 29865
## - Age.of.mother 1    17289 56476447 29865
## - Age.of.father 1    18241 56477398 29865
## - Education.of.father..years. 1    19885 56479043 29865
## - Marital      1    21654 56480811 29865
## - LOutcome     1    25512 56484669 29866
## - Trimester.Prenatal 1    28360 56487517 29866
## - Institution.type 1    32213 56491370 29866
## - BDead        1    45734 56504891 29867
## - Smoker       1    47301 56506458 29867
## - Visits       1    52004 56511161 29867
## - Birth.Attendant 1    62621 56521778 29868
## - Wt.Gain      1   108903 56568061 29870
## <none>                          56459157 29872
## - Plurality.of.birth 1    193610 56652767 29875
## - Weeks        1   1747615 58206773 29956
## - Birth.weight.group 1 438183442 494642600 36375
##
## Step:  AIC=29837.35
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + Total.Preg + BDead + Terms +
##   LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
##   Birth.weight.group + Marital + Birth.Attendant + Month.Term +
##   Year.Term + Low.Birth + RaceDad + Father.Minority + HispDad +
##   AveCigs + Smoker + AveDrink + Wt.Gain
##
##               Df Sum of Sq      RSS   AIC
## - HispDad      6    160858 56867792 29798
## - Race         2     11986 56718920 29822

```

```

## - Race.of.child      1      86 56707020 29829
## - RaceDad            1     399 56707333 29829
## - Total.Preg         1    1793 56708727 29829
## - AveDrink           1    1891 56708825 29829
## - AveCigs            1    2304 56709238 29829
## - Father.Minority    1    2566 56709500 29829
## - Education.of.mother..years. 1    4180 56711115 29830
## - Prenatal           1    4266 56711200 29830
## - Month.Term         1    4902 56711836 29830
## - Year.Term          1    8229 56715163 29830
## - Terms              1    8253 56715187 29830
## - Low.Birth          1   12180 56719114 29830
## - Age.of.mother      1   13737 56720672 29830
## - Gender             1   15651 56722586 29830
## - Education.of.father..years. 1   21436 56728370 29830
## - Age.of.father      1   22557 56729492 29831
## - Marital            1   22623 56729557 29831
## - Trimester.Prenatal 1   25162 56732096 29831
## - LOutcome           1   30134 56737069 29831
## - Institution.type   1   33355 56740289 29831
## - Smoker             1   44980 56751915 29832
## - BDead              1   45508 56752442 29832
## - Visits             1   60601 56767535 29833
## - Birth.Attendant    1   69903 56776837 29833
## - Wt.Gain            1  116144 56823078 29835
## <none>                56706934 29837
## - Plurality.of.birth 1  204363 56911297 29840
## - Weeks              1  1757811 58464745 29921
## - Birth.weight.group 1 439882350 496589284 36339
##
## Step: AIC=29797.81
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Race.of.child + Race + Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + Total.Preg + BDead + Terms +
##   LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
##   Birth.weight.group + Marital + Birth.Attendant + Month.Term +
##   Year.Term + Low.Birth + RaceDad + Father.Minority + AveCigs +
##   Smoker + AveDrink + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Race        2    10281 56878073 29782
## - RaceDad      1         4 56867796 29790
## - AveDrink     1         23 56867815 29790
## - Race.of.child 1        988 56868780 29790
## - Total.Preg   1       1567 56869359 29790
## - AveCigs      1       2933 56870725 29790
## - Prenatal     1       3137 56870929 29790
## - Year.Term    1       5604 56873396 29790
## - Terms        1       6142 56873933 29790
## - Month.Term   1       6727 56874519 29790
## - Father.Minority 1       7606 56875398 29790
## - Education.of.father..years. 1     12273 56880064 29790
## - Gender       1      14069 56881861 29791
## - Age.of.mother 1     15230 56883022 29791

```

```

## - Age.of.father          1      16300  56884092 29791
## - Low.Birth              1      16328  56884120 29791
## - Education.of.mother..years. 1      17510  56885302 29791
## - Marital                1      18070  56885862 29791
## - Trimester.Prenatal     1      26241  56894033 29791
## - Institution.type       1      32270  56900061 29792
## - LOutcome               1      32464  56900256 29792
## - BDead                  1      46204  56913996 29792
## - Smoker                 1      55909  56923701 29793
## - Visits                 1      59957  56927749 29793
## - Birth.Attendant        1      65257  56933048 29793
## - Wt.Gain                 1     104521  56972313 29795
## <none>                    1          56867792 29798
## - Plurality.of.birth     1     204399  57072191 29801
## - Weeks                  1     1771782  58639574 29882
## - Birth.weight.group     1  440354435  497222227 36295
##
## Step: AIC=29782.34
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##      Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
##      Education.of.mother..years. + Total.Preg + BDead + Terms +
##      LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
##      Birth.weight.group + Marital + Birth.Attendant + Month.Term +
##      Year.Term + Low.Birth + RaceDad + Father.Minority + AveCigs +
##      Smoker + AveDrink + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - AveDrink      1         28  56878101 29774
## - Total.Preg     1        1370  56879443 29774
## - AveCigs        1        2529  56880603 29774
## - Prenatal       1        3297  56881371 29775
## - RaceDad        1        3929  56882002 29775
## - Year.Term      1        5653  56883726 29775
## - Terms          1        6461  56884535 29775
## - Month.Term     1        6534  56884607 29775
## - Race.of.child  1        7932  56886005 29775
## - Education.of.father..years. 1      12298  56890372 29775
## - Gender         1       13920  56891994 29775
## - Age.of.mother   1       14793  56892866 29775
## - Age.of.father   1       15959  56894032 29775
## - Low.Birth       1       16710  56894783 29775
## - Education.of.mother..years. 1      18424  56896497 29775
## - Marital         1       18663  56896736 29775
## - Trimester.Prenatal 1      26068  56904141 29776
## - Institution.type 1      32133  56910206 29776
## - LOutcome        1      32795  56910868 29776
## - BDead           1      45954  56924027 29777
## - Smoker          1      55889  56933963 29777
## - Visits          1      57875  56935949 29777
## - Birth.Attendant  1      68887  56946961 29778
## - Father.Minority  1     100989  56979062 29780
## - Wt.Gain         1     106177  56984250 29780
## <none>            1          56878073 29782
## - Plurality.of.birth 1     201933  57080006 29785

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```

## - Weeks          1  1770687  58648760 29866
## - Birth.weight.group 1 442828910 499706984 36294
##
## Step: AIC=29774.34
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + Total.Preg + BDead + Terms +
##   LOutcome + Weeks + Prenatal + Trimester.Prenatal + Visits +
##   Birth.weight.group + Marital + Birth.Attendant + Month.Term +
##   Year.Term + Low.Birth + RaceDad + Father.Minority + AveCigs +
##   Smoker + Wt.Gain
##
##
##              Df Sum of Sq      RSS    AIC
## - Total.Preg      1      1371  56879472 29766
## - AveCigs          1      2523  56880625 29766
## - Prenatal         1      3279  56881380 29767
## - RaceDad          1      3930  56882031 29767
## - Year.Term        1      5638  56883739 29767
## - Terms            1      6440  56884541 29767
## - Month.Term       1      6524  56884625 29767
## - Race.of.child    1      7930  56886032 29767
## - Education.of.father..years. 1  12296  56890398 29767
## - Gender           1     13907  56892008 29767
## - Age.of.mother     1     14768  56892869 29767
## - Age.of.father     1     15935  56894036 29767
## - Low.Birth         1     16691  56894792 29767
## - Education.of.mother..years. 1  18396  56896497 29767
## - Marital           1     18656  56896758 29767
## - Trimester.Prenatal 1     26040  56904142 29768
## - Institution.type  1     32138  56910239 29768
## - LOutcome          1     32802  56910903 29768
## - BDead             1     45966  56924067 29769
## - Smoker            1     55936  56934037 29769
## - Visits            1     57874  56935975 29769
## - Birth.Attendant   1     68951  56947052 29770
## - Father.Minority   1    100986  56979087 29772
## - Wt.Gain           1    106231  56984333 29772
## <none>                                56878101 29774
## - Plurality.of.birth 1    201923  57080024 29777
## - Weeks             1    1770853  58648954 29858
## - Birth.weight.group 1 442951405 499829507 36286
##
## Step: AIC=29766.4
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + BDead + Terms + LOutcome +
##   Weeks + Prenatal + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Month.Term + Year.Term + Low.Birth +
##   RaceDad + Father.Minority + AveCigs + Smoker + Wt.Gain
##
##
##              Df Sum of Sq      RSS    AIC
## - AveCigs          1      2552  56882024 29759
## - Prenatal         1      3137  56882609 29759
## - RaceDad          1      3851  56883323 29759

