2353 Final Project Life Exp

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```
knitr::opts_chunk$set(echo = TRUE)
library(haven)
library(psych)
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
## v ggplot2 3.4.0      v purrr   1.0.1
## v tibble  3.1.8      v dplyr   1.0.10
## v tidyr   1.2.1      v stringr 1.5.0
## v readr   2.1.3      v forcats 0.5.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x ggplot2::%+%()   masks psych::%+%()
## x ggplot2::alpha() masks psych::alpha()
## x dplyr::filter()  masks stats::filter()
## x dplyr::lag()     masks stats::lag()
```

```
library(ggplot2)
library(lmtest)
```

```
## Loading required package: zoo
##
## Attaching package: 'zoo'
##
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
library(MASS)
```

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

```
library(psych)
library(lars)
```

```
## Loaded lars 1.3
##
##
## Attaching package: 'lars'
##
## The following object is masked from 'package:psych':
##
##     error.bars
```

```
library(leaps)
library(glmnet)
```

```
## Loading required package: Matrix
##
## Attaching package: 'Matrix'
##
## The following objects are masked from 'package:tidyr':
##
##     expand, pack, unpack
##
## Loaded glmnet 4.1-6
```

```
library(pander)
library(caret)
```

```
## Loading required package: lattice
##
## Attaching package: 'caret'
##
## The following object is masked from 'package:purrr':
##
##     lift
```

```
library(corrplot)
```

```
## corrplot 0.92 loaded
```

```
library(car)
```

```
## Loading required package: carData
##
## Attaching package: 'car'
##
## The following object is masked from 'package:dplyr':
##
##     recode
##
## The following object is masked from 'package:purrr':
##
##     some
##
```

```
## The following object is masked from 'package:psych':
##
##     logit
```

```
library(faraway)
```

```
##
## Attaching package: 'faraway'
##
## The following objects are masked from 'package:car':
##
##     logit, vif
##
## The following object is masked from 'package:lattice':
##
##     melanoma
##
## The following object is masked from 'package:psych':
##
##     logit
```

```
library(readr)
library(corrplot)
library(r02pro)
```

HEAD Data Preparation

```
my_data <- read.csv("Life Expectancy Data.csv")
head(my_data)
```

```
##       Country Year     Status Life.expectancy Adult.Mortality infant.deaths
## 1 Afghanistan 2015 Developing            65.0             263            62
## 2 Afghanistan 2014 Developing            59.9             271            64
## 3 Afghanistan 2013 Developing            59.9             268            66
## 4 Afghanistan 2012 Developing            59.5             272            69
## 5 Afghanistan 2011 Developing            59.2             275            71
## 6 Afghanistan 2010 Developing            58.8             279            74
##   Alcohol percentage.expenditure Hepatitis.B Measles  BMI under.five.deaths
## 1    0.01              71.279624          65    1154 19.1                83
## 2    0.01              73.523582          62     492 18.6                86
## 3    0.01              73.219243          64     430 18.1                89
## 4    0.01              78.184215          67    2787 17.6                93
## 5    0.01               7.097109          68    3013 17.2                97
## 6    0.01              79.679367          66    1989 16.7               102
##   Polio Total.expenditure Diphtheria HIV.AIDS       GDP Population
## 1     6              8.16         65      0.1 584.25921   33736494
## 2    58              8.18         62      0.1 612.69651     327582
## 3    62              8.13         64      0.1 631.74498   31731688
## 4    67              8.52         67      0.1 669.95900    3696958
## 5    68              7.87         68      0.1  63.53723    2978599
## 6    66              9.20         66      0.1 553.32894    2883167
##   thinness..1.19.years thinness.5.9.years Income.composition.of.resources
```

```
## 1                 17.2              17.3                           0.479
## 2                 17.5              17.5                           0.476
## 3                 17.7              17.7                           0.470
## 4                 17.9              18.0                           0.463
## 5                 18.2              18.2                           0.454
## 6                 18.4              18.4                           0.448
##   Schooling
## 1      10.1
## 2      10.0
## 3       9.9
## 4       9.8
## 5       9.5
## 6       9.2
```

```
dim(my_data)
```

```
## [1] 2938   22
```

```
for (i in colnames(my_data)) {
  print(i)
  print(sum(is.na(my_data$i)))
}
```

```
## [1] "Country"
## [1] 0
## [1] "Year"
## [1] 0
## [1] "Status"
## [1] 0
## [1] "Life.expectancy"
## [1] 0
## [1] "Adult.Mortality"
## [1] 0
## [1] "infant.deaths"
## [1] 0
## [1] "Alcohol"
## [1] 0
## [1] "percentage.expenditure"
## [1] 0
## [1] "Hepatitis.B"
## [1] 0
## [1] "Measles"
## [1] 0
## [1] "BMI"
## [1] 0
## [1] "under.five.deaths"
## [1] 0
## [1] "Polio"
## [1] 0
## [1] "Total.expenditure"
## [1] 0
## [1] "Diphtheria"
## [1] 0
```

```
## [1] "HIV.AIDS"
## [1] 0
## [1] "GDP"
## [1] 0
## [1] "Population"
## [1] 0
## [1] "thinness..1.19.years"
## [1] 0
## [1] "thinness.5.9.years"
## [1] 0
## [1] "Income.composition.of.resources"
## [1] 0
## [1] "Schooling"
## [1] 0
```

```
dim(my_data)
```

```
## [1] 2938   22
```

```
summary(my_data)
```

```
##    Country               Year         Status          Life.expectancy
##  Length:2938        Min.   :2000   Length:2938        Min.   :36.30
##  Class :character   1st Qu.:2004   Class :character   1st Qu.:63.10
##  Mode  :character   Median :2008   Mode  :character   Median :72.10
##                     Mean   :2008                      Mean   :69.22
##                     3rd Qu.:2012                      3rd Qu.:75.70
##                     Max.   :2015                      Max.   :89.00
##                                                       NA's   :10
##  Adult.Mortality infant.deaths       Alcohol        percentage.expenditure
##  Min.   :  1.0   Min.   :   0.0   Min.   : 0.0100   Min.   :    0.000
##  1st Qu.: 74.0   1st Qu.:   0.0   1st Qu.: 0.8775   1st Qu.:    4.685
##  Median :144.0   Median :   3.0   Median : 3.7550   Median :   64.913
##  Mean   :164.8   Mean   :  30.3   Mean   : 4.6029   Mean   :  738.251
##  3rd Qu.:228.0   3rd Qu.:  22.0   3rd Qu.: 7.7025   3rd Qu.:  441.534
##  Max.   :723.0   Max.   :1800.0   Max.   :17.8700   Max.   :19479.912
##  NA's   :10                       NA's   :194
##   Hepatitis.B       Measles               BMI        under.five.deaths
##  Min.   : 1.00   Min.   :     0.0   Min.   : 1.00   Min.   :   0.00
##  1st Qu.:77.00   1st Qu.:     0.0   1st Qu.:19.30   1st Qu.:   0.00
##  Median :92.00   Median :    17.0   Median :43.50   Median :   4.00
##  Mean   :80.94   Mean   :  2419.6   Mean   :38.32   Mean   :  42.04
##  3rd Qu.:97.00   3rd Qu.:   360.2   3rd Qu.:56.20   3rd Qu.:  28.00
##  Max.   :99.00   Max.   :212183.0   Max.   :87.30   Max.   :2500.00
##  NA's   :553                        NA's   :34
##      Polio       Total.expenditure   Diphtheria       HIV.AIDS
##  Min.   : 3.00   Min.   : 0.370    Min.   : 2.00   Min.   : 0.100
##  1st Qu.:78.00   1st Qu.: 4.260    1st Qu.:78.00   1st Qu.: 0.100
##  Median :93.00   Median : 5.755    Median :93.00   Median : 0.100
##  Mean   :82.55   Mean   : 5.938    Mean   :82.32   Mean   : 1.742
##  3rd Qu.:97.00   3rd Qu.: 7.492    3rd Qu.:97.00   3rd Qu.: 0.800
##  Max.   :99.00   Max.   :17.600    Max.   :99.00   Max.   :50.600
##  NA's   :19      NA's   :226       NA's   :19
```

```
##       GDP               Population        thinness..1.19.years
##  Min.   :     1.68   Min.   :3.400e+01   Min.   : 0.10
##  1st Qu.:   463.94   1st Qu.:1.958e+05   1st Qu.: 1.60
##  Median :  1766.95   Median :1.387e+06   Median : 3.30
##  Mean   :  7483.16   Mean   :1.275e+07   Mean   : 4.84
##  3rd Qu.:  5910.81   3rd Qu.:7.420e+06   3rd Qu.: 7.20
##  Max.   :119172.74   Max.   :1.294e+09   Max.   :27.70
##  NA's   :448         NA's   :652         NA's   :34
##  thinness.5.9.years Income.composition.of.resources   Schooling
##  Min.   : 0.10      Min.   :0.0000                  Min.   : 0.00
##  1st Qu.: 1.50      1st Qu.:0.4930                  1st Qu.:10.10
##  Median : 3.30      Median :0.6770                  Median :12.30
##  Mean   : 4.87      Mean   :0.6276                  Mean   :11.99
##  3rd Qu.: 7.20      3rd Qu.:0.7790                  3rd Qu.:14.30
##  Max.   :28.60      Max.   :0.9480                  Max.   :20.70
##  NA's   :34         NA's   :167                     NA's   :163
```

```
names(my_data)
```

```
##  [1] "Country"                          "Year"
##  [3] "Status"                           "Life.expectancy"
##  [5] "Adult.Mortality"                  "infant.deaths"
##  [7] "Alcohol"                          "percentage.expenditure"
##  [9] "Hepatitis.B"                      "Measles"
## [11] "BMI"                              "under.five.deaths"
## [13] "Polio"                            "Total.expenditure"
## [15] "Diphtheria"                       "HIV.AIDS"
## [17] "GDP"                              "Population"
## [19] "thinness..1.19.years"             "thinness.5.9.years"
## [21] "Income.composition.of.resources" "Schooling"
```

```
my_data1 <- my_data %>%
  na.omit() %>%
  mutate(Developing = as.integer(Status == "Developing")) # Change status to numeric
ncol(my_data1)
```

```
## [1] 23
```

```
my_data1<-my_data1[,-c(1, 2, 3)] # remove country, year, status
ncol(my_data1)
```

```
## [1] 20
```

```
summary(my_data1)
```

```
##  Life.expectancy Adult.Mortality infant.deaths      Alcohol
##  Min.   :44.0    Min.   :  1.0   Min.   :   0.00   Min.   : 0.010
##  1st Qu.:64.4    1st Qu.: 77.0   1st Qu.:   1.00   1st Qu.: 0.810
##  Median :71.7    Median :148.0   Median :   3.00   Median : 3.790
##  Mean   :69.3    Mean   :168.2   Mean   :  32.55   Mean   : 4.533
##  3rd Qu.:75.0    3rd Qu.:227.0   3rd Qu.:  22.00   3rd Qu.: 7.340
```

```
##  Max.   :89.0    Max.   :723.0   Max.   :1600.00   Max.   :17.870
##  percentage.expenditure  Hepatitis.B       Measles            BMI
##  Min.   :    0.00       Min.   : 2.00   Min.   :     0   Min.   : 2.00
##  1st Qu.:   37.44       1st Qu.:74.00   1st Qu.:     0   1st Qu.:19.50
##  Median :  145.10       Median :89.00   Median :    15   Median :43.70
##  Mean   :  698.97       Mean   :79.22   Mean   :  2224   Mean   :38.13
##  3rd Qu.:  509.39       3rd Qu.:96.00   3rd Qu.:   373   3rd Qu.:55.80
##  Max.   :18961.35       Max.   :99.00   Max.   :131441   Max.   :77.10
##  under.five.deaths     Polio       Total.expenditure   Diphtheria
##  Min.   :   0.00   Min.   : 3.00   Min.   : 0.740    Min.   : 2.00
##  1st Qu.:   1.00   1st Qu.:81.00   1st Qu.: 4.410    1st Qu.:82.00
##  Median :   4.00   Median :93.00   Median : 5.840    Median :92.00
##  Mean   :  44.22   Mean   :83.56   Mean   : 5.956    Mean   :84.16
##  3rd Qu.:  29.00   3rd Qu.:97.00   3rd Qu.: 7.470    3rd Qu.:97.00
##  Max.   :2100.00   Max.   :99.00   Max.   :14.390    Max.   :99.00
##     HIV.AIDS           GDP              Population        thinness..1.19.years
##  Min.   : 0.100   Min.   :     1.68   Min.   :3.400e+01   Min.   : 0.100
##  1st Qu.: 0.100   1st Qu.:   462.15   1st Qu.:1.919e+05   1st Qu.: 1.600
##  Median : 0.100   Median :  1592.57   Median :1.420e+06   Median : 3.000
##  Mean   : 1.984   Mean   :  5566.03   Mean   :1.465e+07   Mean   : 4.851
##  3rd Qu.: 0.700   3rd Qu.:  4718.51   3rd Qu.:7.659e+06   3rd Qu.: 7.100
##  Max.   :50.600   Max.   :119172.74   Max.   :1.294e+09   Max.   :27.200
##  thinness.5.9.years Income.composition.of.resources   Schooling
##  Min.   : 0.100     Min.   :0.0000                  Min.   : 4.20
##  1st Qu.: 1.700     1st Qu.:0.5090                  1st Qu.:10.30
##  Median : 3.200     Median :0.6730                  Median :12.30
##  Mean   : 4.908     Mean   :0.6316                  Mean   :12.12
##  3rd Qu.: 7.100     3rd Qu.:0.7510                  3rd Qu.:14.00
##  Max.   :28.200     Max.   :0.9360                  Max.   :20.70
##    Developing
##  Min.   :0.0000
##  1st Qu.:1.0000
##  Median :1.0000
##  Mean   :0.8532
##  3rd Qu.:1.0000
##  Max.   :1.0000
```

