project

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2023-11-21

(1) Data cleaning

```
rm(list = ls())
gc()
```

```
##          used (Mb) gc trigger (Mb) max used (Mb)
## Ncells 469564 25.1    1011181 54.1   660860 35.3
## Vcells 877861  6.7    8388608 64.0  1800812 13.8
```

```
set.seed(123)
############### (1) Data cleaning ########################################
library(NHANES)
df <- NHANES[NHANES$Age >= 18 & NHANES$Age < 60, ]
# colSums(is.na(df)) / nrow(df)
df <- df[, which(colSums(is.na(df)) / nrow(df) < 0.3)]
# colSums(is.na(df)) / nrow(df)
# df$BPSysAve
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

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

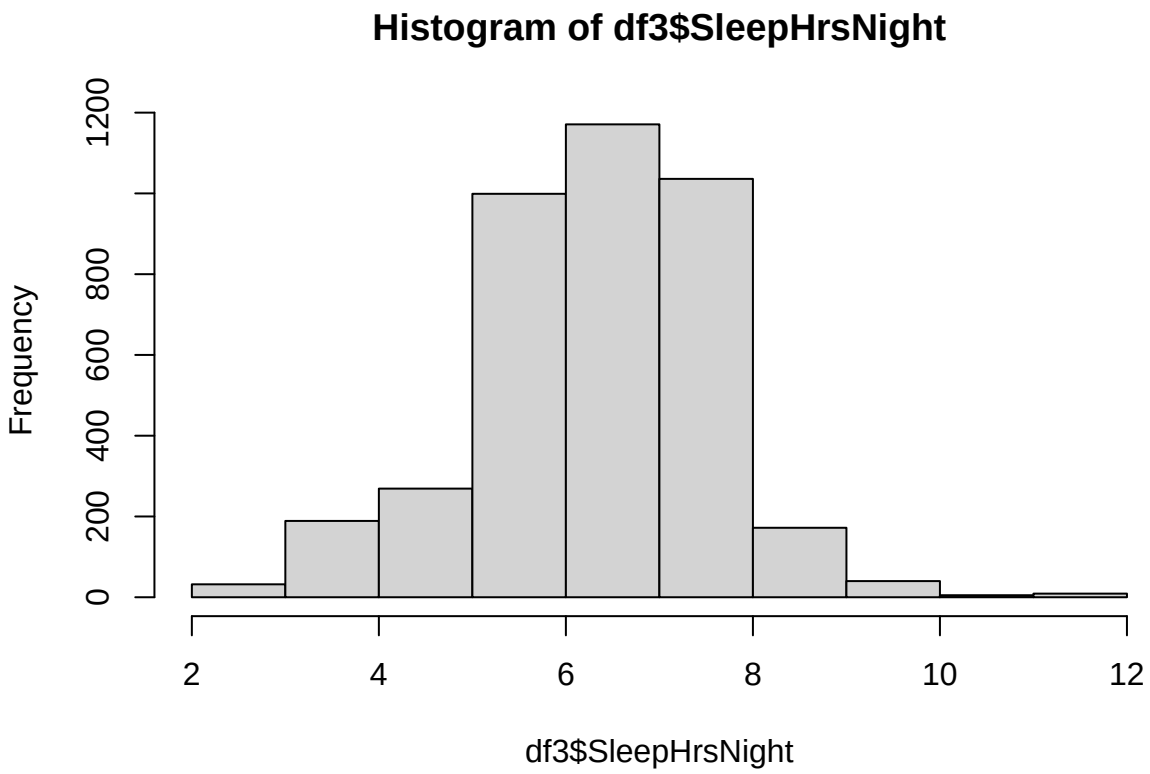
```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
df2 <- df %>% select(
  SleepHrsNight,
  TotChol,
  DirectChol,
  Age,
  Gender,
  Race1,
  BMI,
  BPDiaAve,
  BPSysAve,
  AlcoholYear,
  Poverty,
  HomeRooms,
```

```
  SexNumPartnLife,
  SexNumPartYear,
  DaysMentHlthBad
)

# Hmisc::describe(df2)
df3 <- na.omit(df2)
#df3$SleepHrsNight <- df3$SleepHrsNight * 60
#df3 <- df3[, -which(names(df3) %in% "SleepHrsNight")]
# cor(df3$BPSysAve,df3$BPDiaAve)
psych::describe(df3)
```