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## - Year.Term          1      6221 56885693 29759
## - Month.Term         1      6779 56886251 29759
## - Race.of.child      1      8045 56887517 29759
## - Education.of.father..years. 1 12326 56891798 29759
## - Gender             1     13714 56893186 29759
## - Age.of.father       1     15622 56895094 29759
## - Low.Birth          1     16554 56896026 29759
## - Age.of.mother       1     17485 56896957 29759
## - Terms              1     17583 56897055 29759
## - Marital            1     18822 56898294 29759
## - Education.of.mother..years. 1 21358 56900830 29760
## - Trimester.Prenatal 1     26096 56905568 29760
## - Institution.type    1     32428 56911900 29760
## - BDead              1     49653 56929125 29761
## - Smoker             1     55590 56935062 29761
## - Visits             1     57190 56936662 29761
## - LOutcome           1     60989 56940461 29762
## - Birth.Attendant     1     70552 56950024 29762
## - Father.Minority     1     99676 56979148 29764
## - Wt.Gain            1    105290 56984762 29764
## <none>                1    56879472 29766
## - Plurality.of.birth 1    200627 57080099 29769
## - Weeks              1    1769738 58649210 29850
## - Birth.weight.group 1 445571233 502450705 36294
##
## Step: AIC=29758.53
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + BDead + Terms + LOutcome +
##   Weeks + Prenatal + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Month.Term + Year.Term + Low.Birth +
##   RaceDad + Father.Minority + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Prenatal    1      3323 56885347 29751
## - RaceDad      1      3762 56885786 29751
## - Year.Term    1      6117 56888142 29751
## - Month.Term   1      6791 56888815 29751
## - Race.of.child 1      7880 56889905 29751
## - Education.of.father..years. 1 12495 56894520 29751
## - Gender       1     13869 56895894 29751
## - Age.of.father 1     15964 56897988 29751
## - Low.Birth    1     16998 56899022 29751
## - Age.of.mother 1     17350 56899375 29751
## - Terms        1     17553 56899578 29751
## - Marital      1     18602 56900626 29752
## - Education.of.mother..years. 1 21148 56903172 29752
## - Trimester.Prenatal 1 26492 56908517 29752
## - Institution.type 1 32470 56914495 29752
## - BDead        1     49686 56931710 29753
## - Visits       1     56637 56938661 29754
## - LOutcome     1     60681 56942706 29754
## - Birth.Attendant 1 71425 56953450 29754
## - Father.Minority 1 98820 56980845 29756

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## - Wt.Gain          1      104789  56986813 29756
## <none>                                56882024 29759
## - Plurality.of.birth 1      199499  57081523 29761
## - Smoker            1      251711  57133735 29764
## - Weeks             1      1772103  58654127 29843
## - Birth.weight.group 1  445569195  502451219 36286
##
## Step: AIC=29750.7
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + BDead + Terms + LOutcome +
##   Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Month.Term + Year.Term + Low.Birth +
##   RaceDad + Father.Minority + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS    AIC
## - RaceDad      1      3687  56889034 29743
## - Year.Term     1      6263  56891610 29743
## - Month.Term    1      6734  56892082 29743
## - Race.of.child 1      7954  56893302 29743
## - Gender        1     13856  56899204 29743
## - Education.of.father..years. 1  14072  56899420 29743
## - Age.of.father  1     16168  56901515 29744
## - Low.Birth      1     17222  56902570 29744
## - Age.of.mother  1     17349  56902696 29744
## - Terms         1     17632  56902979 29744
## - Marital        1     19561  56904909 29744
## - Education.of.mother..years. 1  21034  56906381 29744
## - Institution.type 1  34325  56919672 29745
## - Trimester.Prenatal 1  36694  56922041 29745
## - BDead          1     49779  56935127 29745
## - LOutcome       1     60435  56945782 29746
## - Visits         1     65395  56950742 29746
## - Birth.Attendant 1     70363  56955711 29746
## - Father.Minority 1     99129  56984477 29748
## - Wt.Gain        1    104387  56989735 29748
## <none>                                56885347 29751
## - Plurality.of.birth 1    200864  57086212 29753
## - Smoker         1    252289  57137636 29756
## - Weeks          1    1773473  58658821 29835
## - Birth.weight.group 1  445623489  502508837 36278
##
## Step: AIC=29742.89
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Race.of.child + Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + BDead + Terms + LOutcome +
##   Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Month.Term + Year.Term + Low.Birth +
##   Father.Minority + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS    AIC
## - Race.of.child  1      4276  56893310 29735
## - Year.Term       1      6262  56895296 29735
## - Month.Term      1      6966  56896000 29735

```

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## - Gender 1 13925 56902959 29736
## - Education.of.father..years. 1 14659 56903693 29736
## - Age.of.father 1 16186 56905220 29736
## - Age.of.mother 1 17221 56906255 29736
## - Terms 1 17373 56906407 29736
## - Low.Birth 1 17458 56906492 29736
## - Marital 1 21387 56910421 29736
## - Education.of.mother..years. 1 21536 56910570 29736
## - Institution.type 1 34045 56923079 29737
## - Trimester.Prenatal 1 36400 56925434 29737
## - BDead 1 49709 56938743 29738
## - LOutcome 1 59923 56948957 29738
## - Visits 1 64645 56953679 29738
## - Birth.Attendant 1 70791 56959825 29739
## - Father.Minority 1 104595 56993629 29740
## - Wt.Gain 1 105143 56994177 29740
## <none> 56889034 29743
## - Plurality.of.birth 1 200243 57089277 29745
## - Smoker 1 251551 57140585 29748
## - Weeks 1 1790058 58679092 29828
## - Birth.weight.group 1 445645121 502534156 36271
##
## Step: AIC=29735.11
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Age.of.father + Age.of.mother + Education.of.father..years. +
## Education.of.mother..years. + BDead + Terms + LOutcome +
## Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
## Marital + Birth.Attendant + Month.Term + Year.Term + Low.Birth +
## Father.Minority + Smoker + Wt.Gain
##
## Df Sum of Sq RSS AIC
## - Year.Term 1 6297 56899607 29727
## - Month.Term 1 6875 56900185 29727
## - Gender 1 14182 56907491 29728
## - Education.of.father..years. 1 14448 56907758 29728
## - Low.Birth 1 16887 56910197 29728
## - Age.of.father 1 17192 56910502 29728
## - Age.of.mother 1 17342 56910652 29728
## - Terms 1 17603 56910912 29728
## - Marital 1 19630 56912940 29728
## - Education.of.mother..years. 1 21704 56915013 29728
## - Institution.type 1 33684 56926994 29729
## - Trimester.Prenatal 1 36107 56929416 29729
## - BDead 1 49881 56943191 29730
## - LOutcome 1 60718 56954028 29730
## - Visits 1 65060 56958370 29731
## - Birth.Attendant 1 70834 56964143 29731
## - Wt.Gain 1 105191 56998501 29733
## <none> 56893310 29735
## - Father.Minority 1 162805 57056114 29736
## - Plurality.of.birth 1 198846 57092156 29738
## - Smoker 1 250276 57143586 29740
## - Weeks 1 1786981 58680291 29820
## - Birth.weight.group 1 446930977 503824286 36270

```



```
##
## Step: AIC=29727.43
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + BDead + Terms + LOutcome +
##   Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Month.Term + Low.Birth + Father.Minority +
##   Smoker + Wt.Gain
##
```

	Df	Sum of Sq	RSS	AIC
## - Terms	1	11333	56910940	29720
## - Gender	1	13827	56913434	29720
## - Education.of.father..years.	1	14551	56914158	29720
## - Low.Birth	1	16591	56916198	29720
## - Age.of.mother	1	17336	56916944	29720
## - Age.of.father	1	17371	56916978	29720
## - Marital	1	20312	56919919	29720
## - Month.Term	1	22179	56921786	29721
## - Education.of.mother..years.	1	22776	56922384	29721
## - Institution.type	1	32367	56931974	29721
## - Trimester.Prenatal	1	36303	56935910	29721
## - BDead	1	51141	56950748	29722
## - LOutcome	1	55793	56955400	29722
## - Visits	1	65634	56965241	29723
## - Birth.Attendant	1	71282	56970890	29723
## - Wt.Gain	1	105301	57004909	29725
## <none>			56899607	29727
## - Father.Minority	1	162196	57061803	29728
## - Plurality.of.birth	1	196951	57096558	29730
## - Smoker	1	252696	57152304	29733
## - Weeks	1	1784138	58683745	29812
## - Birth.weight.group	1	447023825	503923432	36263

```
##
## Step: AIC=29720.03
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
##   Age.of.father + Age.of.mother + Education.of.father..years. +
##   Education.of.mother..years. + BDead + LOutcome + Weeks +
##   Trimester.Prenatal + Visits + Birth.weight.group + Marital +
##   Birth.Attendant + Month.Term + Low.Birth + Father.Minority +
##   Smoker + Wt.Gain
##
```