```
head(my_data1)
```

```
##   Life.expectancy Adult.Mortality infant.deaths Alcohol percentage.expenditure
## 1            65.0             263            62    0.01              71.279624
## 2            59.9             271            64    0.01              73.523582
## 3            59.9             268            66    0.01              73.219243
## 4            59.5             272            69    0.01              78.184215
## 5            59.2             275            71    0.01               7.097109
## 6            58.8             279            74    0.01              79.679367
##   Hepatitis.B Measles  BMI under.five.deaths Polio Total.expenditure Diphtheria
## 1          65    1154 19.1                83     6               8.16         65
## 2          62     492 18.6                86    58               8.18         62
## 3          64     430 18.1                89    62               8.13         64
## 4          67    2787 17.6                93    67               8.52         67
## 5          68    3013 17.2                97    68               7.87         68
## 6          66    1989 16.7               102    66               9.20         66
##   HIV.AIDS       GDP Population thinness..1.19.years thinness.5.9.years
```

```
## 1      0.1 584.25921   33736494                17.2               17.3
## 2      0.1 612.69651     327582                17.5               17.5
## 3      0.1 631.74498   31731688                17.7               17.7
## 4      0.1 669.95900    3696958                17.9               18.0
## 5      0.1  63.53723    2978599                18.2               18.2
## 6      0.1 553.32894    2883167                18.4               18.4
##   Income.composition.of.resources Schooling Developing
## 1                           0.479      10.1          1
## 2                           0.476      10.0          1
## 3                           0.470       9.9          1
## 4                           0.463       9.8          1
## 5                           0.454       9.5          1
## 6                           0.448       9.2          1
```

```
M=cor(my_data1)
M
```

```
##                                 Life.expectancy Adult.Mortality infant.deaths
## Life.expectancy                      1.00000000    -0.702523062  -0.169073804
## Adult.Mortality                     -0.70252306     1.000000000   0.042450237
## infant.deaths                       -0.16907380     0.042450237   1.000000000
## Alcohol                              0.40271832    -0.175535086  -0.106216917
## percentage.expenditure               0.40963082    -0.237609890  -0.090764632
## Hepatitis.B                          0.19993528    -0.105225443  -0.231768937
## Measles                             -0.06888122    -0.003966685   0.532679832
## BMI                                  0.54204159    -0.351542478  -0.234425154
## under.five.deaths                   -0.19226530     0.060365026   0.996905622
## Polio                                0.32729440    -0.199853000  -0.156928805
## Total.expenditure                    0.17471764    -0.085226535  -0.146951117
## Diphtheria                           0.34133123    -0.191428759  -0.161871004
## HIV.AIDS                            -0.59223629     0.550690745   0.007711547
## GDP                                  0.44132181    -0.255034733  -0.098092020
## Population                          -0.02230498    -0.015011838   0.671758310
## thinness..1.19.years                -0.45783819     0.272230044   0.463415256
## thinness.5.9.years                  -0.45750829     0.286722882   0.461907925
## Income.composition.of.resources      0.72108259    -0.442203288  -0.134753863
## Schooling                            0.72763003    -0.421170523  -0.214371900
## Developing                          -0.44279758     0.278172847   0.108756919
##                                        Alcohol percentage.expenditure Hepatitis.B
## Life.expectancy                     0.40271832             0.40963082  0.19993528
## Adult.Mortality                    -0.17553509            -0.23760989 -0.10522544
## infant.deaths                      -0.10621692            -0.09076463 -0.23176894
## Alcohol                             1.00000000             0.41704736  0.10988939
## percentage.expenditure              0.41704736             1.00000000  0.01676017
## Hepatitis.B                         0.10988939             0.01676017  1.00000000
## Measles                            -0.05011023            -0.06307079 -0.12479999
## BMI                                 0.35339621             0.24273824  0.14330179
## under.five.deaths                  -0.10108216            -0.09215806 -0.24076603
## Polio                               0.24031453             0.12862605  0.46333080
## Total.expenditure                   0.21488509             0.18387236  0.11332668
## Diphtheria                          0.24295143             0.13481324  0.58898993
## HIV.AIDS                           -0.02711264            -0.09508499 -0.09480197
## GDP                                 0.44343279             0.95929886  0.04184950
## Population                         -0.02888023            -0.01679214 -0.12972265
```

```
## thinness..1.19.years            -0.40375499           -0.25503460 -0.12940595
## thinness.5.9.years              -0.38620819           -0.25563544 -0.13325099
## Income.composition.of.resources  0.56107433            0.40216974  0.18492097
## Schooling                        0.61697481            0.42208845  0.21518159
## Developing                      -0.60778179           -0.46168832 -0.14035064
##                                      Measles         BMI under.five.deaths
## Life.expectancy                 -0.068881222  0.54204159       -0.19226530
## Adult.Mortality                 -0.003966685 -0.35154248        0.06036503
## infant.deaths                    0.532679832 -0.23442515        0.99690562
## Alcohol                         -0.050110235  0.35339621       -0.10108216
## percentage.expenditure          -0.063070789  0.24273824       -0.09215806
## Hepatitis.B                     -0.124799993  0.14330179       -0.24076603
## Measles                          1.000000000 -0.15324546        0.51750556
## BMI                             -0.153245464  1.00000000       -0.24213740
## under.five.deaths                0.517505563 -0.24213740        1.00000000
## Polio                           -0.057850133  0.18626797       -0.17116419
## Total.expenditure               -0.113582738  0.18946896       -0.14580310
## Diphtheria                      -0.058605907  0.17629450       -0.17844819
## HIV.AIDS                        -0.003521854 -0.21089675        0.01947593
## GDP                             -0.064767590  0.26611397       -0.10033126
## Population                       0.321946377 -0.08141598        0.65867969
## thinness..1.19.years             0.180641506 -0.54701751        0.46478470
## thinness.5.9.years               0.174946217 -0.55409398        0.46228938
## Income.composition.of.resources -0.058277256  0.51050483       -0.14809728
## Schooling                       -0.115660481  0.55484390       -0.22601262
## Developing                       0.071963263 -0.29837983        0.10984742
##                                       Polio Total.expenditure  Diphtheria
## Life.expectancy                  0.32729440        0.17471764  0.34133123
## Adult.Mortality                 -0.19985300       -0.08522653 -0.19142876
## infant.deaths                   -0.15692881       -0.14695112 -0.16187100
## Alcohol                          0.24031453        0.21488509  0.24295143
## percentage.expenditure           0.12862605        0.18387236  0.13481324
## Hepatitis.B                      0.46333080        0.11332668  0.58898993
## Measles                         -0.05785013       -0.11358274 -0.05860591
## BMI                              0.18626797        0.18946896  0.17629450
## under.five.deaths               -0.17116419       -0.14580310 -0.17844819
## Polio                            1.00000000        0.11976798  0.60924547
## Total.expenditure                0.11976798        1.00000000  0.12991481
## Diphtheria                       0.60924547        0.12991481  1.00000000
## HIV.AIDS                        -0.10788547        0.04310066 -0.11760107
## GDP                              0.15680869        0.18037347  0.15843774
## Population                      -0.04538657       -0.07996224 -0.03989754
## thinness..1.19.years            -0.16406959       -0.20987232 -0.18724165
## thinness.5.9.years              -0.17448925       -0.21786479 -0.18095238
## Income.composition.of.resources  0.31468159        0.18365319  0.34326177
## Schooling                        0.35014660        0.24378345  0.35039793
## Developing                      -0.20191667       -0.19253779 -0.20165411
##                                     HIV.AIDS         GDP   Population
## Life.expectancy                 -0.592236293  0.44132181 -0.022304978
## Adult.Mortality                  0.550690745 -0.25503473 -0.015011838
## infant.deaths                    0.007711547 -0.09809202  0.671758310
## Alcohol                         -0.027112636  0.44343279 -0.028880232
## percentage.expenditure          -0.095084991  0.95929886 -0.016792141
## Hepatitis.B                     -0.094801971  0.04184950 -0.129722655
```

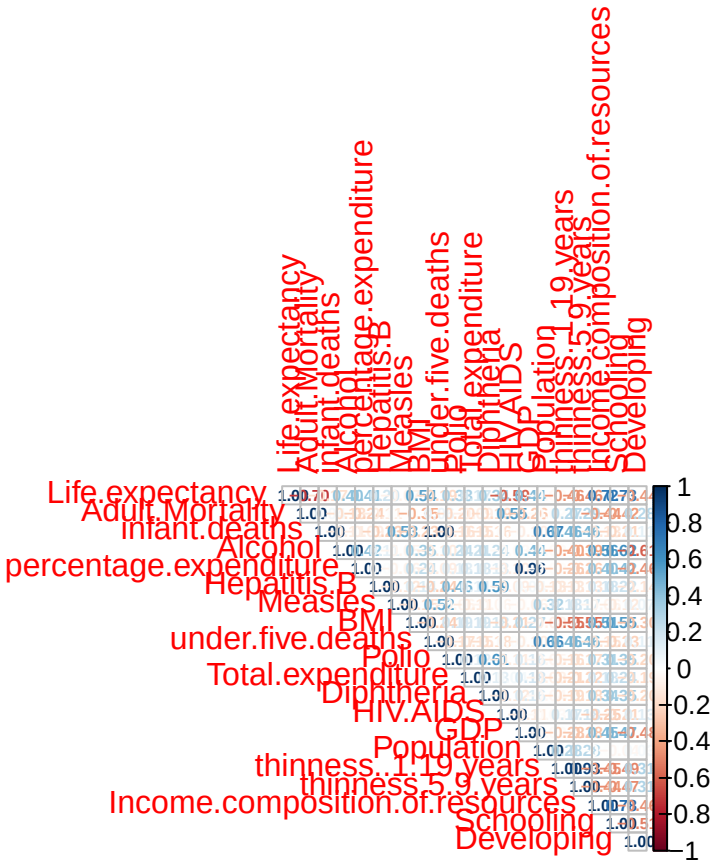
```
## Measles                         -0.003521854 -0.06476759  0.321946377
## BMI                             -0.210896746  0.26611397 -0.081415982
## under.five.deaths                0.019475927 -0.10033126  0.658679691
## Polio                           -0.107885468  0.15680869 -0.045386572
## Total.expenditure                0.043100657  0.18037347 -0.079962237
## Diphtheria                      -0.117601074  0.15843774 -0.039897537
## HIV.AIDS                         1.000000000 -0.10808060 -0.027800562
## GDP                             -0.108080600  1.00000000 -0.020368964
## Population                      -0.027800562 -0.02036896  1.000000000
## thinness..1.19.years             0.172591767 -0.27749835  0.282529280
## thinness.5.9.years               0.183146727 -0.27795855  0.277913374
## Income.composition.of.resources -0.248589855  0.44685551 -0.008132466
## Schooling                       -0.211840201  0.46794697 -0.040312419
## Developing                       0.129555493 -0.48480102  0.034790186
##                                 thinness..1.19.years thinness.5.9.years
## Life.expectancy                            -0.4578382         -0.4575083
## Adult.Mortality                             0.2722300          0.2867229
## infant.deaths                               0.4634153          0.4619079
## Alcohol                                    -0.4037550         -0.3862082
## percentage.expenditure                     -0.2550346         -0.2556354
## Hepatitis.B                                -0.1294060         -0.1332510
## Measles                                     0.1806415          0.1749462
## BMI                                        -0.5470175         -0.5540940
## under.five.deaths                           0.4647847          0.4622894
## Polio                                      -0.1640696         -0.1744893
## Total.expenditure                          -0.2098723         -0.2178648
## Diphtheria                                 -0.1872416         -0.1809524
## HIV.AIDS                                    0.1725918          0.1831467
## GDP                                        -0.2774983         -0.2779586
## Population                                  0.2825293          0.2779134
## thinness..1.19.years                        1.0000000          0.9279134
## thinness.5.9.years                          0.9279134          1.0000000
## Income.composition.of.resources            -0.4536789         -0.4384837
## Schooling                                  -0.4911992         -0.4724820
## Developing                                  0.3080053          0.3072786
##                                 Income.composition.of.resources   Schooling
## Life.expectancy                                      0.721082593  0.72763003
## Adult.Mortality                                     -0.442203288 -0.42117052
## infant.deaths                                       -0.134753863 -0.21437190
## Alcohol                                              0.561074332  0.61697481
## percentage.expenditure                               0.402169736  0.42208845
## Hepatitis.B                                          0.184920970  0.21518159
## Measles                                             -0.058277256 -0.11566048
## BMI                                                  0.510504831  0.55484390
## under.five.deaths                                   -0.148097276 -0.22601262
## Polio                                                0.314681594  0.35014660
## Total.expenditure                                    0.183653190  0.24378345
## Diphtheria                                           0.343261772  0.35039793
## HIV.AIDS                                            -0.248589855 -0.21184020
## GDP                                                  0.446855511  0.46794697
## Population                                          -0.008132466 -0.04031242
## thinness..1.19.years                                -0.453678854 -0.49119921
## thinness.5.9.years                                  -0.438483721 -0.47248203
## Income.composition.of.resources                      1.000000000  0.78474058
```