```
##                 vars    n   mean    sd median trimmed   mad   min     max
## SleepHrsNight      1 3922   6.83  1.30   7.00    6.90  1.48  2.00   12.00
## TotChol            2 3922   5.08  1.06   5.02    5.03  1.04  1.53   13.65
## DirectChol         3 3922   1.35  0.42   1.29    1.31  0.39  0.39    3.83
## Age                4 3922  39.34 11.63  40.00   39.41 14.83 18.00   59.00
## Gender*            5 3922   1.54  0.50   2.00    1.55  0.00  1.00    2.00
## Race1*             6 3922   3.57  1.04   4.00    3.76  0.00  1.00    5.00
## BMI                7 3922  28.64  6.59  27.50   28.05  6.08 15.02   69.00
## BPDiaAve           8 3922  71.51 11.40  72.00   71.62 10.38  0.00  116.00
## BPSysAve           9 3922 117.72 14.28 116.00  116.85 13.34 78.00  226.00
## AlcoholYear       10 3922  71.91 95.14  24.00   52.26 35.58  0.00  364.00
## Poverty           11 3922   3.01  1.66   3.15    3.08  2.65  0.00    5.00
## HomeRooms         12 3922   6.14  2.29   6.00    6.02  1.48  1.00   13.00
## SexNumPartnLife   13 3922  16.21 61.34   6.00    8.64  5.93  0.00 2000.00
## SexNumPartYear    14 3922   1.38  3.04   1.00    0.99  0.00  0.00   69.00
## DaysMentHlthBad   15 3922   4.41  7.99   0.00    2.34  0.00  0.00   30.00
##                   range  skew kurtosis   se
## SleepHrsNight     10.00 -0.25     0.72 0.02
## TotChol           12.12  0.76     2.22 0.02
## DirectChol         3.44  1.15     2.49 0.01
## Age               41.00 -0.06    -1.18 0.19
## Gender*            1.00 -0.17    -1.97 0.01
## Race1*             4.00 -1.48     1.25 0.02
## BMI               53.98  1.10     2.20 0.11
## BPDiaAve         116.00 -0.30     2.51 0.18
## BPSysAve         148.00  1.08     3.90 0.23
## AlcoholYear      364.00  1.62     1.82 1.52
## Poverty            5.00 -0.15    -1.43 0.03
## HomeRooms         12.00  0.53     0.27 0.04
## SexNumPartnLife 2000.00 17.33   399.45 0.98
## SexNumPartYear    69.00 12.99   222.05 0.05
## DaysMentHlthBad   30.00  2.19     3.89 0.13
```

```
# psych::pairs.panels(df3)
hist(df3$SleepHrsNight)
```




```
# colSums(is.na(df2)) / nrow(df2)
fit0 <-
  lm(SleepHrsNight ~ .,
     data = df3)
#data type
df3$Gender <- ifelse(df3$Gender == "male", 0, 1)
df3 <- df3 %>%
  mutate(
    Race1 = case_when(
      Race1 == 'Black' ~ 1,
      Race1 == 'Hispanic' ~ 2,
      Race1 == 'Mexican' ~ 3,
      Race1 == 'White' ~ 4,
      Race1 == 'Other' ~ 5,
      TRUE ~ NA_integer_  # Default value if none of the conditions are met
    )
  )
```

(2) Baseline characteristics

```
Hmisc::describe(df3)
```

```
## df3
##
```

```
##  15  Variables      3922  Observations
## --------------------------------------------------------------------------------
## SleepHrsNight
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       11    0.938    6.829    1.398        4        5
##      .25      .50      .75      .90      .95
##        6        7        8        8        9
##
## lowest :  2  3  4  5  6, highest:  8  9 10 11 12
##
## Value          2     3     4     5     6     7     8     9    10    11    12
## Frequency      3    29   189   269   999  1171  1036   172    40     5     9
## Proportion 0.001 0.007 0.048 0.069 0.255 0.299 0.264 0.044 0.010 0.001 0.002
## --------------------------------------------------------------------------------
## TotChol
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0      212        1    5.083    1.169    3.540    3.830
##      .25      .50      .75      .90      .95
##    4.320    5.020    5.720    6.390    6.877
##
## lowest :  1.53  2.43  2.59  2.69  2.74, highest:  9.31  9.34  9.90 12.28 13.65
## --------------------------------------------------------------------------------
## DirectChol
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       99        1    1.351   0.4553     0.80     0.88
##      .25      .50      .75      .90      .95
##     1.06     1.29     1.58     1.91     2.12
##
## lowest : 0.39 0.41 0.52 0.54 0.57, highest: 3.41 3.44 3.59 3.72 3.83
## --------------------------------------------------------------------------------
## Age
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       42    0.999    39.34    13.42       21       23
##      .25      .50      .75      .90      .95
##       29       40       49       55       57
##
## lowest : 18 19 20 21 22, highest: 55 56 57 58 59
## --------------------------------------------------------------------------------
## Gender
##        n  missing distinct     Info      Sum     Mean      Gmd
##     3922        0        2    0.745     1795   0.4577   0.4965
##
## --------------------------------------------------------------------------------
## Race1
##        n  missing distinct     Info     Mean      Gmd
##     3922        0        5    0.668    3.574   0.9307
##
## lowest : 1 2 3 4 5, highest: 1 2 3 4 5
##
## Value          1     2     3     4     5
## Frequency    387   215   345  2709   266
## Proportion 0.099 0.055 0.088 0.691 0.068
## --------------------------------------------------------------------------------
## BMI
```