	Df	Sum of Sq	RSS	AIC
## - Month.Term	1	13379	56924319	29713
## - Gender	1	14240	56925180	29713
## - Education.of.father..years.	1	15046	56925986	29713
## - Low.Birth	1	16111	56927051	29713
## - Age.of.father	1	17223	56928164	29713
## - Marital	1	18557	56929497	29713
## - Age.of.mother	1	20107	56931048	29713
## - Education.of.mother..years.	1	23202	56934143	29713
## - Institution.type	1	31245	56942185	29714
## - Trimester.Prenatal	1	37157	56948097	29714
## - BDead	1	51121	56962062	29715
## - LOutcome	1	64245	56975186	29715

```
## - Visits 1 69891 56980831 29716
## - Birth.Attendant 1 72000 56982940 29716
## - Wt.Gain 1 105909 57016850 29718
## <none> 56910940 29720
## - Father.Minority 1 159499 57070440 29720
## - Plurality.of.birth 1 198600 57109540 29722
## - Smoker 1 245872 57156812 29725
## - Weeks 1 1782760 58693701 29805
## - Birth.weight.group 1 447251159 504162099 36256
##
## Step: AIC=29712.72
## Birth.Weight ~ Institution.type + Plurality.of.birth + Gender +
## Age.of.father + Age.of.mother + Education.of.father..years. +
## Education.of.mother..years. + BDead + LOutcome + Weeks +
## Trimester.Prenatal + Visits + Birth.weight.group + Marital +
## Birth.Attendant + Low.Birth + Father.Minority + Smoker +
## Wt.Gain
##
```

	Df	Sum of Sq	RSS	AIC
## - Gender	1	13726	56938045	29705
## - Education.of.father..years.	1	14832	56939151	29705
## - Low.Birth	1	15850	56940169	29706
## - Age.of.father	1	16844	56941163	29706
## - Marital	1	18329	56942648	29706
## - Age.of.mother	1	19820	56944139	29706
## - Education.of.mother..years.	1	23965	56948284	29706
## - Institution.type	1	30297	56954616	29706
## - Trimester.Prenatal	1	37645	56961964	29707
## - BDead	1	49210	56973529	29707
## - LOutcome	1	55589	56979908	29708
## - Visits	1	67131	56991450	29708
## - Birth.Attendant	1	73868	56998188	29709
## - Wt.Gain	1	104298	57028617	29710
## <none>			56924319	29713
## - Father.Minority	1	159745	57084064	29713
## - Plurality.of.birth	1	195989	57120308	29715
## - Smoker	1	245815	57170134	29718
## - Weeks	1	1781826	58706145	29797
## - Birth.weight.group	1	447973115	504897434	36253

```
##
## Step: AIC=29705.44
## Birth.Weight ~ Institution.type + Plurality.of.birth + Age.of.father +
## Age.of.mother + Education.of.father..years. + Education.of.mother..years. +
## BDead + LOutcome + Weeks + Trimester.Prenatal + Visits +
## Birth.weight.group + Marital + Birth.Attendant + Low.Birth +
## Father.Minority + Smoker + Wt.Gain
##
```

	Df	Sum of Sq	RSS	AIC
## - Low.Birth	1	14921	56952967	29698
## - Education.of.father..years.	1	15442	56953487	29698
## - Marital	1	17802	56955848	29698
## - Age.of.father	1	18243	56956289	29698
## - Age.of.mother	1	21621	56959666	29699
## - Education.of.mother..years.	1	24514	56962559	29699

```

## - Institution.type          1      29201  56967247 29699
## - Trimester.Prenatal       1      37634  56975680 29699
## - BDead                    1      50937  56988983 29700
## - LOutcome                  1      54924  56992970 29700
## - Visits                    1      65985  57004030 29701
## - Birth.Attendant           1      72166  57010211 29701
## - Wt.Gain                   1     104074  57042119 29703
## <none>                      1     161062  57099107 29706
## - Father.Minority           1     193981  57132026 29708
## - Plurality.of.birth        1     242504  57180549 29710
## - Weeks                     1     1768701  58706747 29789
## - Birth.weight.group        1  456611926 513549971 36296
##
## Step: AIC=29698.22
## Birth.Weight ~ Institution.type + Plurality.of.birth + Age.of.father +
##   Age.of.mother + Education.of.father..years. + Education.of.mother..years. +
##   BDead + LOutcome + Weeks + Trimester.Prenatal + Visits +
##   Birth.weight.group + Marital + Birth.Attendant + Father.Minority +
##   Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Education.of.father..years.  1      14355  56967322 29691
## - Age.of.father                 1      18747  56971714 29691
## - Marital                       1      18895  56971862 29691
## - Age.of.mother                 1      20908  56973875 29691
## - Education.of.mother..years.   1      23004  56975971 29691
## - Institution.type              1      30211  56983178 29692
## - Trimester.Prenatal            1      38466  56991433 29692
## - BDead                        1      50292  57003259 29693
## - LOutcome                      1      55761  57008728 29693
## - Visits                        1      67454  57020420 29694
## - Birth.Attendant               1      71933  57024900 29694
## - Wt.Gain                       1     102345  57055312 29696
## <none>                          1     160400  57113367 29699
## - Father.Minority               1     228510  57181477 29702
## - Plurality.of.birth            1     239194  57192161 29703
## - Weeks                         1     1879256  58832223 29788
## - Birth.weight.group            1  616433714 673386680 37100
##
## Step: AIC=29690.97
## Birth.Weight ~ Institution.type + Plurality.of.birth + Age.of.father +
##   Age.of.mother + Education.of.mother..years. + BDead + LOutcome +
##   Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
##   Marital + Birth.Attendant + Father.Minority + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## - Education.of.mother..years.   1       9377  56976699 29683
## - Age.of.father                 1      17217  56984538 29684
## - Marital                       1      21546  56988867 29684
## - Age.of.mother                 1      22632  56989953 29684
## - Institution.type              1      29698  56997019 29685
## - Trimester.Prenatal            1      36179  57003501 29685

```

```

## - BDead 1 49518 57016839 29686
## - LOutcome 1 55287 57022609 29686
## - Visits 1 70785 57038106 29687
## - Birth.Attendant 1 75110 57042431 29687
## - Wt.Gain 1 104971 57072293 29688
## <none> 56967322 29691
## - Father.Minority 1 154513 57121835 29691
## - Plurality.of.birth 1 227372 57194693 29695
## - Smoker 1 240804 57208125 29696
## - Weeks 1 1880419 58847741 29780
## - Birth.weight.group 1 616458889 673426211 37093
##
## Step: AIC=29683.46
## Birth.Weight ~ Institution.type + Plurality.of.birth + Age.of.father +
## Age.of.mother + BDead + LOutcome + Weeks + Trimester.Prenatal +
## Visits + Birth.weight.group + Marital + Birth.Attendant +
## Father.Minority + Smoker + Wt.Gain
##
## Df Sum of Sq RSS AIC
## - Marital 1 16197 56992896 29676
## - Age.of.mother 1 16780 56993478 29676
## - Age.of.father 1 16936 56993635 29676
## - Institution.type 1 31570 57008269 29677
## - Trimester.Prenatal 1 40160 57016859 29678
## - BDead 1 49675 57026374 29678
## - Visits 1 65116 57041815 29679
## - LOutcome 1 68310 57045009 29679
## - Birth.Attendant 1 75297 57051996 29679
## - Wt.Gain 1 99127 57075826 29681
## <none> 56976699 29683
## - Father.Minority 1 171462 57148161 29684
## - Plurality.of.birth 1 228821 57205520 29687
## - Smoker 1 237932 57214631 29688
## - Weeks 1 1881652 58858350 29773
## - Birth.weight.group 1 616459951 673436650 37085
##
## Step: AIC=29676.3
## Birth.Weight ~ Institution.type + Plurality.of.birth + Age.of.father +
## Age.of.mother + BDead + LOutcome + Weeks + Trimester.Prenatal +
## Visits + Birth.weight.group + Birth.Attendant + Father.Minority +
## Smoker + Wt.Gain
##
## Df Sum of Sq RSS AIC
## - Age.of.father 1 16229 57009125 29669
## - Age.of.mother 1 26245 57019141 29670
## - Institution.type 1 32097 57024993 29670
## - Trimester.Prenatal 1 34140 57027036 29670
## - BDead 1 49994 57042890 29671
## - LOutcome 1 67991 57060886 29672
## - Visits 1 68979 57061875 29672
## - Birth.Attendant 1 78642 57071538 29672
## - Wt.Gain 1 102414 57095310 29674
## <none> 56992896 29676
## - Father.Minority 1 209740 57202636 29679

