

Predicting Asthma Rates in California

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```
setwd("/Users/pranjalsrivastava/Desktop/Projects/Predicting Emergency Department Visits for Asthma")

library(tidyr)

## Warning: package 'tidyr' was built under R version 4.1.2

library(magrittr)

## Warning: package 'magrittr' was built under R version 4.1.2

## 
## Attaching package: 'magrittr'

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

library(ggplot2)

## Warning: package 'ggplot2' was built under R version 4.1.2

library(dplyr)

## Warning: package 'dplyr' was built under R version 4.1.2

## 
## Attaching package: 'dplyr'

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

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

```

library(haven)

## Warning: package 'haven' was built under R version 4.1.2

library(nortest)
library(leaps)
library(faraway)

## Warning: package 'faraway' was built under R version 4.1.2

##Data Cleaning

cal_envir1 <- read.csv("Clean_Cal_Environtmentdata.csv")
#cal_envir1 <- cal_envir %>% dplyr::select(Pesticides, `Tox. Release`, `Pollution Burden Score`, PM2.5,
summary(cal_envir1)

##      X.3          X.2          X.1          X
## Min.   : 1   Min.   : 1   Min.   : 1   Min.   : 1
## 1st Qu.:1998 1st Qu.:1998 1st Qu.:1998 1st Qu.:1998
## Median :3995 Median :3995 Median :3995 Median :3995
## Mean   :3995 Mean   :3995 Mean   :3995 Mean   :3995
## 3rd Qu.:5992 3rd Qu.:5992 3rd Qu.:5992 3rd Qu.:5992
## Max.   :7989  Max.   :7989  Max.   :7989  Max.   :7989
##   Census.T tract    Pesticides     Tox..Release   Pollution.Burden.Score
## Min.   :6.001e+09  Min.   : 0.0  Min.   : 0.0  Min.   : 1.213
## 1st Qu.:6.037e+09 1st Qu.: 0.0  1st Qu.: 112.4 1st Qu.: 4.074
## Median :6.059e+09  Median : 0.0  Median : 457.4  Median : 5.192
## Mean   :6.055e+09  Mean   : 269.9  Mean   : 1615.7  Mean   : 5.217
## 3rd Qu.:6.073e+09 3rd Qu.: 0.2  3rd Qu.: 1630.3 3rd Qu.: 6.321
## Max.   :6.115e+09  Max.   :80811.1  Max.   :96985.6  Max.   :10.000
##      PM2.5        Traffic       Ozone        Asthma
## Min.   : 1.875  Min.   : 20.75  Min.   :0.02655  Min.   : 4.28
## 1st Qu.: 8.578  1st Qu.: 553.59  1st Qu.:0.04193  1st Qu.: 30.06
## Median :10.125  Median : 880.41  Median :0.04716  Median : 45.77
## Mean   :10.157  Mean   : 1116.40  Mean   :0.04865  Mean   : 52.00
## 3rd Qu.:11.939  3rd Qu.: 1383.99  3rd Qu.:0.05680  3rd Qu.: 65.83
## Max.   :16.395  Max.   :45752.00  Max.   :0.07313  Max.   :243.29

cal_envir2 <- na.omit(cal_envir1)
summary(cal_envir2)

##      X.3          X.2          X.1          X
## Min.   : 1   Min.   : 1   Min.   : 1   Min.   : 1
## 1st Qu.:1998 1st Qu.:1998 1st Qu.:1998 1st Qu.:1998
## Median :3995 Median :3995 Median :3995 Median :3995
## Mean   :3995 Mean   :3995 Mean   :3995 Mean   :3995
## 3rd Qu.:5992 3rd Qu.:5992 3rd Qu.:5992 3rd Qu.:5992
## Max.   :7989  Max.   :7989  Max.   :7989  Max.   :7989
##   Census.T tract    Pesticides     Tox..Release   Pollution.Burden.Score
## Min.   :6.001e+09  Min.   : 0.0  Min.   : 0.0  Min.   : 1.213

```

```

## 1st Qu.:6.037e+09 1st Qu.: 0.0 1st Qu.: 112.4 1st Qu.: 4.074
## Median :6.059e+09 Median : 0.0 Median : 457.4 Median : 5.192
## Mean :6.055e+09 Mean : 269.9 Mean : 1615.7 Mean : 5.217
## 3rd Qu.:6.073e+09 3rd Qu.: 0.2 3rd Qu.: 1630.3 3rd Qu.: 6.321
## Max. :6.115e+09 Max. :80811.1 Max. :96985.6 Max. :10.000
## PM2.5 Traffic Ozone Asthma
## Min. : 1.875 Min. : 20.75 Min. :0.02655 Min. : 4.28
## 1st Qu.: 8.578 1st Qu.: 553.59 1st Qu.:0.04193 1st Qu.: 30.06
## Median :10.125 Median : 880.41 Median :0.04716 Median : 45.77
## Mean :10.157 Mean : 1116.40 Mean :0.04865 Mean : 52.00
## 3rd Qu.:11.939 3rd Qu.: 1383.99 3rd Qu.:0.05680 3rd Qu.: 65.83
## Max. :16.395 Max. :45752.00 Max. :0.07313 Max. :243.29

```

```
write.csv(cal_envir2, "Clean_Cal_Environmentdata.csv")
```

```
##Univariate Analysis & Standard Deviation
```

```
#Print observations
nrow(cal_envir2)
```

```
## [1] 7989
```

```
#Univariate
summary(cal_envir2)
```

```

## X.3 X.2 X.1 X
## Min. : 1 Min. : 1 Min. : 1 Min. : 1
## 1st Qu.:1998 1st Qu.:1998 1st Qu.:1998 1st Qu.:1998
## Median :3995 Median :3995 Median :3995 Median :3995
## Mean :3995 Mean :3995 Mean :3995 Mean :3995
## 3rd Qu.:5992 3rd Qu.:5992 3rd Qu.:5992 3rd Qu.:5992
## Max. :7989 Max. :7989 Max. :7989 Max. :7989
## Census.T tract Pesticides Tox..Release Pollution.Burden.Score
## Min. :6.001e+09 Min. : 0.0 Min. : 0.0 Min. : 1.213
## 1st Qu.:6.037e+09 1st Qu.: 0.0 1st Qu.: 112.4 1st Qu.: 4.074
## Median :6.059e+09 Median : 0.0 Median : 457.4 Median : 5.192
## Mean :6.055e+09 Mean : 269.9 Mean : 1615.7 Mean : 5.217
## 3rd Qu.:6.073e+09 3rd Qu.: 0.2 3rd Qu.: 1630.3 3rd Qu.: 6.321
## Max. :6.115e+09 Max. :80811.1 Max. :96985.6 Max. :10.000
## PM2.5 Traffic Ozone Asthma
## Min. : 1.875 Min. : 20.75 Min. :0.02655 Min. : 4.28
## 1st Qu.: 8.578 1st Qu.: 553.59 1st Qu.:0.04193 1st Qu.: 30.06
## Median :10.125 Median : 880.41 Median :0.04716 Median : 45.77
## Mean :10.157 Mean : 1116.40 Mean :0.04865 Mean : 52.00
## 3rd Qu.:11.939 3rd Qu.: 1383.99 3rd Qu.:0.05680 3rd Qu.: 65.83
## Max. :16.395 Max. :45752.00 Max. :0.07313 Max. :243.29