```
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0     1139        1    28.64    7.162    19.99    21.20
##      .25      .50      .75      .90      .95
##    23.90    27.50    32.25    37.20    40.74
##
## lowest : 15.02 15.80 15.98 16.51 16.70, highest: 62.80 63.30 63.91 67.83 69.00
## ---------------------------------------------------------------------------
## BPDiaAve
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       84    0.999    71.51    12.42       54       58
##      .25      .50      .75      .90      .95
##       65       72       78       85       89
##
## lowest :   0  20  21  22  25, highest: 108 109 110 114 116
## ---------------------------------------------------------------------------
## BPSysAve
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       99    0.999    117.7    15.36       98      102
##      .25      .50      .75      .90      .95
##      108      116      125      134      142
##
## lowest :  78  83  84  85  86, highest: 184 191 202 209 226
## ---------------------------------------------------------------------------
## AlcoholYear
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       56    0.993    71.91     93.2        0        0
##      .25      .50      .75      .90      .95
##        4       24      104      208      300
##
## lowest :   0   1   2   3   4, highest: 260 300 312 360 364
## ---------------------------------------------------------------------------
## Poverty
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0      398    0.984    3.009    1.892    0.450    0.751
##      .25      .50      .75      .90      .95
##    1.380    3.150    5.000    5.000    5.000
##
## lowest : 0.00 0.02 0.03 0.04 0.05, highest: 4.95 4.96 4.97 4.99 5.00
## ---------------------------------------------------------------------------
## HomeRooms
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       13     0.98    6.141    2.528        3        4
##      .25      .50      .75      .90      .95
##        4        6        7        9       10
##
## lowest :  1  2  3  4  5, highest:  9 10 11 12 13
##
## Value          1     2     3     4     5     6     7     8     9    10    11
## Frequency     59    46   258   622   692   703   575   371   263   165    79
## Proportion 0.015 0.012 0.066 0.159 0.176 0.179 0.147 0.095 0.067 0.042 0.020
##
## Value         12    13
## Frequency     42    47
## Proportion 0.011 0.012
```

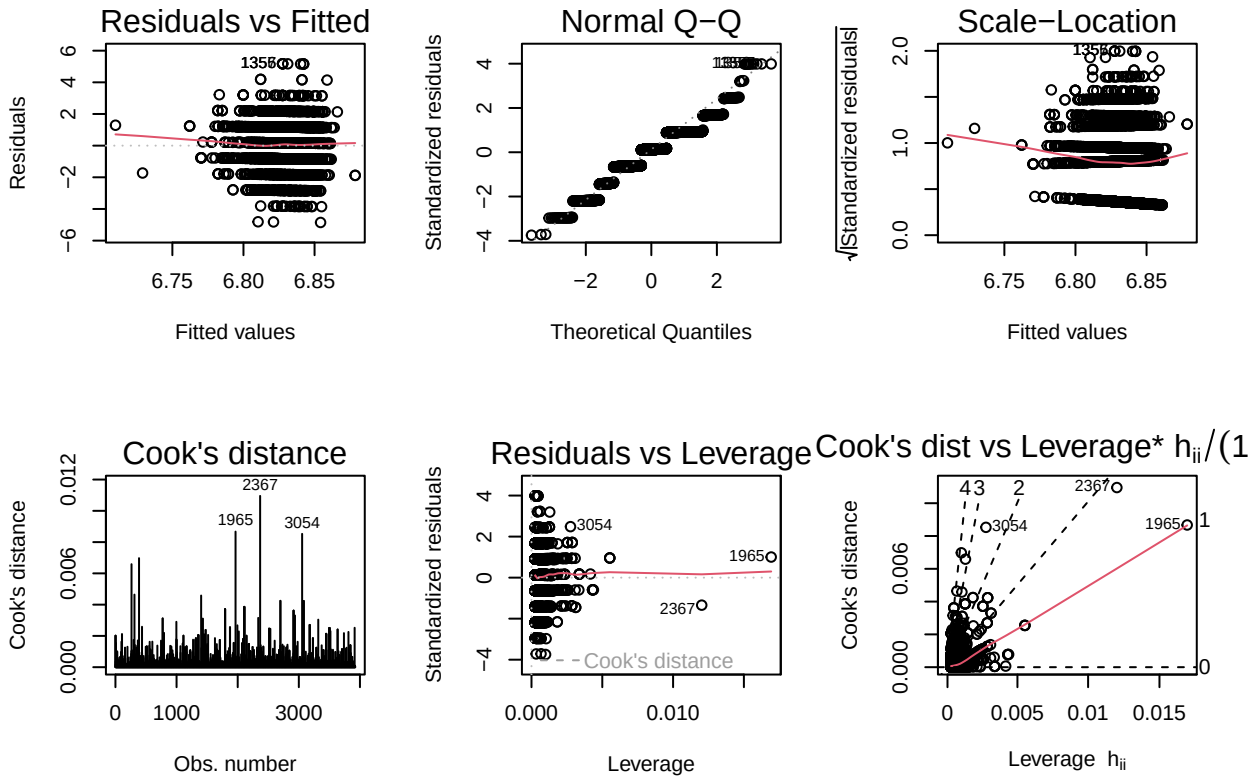
```
## ------------------------------------------------------------------------------
## SexNumPartnLife
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       81    0.996    16.21    21.98        1        1
##      .25      .50      .75      .90      .95
##        3        6       15       30       50
##
## lowest :    0    1    2    3    4, highest:  600  800  999 1000 2000
## ------------------------------------------------------------------------------
## SexNumPartYear
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       22    0.673    1.381    1.286        0        0
##      .25      .50      .75      .90      .95
##        1        1        1        2        3
##
## lowest :  0  1  2  3  4, highest: 19 20 30 50 69
## ------------------------------------------------------------------------------
## DaysMentHlthBad
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     3922        0       28    0.841    4.412    6.821        0        0
##      .25      .50      .75      .90      .95
##        0        0        5       15       30
##
## lowest :  0  1  2  3  4, highest: 25 26 27 29 30
## ------------------------------------------------------------------------------
```

(3) linear regression model

```
##simple linear regression##
model1 = lm(df3$SleepHrsNight ~ df3$TotChol, data = df3)
summary(model1)
```

```
##
## Call:
## lm(formula = df3$SleepHrsNight ~ df3$TotChol, data = df3)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.8542 -0.8298  0.1652  1.1616  5.1725
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  6.89986    0.10145  68.014   <2e-16 ***
## df3$TotChol -0.01391    0.01954  -0.712    0.477
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.296 on 3920 degrees of freedom
## Multiple R-squared:  0.0001292,  Adjusted R-squared:  -0.0001258
## F-statistic: 0.5066 on 1 and 3920 DF,  p-value: 0.4766
```