```

```

## - Plurality.of.birth 1 228453 57221349 29680
## - Smoker 1 254156 57247052 29682
## - Weeks 1 1879509 58872404 29766
## - Birth.weight.group 1 616652662 673645558 37078
##
## Step: AIC=29669.15
## Birth.Weight ~ Institution.type + Plurality.of.birth + Age.of.mother +
## BDead + LOutcome + Weeks + Trimester.Prenatal + Visits +
## Birth.weight.group + Birth.Attendant + Father.Minority +
## Smoker + Wt.Gain
##
##
## Df Sum of Sq RSS AIC
## - Age.of.mother 1 10297 57019422 29662
## - Institution.type 1 31924 57041049 29663
## - Trimester.Prenatal 1 33386 57042511 29663
## - BDead 1 49902 57059027 29664
## - LOutcome 1 64762 57073887 29665
## - Visits 1 67866 57076991 29665
## - Birth.Attendant 1 79681 57088806 29665
## - Wt.Gain 1 101689 57110814 29666
## <none> 57009125 29669
## - Father.Minority 1 211032 57220157 29672
## - Plurality.of.birth 1 229049 57238174 29673
## - Smoker 1 259970 57269095 29675
## - Weeks 1 1873941 58883066 29758
## - Birth.weight.group 1 617112713 674121838 37072
##
## Step: AIC=29661.69
## Birth.Weight ~ Institution.type + Plurality.of.birth + BDead +
## LOutcome + Weeks + Trimester.Prenatal + Visits + Birth.weight.group +
## Birth.Attendant + Father.Minority + Smoker + Wt.Gain
##
##
## Df Sum of Sq RSS AIC
## - Trimester.Prenatal 1 30071 57049493 29655
## - Institution.type 1 31115 57050537 29655
## - BDead 1 49140 57068562 29656
## - Visits 1 72761 57092183 29658
## - Birth.Attendant 1 77792 57097214 29658
## - LOutcome 1 89422 57108844 29658
## - Wt.Gain 1 99847 57119269 29659
## <none> 57019422 29662
## - Father.Minority 1 224459 57243881 29665
## - Plurality.of.birth 1 225775 57245197 29666
## - Smoker 1 284565 57303987 29669
## - Weeks 1 1863894 58883316 29750
## - Birth.weight.group 1 619589398 676608820 37075
##
## Step: AIC=29655.26
## Birth.Weight ~ Institution.type + Plurality.of.birth + BDead +
## LOutcome + Weeks + Visits + Birth.weight.group + Birth.Attendant +
## Father.Minority + Smoker + Wt.Gain
##
##
## Df Sum of Sq RSS AIC
## - Institution.type 1 32091 57081584 29649

```

```

## - Visits          1      47947  57097440 29650
## - BDead           1      48840  57098333 29650
## - Birth.Attendant 1      76981  57126474 29651
## - LOutcome        1      93330  57142823 29652
## - Wt.Gain         1      97398  57146891 29652
## <none>                                57049493 29655
## - Plurality.of.birth 1    215365  57264858 29659
## - Father.Minority  1    215392  57264885 29659
## - Smoker          1    278968  57328461 29662
## - Weeks           1   1938100  58987593 29747
## - Birth.weight.group 1 619560838 676610331 37067
##
## Step: AIC=29648.94
## Birth.Weight ~ Plurality.of.birth + BDead + LOutcome + Weeks +
## Visits + Birth.weight.group + Birth.Attendant + Father.Minority +
## Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS    AIC
## - Visits      1     48345  57129928 29643
## - BDead       1     49091  57130675 29644
## - Birth.Attendant 1     63305  57144889 29644
## - LOutcome    1     91229  57172813 29646
## - Wt.Gain     1     98215  57179799 29646
## <none>                                57081584 29649
## - Father.Minority 1    211976  57293560 29652
## - Plurality.of.birth 1    216902  57298486 29652
## - Smoker       1    274724  57356308 29655
## - Weeks        1   1942333  59023917 29741
## - Birth.weight.group 1 620338623 677420207 37062
##
## Step: AIC=29643.48
## Birth.Weight ~ Plurality.of.birth + BDead + LOutcome + Weeks +
## Birth.weight.group + Birth.Attendant + Father.Minority +
## Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS    AIC
## - BDead       1     50280  57180208 29638
## - Birth.Attendant 1     59230  57189159 29639
## - LOutcome    1     84978  57214906 29640
## - Wt.Gain     1    103830  57233758 29641
## <none>                                57129928 29643
## - Plurality.of.birth 1    189127  57319056 29645
## - Father.Minority  1    209013  57338942 29646
## - Smoker       1    285379  57415308 29650
## - Weeks        1   1976420  59106348 29738
## - Birth.weight.group 1 627834915 684964844 37088
##
## Step: AIC=29638.11
## Birth.Weight ~ Plurality.of.birth + LOutcome + Weeks + Birth.weight.group +
## Birth.Attendant + Father.Minority + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS    AIC
## - Birth.Attendant 1     57334  57237542 29633
## - LOutcome        1     96876  57277084 29635

```

```

## - Wt.Gain          1      105747  57285955 29636
## <none>              57180208 29638
## - Plurality.of.birth 1      192959  57373167 29640
## - Father.Minority   1      209520  57389728 29641
## - Smoker            1      294076  57474284 29645
## - Weeks             1      1973894  59154102 29732
## - Birth.weight.group 1 628814333 685994541 37084
##
## Step: AIC=29633.11
## Birth.Weight ~ Plurality.of.birth + LOutcome + Weeks + Birth.weight.group +
##   Father.Minority + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS    AIC
## - LOutcome      1      100537  57338079 29630
## - Wt.Gain        1      106349  57343892 29631
## <none>            57237542 29633
## - Plurality.of.birth 1      199554  57437097 29636
## - Father.Minority   1      206460  57444003 29636
## - Smoker          1      282452  57519994 29640
## - Weeks           1      2001068  59238611 29728
## - Birth.weight.group 1 628934947 686172489 37077
##
## Step: AIC=29630.37
## Birth.Weight ~ Plurality.of.birth + Weeks + Birth.weight.group +
##   Father.Minority + Smoker + Wt.Gain
##
##              Df Sum of Sq      RSS    AIC
## - Wt.Gain        1       74646  57412725 29626
## <none>            57338079 29630
## - Plurality.of.birth 1      174053  57512132 29631
## - Father.Minority   1      205068  57543147 29633
## - Smoker           1      262992  57601071 29636
## - Weeks            1      1930453  59268532 29722
## - Birth.weight.group 1 642991879 700329959 37130
##
## Step: AIC=29626.27
## Birth.Weight ~ Plurality.of.birth + Weeks + Birth.weight.group +
##   Father.Minority + Smoker
##
##              Df Sum of Sq      RSS    AIC
## - Plurality.of.birth 1      146926  57559652 29626
## <none>            57412725 29626
## - Father.Minority   1      211615  57624340 29629
## - Smoker            1      258320  57671045 29632
## - Weeks             1      1940021  59352746 29718
## - Birth.weight.group 1 664918304 722331029 37215
##
## Step: AIC=29625.93
## Birth.Weight ~ Weeks + Birth.weight.group + Father.Minority +
##   Smoker
##
##              Df Sum of Sq      RSS    AIC
## <none>            57559652 29626
## - Father.Minority   1      188753  57748404 29628

```

```
## - Smoker          1    237649  57797301 29630
## - Weeks           1    2075355  59635007 29724
## - Birth.weight.group 1 703623597 761183249 37364
```

```
back_reg$terms
```

```
## Birth.Weight ~ Weeks + Birth.weight.group + Father.Minority +
##   Smoker
## attr("variables")
## list(Birth.Weight, Weeks, Birth.weight.group, Father.Minority,
##   Smoker)
## attr("factors")
##           Weeks Birth.weight.group Father.Minority Smoker
## Birth.Weight      0              0              0      0
## Weeks             1              0              0      0
## Birth.weight.group 0              1              0      0
## Father.Minority    0              0              1      0
## Smoker             0              0              0      1
## attr("term.labels")
## [1] "Weeks"          "Birth.weight.group" "Father.Minority"
## [4] "Smoker"
## attr("order")
## [1] 1 1 1 1
## attr("intercept")
## [1] 1
## attr("response")
## [1] 1
## attr(".Environment")
## <environment: R_GlobalEnv>
## attr("predvars")
## list(Birth.Weight, Weeks, Birth.weight.group, Father.Minority,
##   Smoker)
## attr("dataClasses")
##           Birth.Weight      Weeks Birth.weight.group      Father.Minority
##           "numeric"        "numeric"        "numeric"        "character"
##           Smoker
##           "character"
```