```
## Schooling                                        0.784740581  1.00000000
## Developing                                      -0.463614945 -0.51254296
##                                  Developing
## Life.expectancy                  -0.44279758
## Adult.Mortality                   0.27817285
## infant.deaths                     0.10875692
## Alcohol                          -0.60778179
## percentage.expenditure           -0.46168832
## Hepatitis.B                      -0.14035064
## Measles                           0.07196326
## BMI                              -0.29837983
## under.five.deaths                 0.10984742
## Polio                            -0.20191667
## Total.expenditure                -0.19253779
## Diphtheria                       -0.20165411
## HIV.AIDS                          0.12955549
## GDP                              -0.48480102
## Population                        0.03479019
## thinness..1.19.years              0.30800531
## thinness.5.9.years                0.30727858
## Income.composition.of.resources  -0.46361494
## Schooling                        -0.51254296
## Developing                        1.00000000
```

```
which.min(abs(M))
```

```
## [1] 133
```

```
corrplot(M,method = "number",type="upper",number.cex = 0.5) # make correlation plot
```



Define Training and test dataset

```
set.seed(0)
tr_size <- nrow(my_data1) * 0.7 # training sample size
tr_ind <-sample(nrow(my_data1), tr_size)
data_tr <-my_data1[tr_ind, ] # training data
data_te <-my_data1[-tr_ind, ] # test data
ncol(my_data1)
```

```
## [1] 20
```

```
nrow(my_data1)
```

```
## [1] 1649
```

```
nrow(data_tr)
```

```
## [1] 1154
```

```
nrow(data_te)
```

```
## [1] 495
```

Train Model

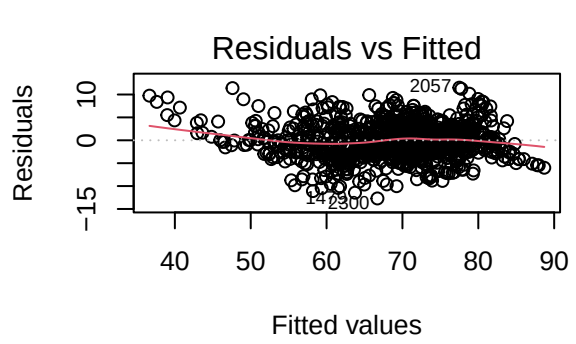
```r
set.seed(0)
model <- lm(Life.expectancy~., data = data_tr)
summary(model)
```

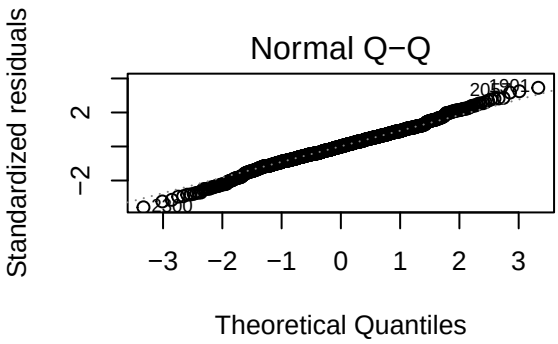
```
##
## Call:
## lm(formula = Life.expectancy ~ ., data = data_tr)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -12.704  -2.164   0.010   2.225  11.494
##
## Coefficients:
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     5.461e+01  1.021e+00  53.507  < 2e-16 ***
## Adult.Mortality                -1.594e-02  1.137e-03 -14.021  < 2e-16 ***
## infant.deaths                   1.022e-01  1.487e-02   6.875 1.02e-11 ***
## Alcohol                        -1.207e-01  3.887e-02  -3.105  0.00195 **
## percentage.expenditure          3.241e-04  2.169e-04   1.494  0.13533
## Hepatitis.B                    -1.068e-02  5.205e-03  -2.052  0.04038 *
## Measles                        -1.038e-05  1.317e-05  -0.788  0.43066
## BMI                             3.401e-02  7.083e-03   4.802 1.78e-06 ***
## under.five.deaths              -7.607e-02  1.071e-02  -7.102 2.16e-12 ***
## Polio                           1.222e-02  6.156e-03   1.986  0.04731 *
## Total.expenditure               3.363e-02  4.801e-02   0.700  0.48377
## Diphtheria                      1.590e-02  7.184e-03   2.214  0.02705 *
## HIV.AIDS                       -4.386e-01  2.158e-02 -20.325  < 2e-16 ***
## GDP                             9.858e-06  3.440e-05   0.287  0.77450
## Population                     -1.724e-09  2.116e-09  -0.815  0.41542
## thinness..1.19.years           -1.341e-02  5.635e-02  -0.238  0.81193
## thinness.5.9.years             -5.432e-02  5.579e-02  -0.974  0.33043
## Income.composition.of.resources  1.045e+01  1.015e+00  10.293  < 2e-16 ***
## Schooling                       8.510e-01  6.999e-02  12.159  < 2e-16 ***
## Developing                     -1.144e+00  4.059e-01  -2.818  0.00491 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.576 on 1134 degrees of freedom
## Multiple R-squared:  0.835,  Adjusted R-squared:  0.8323
## F-statistic: 302.1 on 19 and 1134 DF,  p-value: < 2.2e-16
```

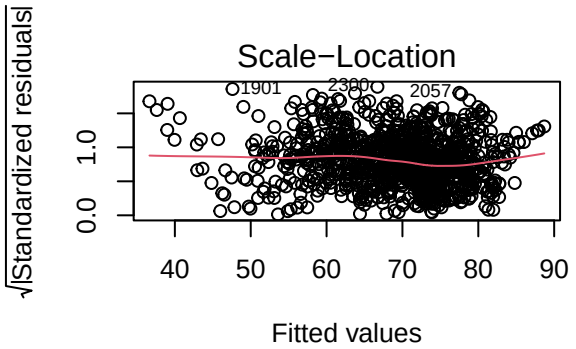
```r
alias(model)# Check that the predictors of the model do not contain a large number of repeated values
```

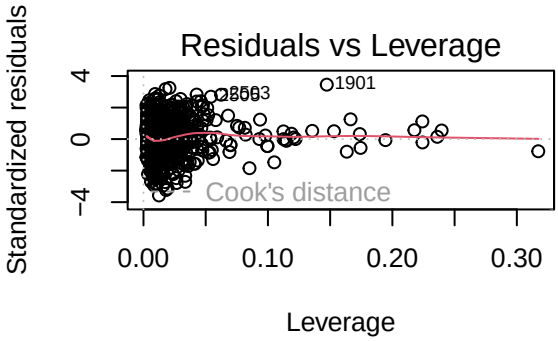
```
## Model :
## Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol +
##     percentage.expenditure + Hepatitis.B + Measles + BMI + under.five.deaths +
##     Polio + Total.expenditure + Diphtheria + HIV.AIDS + GDP +
##     Population + thinness..1.19.years + thinness.5.9.years +
##     Income.composition.of.resources + Schooling + Developing
```

```r
par (mfrow = c(2,2))
plot (model)
```

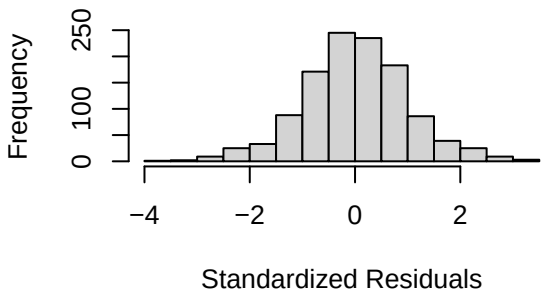









```
hist(rstandard(model), main = "", xlab = "Standardized Residuals")
par(mfrow = c (1,1))
```




```
shapiro.test(model$residuals) # less than .05 so it is normal distribute.
```

```
##
##  Shapiro-Wilk normality test
##
## data:  model$residuals
## W = 0.99402, p-value = 0.0001406
```

```
dwtest(model) # value is close to 2.0, so there is no autocorrelation detected.
```

```
##
##  Durbin-Watson test
##
## data:  model
## DW = 2.0436, p-value = 0.7729
## alternative hypothesis: true autocorrelation is greater than 0
```

```
bptest(model) # p-value is less than 0.05, we reject null hypothesis,
```

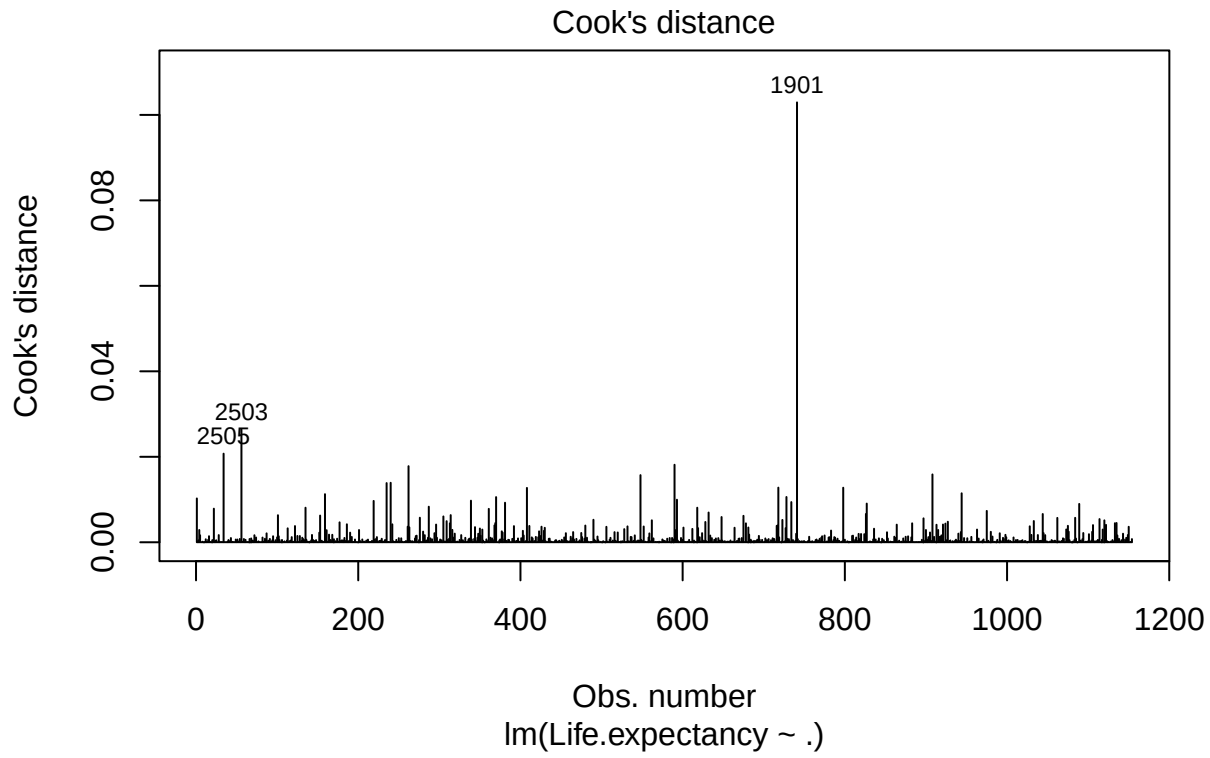
```
##
##  studentized Breusch-Pagan test
##
## data:  model
## BP = 125.61, df = 19, p-value < 2.2e-16
```

```
#no heteroscedasticity in model.