```r
par(mfrow = c(2, 3)) #read more from ?plot.lm
plot(model1, which = 1)
plot(model1, which = 2)
plot(model1, which = 3)
plot(model1, which = 4)
plot(model1, which = 5)
plot(model1, which = 6)
```




```r
par(mfrow = c(1, 1)) # reset

## multiple linear regression##
m_initial = lm(SleepHrsNight ~ TotChol + Age + Gender + factor(Race1), df3)
summary(m_initial)
```

```
##
## Call:
## lm(formula = SleepHrsNight ~ TotChol + Age + Gender + factor(Race1),
##     data = df3)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.9588 -0.8155  0.1140  1.0490  5.3532
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)     6.705872   0.124437  53.890  < 2e-16 ***
```

```
## TotChol         0.002877   0.020350   0.141 0.887570
## Age            -0.008276   0.001874  -4.416 1.03e-05 ***
## Gender          0.200836   0.041361   4.856 1.25e-06 ***
## factor(Race1)2  0.191060   0.109405   1.746 0.080829 .
## factor(Race1)3  0.420208   0.095508   4.400 1.11e-05 ***
## factor(Race1)4  0.389393   0.070200   5.547 3.10e-08 ***
## factor(Race1)5  0.381915   0.102533   3.725 0.000198 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.285 on 3914 degrees of freedom
## Multiple R-squared:  0.01889,    Adjusted R-squared:  0.01713
## F-statistic: 10.76 on 7 and 3914 DF,  p-value: 1.664e-13
```

```
m_knrisk = lm(
  SleepHrsNight ~ TotChol + Age + Gender + factor(Race1) + BMI + BPDiaAve +
    BPSysAve + AlcoholYear + DaysMentHlthBad,
  df3
)
summary(m_knrisk)
```

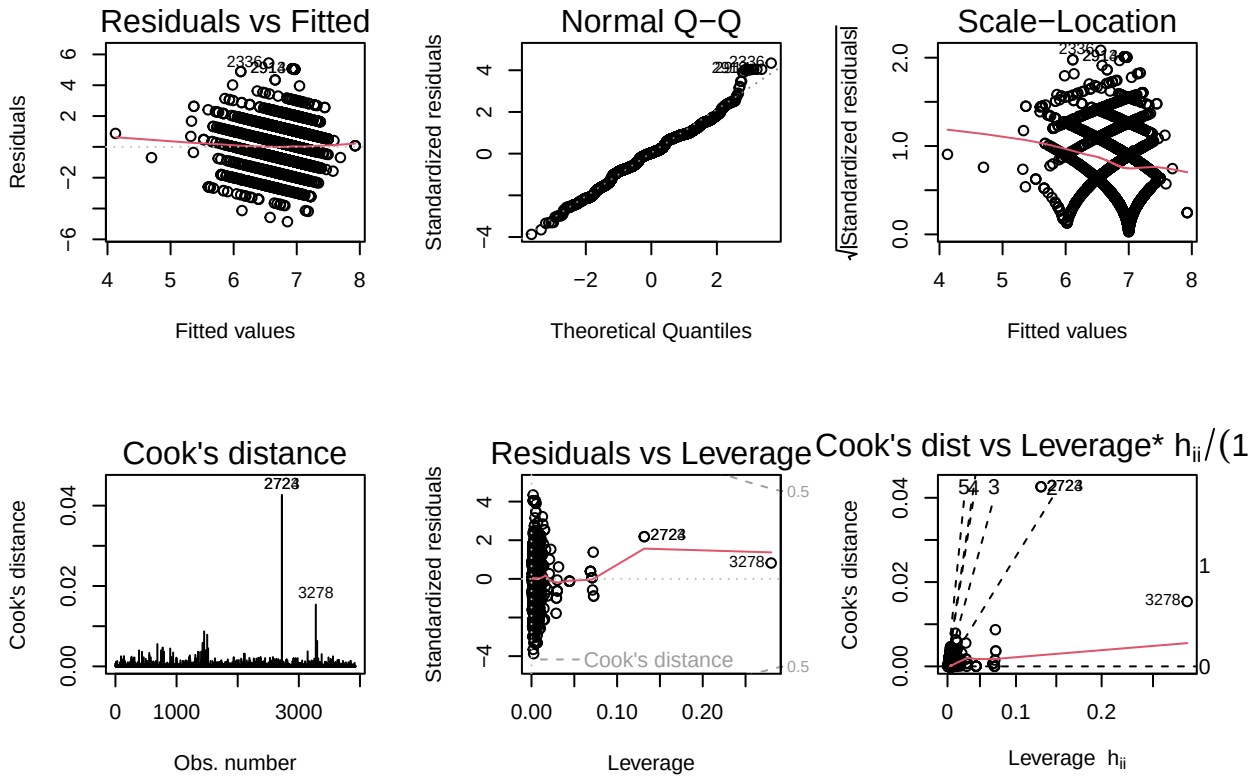
```
##
## Call:
## lm(formula = SleepHrsNight ~ TotChol + Age + Gender + factor(Race1) +
##     BMI + BPDiaAve + BPSysAve + AlcoholYear + DaysMentHlthBad,
##     data = df3)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.0151 -0.8371  0.0538  0.9651  5.3364
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)      7.1462829  0.2154155  33.174  < 2e-16 ***
## TotChol          0.0027643  0.0202261   0.137 0.891300
## Age             -0.0087863  0.0019017  -4.620 3.96e-06 ***
## Gender           0.2421933  0.0423999   5.712 1.20e-08 ***
## factor(Race1)2   0.1615075  0.1080191   1.495 0.134949
## factor(Race1)3   0.3670216  0.0943591   3.890 0.000102 ***
## factor(Race1)4   0.3361684  0.0697583   4.819 1.50e-06 ***
## factor(Race1)5   0.3107938  0.1019396   3.049 0.002313 **
## BMI             -0.0032441  0.0032012  -1.013 0.310923
## BPDiaAve         0.0020128  0.0021165   0.951 0.341646
## BPSysAve        -0.0030312  0.0017413  -1.741 0.081793 .
## AlcoholYear      0.0006543  0.0002219   2.949 0.003209 **
## DaysMentHlthBad -0.0299239  0.0025406 -11.778  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.262 on 3909 degrees of freedom
## Multiple R-squared:  0.05591,    Adjusted R-squared:  0.05302
## F-statistic: 19.29 on 12 and 3909 DF,  p-value: < 2.2e-16
```