```

```
#SD
sd(cal_envir2$Pesticides)
```

```
## [1] 2331.122
```

```

sd(cal_envir2$'Tox. Release')

## [1] NA

sd(cal_envir2$'Pollution Burden Score')

## [1] NA

sd(cal_envir2$PM2.5)

## [1] 2.165989

sd(cal_envir2$Traffic)

## [1] 988.4462

sd(cal_envir2$Ozone)

## [1] 0.01046916

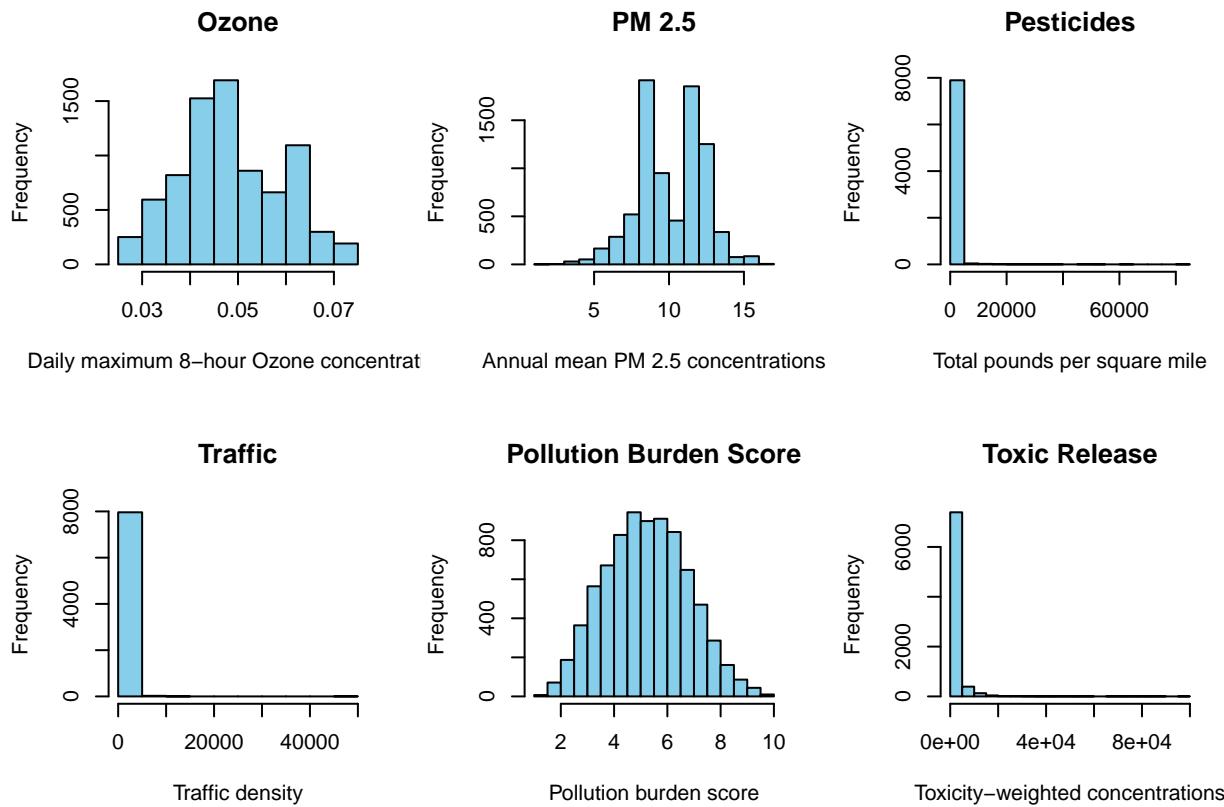
sd(cal_envir2$Asthma)

## [1] 30.55984

##Exploratory Plots

#Histograms
par(mfrow = c(2,3))
hist(cal_envir2$Ozone, main = "Ozone", xlab = "Daily maximum 8-hour Ozone concentration" , col = "skyblue")
hist(cal_envir2$PM2.5, main = "PM 2.5" , xlab = "Annual mean PM 2.5 concentrations" , col = "skyblue")
hist(cal_envir2$Pesticides, main = "Pesticides" , xlab = "Total pounds per square mile" , col = "skyblue")
hist(cal_envir2$Traffic, main = "Traffic" , xlab = "Traffic density" , col = "skyblue")
hist(cal_envir2$Pollution.Burden.Score, main = "Pollution Burden Score" , xlab = "Pollution burden score" , col = "skyblue")
hist(cal_envir2$Tox..Release, main = "Toxic Release" , xlab = "Toxicity-weighted concentrations" , col = "skyblue")

```



```
#Scatter plots
y <- cal_envir2$Asthma
par(mfrow= c(2,3))
plot(cal_envir2$Ozone,y,
     xlab = "Ozone", ylab = "Asthma",
     main = "Ozone and Asthma", col = "blue")
abline(lm(y ~ cal_envir2$Ozone, data = cal_envir2), col = "red")

plot(cal_envir2$PM2.5,y,
      xlab = "PM2.5", ylab = "Asthma",
      main = "PM 2.5 and Asthma", col = "blue")
abline(lm(y ~ cal_envir2$PM2.5, data = cal_envir2), col = "red")

plot(cal_envir2$Pesticides,y,
      xlab = "Pesticides", ylab = "Asthma",
      main = "Pesticides and Asthma", col = "blue")
abline(lm(y ~ cal_envir2$Pesticides, data = cal_envir2), col = "red")

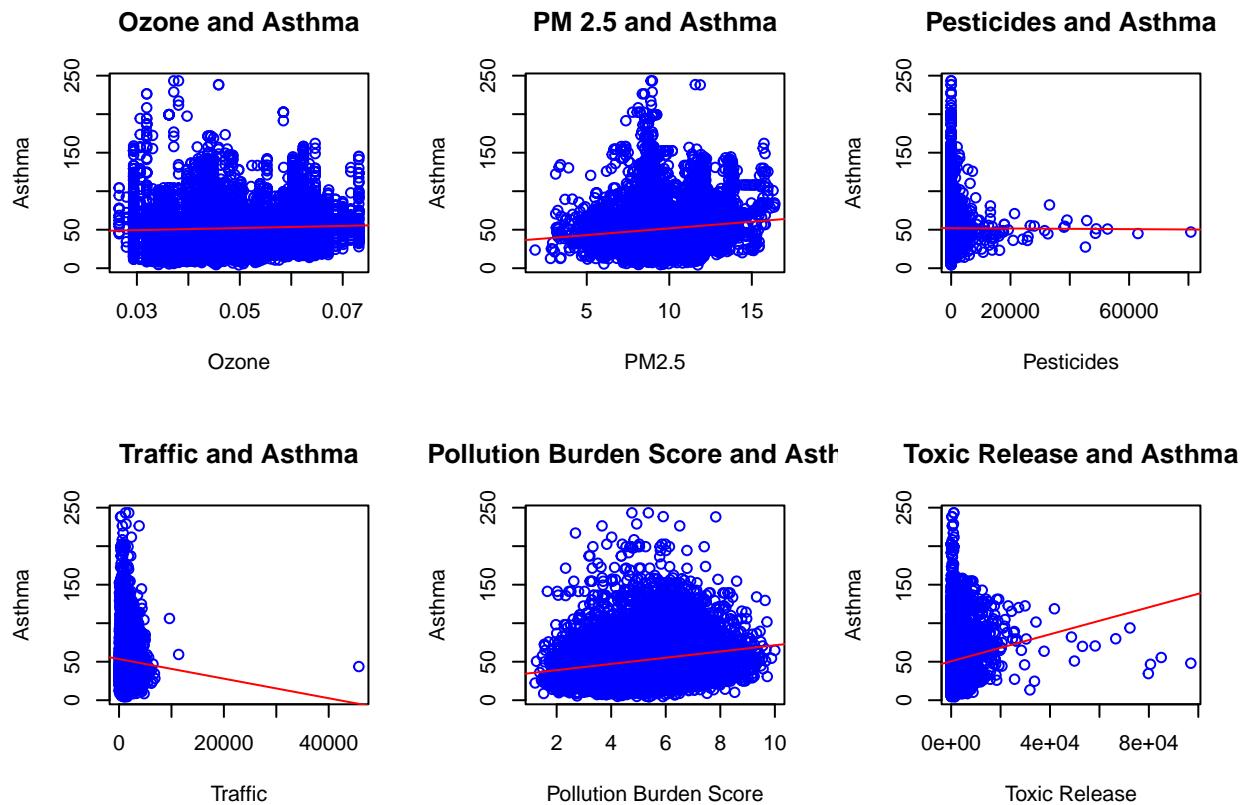
plot(cal_envir2$Traffic,y,
      xlab = "Traffic", ylab = "Asthma",
      main = "Traffic and Asthma", col = "blue")
abline(lm(y ~ cal_envir2$Traffic, data = cal_envir2), col = "red")

plot(cal_envir2$Pollution.Burden.Score, y,
      xlab = "Pollution Burden Score", ylab = "Asthma",
      main = "Pollution Burden Score and Asthma", col = "blue")
abline(lm(y ~ cal_envir2$Pollution.Burden.Score, data = cal_envir2), col = "red")
```

```

plot(cal_envir2$Tox..Release,y,
      xlab = "Toxic Release", ylab = "Asthma",
      main = "Toxic Release and Asthma", col = "blue")
abline(lm(y ~ cal_envir2$Tox..Release, data = cal_envir2), col = "red")