Part D

Forwards Stepwise with Mallows-CP (AIC)

```
births_lm = lm(Birth.Weight ~ 1, data = birthsNew)
library(stats)
forwards_reg = step(births_lm,
  scope = list(lower = ~1, upper = ~Institution.type + Plurality.of.birth + Gender + Race,
  direction = "forward",
  data = birthsNew,
  k = 2)
```

```
## Start:  AIC=38634.26
## Birth.Weight ~ 1
```



```

##
##
## + Birth.weight.group      1 1114111893    60013021 29715
## + Low.Birth               1  513906329    660218585 36909
## + Weeks                   1  391217674    782907240 37420
## + Plurality.of.birth     1 117849687   1056275227 38319
## + Wt.Gain                 1   37309776   1136815138 38539
## + Race                    2   31598993   1142525921 38556
## + Mother.Minority        1   28981959   1145142955 38561
## + Father.Minority        1   20806645   1153318269 38583
## + Smoker                 1   16601208   1157523706 38594
## + Visits                 1   14727092   1159397822 38598
## + AveCigs                1   14100044   1160024870 38600
## + Gender                 1   12561149   1161563765 38604
## + Marital                1    8584001   1165540913 38614
## + Race.of.child          1    6127536   1167997378 38621
## + RaceMom                1    6127536   1167997378 38621
## + RaceDad                1   4405648   1169719266 38625
## + Institution.type       1   3105655   1171019259 38628
## + Age.of.mother          1   3035967   1171088947 38628
## + Terms                  1   2608356   1171516558 38630
## + Birth.Attendant        1   2439885   1171685029 38630
## + Education.of.mother..years. 1   2216889   1171908025 38631
## + Numchild               1   2132495   1171992419 38631
## + BDead                  1   2116566   1172008348 38631
## + Education.of.father..years. 1   1393373   1172731541 38633
## + LOutcome               1   1060281   1173064632 38634
## <none>                   1174124914 38634
## + Age.of.father          1    567282   1173557632 38635
## + Year.Term              1    512137   1173612777 38635
## + Trimester.Prenatal     1    368075   1173756839 38635
## + Month.Term             1    337319   1173787595 38635
## + Prenatal               1     7085   1174117829 38636
## + Total.Preg             1     7024   1174117890 38636
## + AveDrink               1     3464   1174121449 38636
## + HispMom                6   3786013   1170338901 38637
## + HispDad                6   2280357   1171844557 38640
##
## Step:  AIC=29715.11
## Birth.Weight ~ Birth.weight.group
##
##
## Df Sum of Sq    RSS    AIC
## + Weeks      1   2036798 57976223 29614
## + Plurality.of.birth 1   225090 59787931 29706
## + Low.Birth   1   203281 59809740 29707
## + Smoker      1   196683 59816338 29707
## + Father.Minority 1   172419 59840602 29708
## + AveCigs     1   159565 59853457 29709
## + Mother.Minority 1   156030 59856991 29709
## + Race        2   172146 59840875 29710
## + Birth.Attendant 1    78795 59934226 29713
## + Marital     1    72142 59940880 29714
## + BDead       1    60167 59952854 29714
## + Wt.Gain     1    50702 59962319 29715

```

```

## + Visits 1 45649 59967372 29715
## + HispDad 6 239995 59773026 29715
## <none> 60013021 29715
## + Race.of.child 1 30424 59982598 29716
## + RaceMom 1 30424 59982598 29716
## + RaceDad 1 22140 59990881 29716
## + Trimester.Prenatal 1 20504 59992517 29716
## + Institution.type 1 17009 59996012 29716
## + Prenatal 1 8545 60004476 29717
## + Education.of.father..years. 1 5011 60008010 29717
## + Age.of.mother 1 4591 60008430 29717
## + Month.Term 1 3557 60009464 29717
## + Total.Preg 1 2374 60010647 29717
## + LOutcome 1 2300 60010722 29717
## + Terms 1 1408 60011613 29717
## + Year.Term 1 1295 60011726 29717
## + Education.of.mother..years. 1 847 60012174 29717
## + Age.of.father 1 843 60012178 29717
## + AveDrink 1 776 60012245 29717
## + Gender 1 564 60012457 29717
## + Numchild 1 132 60012889 29717
## + HispMom 6 157986 59855035 29719
##
## Step: AIC=29613.53
## Birth.Weight ~ Birth.weight.group + Weeks
##
## Df Sum of Sq RSS AIC
## + Smoker 1 227819 57748404 29604
## + Father.Minority 1 178923 57797301 29606
## + AveCigs 1 169954 57806270 29607
## + Mother.Minority 1 162079 57814144 29607
## + Race 2 167026 57809198 29609
## + Marital 1 123813 57852410 29609
## + Plurality.of.birth 1 106106 57870118 29610
## + BDead 1 69567 57906656 29612
## + Age.of.mother 1 63012 57913212 29612
## + Wt.Gain 1 52124 57924100 29613
## + Birth.Attendant 1 51080 57925143 29613
## + RaceDad 1 49908 57926316 29613
## + Race.of.child 1 43724 57932499 29613
## + RaceMom 1 43724 57932499 29613
## + LOutcome 1 42233 57933990 29613
## <none> 57976223 29614
## + Total.Preg 1 33437 57942786 29614
## + Low.Birth 1 30185 57946039 29614
## + Visits 1 28059 57948165 29614
## + Numchild 1 22345 57953878 29614
## + Education.of.father..years. 1 17315 57958908 29615
## + Institution.type 1 14897 57961327 29615
## + Gender 1 9659 57966565 29615
## + Age.of.father 1 8544 57967679 29615
## + Terms 1 8488 57967736 29615
## + Prenatal 1 3906 57972318 29615
## + Education.of.mother..years. 1 1258 57974966 29616

```

```
## + Trimester.Prenatal      1      1074 57975149 29616
## + Month.Term              1        960 57975264 29616
## + AveDrink                1         87 57976137 29616
## + Year.Term               1         47 57976176 29616
## + HispDad                 6     191319 57784904 29616
## + HispMom                  6     120326 57855897 29619
```

```
##
```

```
## Step: AIC=29603.72
```

```
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker
```

```
##
```

	Df	Sum of Sq	RSS	AIC
## + Father.Minority	1	188753	57559652	29596
## + Mother.Minority	1	185034	57563370	29596
## + Race	2	189531	57558873	29598
## + Plurality.of.birth	1	124064	57624340	29599
## + Marital	1	81424	57666980	29602
## + Birth.Attendant	1	62732	57685673	29602
## + BDead	1	62338	57686067	29602
## + RaceDad	1	59316	57689089	29603
## + Race.of.child	1	55199	57693206	29603
## + RaceMom	1	55199	57693206	29603
## + Wt.Gain	1	54329	57694075	29603
## + LOutcome	1	53532	57694872	29603
## + Total.Preg	1	45647	57702757	29603
## <none>			57748404	29604
## + Low.Birth	1	37444	57710960	29604
## + Age.of.mother	1	33281	57715123	29604
## + Numchild	1	28761	57719643	29604
## + Visits	1	19738	57728666	29605
## + Institution.type	1	16515	57731889	29605
## + Terms	1	15062	57733342	29605
## + Gender	1	11801	57736603	29605
## + Education.of.father..years.	1	5178	57743226	29605
## + Trimester.Prenatal	1	3157	57745247	29606
## + Age.of.father	1	2979	57745425	29606
## + Year.Term	1	1110	57747294	29606
## + Prenatal	1	993	57747411	29606
## + Month.Term	1	981	57747423	29606
## + Education.of.mother..years.	1	978	57747426	29606
## + AveCigs	1	463	57747941	29606
## + AveDrink	1	208	57748196	29606
## + HispDad	6	167355	57581049	29607
## + HispMom	6	101541	57646863	29610

```
##
```

```
## Step: AIC=29595.89
```

```
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority
```

```
##
```