```
m_full = lm(
  SleepHrsNight ~ TotChol + Age + Gender + factor(Race1) + BMI + BPDiaAve +
```

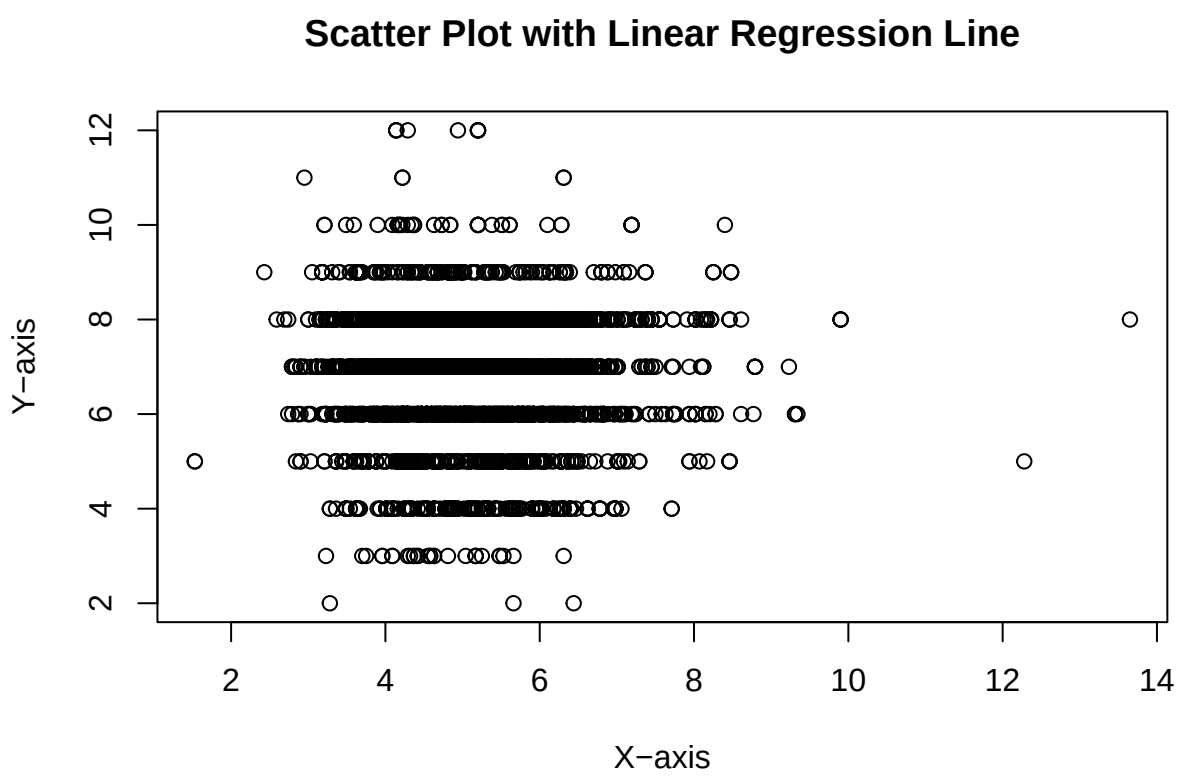
```
    BPSysAve + AlcoholYear + DaysMentHlthBad + HomeRooms + SexNumPartnLife +
    SexNumPartYear + Poverty,
  df3
)
summary(m_full)
```

```
##
## Call:
## lm(formula = SleepHrsNight ~ TotChol + Age + Gender + factor(Race1) +
##     BMI + BPDiaAve + BPSysAve + AlcoholYear + DaysMentHlthBad +
##     HomeRooms + SexNumPartnLife + SexNumPartYear + Poverty, data = df3)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.8534 -0.8280  0.0354  0.9312  5.4440
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)       6.8271794  0.2226486  30.663  < 2e-16 ***
## TotChol           0.0047184  0.0201452   0.234 0.814828
## Age              -0.0107341  0.0019748  -5.435 5.80e-08 ***
## Gender            0.2300247  0.0423898   5.426 6.10e-08 ***
## factor(Race1)2    0.1634606  0.1075484   1.520 0.128622
## factor(Race1)3    0.3982799  0.0942020   4.228 2.41e-05 ***
## factor(Race1)4    0.2862593  0.0702207   4.077 4.66e-05 ***
## factor(Race1)5    0.2854605  0.1016592   2.808 0.005010 **
## BMI              -0.0026447  0.0031871  -0.830 0.406694
## BPDiaAve          0.0018866  0.0021093   0.894 0.371149
## BPSysAve         -0.0022470  0.0017400  -1.291 0.196654
## AlcoholYear       0.0005280  0.0002223   2.375 0.017598 *
## DaysMentHlthBad -0.0280171  0.0025566 -10.959  < 2e-16 ***
## HomeRooms         0.0260173  0.0095185   2.733 0.006298 **
## SexNumPartnLife -0.0011068  0.0003339  -3.315 0.000925 ***
## SexNumPartYear    0.0187508  0.0067967   2.759 0.005828 **
## Poverty           0.0522337  0.0137235   3.806 0.000143 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.255 on 3905 degrees of freedom
## Multiple R-squared:  0.06694,    Adjusted R-squared:  0.06312
## F-statistic: 17.51 on 16 and 3905 DF,  p-value: < 2.2e-16
```