```



```
##Fitting a Model
```

```

#fitting a model
model1 <- lm(Asthma ~ Ozone+PM2.5+Pesticides+Traffic+Pollution.Burden.Score+ Tox..Release, data = cal_en
summary(model1)

```

```

##
## Call:
## lm(formula = Asthma ~ Ozone + PM2.5 + Pesticides + Traffic +
##     Pollution.Burden.Score + Tox..Release, data = cal_envir2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -57.482 -20.560 -6.274  12.968 194.008 
## 
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)    
## (Intercept) 3.228e+01  1.906e+00 16.938 < 2e-16 ***
## Ozone        2.726e+01  3.620e+01  0.753   0.452    
## PM2.5       -3.069e-01  2.158e-01 -1.422   0.155    
## Pesticides  -2.338e-04  1.442e-04 -1.621   0.105    
## Traffic      -4.007e-03 3.619e-04 -11.072 < 2e-16 ***
## 
```

```

## Pollution.Burden.Score  4.872e+00  2.901e-01  16.797  < 2e-16 ***
## Tox..Release            3.919e-04  9.498e-05   4.126  3.73e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 29.65 on 7982 degrees of freedom
## Multiple R-squared:  0.05921,    Adjusted R-squared:  0.0585
## F-statistic: 83.73 on 6 and 7982 DF,  p-value: < 2.2e-16

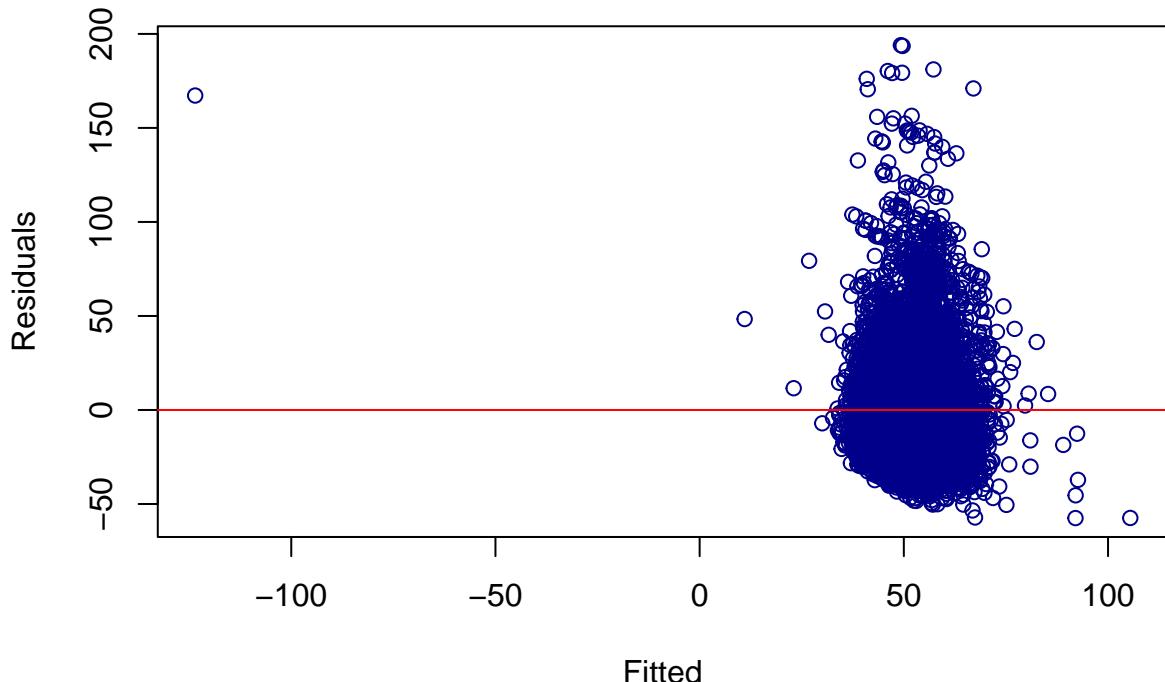
```