AA<-rstudent(model) # Compute standardized residuals to check outlines.
p<-ncol(data_tr)
n<-nrow(data_tr)
which(abs(AA)>qt(1-0.05/(n*2),n-p-1))
```

```
## named integer(0)
```

```
plot(model,which=4)
```




```
vif(model)
```

```
##                  Adult.Mortality                     infant.deaths
##                         1.819167                       254.411298
##                          Alcohol           percentage.expenditure
##                         2.258261                       14.421237
##                      Hepatitis.B                          Measles
##                         1.660452                         1.542678
##                              BMI                 under.five.deaths
##                         1.772660                       238.492903
##                            Polio               Total.expenditure
##                         1.712429                         1.115458
##                       Diphtheria                          HIV.AIDS
```

```
##                          2.049503                          1.500308
##                               GDP                        Population
##                         15.121553                          2.264707
##             thinness..1.19.years               thinness.5.9.years
##                         5.839108                          5.826642
## Income.composition.of.resources                          Schooling
##                         3.069910                          3.606260
##                        Developing
##                         1.867234
```

AIC Selection

```
step(model)
```

```
## Start:  AIC=2960.78
## Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol +
##     percentage.expenditure + Hepatitis.B + Measles + BMI + under.five.deaths +
##     Polio + Total.expenditure + Diphtheria + HIV.AIDS + GDP +
##     Population + thinness..1.19.years + thinness.5.9.years +
##     Income.composition.of.resources + Schooling + Developing
##
##                                   Df Sum of Sq   RSS    AIC
## - thinness..1.19.years             1       0.7 14502 2958.8
## - GDP                              1       1.1 14502 2958.9
## - Total.expenditure                1       6.3 14508 2959.3
## - Measles                          1       7.9 14509 2959.4
## - Population                       1       8.5 14510 2959.5
## - thinness.5.9.years               1      12.1 14513 2959.7
## <none>                                        14501 2960.8
## - percentage.expenditure           1      28.6 14530 2961.0
## - Polio                            1      50.4 14552 2962.8
## - Hepatitis.B                      1      53.9 14555 2963.1
## - Diphtheria                       1      62.7 14564 2963.8
## - Developing                       1     101.6 14603 2966.8
## - Alcohol                          1     123.3 14625 2968.5
## - BMI                              1     294.8 14796 2982.0
## - infant.deaths                    1     604.4 15106 3005.9
## - under.five.deaths                1     645.1 15146 3009.0
## - Income.composition.of.resources  1    1354.7 15856 3061.8
## - Schooling                        1    1890.4 16392 3100.2
## - Adult.Mortality                  1    2514.0 17015 3143.3
## - HIV.AIDS                         1    5282.4 19784 3317.2
##
## Step:  AIC=2958.84
## Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol +
##     percentage.expenditure + Hepatitis.B + Measles + BMI + under.five.deaths +
##     Polio + Total.expenditure + Diphtheria + HIV.AIDS + GDP +
##     Population + thinness.5.9.years + Income.composition.of.resources +
##     Schooling + Developing
##
##                                   Df Sum of Sq   RSS    AIC
## - GDP                              1       1.0 14503 2956.9
## - Total.expenditure                1       6.3 14508 2957.3
```

```
## - Measles                           1       8.0 14510 2957.5
## - Population                        1       8.8 14511 2957.5
## <none>                                          14502 2958.8
## - percentage.expenditure            1      28.6 14531 2959.1
## - Polio                             1      49.8 14552 2960.8
## - thinness.5.9.years                1      52.6 14555 2961.0
## - Hepatitis.B                       1      54.3 14556 2961.1
## - Diphtheria                        1      63.2 14565 2961.9
## - Developing                        1     101.2 14603 2964.9
## - Alcohol                           1     122.6 14625 2966.6
## - BMI                               1     297.2 14799 2980.3
## - infant.deaths                     1     606.4 15108 3004.1
## - under.five.deaths                 1     647.7 15150 3007.3
## - Income.composition.of.resources   1    1361.3 15863 3060.4
## - Schooling                         1    1906.4 16408 3099.4
## - Adult.Mortality                   1    2514.6 17017 3141.4
## - HIV.AIDS                          1    5293.1 19795 3315.9
##
## Step:  AIC=2956.92
## Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol +
##     percentage.expenditure + Hepatitis.B + Measles + BMI + under.five.deaths +
##     Polio + Total.expenditure + Diphtheria + HIV.AIDS + Population +
##     thinness.5.9.years + Income.composition.of.resources + Schooling +
##     Developing
##
##                                   Df Sum of Sq   RSS    AIC
## - Total.expenditure                1       6.1 14509 2955.4
## - Measles                          1       7.9 14511 2955.5
## - Population                       1       9.0 14512 2955.6
## <none>                                         14503 2956.9
## - Polio                            1      50.4 14554 2958.9
## - thinness.5.9.years               1      52.7 14556 2959.1
## - Hepatitis.B                      1      53.7 14557 2959.2
## - Diphtheria                       1      62.7 14566 2959.9
## - Developing                       1     102.2 14605 2963.0
## - Alcohol                          1     122.2 14625 2964.6
## - BMI                              1     297.7 14801 2978.4
## - percentage.expenditure           1     403.1 14906 2986.6
## - infant.deaths                    1     607.1 15110 3002.2
## - under.five.deaths                1     648.2 15151 3005.4
## - Income.composition.of.resources  1    1374.4 15878 3059.4
## - Schooling                        1    1921.7 16425 3098.5
## - Adult.Mortality                  1    2514.1 17017 3139.4
## - HIV.AIDS                         1    5292.7 19796 3313.9
##
## Step:  AIC=2955.4
## Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol +
##     percentage.expenditure + Hepatitis.B + Measles + BMI + under.five.deaths +
##     Polio + Diphtheria + HIV.AIDS + Population + thinness.5.9.years +
##     Income.composition.of.resources + Schooling + Developing
##
##                                   Df Sum of Sq   RSS    AIC
## - Measles                          1       8.4 14518 2954.1
## - Population                       1       8.9 14518 2954.1
```

```
## <none>                                        14509 2955.4
## - Polio                            1      51.1 14560 2957.5
## - Hepatitis.B                      1      52.1 14561 2957.5
## - thinness.5.9.years               1      55.8 14565 2957.8
## - Diphtheria                       1      63.6 14573 2958.5
## - Developing                       1     103.8 14613 2961.6
## - Alcohol                          1     121.7 14631 2963.0
## - BMI                              1     303.0 14812 2977.3
## - percentage.expenditure           1     411.2 14920 2985.7
## - infant.deaths                    1     603.6 15113 3000.4
## - under.five.deaths                1     644.7 15154 3003.6
## - Income.composition.of.resources  1    1371.1 15880 3057.6
## - Schooling                        1    1938.1 16447 3098.1
## - Adult.Mortality                  1    2521.7 17031 3138.3
## - HIV.AIDS                         1    5322.5 19832 3314.0
##
## Step:  AIC=2954.07
## Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol +
##     percentage.expenditure + Hepatitis.B + BMI + under.five.deaths +
##     Polio + Diphtheria + HIV.AIDS + Population + thinness.5.9.years +
##     Income.composition.of.resources + Schooling + Developing
##
##                                   Df Sum of Sq   RSS    AIC
## - Population                       1       6.9 14524 2952.6
## <none>                                         14518 2954.1
## - Polio                            1      50.6 14568 2956.1
## - Hepatitis.B                      1      51.5 14569 2956.2
## - thinness.5.9.years               1      51.7 14569 2956.2
## - Diphtheria                       1      64.1 14582 2957.2
## - Developing                       1     104.8 14622 2960.4
## - Alcohol                          1     125.2 14643 2962.0
## - BMI                              1     314.6 14832 2976.8
## - percentage.expenditure           1     413.3 14931 2984.5
## - infant.deaths                    1     644.6 15162 3002.2
## - under.five.deaths                1     675.0 15192 3004.5
## - Income.composition.of.resources  1    1375.5 15893 3056.5
## - Schooling                        1    1938.8 16456 3096.7
## - Adult.Mortality                  1    2536.2 17054 3137.9
## - HIV.AIDS                         1    5328.9 19846 3312.9
##
## Step:  AIC=2952.62
## Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol +
##     percentage.expenditure + Hepatitis.B + BMI + under.five.deaths +
##     Polio + Diphtheria + HIV.AIDS + thinness.5.9.years + Income.composition.of.resources +
##     Schooling + Developing
##
##                                   Df Sum of Sq   RSS    AIC
## <none>                                         14524 2952.6
## - Polio                            1      50.0 14574 2954.6
## - Hepatitis.B                      1      50.9 14575 2954.7
## - thinness.5.9.years               1      53.7 14578 2954.9
## - Diphtheria                       1      62.7 14587 2955.6
## - Developing                       1     105.1 14630 2958.9
## - Alcohol                          1     125.3 14650 2960.5
```

```
## - BMI                              1     310.1 14834 2975.0
## - percentage.expenditure           1     411.4 14936 2982.8
## - infant.deaths                    1     660.9 15185 3002.0
## - under.five.deaths                1     677.4 15202 3003.2
## - Income.composition.of.resources  1    1382.0 15906 3055.5
## - Schooling                        1    1933.8 16458 3094.9
## - Adult.Mortality                  1    2554.6 17079 3137.6
## - HIV.AIDS                         1    5324.4 19849 3311.0
```

```
##
## Call:
## lm(formula = Life.expectancy ~ Adult.Mortality + infant.deaths +
##     Alcohol + percentage.expenditure + Hepatitis.B + BMI + under.five.deaths +
##     Polio + Diphtheria + HIV.AIDS + thinness.5.9.years + Income.composition.of.resources +
##     Schooling + Developing, data = data_tr)
##
## Coefficients:
##                      (Intercept)                   Adult.Mortality
##                        54.7468812                       -0.0160171
##                     infant.deaths                            Alcohol
##                         0.0945725                       -0.1212779
##           percentage.expenditure                       Hepatitis.B
##                         0.0003858                       -0.0103587
##                               BMI                 under.five.deaths
##                         0.0345796                       -0.0713724
##                             Polio                       Diphtheria
##                         0.0121297                        0.0158760
##                          HIV.AIDS                thinness.5.9.years
##                        -0.4370189                       -0.0651349
## Income.composition.of.resources                         Schooling
##                        10.4991049                        0.8516676
##                        Developing
##                        -1.1615165
```

```
# Find model with lowest AIC
lmod_AIC_B<-lm(Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol +
                 percentage.expenditure + Hepatitis.B + BMI + under.five.deaths +
                 Polio + Diphtheria + HIV.AIDS + thinness.5.9.years +
                 Income.composition.of.resources + Schooling + Developing,
               data = data_tr) # AIC selected model
sum_AIC_B<-summary(lmod_AIC_B)
sum_AIC_B
```

```
##
## Call:
## lm(formula = Life.expectancy ~ Adult.Mortality + infant.deaths +
##     Alcohol + percentage.expenditure + Hepatitis.B + BMI + under.five.deaths +
##     Polio + Diphtheria + HIV.AIDS + thinness.5.9.years + Income.composition.of.resources +
##     Schooling + Developing, data = data_tr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -12.4930  -2.1727   0.0338   2.2373  11.6085
```

```
##
## Coefficients:
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     5.475e+01  9.748e-01  56.161  < 2e-16 ***
## Adult.Mortality                -1.602e-02  1.132e-03 -14.154  < 2e-16 ***
## infant.deaths                   9.457e-02  1.314e-02   7.199 1.10e-12 ***
## Alcohol                        -1.213e-01  3.868e-02  -3.135  0.00176 **
## percentage.expenditure          3.858e-04  6.793e-05   5.680 1.71e-08 ***
## Hepatitis.B                    -1.036e-02  5.182e-03  -1.999  0.04587 *
## BMI                             3.458e-02  7.012e-03   4.932 9.37e-07 ***
## under.five.deaths              -7.137e-02  9.792e-03  -7.289 5.84e-13 ***
## Polio                           1.213e-02  6.127e-03   1.980  0.04797 *
## Diphtheria                      1.588e-02  7.160e-03   2.217  0.02680 *
## HIV.AIDS                       -4.370e-01  2.139e-02 -20.434  < 2e-16 ***
## thinness.5.9.years             -6.513e-02  3.175e-02  -2.052  0.04043 *
## Income.composition.of.resources  1.050e+01  1.009e+00  10.411  < 2e-16 ***
## Schooling                       8.517e-01  6.916e-02  12.314  < 2e-16 ***
## Developing                     -1.162e+00  4.045e-01  -2.871  0.00416 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.571 on 1139 degrees of freedom
## Multiple R-squared:  0.8348, Adjusted R-squared:  0.8328
## F-statistic: 411.1 on 14 and 1139 DF,  p-value: < 2.2e-16
```

```
shapiro.test(lmod_AIC_B$residuals) # less than .05 so it is normal distribute.
```

```
##
##  Shapiro-Wilk normality test
##
## data:  lmod_AIC_B$residuals
## W = 0.99419, p-value = 0.0001846
```

```
dwtest(lmod_AIC_B) # value is close to 2.0, so there is no autocorrelation detected.
```

```
##
##  Durbin-Watson test
##
## data:  lmod_AIC_B
## DW = 2.0495, p-value = 0.801
## alternative hypothesis: true autocorrelation is greater than 0
```

```
bptest(lmod_AIC_B) # p-value is less than 0.05, we reject null hypothesis,
```

```
##
##  studentized Breusch-Pagan test
##
## data:  lmod_AIC_B
## BP = 119.67, df = 14, p-value < 2.2e-16
```

```
#no heteroscedasticity in model.
vif(lmod_AIC_B) # infant.deaths, and under.five.deaths are greater than 5.
```

```
##                  Adult.Mortality                    infant.deaths
##                         1.808486                       199.139250
##                          Alcohol          percentage.expenditure
##                         2.242487                         1.418817
##                     Hepatitis.B                              BMI
##                         1.651012                         1.742053
##                under.five.deaths                           Polio
##                       199.915027                         1.701046
##                       Diphtheria                         HIV.AIDS
##                         2.041567                         1.477832
##               thinness.5.9.years Income.composition.of.resources
##                         1.892364                         3.040356
##                        Schooling                       Developing
##                         3.531003                         1.860123
```

```
#severe correlation between these two and other predictors, the coefficient
#estimates and p-values in the regression output are likely unreliable.
```

BIC Selection

```
set.seed(0)
fit_null<-lm(Life.expectancy~1,data_tr)
step(fit_null, scope = list(lower = fit_null, upper = model), direction = "both",
criterion = "BIC", k = log(n))
```