```
par(mfrow = c(2, 3)) #read more from ?plot.lm
plot(m_full, which = 1)
plot(m_full, which = 2)
plot(m_full, which = 3)
plot(m_full, which = 4)
plot(m_full, which = 5)
plot(m_full, which = 6)
```




```
par(mfrow = c(1, 1)) # reset

plot(
  df3$TotChol,
  df3$SleepHrsNight,
  main = "Scatter Plot with Linear Regression Line",
  xlab = "X-axis",
  ylab = "Y-axis"
)
```

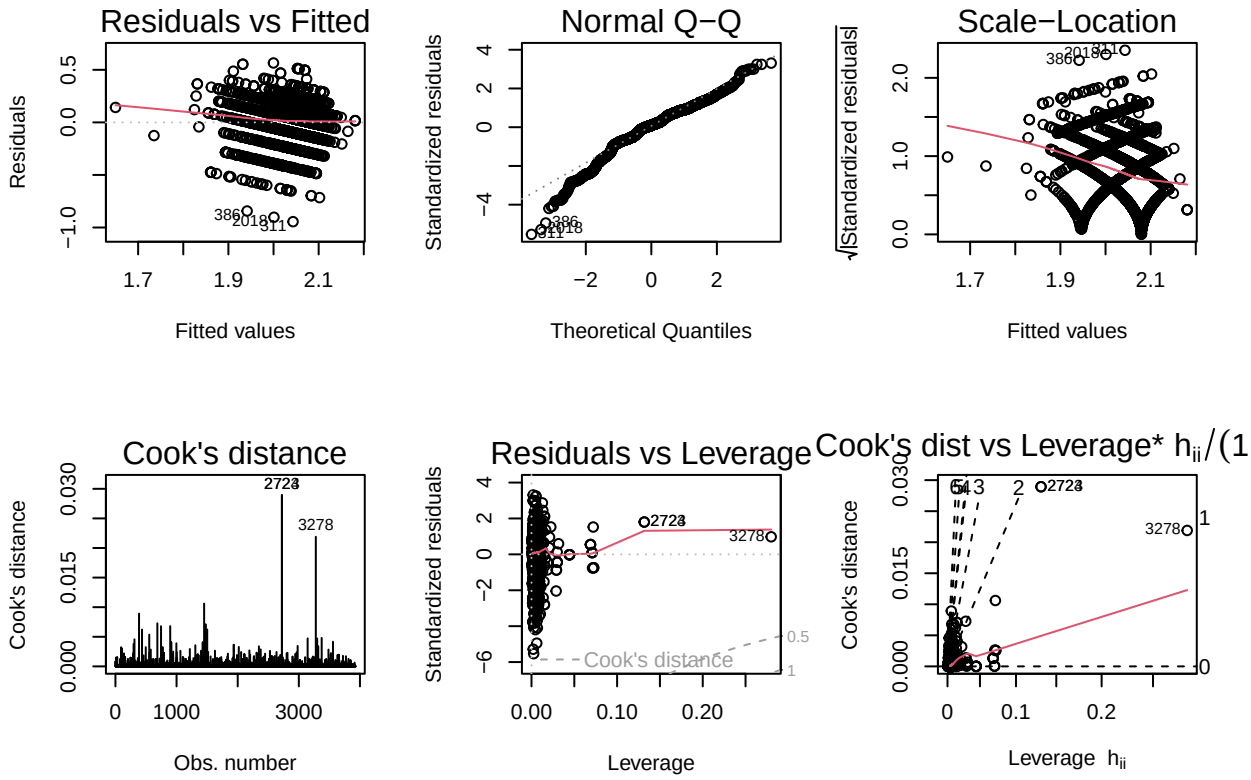



```
#log outcome
df3$logSleepHrsNight = log(df3$SleepHrsNight + 1)
m_logfull_1 = lm(
  logSleepHrsNight ~ TotChol + Age + Gender + factor(Race1) + BMI + BPDiaAve +
    BPSysAve + AlcoholYear + DaysMentHlthBad + HomeRooms + SexNumPartnLife +
    SexNumPartYear + Poverty,
  df3
)
summary(m_logfull_1)
```

```
##
## Call:
## lm(formula = logSleepHrsNight ~ TotChol + Age + Gender + factor(Race1) +
##     BMI + BPDiaAve + BPSysAve + AlcoholYear + DaysMentHlthBad +
##     HomeRooms + SexNumPartnLife + SexNumPartYear + Poverty, data = df3)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.94458 -0.09816  0.01636  0.12163  0.56510
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.033e+00  3.033e-02  67.026  < 2e-16 ***
## TotChol          4.578e-04  2.744e-03   0.167 0.867504
## Age             -1.485e-03  2.690e-04  -5.520 3.60e-08 ***
## Gender           2.838e-02  5.774e-03   4.915 9.26e-07 ***
```