##Diagnostics

```
#Residuals vs. fitted plots
```

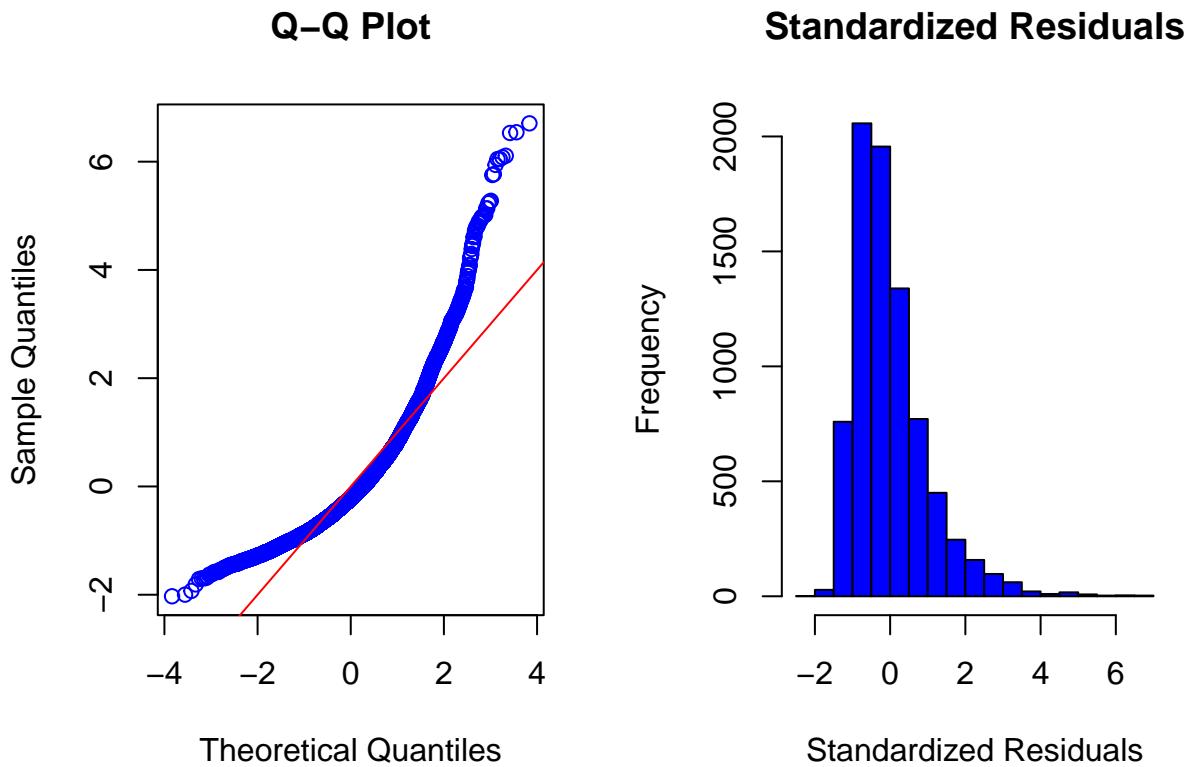
```
par (mfrow = c (1,1))
plot(fitted(model1), residuals(model1), main = "Residuals vs. Fitted" , xlab = "Fitted", ylab = "Residuals")
abline (h=0, col = "red")
```

Residuals vs. Fitted



```
#Quantile-Quantile plots with standardized residuals
```

```
par (mfrow = c(1,2))
qqnorm(rstandard(model1), main = "Q-Q Plot" , col = "blue")
abline(0,1, col = "red")
hist (rstandard(model1), main = "Standardized Residuals", xlab =
"Standardized Residuals" , col = "blue")
```



```
#Normality Shapiro-Wilk Test
#shapiro.test(residuals(model1)) # data too large for Shapiro so using Anderson-Darling normality test

# Anderson-Darling normality test
ad.test(residuals(model1))

## 
##  Anderson-Darling normality test
## 
## data: residuals(model1)
## A = 201.15, p-value < 2.2e-16

# Interpretation for AD test: reject the hypothesis of normality when the p-value is less than or equal to 0.05

# Outliers
range(rstudent(model1))

## [1] -2.028829  6.726322

p <- 2 # one predictor + an intercept
n <- nrow (cal_envir2)
qt(1-.05 /(n*2),n-p-1)

## [1] 4.520488
```

```

#correlation
cal_envir_modified <- cal_envir2[,-1]
cal_envir_corrmatrix <- cor(cal_envir2,cal_envir_modified)
cal_envir_corrmatrix <- round(cal_envir_corrmatrix,2)
cal_envir_corrmatrix

##          X.2    X.1      X Census.T tract Pesticides Tox..Release
## X.3        1.00   1.00   1.00       0.19     -0.04      -0.24
## X.2        1.00   1.00   1.00       0.19     -0.04      -0.24
## X.1        1.00   1.00   1.00       0.19     -0.04      -0.24
## X          1.00   1.00   1.00       0.19     -0.04      -0.24
## Census.T tract      0.19   0.19   0.19       1.00     0.09     -0.17
## Pesticides      -0.04  -0.04  -0.04      0.09     1.00     -0.04
## Tox..Release      -0.24  -0.24  -0.24     -0.17    -0.04      1.00
## Pollution.Burden.Score -0.75  -0.75  -0.75     -0.20     0.04      0.32
## PM2.5           -0.51  -0.51  -0.51     -0.26    -0.08      0.28
## Traffic          -0.18  -0.18  -0.18     -0.08    -0.04      0.10
## Ozone            -0.25  -0.25  -0.25     -0.04    -0.04     -0.07
## Asthma           -0.59  -0.59  -0.59     -0.19     0.00      0.11
##          Pollution.Burden.Score PM2.5 Traffic Ozone Asthma
## X.3             -0.75  -0.51  -0.18  -0.25  -0.59
## X.2             -0.75  -0.51  -0.18  -0.25  -0.59
## X.1             -0.75  -0.51  -0.18  -0.25  -0.59
## X               -0.75  -0.51  -0.18  -0.25  -0.59
## Census.T tract      -0.20  -0.26  -0.08  -0.04  -0.19
## Pesticides      0.04   -0.08  -0.04  -0.04  0.00
## Tox..Release      0.32   0.28   0.10  -0.07  0.11
## Pollution.Burden.Score 1.00   0.61   0.35  0.18  0.21
## PM2.5            0.61   1.00   0.19  0.43  0.12
## Traffic          0.35   0.19   1.00  -0.03  -0.04
## Ozone            0.18   0.43   -0.03  1.00  0.05
## Asthma           0.21   0.12   -0.04  0.05  1.00

#eigenvalues
cal_envir_eigen <- model.matrix(model1)[,-1]
e <- eigen(t(cal_envir_eigen) %*% cal_envir_eigen)
examen_e <- sqrt(e$val[1] / e$val)
sum(examen_e > 30)

## [1] 3

#variance inflation factors
require(MASS)

## Loading required package: MASS

## Warning: package 'MASS' was built under R version 4.1.2

##
## Attaching package: 'MASS'
```