```
## Start:  AIC=5007.43
## Life.expectancy ~ 1
##
##                                   Df Sum of Sq   RSS    AIC
## + Schooling                        1     46348 41563 4150.0
## + Income.composition.of.resources  1     46324 41586 4150.7
## + Adult.Mortality                  1     42969 44941 4240.2
## + HIV.AIDS                         1     30508 57403 4522.6
## + BMI                              1     24795 63116 4632.1
## + thinness.5.9.years               1     20496 67415 4708.1
## + thinness..1.19.years             1     20454 67456 4708.9
## + Developing                       1     17741 70169 4754.4
## + GDP                              1     16988 70923 4766.7
## + percentage.expenditure           1     14667 73244 4803.8
## + Alcohol                          1     14322 73589 4809.3
## + Polio                            1      9706 78205 4879.5
## + Diphtheria                       1      9526 78385 4882.1
## + under.five.deaths                1      3146 84765 4972.4
## + Hepatitis.B                      1      2772 85139 4977.5
## + infant.deaths                    1      2460 85450 4981.7
## + Total.expenditure                1      1948 85962 4988.6
## <none>                                         87911 5007.4
## + Measles                          1       276 87635 5010.9
## + Population                       1        38 87873 5014.0
```

```
##
## Step:  AIC=4150.01
## Life.expectancy ~ Schooling
##
##                                  Df Sum of Sq   RSS    AIC
## + HIV.AIDS                        1     17966 23597 3503.8
## + Adult.Mortality                 1     16736 24827 3562.4
## + Income.composition.of.resources  1      5400 36164 3996.5
## + BMI                             1      2063 39500 4098.3
## + thinness.5.9.years              1      1844 39720 4104.7
## + thinness..1.19.years            1      1437 40126 4116.5
## + GDP                             1      1100 40463 4126.1
## + percentage.expenditure          1      1046 40517 4127.7
## + Polio                           1       776 40787 4135.3
## + Diphtheria                      1       644 40919 4139.1
## + Developing                      1       555 41008 4141.5
## + Alcohol                         1       355 41208 4147.2
## <none>                                        41563 4150.0
## + Hepatitis.B                     1        75 41488 4155.0
## + Measles                         1        38 41525 4156.0
## + under.five.deaths               1        33 41530 4156.1
## + Total.expenditure               1        25 41538 4156.4
## + Population                      1         8 41555 4156.8
## + infant.deaths                   1         2 41561 4157.0
## - Schooling                       1     46348 87911 5007.4
##
## Step:  AIC=3503.81
## Life.expectancy ~ Schooling + HIV.AIDS
##
##                                  Df Sum of Sq   RSS    AIC
## + Adult.Mortality                 1      4770 18827 3250.3
## + Income.composition.of.resources  1      3110 20487 3347.7
## + GDP                             1      1017 22581 3460.0
## + percentage.expenditure          1       992 22605 3461.3
## + BMI                             1       984 22613 3461.7
## + thinness.5.9.years              1       641 22956 3479.1
## + thinness..1.19.years            1       500 23097 3486.1
## + Diphtheria                      1       486 23111 3486.8
## + Polio                           1       452 23146 3488.6
## + Developing                      1       395 23202 3491.4
## <none>                                        23597 3503.8
## + under.five.deaths               1        98 23499 3506.0
## + Total.expenditure               1        90 23507 3506.4
## + infant.deaths                   1        47 23550 3508.5
## + Hepatitis.B                     1        21 23577 3509.9
## + Measles                         1         8 23590 3510.5
## + Population                      1         5 23592 3510.6
## + Alcohol                         1         1 23596 3510.8
## - HIV.AIDS                        1     17966 41563 4150.0
## - Schooling                       1     33805 57403 4522.6
##
## Step:  AIC=3250.26
## Life.expectancy ~ Schooling + HIV.AIDS + Adult.Mortality
##
```

```
##                                   Df Sum of Sq   RSS    AIC
## + Income.composition.of.resources  1    2088.5 16739 3121.6
## + GDP                              1     725.8 18102 3211.9
## + percentage.expenditure           1     704.4 18123 3213.3
## + BMI                              1     623.1 18204 3218.5
## + thinness.5.9.years               1     428.3 18399 3230.8
## + thinness..1.19.years             1     388.2 18439 3233.3
## + Diphtheria                       1     357.2 18470 3235.2
## + Polio                            1     285.0 18542 3239.7
## + Developing                       1     231.8 18596 3243.0
## <none>                                         18827 3250.3
## + under.five.deaths                1     105.0 18722 3250.9
## + infant.deaths                    1      63.3 18764 3253.4
## + Total.expenditure                1      49.4 18778 3254.3
## + Hepatitis.B                      1      17.6 18810 3256.2
## + Alcohol                          1      15.4 18812 3256.4
## + Population                       1       5.1 18822 3257.0
## + Measles                          1       2.9 18824 3257.1
## - Adult.Mortality                  1    4769.9 23597 3503.8
## - HIV.AIDS                         1    5999.7 24827 3562.4
## - Schooling                        1   20937.3 39765 4106.0
##
## Step:  AIC=3121.63
## Life.expectancy ~ Schooling + HIV.AIDS + Adult.Mortality + Income.composition.of.resources
##
##                                   Df Sum of Sq   RSS    AIC
## + percentage.expenditure           1     459.1 16280 3096.6
## + GDP                              1     437.7 16301 3098.1
## + BMI                              1     425.0 16314 3099.0
## + thinness.5.9.years               1     249.5 16489 3111.4
## + thinness..1.19.years             1     206.5 16532 3114.4
## + Diphtheria                       1     194.5 16544 3115.2
## + Polio                            1     169.1 16570 3117.0
## + under.five.deaths                1     157.3 16582 3117.8
## + Developing                       1     124.6 16614 3120.1
## + infant.deaths                    1     109.6 16629 3121.1
## <none>                                         16739 3121.6
## + Total.expenditure                1      44.7 16694 3125.6
## + Alcohol                          1      29.1 16710 3126.7
## + Population                       1      14.7 16724 3127.7
## + Hepatitis.B                      1       7.9 16731 3128.1
## + Measles                          1       0.1 16739 3128.7
## - Income.composition.of.resources  1    2088.5 18827 3250.3
## - Adult.Mortality                  1    3748.0 20487 3347.7
## - Schooling                        1    3916.8 20656 3357.2
## - HIV.AIDS                         1    5740.0 22479 3454.8
##
## Step:  AIC=3096.59
## Life.expectancy ~ Schooling + HIV.AIDS + Adult.Mortality + Income.composition.of.resources +
##     percentage.expenditure
##
##                                   Df Sum of Sq   RSS    AIC
## + BMI                              1     435.4 15844 3072.4
## + thinness.5.9.years               1     217.3 16062 3088.1
```

```
## + Diphtheria                       1     212.4 16067 3088.5
## + Polio                            1     193.5 16086 3089.8
## + thinness..1.19.years             1     185.3 16094 3090.4
## + under.five.deaths                1     158.8 16121 3092.3
## + infant.deaths                    1     108.4 16171 3095.9
## <none>                                         16280 3096.6
## + Alcohol                          1      96.8 16183 3096.8
## + Total.expenditure                1      24.8 16255 3101.9
## + Hepatitis.B                      1      22.7 16257 3102.0
## + Developing                       1      20.2 16260 3102.2
## + Population                       1      14.2 16266 3102.6
## + GDP                              1       2.4 16277 3103.5
## + Measles                          1       0.1 16280 3103.6
## - percentage.expenditure           1     459.1 16739 3121.6
## - Income.composition.of.resources  1    1843.1 18123 3213.3
## - Schooling                        1    3328.1 19608 3304.2
## - Adult.Mortality                  1    3594.7 19875 3319.8
## - HIV.AIDS                         1    5854.4 22134 3444.0
##
## Step:  AIC=3072.35
## Life.expectancy ~ Schooling + HIV.AIDS + Adult.Mortality + Income.composition.of.resources +
##     percentage.expenditure + BMI
##
##                                   Df Sum of Sq   RSS    AIC
## + Diphtheria                       1     239.9 15604 3061.8
## + Polio                            1     207.0 15637 3064.2
## + Alcohol                          1     118.1 15726 3070.8
## <none>                                         15844 3072.4
## + under.five.deaths                1      92.2 15752 3072.7
## + thinness.5.9.years               1      56.2 15788 3075.3
## + infant.deaths                    1      53.9 15790 3075.5
## + thinness..1.19.years             1      46.1 15798 3076.0
## + Hepatitis.B                      1      20.5 15824 3077.9
## + Developing                       1      18.5 15826 3078.1
## + Measles                          1       8.8 15836 3078.8
## + Total.expenditure                1       8.8 15836 3078.8
## + Population                       1       4.1 15840 3079.1
## + GDP                              1       1.7 15843 3079.3
## - BMI                              1     435.4 16280 3096.6
## - percentage.expenditure           1     469.6 16314 3099.0
## - Income.composition.of.resources  1    1655.0 17499 3179.9
## - Schooling                        1    2429.6 18274 3229.9
## - Adult.Mortality                  1    3376.7 19221 3288.2
## - HIV.AIDS                         1    5727.9 21572 3421.4
##
## Step:  AIC=3061.8
## Life.expectancy ~ Schooling + HIV.AIDS + Adult.Mortality + Income.composition.of.resources +
##     percentage.expenditure + BMI + Diphtheria
##
##                                   Df Sum of Sq   RSS    AIC
## + Alcohol                          1     132.3 15472 3059.0
## <none>                                         15604 3061.8
## + under.five.deaths                1      56.1 15548 3064.7
## + Polio                            1      50.5 15554 3065.1
```

```
## + thinness.5.9.years               1      46.3 15558 3065.4
## + thinness..1.19.years             1      38.8 15566 3066.0
## + infant.deaths                    1      29.2 15575 3066.7
## + Hepatitis.B                      1      24.9 15580 3067.0
## + Developing                       1      15.6 15589 3067.7
## + Measles                          1      11.4 15593 3068.0
## + Total.expenditure                1       3.2 15601 3068.6
## + Population                       1       2.3 15602 3068.7
## + GDP                              1       1.3 15603 3068.8
## - Diphtheria                       1     239.9 15844 3072.4
## - BMI                              1     462.9 16067 3088.5
## - percentage.expenditure           1     489.1 16094 3090.4
## - Income.composition.of.resources  1    1490.0 17095 3160.0
## - Schooling                        1    2186.1 17791 3206.1
## - Adult.Mortality                  1    3312.8 18917 3276.9
## - HIV.AIDS                         1    5743.2 21348 3416.4
##
## Step:  AIC=3059.02
## Life.expectancy ~ Schooling + HIV.AIDS + Adult.Mortality + Income.composition.of.resources +
##     percentage.expenditure + BMI + Diphtheria + Alcohol
##
##                                   Df Sum of Sq   RSS    AIC
## <none>                                         15472 3059.0
## + Developing                       1      83.5 15389 3059.8
## + thinness.5.9.years               1      66.5 15406 3061.1
## + thinness..1.19.years             1      58.4 15414 3061.7
## - Alcohol                          1     132.3 15604 3061.8
## + Polio                            1      52.8 15419 3062.1
## + under.five.deaths                1      49.6 15423 3062.4
## + Hepatitis.B                      1      27.6 15445 3064.0
## + infant.deaths                    1      26.0 15446 3064.1
## + Measles                          1      12.8 15459 3065.1
## + Total.expenditure                1       4.9 15467 3065.7
## + Population                       1       2.7 15470 3065.9
## + GDP                              1       2.4 15470 3065.9
## - Diphtheria                       1     254.1 15726 3070.8
## - BMI                              1     487.0 15959 3087.7
## - percentage.expenditure           1     574.6 16047 3094.1
## - Income.composition.of.resources  1    1600.0 17072 3165.5
## - Schooling                        1    2309.9 17782 3212.5
## - Adult.Mortality                  1    3102.7 18575 3262.9
## - HIV.AIDS                         1    5571.4 21044 3406.9


##
## Call:
## lm(formula = Life.expectancy ~ Schooling + HIV.AIDS + Adult.Mortality +
##     Income.composition.of.resources + percentage.expenditure +
##     BMI + Diphtheria + Alcohol, data = data_tr)
##
## Coefficients:
##                       (Intercept)                         Schooling
##                        51.6253207                         0.9161955
##                          HIV.AIDS                    Adult.Mortality
##                        -0.4441776                        -0.0174209
```

```
## Income.composition.of.resources           percentage.expenditure
##                       11.1794749                       0.0004363
##                              BMI                       Diphtheria
##                        0.0401836                       0.0240417
##                          Alcohol
##                       -0.1124538
```

```
lmod_BIC_BO<-lm(Life.expectancy ~ Schooling + HIV.AIDS + Adult.Mortality +
                  Income.composition.of.resources +
                  percentage.expenditure + BMI + Diphtheria + Alcohol,data_tr) # BIC selected model
sum_BIC_BO<-summary(lmod_BIC_BO)
sum_BIC_BO
```