```
## factor(Race1)2   2.478e-02  1.465e-02   1.691 0.090882 .
## factor(Race1)3   5.693e-02  1.283e-02   4.437 9.38e-06 ***
## factor(Race1)4   4.259e-02  9.566e-03   4.453 8.72e-06 ***
## factor(Race1)5   4.232e-02  1.385e-02   3.056 0.002260 **
## BMI             -4.730e-04  4.342e-04  -1.090 0.275981
## BPDiaAve         3.782e-04  2.873e-04   1.316 0.188144
## BPSysAve        -2.977e-04  2.370e-04  -1.256 0.209220
## AlcoholYear      8.234e-05  3.028e-05   2.719 0.006578 **
## DaysMentHlthBad -4.145e-03  3.483e-04 -11.903  < 2e-16 ***
## HomeRooms        3.765e-03  1.297e-03   2.904 0.003705 **
## SexNumPartnLife -1.623e-04  4.548e-05  -3.569 0.000362 ***
## SexNumPartYear   2.441e-03  9.258e-04   2.637 0.008400 **
## Poverty          8.175e-03  1.869e-03   4.373 1.26e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1709 on 3905 degrees of freedom
## Multiple R-squared:  0.07513,    Adjusted R-squared:  0.07134
## F-statistic: 19.83 on 16 and 3905 DF,  p-value: < 2.2e-16
```

```
par(mfrow = c(2, 3)) #read more from ?plot.lm
plot(m_logfull_1, which = 1)
plot(m_logfull_1, which = 2)
plot(m_logfull_1, which = 3)
plot(m_logfull_1, which = 4)
plot(m_logfull_1, which = 5)
plot(m_logfull_1, which = 6)
```

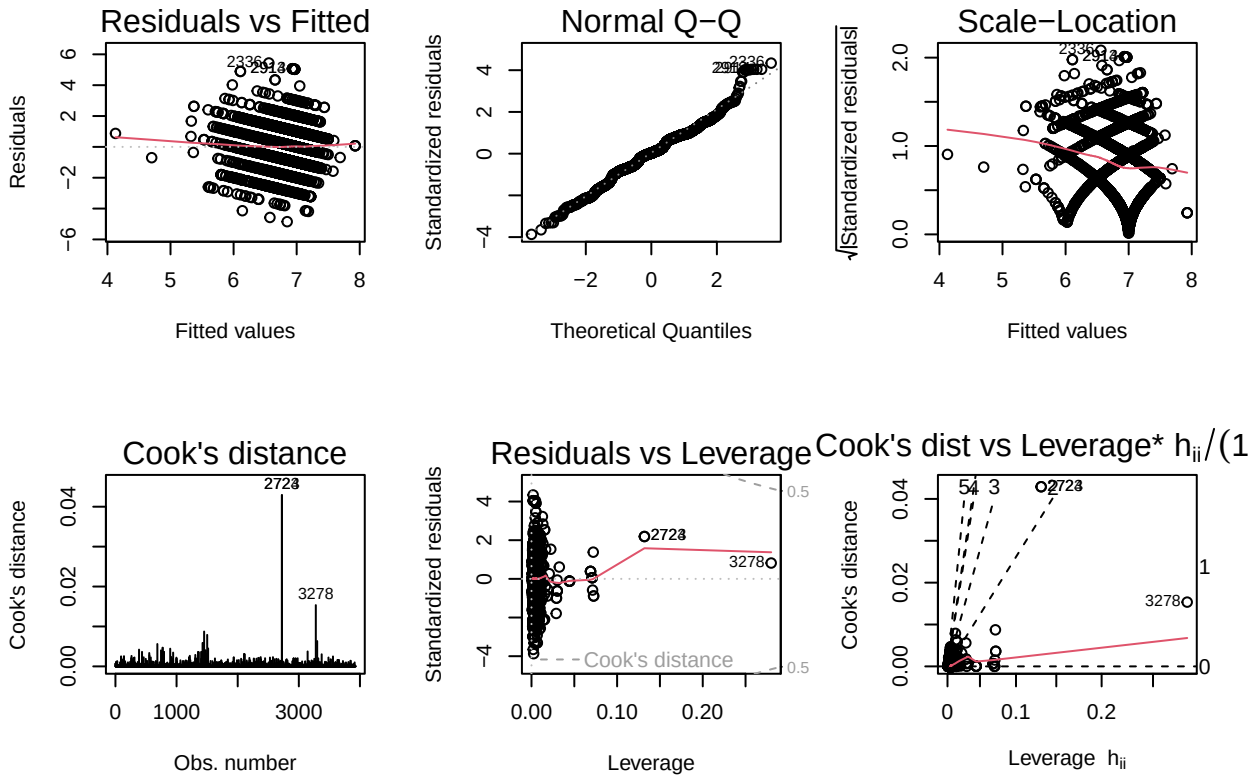



```
par(mfrow = c(1, 1)) # reset

#log x
df3$logTotChol = log(df3$TotChol + 1)
m_logfull_2 = lm(
  SleepHrsNight ~ logTotChol + Age + Gender + factor(Race1) + BMI + BPDiaAve +
    BPSysAve + AlcoholYear + DaysMentHlthBad + HomeRooms + SexNumPartnLife +
    SexNumPartYear + Poverty,
  df3
)
summary(m_logfull_2)
```