	Df	Sum of Sq	RSS	AIC
## + Plurality.of.birth	1	146926	57412725	29590
## + Birth.Attendant	1	66353	57493299	29594
## + BDead	1	62012	57497640	29595
## + LOutcome	1	54395	57505256	29595
## + Total.Preg	1	53896	57505755	29595
## + Wt.Gain	1	47520	57512132	29595

```

## + Low.Birth      1      40860 57518791 29596
## <none>           57559652 29596
## + Numchild      1      33390 57526261 29596
## + Marital        1      31150 57528502 29596
## + Visits         1      19812 57539839 29597
## + Terms          1      19194 57540457 29597
## + Institution.type 1      18665 57540987 29597
## + Age.of.mother  1      18092 57541560 29597
## + Mother.Minority 1      14094 57545557 29597
## + Gender         1      10315 57549337 29597
## + Education.of.father..years. 1      8099 57551553 29598
## + Trimester.Prenatal 1      6219 57553433 29598
## + Year.Term      1      1836 57557816 29598
## + AveCigs        1      1804 57557848 29598
## + Race.of.child  1      1201 57558450 29598
## + RaceMom        1      1201 57558450 29598
## + RaceDad        1      1099 57558553 29598
## + Month.Term     1       900 57558751 29598
## + Age.of.father  1       495 57559157 29598
## + Education.of.mother..years. 1      331 57559320 29598
## + AveDrink       1       114 57559538 29598
## + Prenatal       1        46 57559606 29598
## + Race           2      15965 57543686 29599
## + HispDad        6     133561 57426091 29601
## + HispMom        6      90921 57468731 29603
##
## Step:  AIC=29590.23
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority +
##   Plurality.of.birth
##
##              Df Sum of Sq      RSS      AIC
## + Wt.Gain      1      74646 57338079 29588
## + LOutcome     1      68834 57343892 29589
## + Total.Preg   1      67733 57344992 29589
## + Birth.Attendant 1      60928 57351797 29589
## + BDead        1      59977 57352748 29589
## + Numchild     1      46304 57366421 29590
## + Visits       1      44219 57368506 29590
## <none>         57412725 29590
## + Marital      1      36992 57375733 29590
## + Age.of.mother 1      26269 57386456 29591
## + Terms        1      21364 57391361 29591
## + Institution.type 1      18222 57394503 29591
## + Mother.Minority 1      16762 57395963 29591
## + Low.Birth    1      14476 57398249 29592
## + Education.of.father..years. 1     13732 57398993 29592
## + Gender       1      12431 57400294 29592
## + Trimester.Prenatal 1       6030 57406695 29592
## + AveCigs      1       2260 57410465 29592
## + Race.of.child 1       2096 57410629 29592
## + RaceMom      1       2096 57410629 29592
## + Age.of.father 1       2092 57410633 29592
## + Year.Term    1       1874 57410851 29592
## + Month.Term   1        852 57411873 29592

```

```

## + RaceDad          1      814 57411911 29592
## + Prenatal          1      165 57412560 29592
## + Education.of.mother..years. 1      67 57412658 29592
## + AveDrink          1       57 57412668 29592
## + Race              2     18276 57394449 29593
## + HispDad           6    127598 57285127 29596
## + HispMom           6     88767 57323958 29598
##
## Step: AIC=29588.32
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority +
##   Plurality.of.birth + Wt.Gain
##
##              Df Sum of Sq      RSS      AIC
## + LOutcome      1    100537 57237542 29585
## + Total.Preg     1     93688 57244391 29585
## + Numchild       1     73378 57264701 29586
## + Birth.Attendant 1     60995 57277084 29587
## + BDead          1     60253 57277826 29587
## + Visits         1     38887 57299192 29588
## <none>                                57338079 29588
## + Marital        1     34852 57303228 29588
## + Age.of.mother   1     33529 57304550 29589
## + Terms           1     23698 57314381 29589
## + Institution.type 1     17410 57320670 29589
## + Low.Birth       1     15753 57322326 29590
## + Mother.Minority 1     15415 57322664 29590
## + Gender          1     12677 57325403 29590
## + Trimester.Prenatal 1      8191 57329888 29590
## + Education.of.father..years. 1      7943 57330136 29590
## + Age.of.father   1      3712 57334367 29590
## + Year.Term       1      2818 57335261 29590
## + AveCigs         1      2466 57335613 29590
## + Race.of.child   1      2223 57335856 29590
## + RaceMom         1      2223 57335856 29590
## + Month.Term      1       745 57337334 29590
## + Education.of.mother..years. 1      664 57337415 29590
## + RaceDad         1       498 57337582 29590
## + AveDrink        1      158 57337922 29590
## + Prenatal        1        0 57338079 29590
## + Race            2     16370 57321709 29592
## + HispDad         6    140259 57197821 29593
## + HispMom         6     83816 57254263 29596
##
## Step: AIC=29585.06
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority +
##   Plurality.of.birth + Wt.Gain + LOutcome
##
##              Df Sum of Sq      RSS      AIC
## + Birth.Attendant 1      57334 57180208 29584
## + BDead           1     48384 57189159 29584
## + Visits          1     45447 57192095 29585
## <none>                                57237542 29585
## + Marital        1     25638 57211904 29586
## + Total.Preg     1     19717 57217826 29586

```

```

## + Institution.type          1      19429 57218113 29586
## + Mother.Minority          1      16022 57221521 29586
## + Low.Birth                1      15879 57221663 29586
## + Gender                   1      12842 57224701 29586
## + Education.of.father..years. 1      10024 57227519 29586
## + Age.of.mother            1       9129 57228413 29587
## + Month.Term               1       8552 57228990 29587
## + Numchild                 1       7860 57229682 29587
## + Terms                   1       6106 57231436 29587
## + Trimester.Prenatal       1       5487 57232055 29587
## + AveCigs                  1       3345 57234197 29587
## + Year.Term                1       2446 57235096 29587
## + Race.of.child            1       2067 57235476 29587
## + RaceMom                  1       2067 57235476 29587
## + RaceDad                  1        851 57236692 29587
## + Prenatal                 1        331 57237211 29587
## + Age.of.father            1        322 57237220 29587
## + AveDrink                 1        163 57237379 29587
## + Education.of.mother..years. 1         0 57237542 29587
## + Race                     2      17269 57220274 29588
## + HispDad                  6     131140 57106402 29590
## + HispMom                  6      78216 57159326 29593
##
## Step: AIC=29584.05
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority +
##   Plurality.of.birth + Wt.Gain + LOutcome + Birth.Attendant
##
##              Df Sum of Sq      RSS      AIC
## + BDead        1      50280 57129928 29583
## + Visits        1     49533 57130675 29584
## + <none>                57180208 29584
## + Institution.type      1     32749 57147459 29584
## + Marital              1     23709 57156499 29585
## + Total.Preg           1     17400 57162808 29585
## + Low.Birth            1     16317 57163891 29585
## + Gender              1     14136 57166072 29585
## + Mother.Minority      1     13246 57166962 29585
## + Age.of.mother        1     10802 57169406 29586
## + Education.of.father..years. 1      8887 57171321 29586
## + Month.Term           1      7040 57173168 29586
## + Terms               1      6367 57173841 29586
## + Numchild            1      5582 57174626 29586
## + Trimester.Prenatal   1      5310 57174898 29586
## + AveCigs             1      2573 57177635 29586
## + Race.of.child        1      2031 57178177 29586
## + RaceMom              1      2031 57178177 29586
## + Year.Term            1      1777 57178431 29586
## + Prenatal             1        674 57179534 29586
## + RaceDad              1        649 57179559 29586
## + AveDrink             1        282 57179926 29586
## + Age.of.father        1         87 57180121 29586
## + Education.of.mother..years. 1         4 57180204 29586
## + Race                 2     13849 57166359 29587
## + HispDad             6    134064 57046144 29589