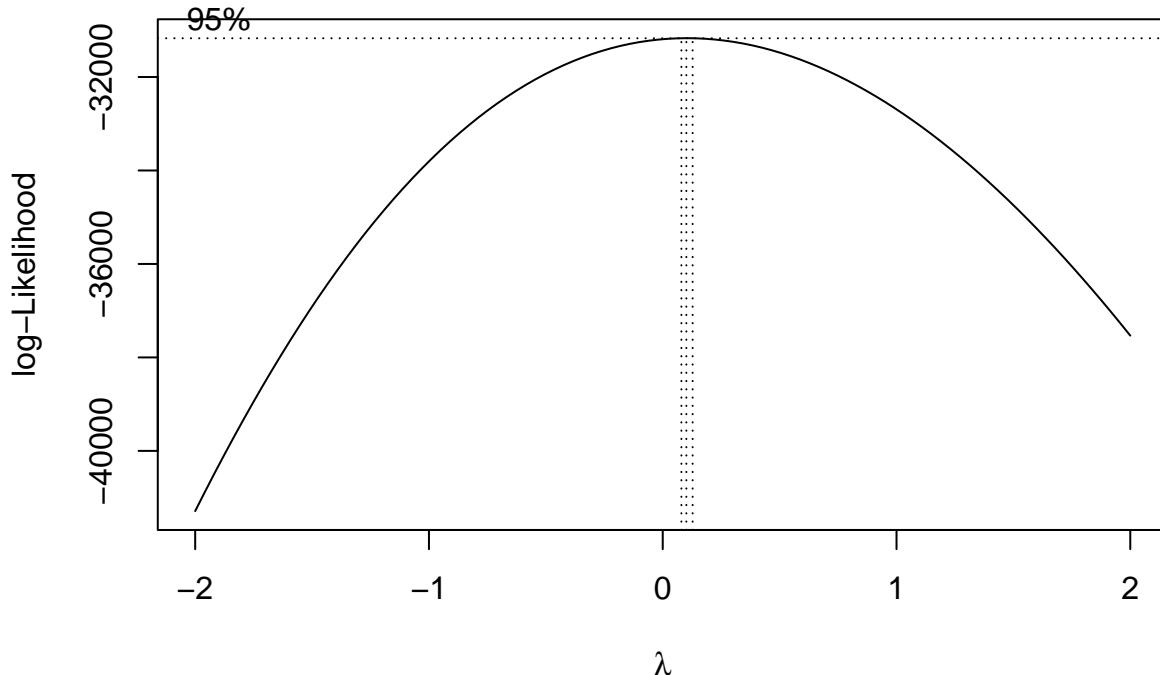
```
## The following object is masked from 'package:dplyr':
##
##     select
```

```
require(faraway)
cal_envir_vif <- vif(model1)
cal_envir_vif
```

##	Ozone	PM2.5	Pesticides
##	1.305141	1.984789	1.026330
##	Traffic	Pollution.Burden.Score	Tox..Release
##	1.162388	1.843443	1.180576

```
##Modified model Box-Cox Method
```

```
#boxcox
a <- boxcox(model1, plotit = TRUE)
```



```
#finding lambda
a$x[which.max(a$y)]
```

```
## [1] 0.1010101
```

```
##Making a new model (Model 2)
```

```
#Model2 With y Transformed
```

```
model2 <- lm(Asthma^(10/99) ~ Ozone + PM2.5 + Pesticides + Traffic + Pollution.Burden.Score + Tox..Release)
summary(model2)
```

```

## 
## Call:
## lm(formula = Asthma^(10/99) ~ Ozone + PM2.5 + Pesticides + Traffic +
##      Pollution.Burden.Score + Tox..Release, data = cal_envir2)
##
## Residuals:
##       Min     1Q   Median     3Q    Max 
## -0.31252 -0.05585 -0.00034  0.05303  0.48817
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)    
## (Intercept)           1.384e+00  5.272e-03 262.509 < 2e-16 ***
## Ozone                  4.997e-01  1.001e-01   4.990 6.17e-07 ***
## PM2.5                 -9.612e-04  5.969e-04  -1.610   0.107    
## Pesticides            -4.919e-09  3.988e-07  -0.012   0.990    
## Traffic                -1.122e-05  1.001e-06 -11.205 < 2e-16 ***
## Pollution.Burden.Score 1.557e-02  8.024e-04  19.410 < 2e-16 ***
## Tox..Release           1.061e-06  2.627e-07   4.039 5.43e-05 ***
## ---                     
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.08202 on 7982 degrees of freedom
## Multiple R-squared:  0.08206,    Adjusted R-squared:  0.08137 
## F-statistic: 118.9 on 6 and 7982 DF,  p-value: < 2.2e-16

```

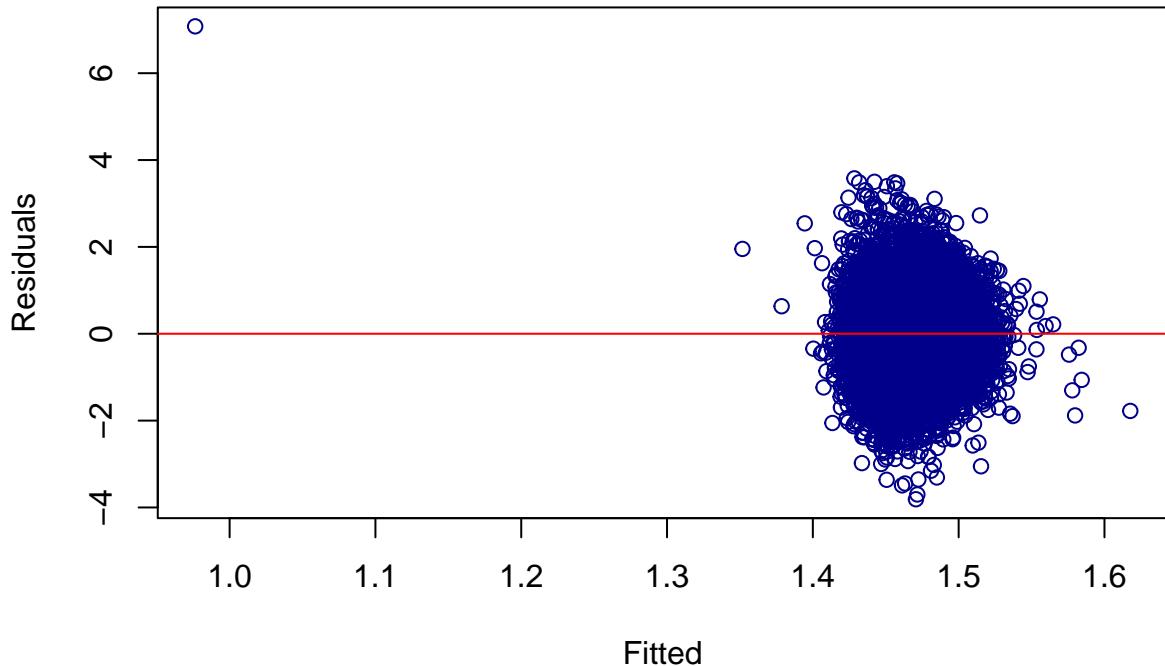
##Model 2 Diagnostics

```

#Residuals vs Fitted Plot
plot(fitted(model2), rstandard(model2),
      xlab = "Fitted",
      ylab = "Residuals", col = "darkblue" , main = "Residuals vs. Fitted")
abline(h=0, col = "red")

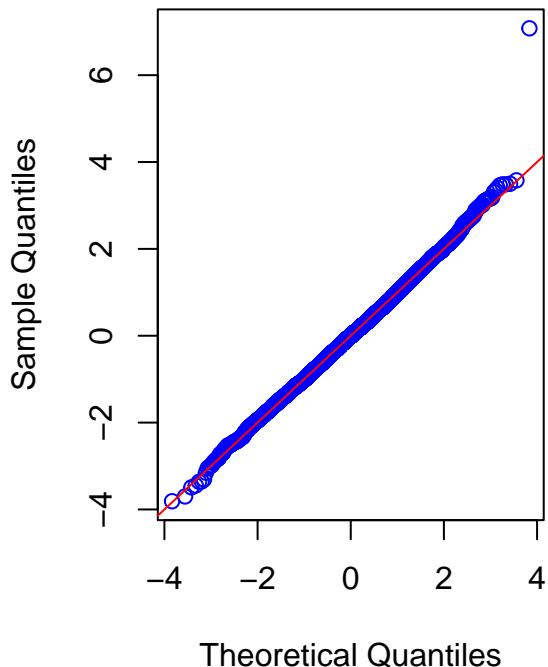
```