```
##
## Call:
## lm(formula = Life.expectancy ~ Schooling + HIV.AIDS + Adult.Mortality +
##     Income.composition.of.resources + percentage.expenditure +
##     BMI + Diphtheria + Alcohol, data = data_tr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -12.7365  -2.1572   0.0879   2.3716  12.3880
##
## Coefficients:
##                                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     51.6253207  0.7516596  68.682  < 2e-16 ***
## Schooling                        0.9161955  0.0700758  13.074  < 2e-16 ***
## HIV.AIDS                        -0.4441776  0.0218750 -20.305  < 2e-16 ***
## Adult.Mortality                 -0.0174209  0.0011497 -15.153  < 2e-16 ***
## Income.composition.of.resources 11.1794749  1.0273773  10.882  < 2e-16 ***
## percentage.expenditure           0.0004363  0.0000669   6.521 1.05e-10 ***
## BMI                              0.0401836  0.0066937   6.003 2.59e-09 ***
## Diphtheria                       0.0240417  0.0055439   4.337 1.57e-05 ***
## Alcohol                         -0.1124538  0.0359347  -3.129   0.0018 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.676 on 1145 degrees of freedom
## Multiple R-squared:  0.824,  Adjusted R-squared:  0.8228
## F-statistic: 670.1 on 8 and 1145 DF,  p-value: < 2.2e-16
```

```
shapiro.test(sum_BIC_BO$residuals) # less than .05 so it is normal distribute.
```

```
##
##  Shapiro-Wilk normality test
##
## data:  sum_BIC_BO$residuals
## W = 0.99204, p-value = 7.021e-06
```

```
dwtest(sum_BIC_BO) # value is close to 2.0, so there is no autocorrelation detected.
```

```
##
```

```
##  Durbin-Watson test
##
## data:  sum_BIC_BO
## DW = 2.0267, p-value = 0.6755
## alternative hypothesis: true autocorrelation is greater than 0
```

```
bptest(sum_BIC_BO) # p-value is less than 0.05, we reject null hypothesis,
```

```
##
##  studentized Breusch-Pagan test
##
## data:  sum_BIC_BO
## BP = 122.44, df = 8, p-value < 2.2e-16
```

```
#no heteroscedasticity in model.
vif(lmod_BIC_BO) #All value between 1 and 5 indicates moderate correlation
```

```
##                      Schooling                       HIV.AIDS
##                       3.420966                       1.458970
##                Adult.Mortality Income.composition.of.resources
##                       1.761482                       2.977498
##          percentage.expenditure                            BMI
##                       1.298893                       1.498168
##                     Diphtheria                        Alcohol
##                       1.155086                       1.826288
```

```
#between a given predictor variable and other predictor variables in the model
```

#lasso

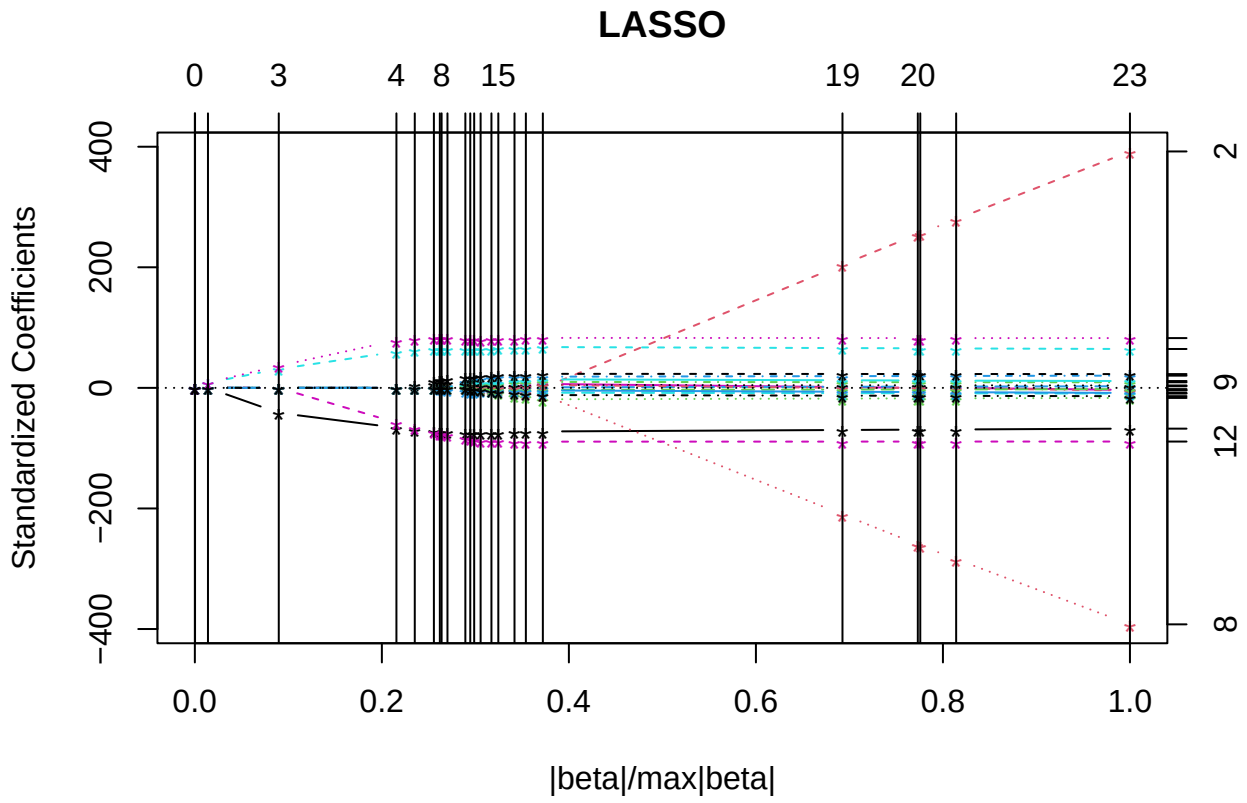
```
set.seed(0)
x_tr  = as.matrix(data_tr[,c(2:ncol(data_tr))])
y_tr  = as.matrix(data_tr[,1])

lar1 <-lars(x_tr,y_tr,type = "lasso")
lar1
```

```
##
## Call:
## lars(x = x_tr, y = y_tr, type = "lasso")
## R-squared: 0.835
## Sequence of LASSO moves:
##      Schooling Income.composition.of.resources Adult.Mortality HIV.AIDS BMI GDP
## Var         18                             17               1       12   7  13
## Step         1                              2               3        4   5   6
##      thinness.5.9.years percentage.expenditure Diphtheria Polio Developing
## Var                  16                      4         11     9         19
## Step                  7                      8          9    10         11
##      thinness..1.19.years under.five.deaths Alcohol Measles Hepatitis.B
## Var                    15                8       3       6           5
## Step                   12               13      14      15          16
```

```
##      Population Total.expenditure infant.deaths Population Population Measles
## Var          14                10             2        -14         14      -6
## Step         17                18            19         20         21      22
##      Measles
## Var        6
## Step      23
```

```
plot(lar1)
```




```
sum1<-summary(lar1)
sum1
```

```
## LARS/LASSO
## Call: lars(x = x_tr, y = y_tr, type = "lasso")
##    Df   Rss       Cp
## 0   1 87911 5722.608
## 1   2 87800 5715.949
## 2   3 80822 5172.240
## 3   4 49795 2747.932
## 4   5 21174  511.822
## 5   6 19075  349.630
## 6   7 17470  226.175
## 7   8 17084  197.984
## 8   9 16979  191.740
## 9  10 16657  168.563
```

```
## 10 11 15922  113.129
## 11 12 15785  104.360
## 12 13 15694   99.237
## 13 14 15579   92.247
## 14 15 15439   83.307
## 15 16 15368   79.803
## 16 17 15242   71.888
## 17 18 15179   69.022
## 18 19 15122   66.523
## 19 20 14644   31.127
## 20 19 14577   23.924
## 21 20 14575   25.786
## 22 19 14552   21.952
## 23 20 14501   20.000
```

```
lar1$Cp[which.min(lar1$Cp)]
```

```
## 23
## 20
```

```
lar1$beta
```

```
##    Adult.Mortality infant.deaths     Alcohol percentage.expenditure
## 0       0.00000000    0.00000000  0.00000000           0.000000e+00
## 1       0.00000000    0.00000000  0.00000000           0.000000e+00
## 2       0.00000000    0.00000000  0.00000000           0.000000e+00
## 3      -0.00977413    0.00000000  0.00000000           0.000000e+00
## 4      -0.01555856    0.00000000  0.00000000           0.000000e+00
## 5      -0.01625819    0.00000000  0.00000000           0.000000e+00
## 6      -0.01678625    0.00000000  0.00000000           0.000000e+00
## 7      -0.01693850    0.00000000  0.00000000           0.000000e+00
## 8      -0.01698179    0.00000000  0.00000000           1.263759e-05
## 9      -0.01708372    0.00000000  0.00000000           5.010667e-05
## 10     -0.01734371    0.00000000  0.00000000           1.683132e-04
## 11     -0.01740584    0.00000000  0.00000000           1.979189e-04
## 12     -0.01745870    0.00000000  0.00000000           2.213531e-04
## 13     -0.01754419    0.00000000  0.00000000           2.547775e-04
## 14     -0.01742236    0.00000000 -0.03848159           2.752585e-04
## 15     -0.01735656    0.00000000 -0.05763878           2.868010e-04
## 16     -0.01721769    0.00000000 -0.09127957           2.946223e-04
## 17     -0.01714550    0.00000000 -0.10985228           2.966879e-04
## 18     -0.01703610    0.00000000 -0.13670145           2.967200e-04
## 19     -0.01646289    0.05327328 -0.12836635           3.109836e-04
## 20     -0.01632439    0.06640825 -0.12625739           3.130763e-04
## 21     -0.01631982    0.06683012 -0.12619202           3.132060e-04
## 22     -0.01625072    0.07292281 -0.12541442           3.156637e-04
## 23     -0.01593616    0.10222767 -0.12070699           3.240908e-04
##     Hepatitis.B       Measles          BMI under.five.deaths       Polio
## 0   0.000000000  0.000000e+00 0.000000000      0.0000000000 0.000000000
## 1   0.000000000  0.000000e+00 0.000000000      0.0000000000 0.000000000
## 2   0.000000000  0.000000e+00 0.000000000      0.0000000000 0.000000000
## 3   0.000000000  0.000000e+00 0.000000000      0.0000000000 0.000000000
## 4   0.000000000  0.000000e+00 0.000000000      0.0000000000 0.000000000
```

```
## 5   0.000000000  0.000000e+00 0.009226295      0.0000000000 0.000000000
## 6   0.000000000  0.000000e+00 0.017592735      0.0000000000 0.000000000
## 7   0.000000000  0.000000e+00 0.019409866      0.0000000000 0.000000000
## 8   0.000000000  0.000000e+00 0.019949278      0.0000000000 0.000000000
## 9   0.000000000  0.000000e+00 0.021655012      0.0000000000 0.000000000
## 10  0.000000000  0.000000e+00 0.026638834      0.0000000000 0.004705920
## 11  0.000000000  0.000000e+00 0.027970276      0.0000000000 0.005949128
## 12  0.000000000  0.000000e+00 0.029006007      0.0000000000 0.006964178
## 13  0.000000000  0.000000e+00 0.030508272     -0.0003299328 0.008273306
## 14  0.000000000  0.000000e+00 0.031388973     -0.0004451650 0.009131204
## 15  0.000000000  3.892713e-06 0.032029851     -0.0006322507 0.009512640
## 16 -0.003821677  1.020530e-05 0.033323547     -0.0010250180 0.011008049
## 17 -0.005932449  1.387622e-05 0.033892430     -0.0015209059 0.011790546
## 18 -0.009032651  1.930010e-05 0.034618761     -0.0022343171 0.012887703
## 19 -0.009891428  3.833197e-06 0.034301700     -0.0407117606 0.012541709
## 20 -0.010098465  1.237070e-07 0.034132101     -0.0503661502 0.012427408
## 21 -0.010105321  0.000000e+00 0.034130667     -0.0506688800 0.012425010
## 22 -0.010208786  0.000000e+00 0.034202682     -0.0551016832 0.012372422
## 23 -0.010680583 -1.037980e-05 0.034010342     -0.0760698238 0.012223766
##    Total.expenditure  Diphtheria   HIV.AIDS          GDP    Population
## 0         0.00000000 0.000000000  0.0000000 0.000000e+00  0.000000e+00
## 1         0.00000000 0.000000000  0.0000000 0.000000e+00  0.000000e+00
## 2         0.00000000 0.000000000  0.0000000 0.000000e+00  0.000000e+00
## 3         0.00000000 0.000000000  0.0000000 0.000000e+00  0.000000e+00
## 4         0.00000000 0.000000000 -0.2844093 0.000000e+00  0.000000e+00
## 5         0.00000000 0.000000000 -0.3237722 0.000000e+00  0.000000e+00
## 6         0.00000000 0.000000000 -0.3603766 1.753426e-05  0.000000e+00
## 7         0.00000000 0.000000000 -0.3709481 2.262704e-05  0.000000e+00
## 8         0.00000000 0.000000000 -0.3740586 2.219802e-05  0.000000e+00
## 9         0.00000000 0.002753284 -0.3828233 2.079696e-05  0.000000e+00
## 10        0.00000000 0.008042292 -0.4082185 1.547943e-05  0.000000e+00
## 11        0.00000000 0.009433611 -0.4149946 1.372975e-05  0.000000e+00
## 12        0.00000000 0.010526295 -0.4203554 1.236560e-05  0.000000e+00
## 13        0.00000000 0.011913307 -0.4287123 1.053257e-05  0.000000e+00
## 14        0.00000000 0.012860711 -0.4313347 1.002596e-05  0.000000e+00
## 15        0.00000000 0.013283016 -0.4326789 9.641978e-06  0.000000e+00
## 16        0.00000000 0.016199077 -0.4354363 1.007761e-05  0.000000e+00
## 17        0.00000000 0.017649942 -0.4368068 1.068202e-05  7.677794e-10
## 18        0.01188347 0.019705278 -0.4393990 1.185902e-05  1.876286e-09
## 19        0.02321738 0.017723575 -0.4389777 1.081630e-05  0.000000e+00
## 20        0.02623053 0.017133681 -0.4387891 1.078337e-05  0.000000e+00
## 21        0.02631770 0.017119181 -0.4387868 1.077247e-05 -2.030679e-11
## 22        0.02799718 0.016890803 -0.4388035 1.056532e-05 -3.110455e-10
## 23        0.03363246 0.015902530 -0.4385905 9.858124e-06 -1.724175e-09
##    thinness..1.19.years thinness.5.9.years Income.composition.of.resources
## 0           0.000000000        0.000000000                          0.000000
## 1           0.000000000        0.000000000                          0.000000
## 2           0.000000000        0.000000000                          1.361789
## 3           0.000000000        0.000000000                          5.065665
## 4           0.000000000        0.000000000                          9.684905
## 5           0.000000000        0.000000000                         10.208501
## 6           0.000000000        0.000000000                         10.447586
## 7           0.000000000       -0.007647153                         10.500950
## 8           0.000000000       -0.009862181                         10.519472
```