```

```

## + HispMom          6      76207 57104001 29592
##
## Step: AIC=29583.41
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority +
##      Plurality.of.birth + Wt.Gain + LOutcome + Birth.Attendant +
##      BDead
##
##
##              Df Sum of Sq      RSS      AIC
## + Visits      1      48345 57081584 29583
## <none>                                57129928 29583
## + Institution.type      1      32489 57097440 29584
## + Marital                1      23562 57106366 29584
## + Low.Birth              1      16922 57113006 29584
## + Mother.Minority        1      13974 57115955 29585
## + Gender                 1      12547 57117381 29585
## + Total.Preg             1      11648 57118281 29585
## + Age.of.mother          1      11518 57118410 29585
## + Education.of.father..years. 1      9473 57120456 29585
## + Month.Term             1      8602 57121326 29585
## + Terms                  1      5869 57124059 29585
## + Numchild               1      5747 57124182 29585
## + Trimester.Prenatal     1      5586 57124343 29585
## + AveCigs                1      2540 57127389 29585
## + Race.of.child          1      1868 57128060 29585
## + RaceMom                1      1868 57128060 29585
## + Year.Term              1      1850 57128078 29585
## + RaceDad                1       753 57129176 29585
## + Prenatal               1       574 57129355 29585
## + AveDrink               1       319 57129609 29585
## + Age.of.father          1        52 57129877 29585
## + Education.of.mother..years. 1        10 57129918 29585
## + Race                   2     14576 57115352 29587
## + HispDad                6    134057 56995872 29588
## + HispMom                6     76508 57053421 29591
##
## Step: AIC=29582.87
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority +
##      Plurality.of.birth + Wt.Gain + LOutcome + Birth.Attendant +
##      BDead + Visits
##
##
##              Df Sum of Sq      RSS      AIC
## <none>                                57081584 29583
## + Institution.type      1      32091 57049493 29583
## + Trimester.Prenatal     1      31047 57050537 29583
## + Low.Birth              1      15843 57065741 29584
## + Mother.Minority        1      15770 57065814 29584
## + Marital                1      14671 57066913 29584
## + Gender                 1      13513 57068071 29584
## + Total.Preg             1      12063 57069521 29584
## + Month.Term             1      11738 57069845 29584
## + Numchild               1       9942 57071641 29584
## + Prenatal               1       7085 57074499 29584
## + Age.of.mother          1      6267 57075317 29584
## + Year.Term              1      3723 57077861 29585

```

```
## + Terms          1      3039 57078545 29585
## + AveCigs         1      2840 57078744 29585
## + Education.of.mother..years. 1      2643 57078941 29585
## + Education.of.father..years. 1      2251 57079333 29585
## + Race.of.child   1      2131 57079453 29585
## + RaceMom         1      2131 57079453 29585
## + Age.of.father   1       890 57080694 29585
## + RaceDad         1       727 57080857 29585
## + AveDrink        1       281 57081303 29585
## + Race            2     16608 57064976 29586
## + HispDad         6    145865 56935719 29587
## + HispMom         6     81899 56999685 29591
```

```
forwards_reg$terms
```

```
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority +
##   Plurality.of.birth + Wt.Gain + LOutcome + Birth.Attendant +
##   BDead + Visits
## attr("variables")
## list(Birth.Weight, Birth.weight.group, Weeks, Smoker, Father.Minority,
##   Plurality.of.birth, Wt.Gain, LOutcome, Birth.Attendant, BDead,
##   Visits)
## attr("factors")
##      Birth.weight.group Weeks Smoker Father.Minority
## Birth.Weight          0      0      0              0
## Birth.weight.group    1      0      0              0
## Weeks                 0      1      0              0
## Smoker                0      0      1              0
## Father.Minority       0      0      0              1
## Plurality.of.birth    0      0      0              0
## Wt.Gain               0      0      0              0
## LOutcome              0      0      0              0
## Birth.Attendant       0      0      0              0
## BDead                 0      0      0              0
## Visits                0      0      0              0
##      Plurality.of.birth Wt.Gain LOutcome Birth.Attendant BDead
## Birth.Weight          0      0      0              0      0
## Birth.weight.group    0      0      0              0      0
## Weeks                 0      0      0              0      0
## Smoker                0      0      0              0      0
## Father.Minority       0      0      0              0      0
## Plurality.of.birth    1      0      0              0      0
## Wt.Gain               0      1      0              0      0
## LOutcome              0      0      1              0      0
## Birth.Attendant       0      0      0              1      0
## BDead                 0      0      0              0      1
## Visits                0      0      0              0      0
##      Visits
## Birth.Weight          0
## Birth.weight.group    0
## Weeks                 0
## Smoker                0
## Father.Minority       0
## Plurality.of.birth    0
```



```
## Wt.Gain          0
## LOutcome         0
## Birth.Attendant  0
## BDead            0
## Visits           1
## attr("term.labels")
## [1] "Birth.weight.group" "Weeks" "Smoker"
## [4] "Father.Minority" "Plurality.of.birth" "Wt.Gain"
## [7] "LOutcome" "Birth.Attendant" "BDead"
## [10] "Visits"
## attr("order")
## [1] 1 1 1 1 1 1 1 1 1 1
## attr("intercept")
## [1] 1
## attr("response")
## [1] 1
## attr(".Environment")
## <environment: R_GlobalEnv>
## attr("predvars")
## list(Birth.Weight, Birth.weight.group, Weeks, Smoker, Father.Minority,
##      Plurality.of.birth, Wt.Gain, LOutcome, Birth.Attendant, BDead,
##      Visits)
## attr("dataClasses")
##      Birth.Weight Birth.weight.group      Weeks      Smoker
##      "numeric"      "numeric"      "numeric"      "character"
##      Father.Minority Plurality.of.birth      Wt.Gain      LOutcome
##      "character"      "numeric"      "numeric"      "numeric"
##      Birth.Attendant      BDead      Visits
##      "numeric"      "numeric"      "numeric"
```

Forwards Stepwise with BIC

Part E

```
births_lm = lm(Birth.Weight ~ 1, data = birthsNew)
library(stats)
forwards_reg = step(births_lm,
  scope = list(lower = ~1, upper = ~Institution.type + Plurality.of.birth + Gender + Race),
  direction = "forward",
  data = birthsNew,
  k = log(3000))
```

```
## Start: AIC=38640.27
## Birth.Weight ~ 1
##
##      Df Sum of Sq      RSS      AIC
## + Birth.weight.group  1 1114111893  60013021 29727
## + Low.Birth           1  513906329  660218585 36921
## + Weeks               1  391217674  782907240 37432
## + Plurality.of.birth  1  117849687 1056275227 38331
## + Wt.Gain              1   37309776 1136815138 38551
## + Mother.Minority     1   28981959 1145142955 38573
```

```

## + Race                2    31598993 1142525921 38574
## + Father.Minority      1    20806645 1153318269 38595
## + Smoker               1    16601208 1157523706 38606
## + Visits               1    14727092 1159397822 38610
## + AveCigs              1    14100044 1160024870 38612
## + Gender               1    12561149 1161563765 38616
## + Marital              1     8584001 1165540913 38626
## + Race.of.child        1     6127536 1167997378 38633
## + RaceMom              1     6127536 1167997378 38633
## + RaceDad              1     4405648 1169719266 38637
## <none>                  1          1174124914 38640
## + Institution.type      1    3105655 1171019259 38640
## + Age.of.mother         1    3035967 1171088947 38641
## + Terms                1    2608356 1171516558 38642
## + Birth.Attendant       1    2439885 1171685029 38642
## + Education.of.mother..years. 1    2216889 1171908025 38643
## + Numchild              1    2132495 1171992419 38643
## + BDead                 1    2116566 1172008348 38643
## + Education.of.father..years. 1    1393373 1172731541 38645
## + LOutcome              1    1060281 1173064632 38646
## + Age.of.father         1     567282 1173557632 38647
## + Year.Term             1     512137 1173612777 38647
## + Trimester.Prenatal    1     368075 1173756839 38647
## + Month.Term            1     337319 1173787595 38647
## + Prenatal              1       7085 1174117829 38648
## + Total.Preg            1       7024 1174117890 38648
## + AveDrink              1       3464 1174121449 38648
## + HispMom               6    3786013 1170338901 38679
## + HispDad               6    2280357 1171844557 38682
##
## Step:  AIC=29727.13
## Birth.Weight ~ Birth.weight.group
##
##              Df Sum of Sq    RSS    AIC
## + Weeks        1    2036798 57976223 29632
## + Plurality.of.birth 1    225090 59787931 29724
## + Low.Birth     1    203281 59809740 29725
## + Smoker        1    196683 59816338 29725
## + Father.Minority 1    172419 59840602 29726
## <none>          1          60013021 29727
## + AveCigs       1    159565 59853457 29727
## + Mother.Minority 1    156030 59856991 29727
## + Birth.Attendant 1     78795 59934226 29731
## + Marital       1     72142 59940880 29732
## + BDead         1     60167 59952854 29732
## + Wt.Gain       1     50702 59962319 29733
## + Visits        1     45649 59967372 29733
## + Race.of.child 1     30424 59982598 29734
## + RaceMom       1     30424 59982598 29734
## + RaceDad       1     22140 59990881 29734
## + Trimester.Prenatal 1    20504 59992517 29734
## + Institution.type 1     17009 59996012 29734
## + Race          2    172146 59840875 29734
## + Prenatal      1       8545 60004476 29735