Residuals vs. Fitted

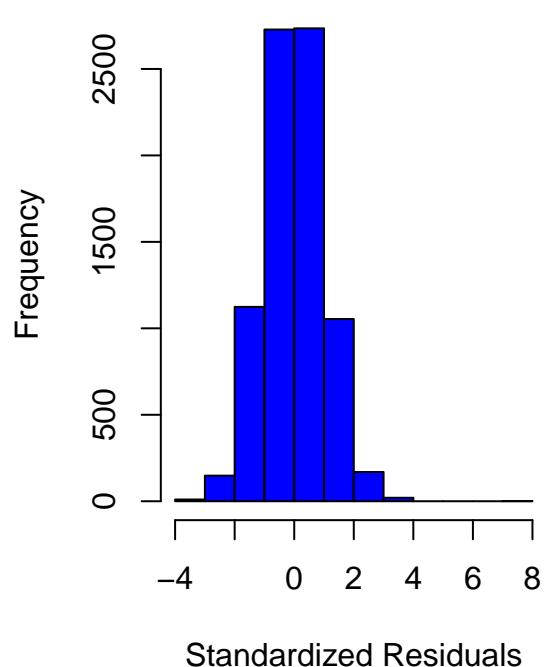


```
# Quantile-Quantile plots with standardized residuals
par (mfrow = c(1,2))
qqnorm(rstandard(model2), main = "Q-Q Plot", col = "blue")
abline(0,1, col = "red")
hist(rstandard(model2), main = "Standardized Residuals", xlab = "Standardized Residuals" , col = "blue")
```

Q-Q Plot



Standardized Residuals



```

##Cooks Distance to Remove Outliers

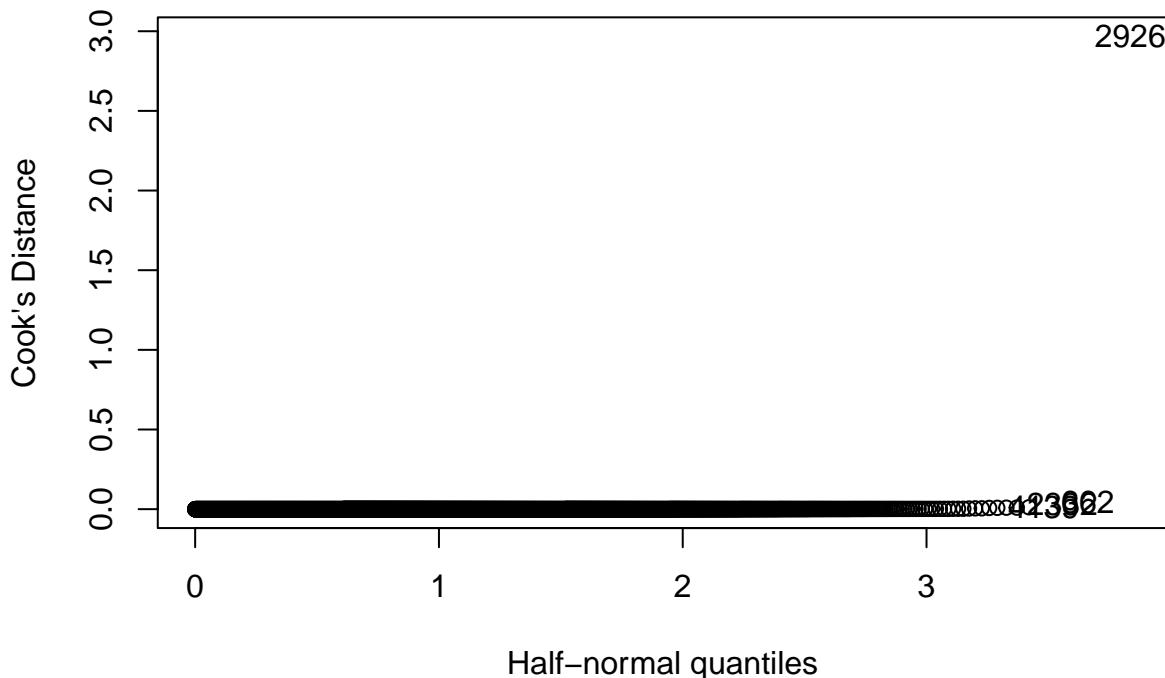
#Cooks distance
cal_envir2$cooked <- cooks.distance(model2)
sample_size <- nrow(cal_envir2)
cal_envir2$outlier <- ifelse((cal_envir2$cooked < 4/sample_size),"keep","delete")
cal_new <- cal_envir2[!(cal_envir2$outlier=="delete"),]

rname <- row.names(cal_envir2)

halfnorm(cal_envir2$cooked,4,labs = rname, ylab = "Cook's Distance" , main = "Cook's Distance vs Half-Normal")

```

Cook's Distance vs Half-Normal



```
##Making a New Model (Model 3) with Outliers Removed
```

```

#Model 3 with new data, outliers removed
model3 <- lm(Asthma^(10/99) ~ Ozone + PM2.5 + Pesticides + Traffic + Pollution.Burden.Score + `Tox..Release`
summary(model3)

```

```

##
## Call:
## lm(formula = Asthma^(10/99) ~ Ozone + PM2.5 + Pesticides + Traffic +
##     Pollution.Burden.Score + Tox..Release, data = cal_new)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.310475 -0.053004  0.000806  0.051883  0.290543
##
## Coefficients:

```

```

##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)           1.376e+00  5.062e-03 271.932 < 2e-16 ***
## Ozone                 5.040e-01  9.816e-02   5.134  2.9e-07 ***
## PM2.5                -6.992e-04 5.928e-04  -1.179 0.238255
## Pesticides            -3.469e-09 5.297e-07  -0.007 0.994775
## Traffic               -1.667e-05 1.175e-06 -14.190 < 2e-16 ***
## Pollution.Burden.Score 1.705e-02 7.926e-04  21.510 < 2e-16 ***
## Tox..Release           1.210e-06 3.475e-07   3.482 0.000501 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.07698 on 7750 degrees of freedom
## Multiple R-squared:  0.1037, Adjusted R-squared:  0.103
## F-statistic: 149.5 on 6 and 7750 DF,  p-value: < 2.2e-16

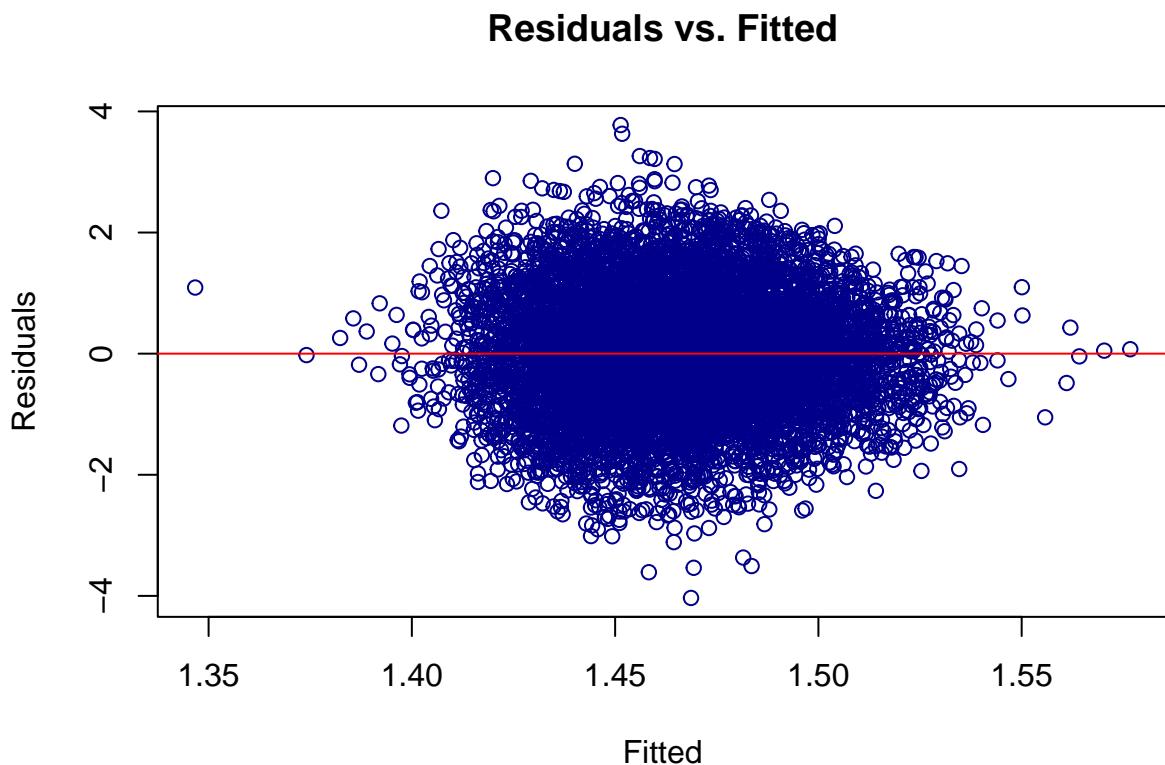
```

```
nrow(cal_new)
```

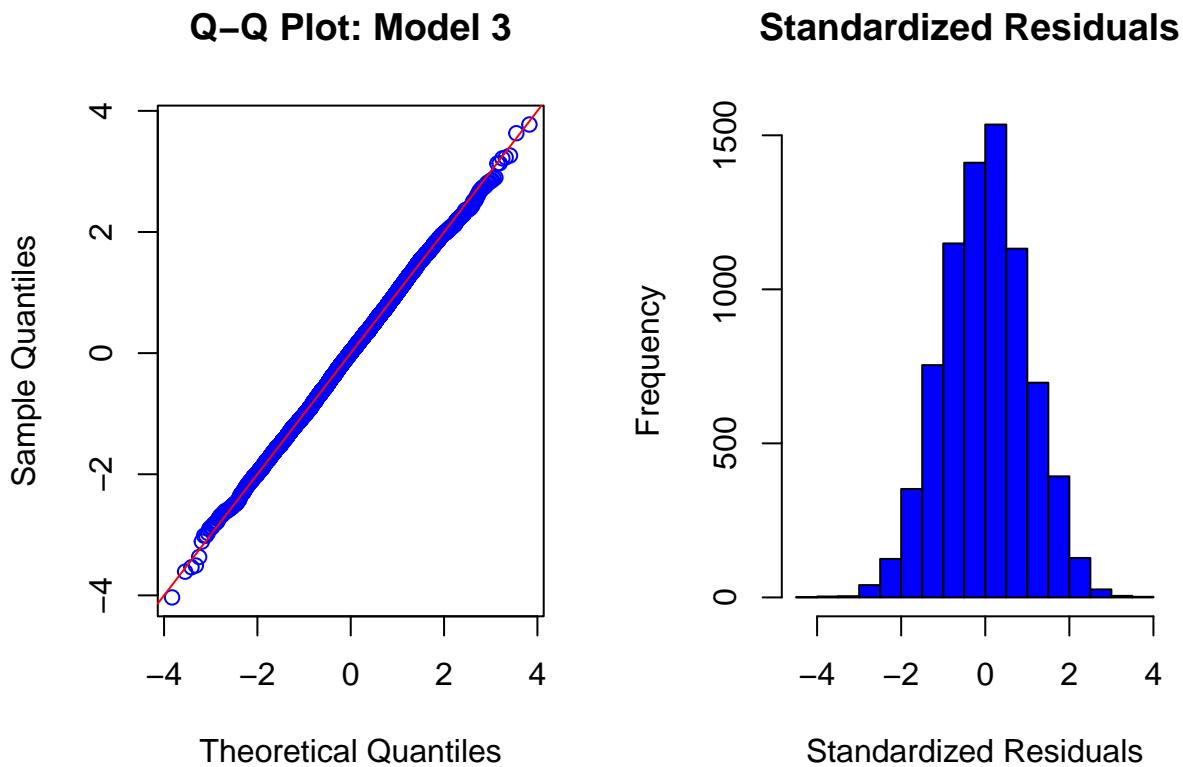
```
## [1] 7757
```

```
## #Diagnostics for Model 3
```

```
#Residuals vs Fitted Plot
plot(fitted(model3), rstandard(model3),
      xlab = "Fitted",
      ylab = "Residuals", col = "darkblue" , main = "Residuals vs. Fitted")
abline(h=0, col = "red")
```



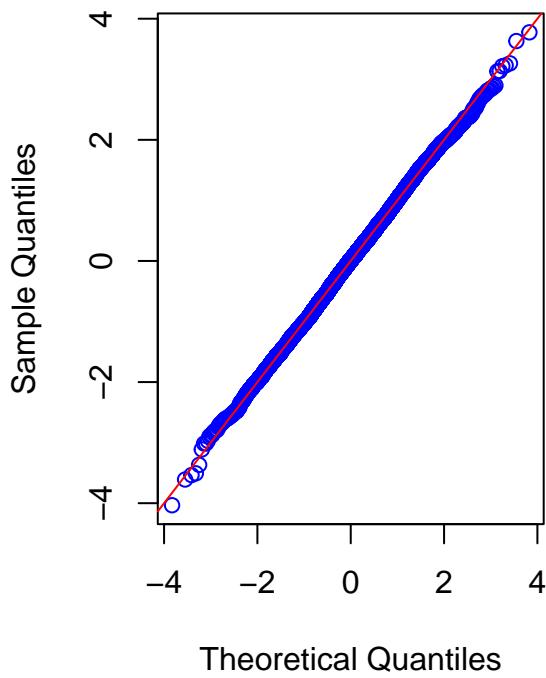
```
# Quantile-Quantile plots with standardized residuals
par (mfrow = c (1,2))
qqnorm(rstandard(model3),main = "Q-Q Plot: Model 3", col = "blue")
abline(0,1, col = "red")
hist(rstandard(model3), main = "Standardized Residuals ", xlab = "Standardized Residuals" , col = "blue")
```