```
## 9           0.000000000       -0.015354612                       10.514569
## 10          0.000000000       -0.031216859                       10.477604
## 11          0.000000000       -0.035232076                       10.460145
## 12         -0.003686124       -0.035327440                       10.442942
## 13         -0.006269579       -0.032955248                       10.467012
## 14         -0.011293011       -0.032821529                       10.625859
## 15         -0.013575342       -0.032039669                       10.699948
## 16         -0.016194088       -0.030454393                       10.810363
## 17         -0.018745256       -0.029476938                       10.872040
## 18         -0.022459133       -0.027415357                       10.966279
## 19         -0.017743114       -0.041434424                       10.694726
## 20         -0.017242693       -0.044819941                       10.628122
## 21         -0.017197546       -0.044931794                       10.625967
## 22         -0.016470887       -0.046195684                       10.593423
## 23         -0.013409425       -0.054316961                       10.445188
##      Schooling  Developing
## 0  0.000000000  0.00000000
## 1  0.002652275  0.00000000
## 2  0.089308465  0.00000000
## 3  0.375602843  0.00000000
## 4  0.811537097  0.00000000
## 5  0.847559456  0.00000000
## 6  0.858130544  0.00000000
## 7  0.859416124  0.00000000
## 8  0.859926272  0.00000000
## 9  0.857069435  0.00000000
## 10 0.845149516  0.00000000
## 11 0.839532849 -0.06585915
## 12 0.834635032 -0.11855471
## 13 0.825369173 -0.20029570
## 14 0.835606260 -0.40270701
## 15 0.840750630 -0.50663931
## 16 0.849590748 -0.70995595
## 17 0.851879851 -0.82708722
## 18 0.854237023 -0.99228196
## 19 0.852547597 -1.07124972
## 20 0.850537862 -1.09326016
## 21 0.850543248 -1.09385558
## 22 0.850644785 -1.10466522
## 23 0.850995134 -1.14381554
## attr(,"scaled:scale")
##  [1] 4.243627e+03 3.835913e+03 1.382431e+02 6.262055e+04 8.853754e+02
##  [6] 3.373326e+05 6.721794e+02 5.156200e+03 7.601753e+02 7.866082e+01
## [11] 7.126279e+02 2.029775e+02 4.042208e+05 2.542815e+09 1.533606e+02
## [16] 1.547321e+02 6.174032e+00 9.702399e+01 1.203980e+01
```

```
lmod_la<-glm(Life.expectancy ~.,family='gaussian',data_tr)
sum_la<-summary(lmod_la)
sum_la
```

```
##
## Call:
## glm(formula = Life.expectancy ~ ., family = "gaussian", data = data_tr)
##
```

```
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -12.704   -2.164    0.010    2.225   11.494
##
## Coefficients:
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     5.461e+01  1.021e+00  53.507  < 2e-16 ***
## Adult.Mortality                -1.594e-02  1.137e-03 -14.021  < 2e-16 ***
## infant.deaths                   1.022e-01  1.487e-02   6.875 1.02e-11 ***
## Alcohol                        -1.207e-01  3.887e-02  -3.105  0.00195 **
## percentage.expenditure          3.241e-04  2.169e-04   1.494  0.13533
## Hepatitis.B                    -1.068e-02  5.205e-03  -2.052  0.04038 *
## Measles                        -1.038e-05  1.317e-05  -0.788  0.43066
## BMI                             3.401e-02  7.083e-03   4.802 1.78e-06 ***
## under.five.deaths              -7.607e-02  1.071e-02  -7.102 2.16e-12 ***
## Polio                           1.222e-02  6.156e-03   1.986  0.04731 *
## Total.expenditure               3.363e-02  4.801e-02   0.700  0.48377
## Diphtheria                      1.590e-02  7.184e-03   2.214  0.02705 *
## HIV.AIDS                       -4.386e-01  2.158e-02 -20.325  < 2e-16 ***
## GDP                             9.858e-06  3.440e-05   0.287  0.77450
## Population                     -1.724e-09  2.116e-09  -0.815  0.41542
## thinness..1.19.years           -1.341e-02  5.635e-02  -0.238  0.81193
## thinness.5.9.years             -5.432e-02  5.579e-02  -0.974  0.33043
## Income.composition.of.resources  1.045e+01  1.015e+00  10.293  < 2e-16 ***
## Schooling                       8.510e-01  6.999e-02  12.159  < 2e-16 ***
## Developing                     -1.144e+00  4.059e-01  -2.818  0.00491 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 12.78774)
##
##     Null deviance: 87911  on 1153  degrees of freedom
## Residual deviance: 14501  on 1134  degrees of freedom
## AIC: 6237.7
##
## Number of Fisher Scoring iterations: 2
```

```
with(sum_la, 1 - deviance/null.deviance) # Adj r square
```

```
## [1] 0.8350451
```

```
shapiro.test(lmod_la$residuals)# less than .05 so it is normal distribute.
```

```
##
##  Shapiro-Wilk normality test
##
## data:  lmod_la$residuals
## W = 0.99402, p-value = 0.0001406
```

```
dwtest(lmod_la) # value is close to 2.0, so there is no autocorrelation detected.
```

```
##
```

```
##  Durbin-Watson test
##
## data:  lmod_la
## DW = 2.0436, p-value = 0.7729
## alternative hypothesis: true autocorrelation is greater than 0
```

```
bptest(lmod_la) # p-value is less than 0.05, we reject null hypothesis, no
```

```
##
##  studentized Breusch-Pagan test
##
## data:  lmod_la
## BP = 125.61, df = 19, p-value < 2.2e-16
```

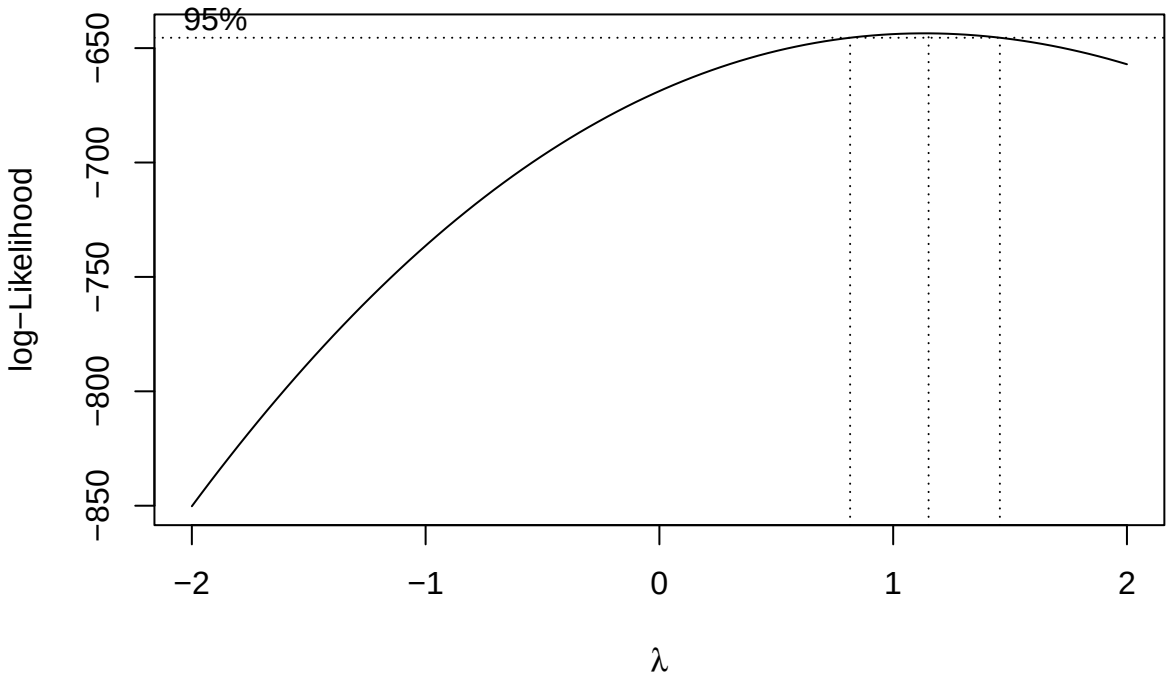
```
#heteroscedasticity in model.
vif(lmod_la) # infant.deaths, under.five.deaths, and GDP are greater than 5.
```

```
##                  Adult.Mortality                     infant.deaths
##                         1.819167                       254.411298
##                          Alcohol           percentage.expenditure
##                         2.258261                        14.421237
##                      Hepatitis.B                          Measles
##                         1.660452                        1.542678
##                              BMI                 under.five.deaths
##                         1.772660                        238.492903
##                             Polio                Total.expenditure
##                         1.712429                          1.115458
##                        Diphtheria                          HIV.AIDS
##                         2.049503                          1.500308
##                               GDP                        Population
##                        15.121553                          2.264707
##             thinness..1.19.years                thinness.5.9.years
##                         5.839108                          5.826642
## Income.composition.of.resources                          Schooling
##                         3.069910                          3.606260
##                       Developing
##                         1.867234
```

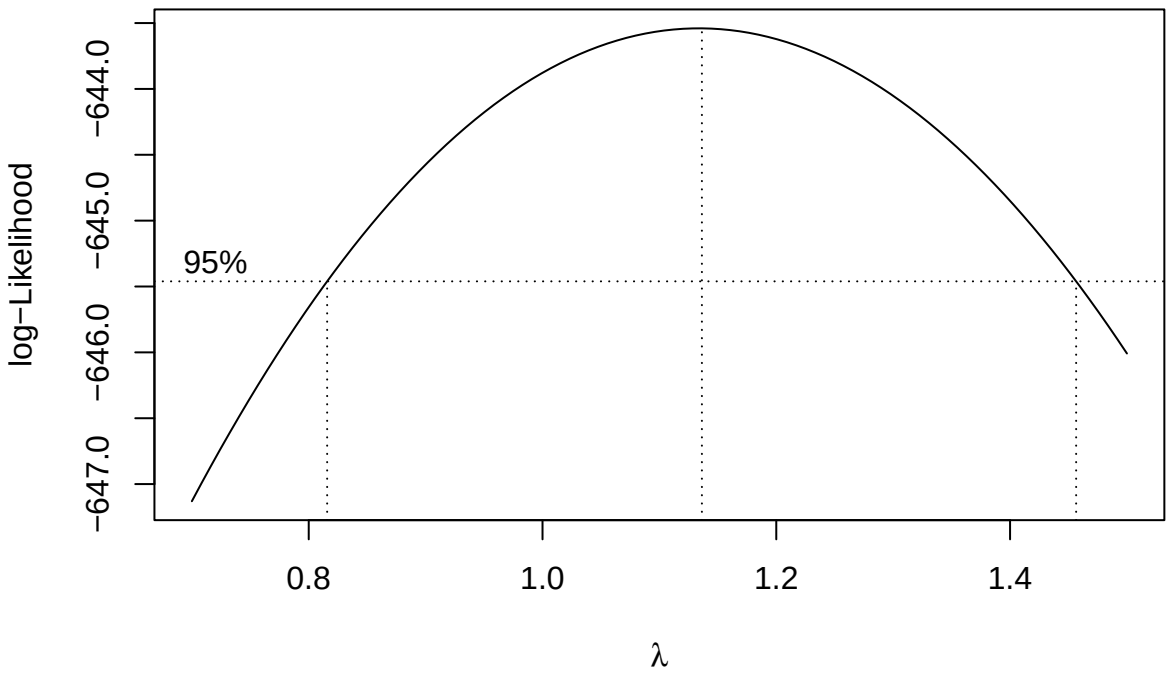
```
#severe correlation between these two and other predictors, the coefficient
#estimates and p-values in the regression output are likely unreliable.
```

Transformation - don't really need transformation.