```

```

## + Education.of.father..years. 1      5011 60008010 29735
## + Age.of.mother                1      4591 60008430 29735
## + Month.Term                   1      3557 60009464 29735
## + Total.Preg                   1      2374 60010647 29735
## + LOutcome                     1      2300 60010722 29735
## + Terms                        1      1408 60011613 29735
## + Year.Term                    1      1295 60011726 29735
## + Education.of.mother..years. 1       847 60012174 29735
## + Age.of.father                1       843 60012178 29735
## + AveDrink                     1       776 60012245 29735
## + Gender                       1       564 60012457 29735
## + Numchild                     1       132 60012889 29735
## + HispDad                      6    239995 59773026 29763
## + HispMom                      6    157986 59855035 29767
##
## Step:  AIC=29631.55
## Birth.Weight ~ Birth.weight.group + Weeks
##
##
##              Df Sum of Sq      RSS      AIC
## + Smoker      1    227819 57748404 29628
## + Father.Minority 1    178923 57797301 29630
## + AveCigs      1    169954 57806270 29631
## + Mother.Minority 1    162079 57814144 29631
## <none>                                57976223 29632
## + Marital      1    123813 57852410 29633
## + Plurality.of.birth 1    106106 57870118 29634
## + BDead        1     69567 57906656 29636
## + Age.of.mother 1     63012 57913212 29636
## + Wt.Gain       1     52124 57924100 29637
## + Birth.Attendant 1     51080 57925143 29637
## + RaceDad       1     49908 57926316 29637
## + Race.of.child 1     43724 57932499 29637
## + RaceMom       1     43724 57932499 29637
## + LOutcome      1     42233 57933990 29637
## + Total.Preg    1     33437 57942786 29638
## + Low.Birth     1     30185 57946039 29638
## + Visits        1     28059 57948165 29638
## + Numchild      1     22345 57953878 29638
## + Education.of.father..years. 1     17315 57958908 29639
## + Institution.type 1     14897 57961327 29639
## + Race          2    167026 57809198 29639
## + Gender        1      9659 57966565 29639
## + Age.of.father 1     8544 57967679 29639
## + Terms         1     8488 57967736 29639
## + Prenatal      1     3906 57972318 29639
## + Education.of.mother..years. 1     1258 57974966 29640
## + Trimester.Prenatal 1     1074 57975149 29640
## + Month.Term    1      960 57975264 29640
## + AveDrink      1      87 57976137 29640
## + Year.Term     1      47 57976176 29640
## + HispDad       6    191319 57784904 29670
## + HispMom       6    120326 57855897 29673
##
## Step:  AIC=29627.74

```

```

## Birth.Weight ~ Birth.weight.group + Weeks + Smoker
##
##
## Df Sum of Sq      RSS      AIC
## + Father.Minority      1    188753 57559652 29626
## + Mother.Minority      1    185034 57563370 29626
## <none>                                57748404 29628
## + Plurality.of.birth      1    124064 57624340 29629
## + Marital                  1     81424 57666980 29632
## + Birth.Attendant          1     62732 57685673 29632
## + BDead                    1     62338 57686067 29632
## + RaceDad                  1     59316 57689089 29633
## + Race.of.child            1     55199 57693206 29633
## + RaceMom                  1     55199 57693206 29633
## + Wt.Gain                   1     54329 57694075 29633
## + LOutcome                  1     53532 57694872 29633
## + Total.Preg                1     45647 57702757 29633
## + Low.Birth                 1     37444 57710960 29634
## + Race                       2    189531 57558873 29634
## + Age.of.mother             1     33281 57715123 29634
## + Numchild                  1     28761 57719643 29634
## + Visits                    1     19738 57728666 29635
## + Institution.type          1     16515 57731889 29635
## + Terms                     1     15062 57733342 29635
## + Gender                    1     11801 57736603 29635
## + Education.of.father..years. 1      5178 57743226 29636
## + Trimester.Prenatal        1      3157 57745247 29636
## + Age.of.father             1      2979 57745425 29636
## + Year.Term                  1      1110 57747294 29636
## + Prenatal                   1       993 57747411 29636
## + Month.Term                 1       981 57747423 29636
## + Education.of.mother..years. 1       978 57747426 29636
## + AveCigs                    1       463 57747941 29636
## + AveDrink                   1       208 57748196 29636
## + HispDad                   6    167355 57581049 29667
## + HispMom                   6    101541 57646863 29670
##
## Step:  AIC=29625.93
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority
##
##
## Df Sum of Sq      RSS      AIC
## <none>                                57559652 29626
## + Plurality.of.birth      1    146926 57412725 29626
## + Birth.Attendant          1     66353 57493299 29630
## + BDead                    1     62012 57497640 29631
## + LOutcome                  1     54395 57505256 29631
## + Total.Preg                1     53896 57505755 29631
## + Wt.Gain                   1     47520 57512132 29632
## + Low.Birth                 1     40860 57518791 29632
## + Numchild                  1     33390 57526261 29632
## + Marital                   1     31150 57528502 29632
## + Visits                    1     19812 57539839 29633
## + Terms                     1     19194 57540457 29633
## + Institution.type          1     18665 57540987 29633
## + Age.of.mother             1     18092 57541560 29633

```

```
## + Mother.Minority      1      14094 57545557 29633
## + Gender                1      10315 57549337 29633
## + Education.of.father..years. 1      8099 57551553 29634
## + Trimester.Prenatal    1      6219 57553433 29634
## + Year.Term             1      1836 57557816 29634
## + AveCigs               1      1804 57557848 29634
## + Race.of.child         1      1201 57558450 29634
## + RaceMom               1      1201 57558450 29634
## + RaceDad               1      1099 57558553 29634
## + Month.Term            1       900 57558751 29634
## + Age.of.father         1       495 57559157 29634
## + Education.of.mother..years. 1      331 57559320 29634
## + AveDrink              1       114 57559538 29634
## + Prenatal              1        46 57559606 29634
## + Race                  2     15965 57543686 29641
## + HispDad               6    133561 57426091 29667
## + HispMom               6     90921 57468731 29669
```

```
forwards_reg$terms
```

```
## Birth.Weight ~ Birth.weight.group + Weeks + Smoker + Father.Minority
## attr("variables")
## list(Birth.Weight, Birth.weight.group, Weeks, Smoker, Father.Minority)
## attr("factors")
##           Birth.weight.group Weeks Smoker Father.Minority
## Birth.Weight                0      0      0              0
## Birth.weight.group          1      0      0              0
## Weeks                       0      1      0              0
## Smoker                      0      0      1              0
## Father.Minority             0      0      0              1
## attr("term.labels")
## [1] "Birth.weight.group" "Weeks"          "Smoker"
## [4] "Father.Minority"
## attr("order")
## [1] 1 1 1 1
## attr("intercept")
## [1] 1
## attr("response")
## [1] 1
## attr(".Environment")
## <environment: R_GlobalEnv>
## attr("predvars")
## list(Birth.Weight, Birth.weight.group, Weeks, Smoker, Father.Minority)
## attr("dataClasses")
##           Birth.Weight Birth.weight.group          Weeks          Smoker
##           "numeric"      "numeric"          "numeric"      "character"
##           Father.Minority
##           "character"
```

By the end of the functions, we see these formulas:

Backwards Mallows-CP: Birth.Weight ~ Plurality.of.birth + BDead + LOutcome + Weeks + Visits + Birth.weight.group + Birth.Attendant + Father.Minority + HispMom + HispDad + Smoker + Wt.Gain

Backwards BIC: Birth.Weight \sim Weeks + Birth.weight.group + Father.Minority + Smoker

Forwards Mallows-CP: Birth.Weight \sim Birth.weight.group + Weeks + Smoker + Father.Minority + Plurality.of.birth + Wt.Gain + LOutcome + Birth.Attendant + BDead + Visits

Forwards BIC: Birth.Weight \sim Birth.weight.group + Weeks + Smoker + Father.Minority

We see that the Backwards Mallows-CP has a total of 12 predictors. This is the most predictors of the four. Backwards BIC calls for a total number of 4 predictors (tied for the least). Forwards Mallows-CP needs 10 predictors and Forwards BIC calls for 4 predictors (like Backwards BIC). Interestingly enough, both BIC (forwards and backwards) call for the same 4 predictors (Weeks, Birth.weight.group, Father.Minority, and Smoker). Notice that these predictors are also in Forwards and Backwards Mallows-CP. Thus, we conclude that the best predictors are Weeks, Birth.weight.group, Father.Minority, and Smoker.