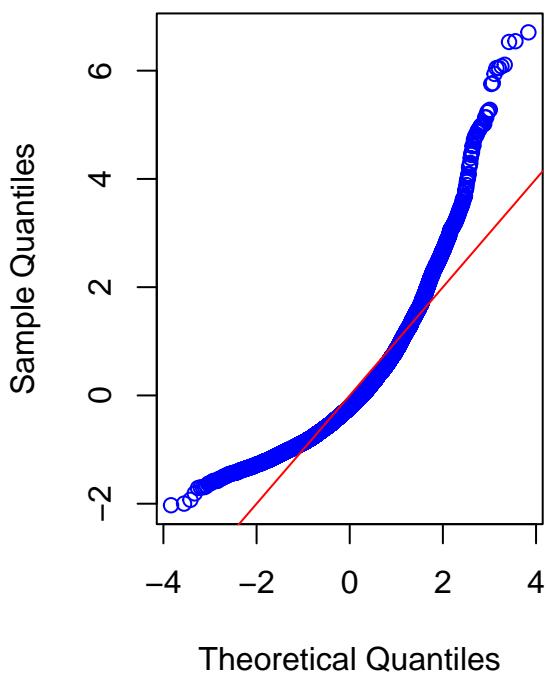
```
##Comparing Model1 and Model3
```

```
#QQplot M1 vs M3
par (mfrow = c (1,2))
qqnorm(rstandard(model3),main = "Q-Q Plot: Model 3", col = "blue")
abline(0,1, col = "red")
qqnorm(rstandard(model1),main = "Q-Q Plot: Model 1", col = "blue")
abline(0,1, col = "red")
```

Q-Q Plot: Model 3



Q-Q Plot: Model 1



```
##Model Selection Based on AIC
```

```
#AIC
```

```
b <- regsubsets(Asthma^(10/99) ~ Ozone + PM2.5 + Pesticides + Traffic + Pollution.Burden.Score + Tox..Re
```



```
rs <- summary(b)
```



```
rs$which
```

```
##      (Intercept) Ozone PM2.5 Pesticides Traffic Pollution.Burden.Score
## 1        TRUE FALSE FALSE    FALSE    FALSE          TRUE
## 2        TRUE FALSE FALSE    FALSE     TRUE          TRUE
## 3        TRUE  TRUE FALSE    FALSE     TRUE          TRUE
## 4        TRUE  TRUE FALSE    FALSE     TRUE          TRUE
## 5        TRUE  TRUE  TRUE    FALSE     TRUE          TRUE
## 6        TRUE  TRUE  TRUE     TRUE     TRUE          TRUE
##      Tox..Release
## 1        FALSE
## 2        FALSE
## 3        FALSE
## 4        TRUE
## 5        TRUE
## 6        TRUE
```

```
rs$rss
```

```
## [1] 47.45882 46.12999 46.00108 45.93700 45.92868 45.92868
```

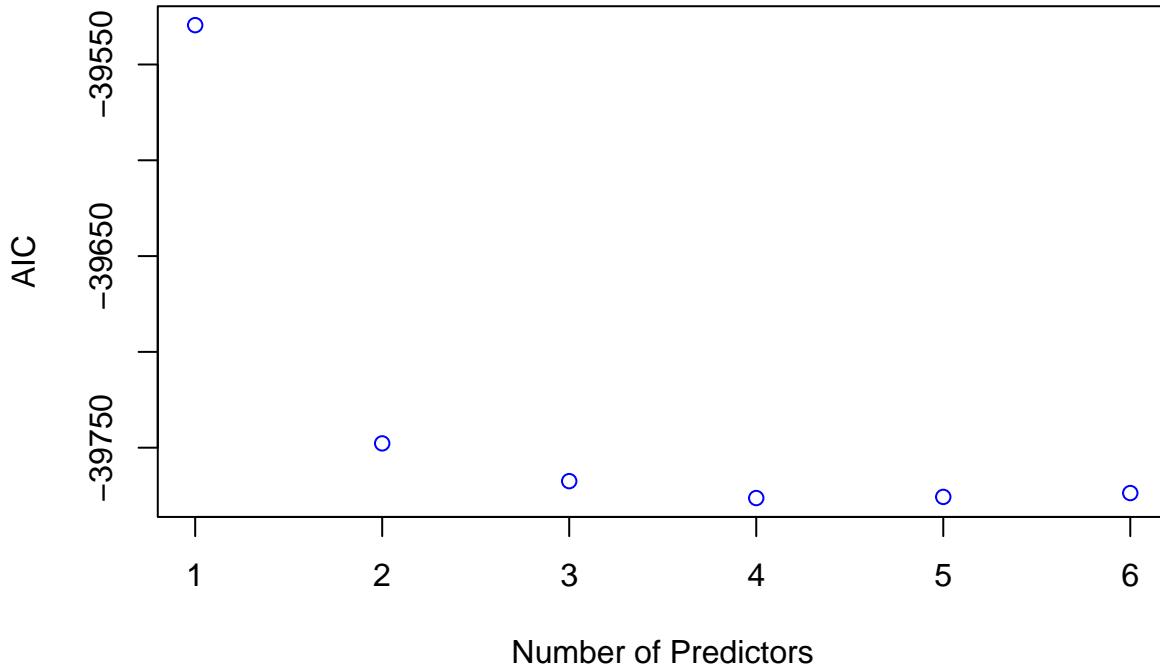
```

n <- nrow(cal_new)
p <- 2:7
AIC <- n*log(rs$rss / n) + 2 * p
AIC

## [1] -39529.46 -39747.75 -39767.46 -39776.27 -39775.68 -39773.68

plot(AIC ~ I(p - 1), ylab = "AIC", xlab = "Number of Predictors" , col = "blue")

```



#Best model is model 4, with Ozone, Traffic, Pollution Burden Score, and Tox. Release as predictors

```

##Final Model (Model 4), removed predictors

#Final Model
model4 <- lm(Asthma^(10/99) ~ Ozone + Traffic + Pollution.Burden.Score + Tox..Release, data=cal_new)
summary(model4)

##
## Call:
## lm(formula = Asthma^(10/99) ~ Ozone + Traffic + Pollution.Burden.Score +
##     Tox..Release, data = cal_new)
##
## Residuals:
##      Min        1Q    Median        3Q       Max
## -0.311433 -0.052913  0.000764  0.051872  0.290632
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 1.374e+00  4.744e-03 289.686 < 2e-16 ***
## Ozone       4.515e-01  8.760e-02   5.155 2.61e-07 ***

```

```
## Traffic           -1.666e-05  1.169e-06 -14.252  < 2e-16 ***
## Pollution.Burden.Score 1.660e-02  6.850e-04  24.230  < 2e-16 ***
## Tox..Release      1.098e-06  3.337e-07   3.289  0.00101 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.07698 on 7752 degrees of freedom
## Multiple R-squared:  0.1036, Adjusted R-squared:  0.1031
## F-statistic: 223.9 on 4 and 7752 DF,  p-value: < 2.2e-16
```

```
confint(model4)
```

```
##                               2.5 %      97.5 %
## (Intercept)          1.365036e+00  1.383636e+00
## Ozone                2.798243e-01  6.232721e-01
## Traffic              -1.895573e-05 -1.437178e-05
## Pollution.Burden.Score 1.525516e-02  1.794077e-02
## Tox..Release         4.433054e-07  1.751696e-06
```

```
model4$coefficients^(99/10)
```

	(Intercept)	Ozone	Traffic
##	2.328741e+01	3.815668e-04	NaN
##	Pollution.Burden.Score	Tox..Release	
##	2.390800e-18	1.000015e-59	