```
boxcox(model, plotit=T)
```




```
b<-boxcox(model, plotit=T, lambda=seq(0.7, 1.5,by=0.01))
```




```
b
```

```
## $x
##   [1] 0.7000000 0.7080808 0.7161616 0.7242424 0.7323232 0.7404040 0.7484848
##   [8] 0.7565657 0.7646465 0.7727273 0.7808081 0.7888889 0.7969697 0.8050505
##  [15] 0.8131313 0.8212121 0.8292929 0.8373737 0.8454545 0.8535354 0.8616162
##  [22] 0.8696970 0.8777778 0.8858586 0.8939394 0.9020202 0.9101010 0.9181818
##  [29] 0.9262626 0.9343434 0.9424242 0.9505051 0.9585859 0.9666667 0.9747475
##  [36] 0.9828283 0.9909091 0.9989899 1.0070707 1.0151515 1.0232323 1.0313131
##  [43] 1.0393939 1.0474747 1.0555556 1.0636364 1.0717172 1.0797980 1.0878788
##  [50] 1.0959596 1.1040404 1.1121212 1.1202020 1.1282828 1.1363636 1.1444444
##  [57] 1.1525253 1.1606061 1.1686869 1.1767677 1.1848485 1.1929293 1.2010101
##  [64] 1.2090909 1.2171717 1.2252525 1.2333333 1.2414141 1.2494949 1.2575758
##  [71] 1.2656566 1.2737374 1.2818182 1.2898990 1.2979798 1.3060606 1.3141414
##  [78] 1.3222222 1.3303030 1.3383838 1.3464646 1.3545455 1.3626263 1.3707071
##  [85] 1.3787879 1.3868687 1.3949495 1.4030303 1.4111111 1.4191919 1.4272727
##  [92] 1.4353535 1.4434343 1.4515152 1.4595960 1.4676768 1.4757576 1.4838384
##  [99] 1.4919192 1.5000000
##
## $y
##   [1] -647.1302 -646.9966 -646.8655 -646.7370 -646.6111 -646.4877 -646.3669
##   [8] -646.2487 -646.1330 -646.0199 -645.9094 -645.8014 -645.6960 -645.5931
##  [15] -645.4928 -645.3950 -645.2998 -645.2071 -645.1169 -645.0293 -644.9442
##  [22] -644.8617 -644.7816 -644.7041 -644.6291 -644.5567 -644.4867 -644.4193
##  [29] -644.3544 -644.2920 -644.2321 -644.1747 -644.1198 -644.0674 -644.0175
##  [36] -643.9701 -643.9252 -643.8828 -643.8429 -643.8054 -643.7705 -643.7380
```

```
##  [43] -643.7080 -643.6805 -643.6554 -643.6328 -643.6127 -643.5950 -643.5798
##  [50] -643.5671 -643.5568 -643.5490 -643.5436 -643.5407 -643.5402 -643.5422
##  [57] -643.5466 -643.5534 -643.5627 -643.5744 -643.5885 -643.6051 -643.6241
##  [64] -643.6455 -643.6693 -643.6956 -643.7243 -643.7553 -643.7888 -643.8247
##  [71] -643.8630 -643.9037 -643.9468 -643.9923 -644.0402 -644.0905 -644.1432
##  [78] -644.1983 -644.2557 -644.3156 -644.3778 -644.4424 -644.5093 -644.5787
##  [85] -644.6504 -644.7245 -644.8009 -644.8797 -644.9608 -645.0443 -645.1302
##  [92] -645.2184 -645.3090 -645.4019 -645.4972 -645.5948 -645.6947 -645.7970
##  [99] -645.9016 -646.0085
```

```
I=which(b$y==max(b$y))
I
```

```
## [1] 55
```

```
b$x[I]
```

```
## [1] 1.136364
```

```
lmod_trans<-lm(Life.expectancy ^(1.136) ~ Adult.Mortality + infant.deaths + Alcohol +
                 percentage.expenditure + Hepatitis.B + BMI + under.five.deaths +
                 Polio + Diphtheria + HIV.AIDS + thinness.5.9.years +
                 Income.composition.of.resources + Schooling + Developing,
               data = data_tr)
summary(lmod_trans)
```

```
##
## Call:
## lm(formula = Life.expectancy^(1.136) ~ Adult.Mortality + infant.deaths +
##     Alcohol + percentage.expenditure + Hepatitis.B + BMI + under.five.deaths +
##     Polio + Diphtheria + HIV.AIDS + thinness.5.9.years + Income.composition.of.resources +
##     Schooling + Developing, data = data_tr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -24.8488  -4.4612   0.0275   4.5137  23.9967
##
## Coefficients:
##                                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     94.2283971  1.9688465  47.860  < 2e-16 ***
## Adult.Mortality                 -0.0321801  0.0022856 -14.080  < 2e-16 ***
## infant.deaths                    0.1870637  0.0265329   7.050 3.09e-12 ***
## Alcohol                         -0.2451812  0.0781263  -3.138  0.00174 **
## percentage.expenditure           0.0008019  0.0001372   5.845 6.59e-09 ***
## Hepatitis.B                     -0.0212295  0.0104670  -2.028  0.04277 *
## BMI                              0.0691134  0.0141619   4.880 1.21e-06 ***
## under.five.deaths               -0.1411592  0.0197774  -7.137 1.69e-12 ***
## Polio                            0.0242620  0.0123743   1.961  0.05016 .
## Diphtheria                       0.0320646  0.0144609   2.217  0.02680 *
## HIV.AIDS                        -0.8588569  0.0431957 -19.883  < 2e-16 ***
## thinness.5.9.years              -0.1363722  0.0641206  -2.127  0.03365 *
## Income.composition.of.resources 21.1613696  2.0368972  10.389  < 2e-16 ***
```

```
## Schooling                         1.7195401  0.1396837  12.310  < 2e-16 ***
## Developing                       -2.4605663  0.8170104  -3.012  0.00266 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.212 on 1139 degrees of freedom
## Multiple R-squared:  0.8332, Adjusted R-squared:  0.8312
## F-statistic: 406.5 on 14 and 1139 DF,  p-value: < 2.2e-16
```

```
shapiro.test(lmod_trans$residuals) # less than .05 so it is normal distribute.
```

```
##
##  Shapiro-Wilk normality test
##
## data:  lmod_trans$residuals
## W = 0.9945, p-value = 0.0003119
```

```
dwtest(lmod_la) # value is close to 2.0, so there is no autocorrelation detected.
```

```
##
##  Durbin-Watson test
##
## data:  lmod_la
## DW = 2.0436, p-value = 0.7729
## alternative hypothesis: true autocorrelation is greater than 0
```

```
bptest(lmod_trans) # p-value is less than 0.05, we reject null hypothesis, no
```

```
##
##  studentized Breusch-Pagan test
##
## data:  lmod_trans
## BP = 113.96, df = 14, p-value < 2.2e-16
```

```
#heteroscedasticity in model.
confint(lmod_trans) # get confident interval for lmod_trans
```

```
##                                       2.5 %        97.5 %
## (Intercept)                    9.036542e+01 98.0913701855
## Adult.Mortality               -3.666453e-02 -0.0276956985
## infant.deaths                  1.350047e-01  0.2391225877
## Alcohol                       -3.984688e-01 -0.0918935112
## percentage.expenditure         5.327487e-04  0.0010710952
## Hepatitis.B                   -4.176629e-02 -0.0006926382
## BMI                            4.132710e-02  0.0968997604
## under.five.deaths             -1.799634e-01 -0.1023550065
## Polio                         -1.698764e-05  0.0485409080
## Diphtheria                     3.691657e-03  0.0604375770
## HIV.AIDS                      -9.436090e-01 -0.7741048302
## thinness.5.9.years            -2.621800e-01 -0.0105643922
## Income.composition.of.resources  1.716488e+01 25.1578615569
## Schooling                      1.445474e+00  1.9936063816
## Developing                    -4.063581e+00 -0.8575519313
```

```
vif(lmod_trans) # infant.deaths, and under.five.deaths are greater than 5.
```

```
##                  Adult.Mortality                     infant.deaths
##                         1.808486                       199.139250
##                          Alcohol           percentage.expenditure
##                         2.242487                         1.418817
##                      Hepatitis.B                              BMI
##                         1.651012                         1.742053
##                under.five.deaths                            Polio
##                       199.915027                         1.701046
##                       Diphtheria                         HIV.AIDS
##                         2.041567                         1.477832
##               thinness.5.9.years Income.composition.of.resources
##                         1.892364                         3.040356
##                        Schooling                       Developing
##                         3.531003                         1.860123
```

```
#severe correlation between these two and other predictors, the coefficient
#estimates and p-values in the regression output are likely unreliable.
```

Prediction

```
# Calculate MSE for each model
result<-predict(model,newdata = data_te,interval='prediction') # Prediction
error <- sum((data_te$Life.expectancy - result)^2)
error
```

```
## [1] 69289.42
```

```
result2<-predict(lmod_AIC_B,newdata = data_te,interval='prediction') # Prediction
error2 <- sum((data_te$Life.expectancy - result2)^2)
error2
```

```
## [1] 68964.6
```

```
result3<-predict(lmod_BIC_BO,newdata = data_te,interval='prediction') # Prediction
error3 <- sum((data_te$Life.expectancy - result3)^2)
error3
```

```
## [1] 72927.3
```

```
result4<-predict(lmod_trans,newdata = data_te,interval='prediction') # Prediction
error4 <- sum((data_te$Life.expectancy - result4)^2)
error4
```

```
## [1] 4613126
```

```
result5<-predict(lmod_la,newdata = data_te,interval='prediction') # Prediction
error5 <- sum((data_te$Life.expectancy - result5)^2)
error5
```

```
## [1] 6552.674
```

```
which.min(c(error, error2, error3, error4, error5)) # Check which method provide lowest MSE.
```

```
## [1] 5
```

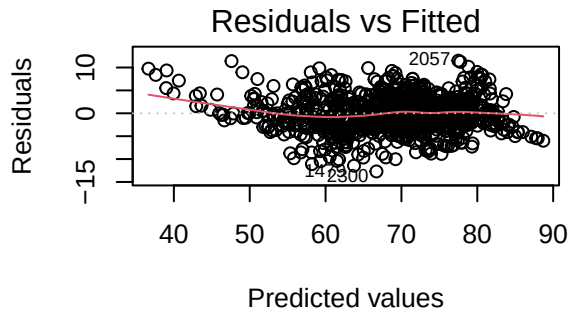
```
# Lasso model has lowest MSE.
x <- model.matrix(lmod_la)
x0 <- apply(x,2,median) # get median characteristics
x0
```

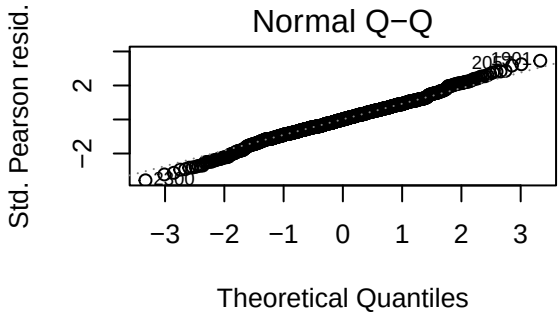
```
##                      (Intercept)                  Adult.Mortality
##                           1.0000                         147.0000
##                     infant.deaths                          Alcohol
##                           3.0000                           3.9550
##           percentage.expenditure                     Hepatitis.B
##                         155.4500                          91.0000
##                          Measles                              BMI
##                          14.0000                          43.5000
##                 under.five.deaths                            Polio
##                           4.0000                          93.0000
##                 Total.expenditure                       Diphtheria
##                           5.8250                          93.0000
##                         HIV.AIDS                              GDP
##                           0.1000                        1677.7636
##                       Population            thinness..1.19.years
##                    1420384.0000                           2.9000
##                thinness.5.9.years Income.composition.of.resources
##                           3.1000                          0.6755
##                        Schooling                      Developing
##                          12.3500                          1.0000
```

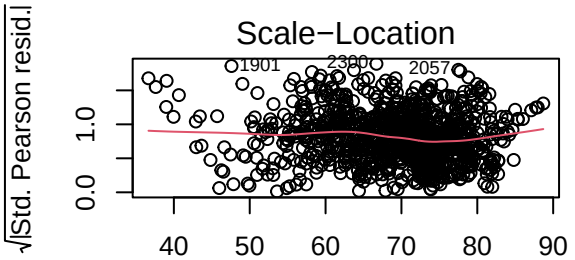
```
pred1 <- predict(lmod_la, newdata = data.frame(t(x0)), interval = "prediction")
sqrt(pred1)
```

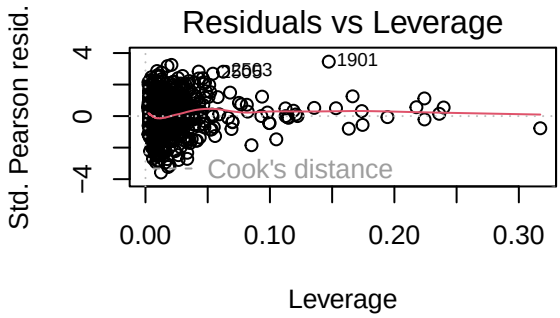
```
##        1
## 8.446604
```

```
par (mfrow = c(2,2))
plot (lmod_la)
```


Residuals vs Fitted
Residuals
Predicted values
2057
2300


Normal Q−Q
Std. Pearson resid.
Theoretical Quantiles


Scale−Location
√|Std. Pearson resid.|
Predicted values
1901
2300
2057


Residuals vs Leverage
Std. Pearson resid.
Leverage
Cook's distance
1901