```
##
## Call:
## lm(formula = SleepHrsNight ~ logTotChol + Age + Gender + factor(Race1) +
##     BMI + BPDiaAve + BPSysAve + AlcoholYear + DaysMentHlthBad +
##     HomeRooms + SexNumPartnLife + SexNumPartYear + Poverty, data = df3)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.8497 -0.8276  0.0368  0.9335  5.4407
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)      6.8300088  0.2782326  24.548  < 2e-16 ***
## logTotChol       0.0071259  0.1247304   0.057 0.954444
```

```
## Age             -0.0106525  0.0019745  -5.395 7.26e-08 ***
## Gender           0.2305375  0.0423961   5.438 5.73e-08 ***
## factor(Race1)2   0.1640112  0.1075538   1.525 0.127360
## factor(Race1)3   0.3990122  0.0942051   4.236 2.33e-05 ***
## factor(Race1)4   0.2869727  0.0702076   4.087 4.45e-05 ***
## factor(Race1)5   0.2857811  0.1016579   2.811 0.004960 **
## BMI             -0.0026393  0.0031873  -0.828 0.407686
## BPDiaAve         0.0019209  0.0021091   0.911 0.362487
## BPSysAve        -0.0022300  0.0017399  -1.282 0.200043
## AlcoholYear      0.0005299  0.0002224   2.383 0.017226 *
## DaysMentHlthBad -0.0280195  0.0025566 -10.960  < 2e-16 ***
## HomeRooms        0.0259722  0.0095189   2.728 0.006391 **
## SexNumPartnLife -0.0011085  0.0003339  -3.320 0.000909 ***
## SexNumPartYear   0.0187184  0.0067976   2.754 0.005920 **
## Poverty          0.0522189  0.0137235   3.805 0.000144 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.255 on 3905 degrees of freedom
## Multiple R-squared:  0.06693,    Adjusted R-squared:  0.06311
## F-statistic: 17.51 on 16 and 3905 DF,  p-value: < 2.2e-16
```

```r
par(mfrow = c(2, 3)) #read more from ?plot.lm
plot(m_logfull_2, which = 1)
plot(m_logfull_2, which = 2)
plot(m_logfull_2, which = 3)
plot(m_logfull_2, which = 4)
plot(m_logfull_2, which = 5)
plot(m_logfull_2, which = 6)
```

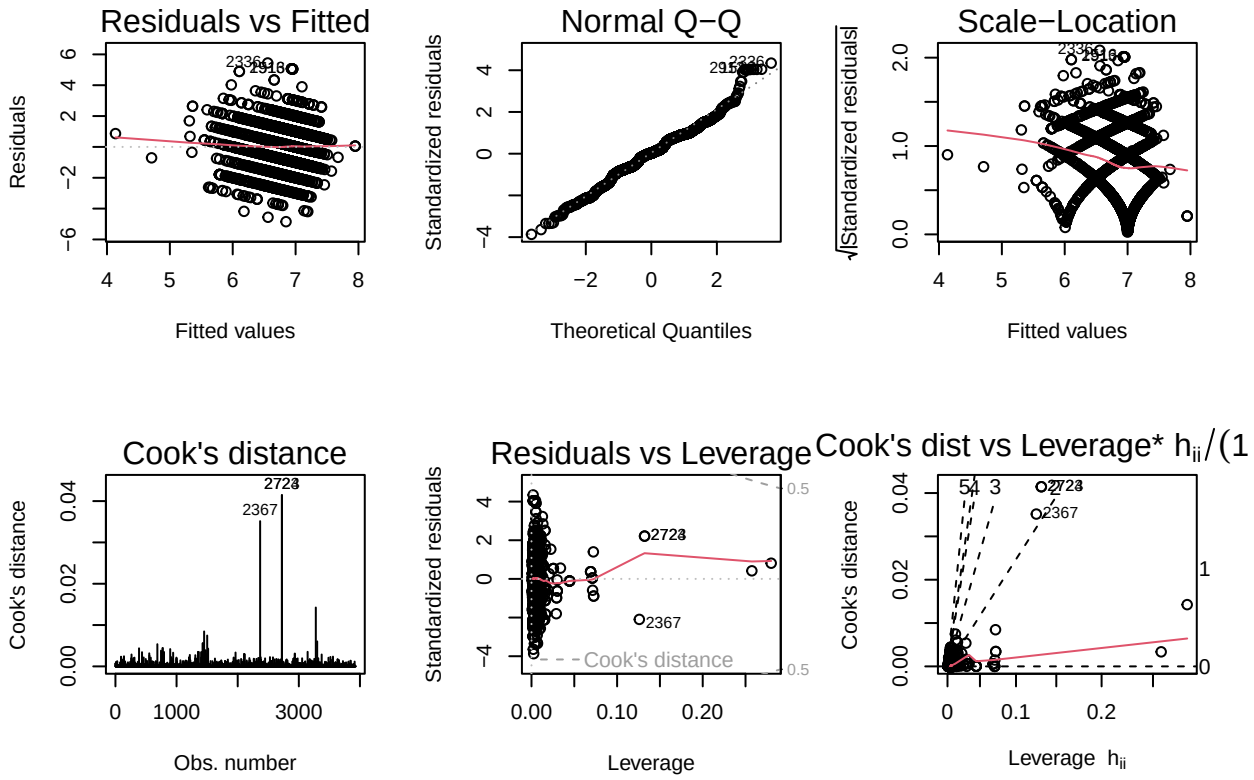



```
par(mfrow = c(1, 1)) # reset

# x^2
df3$sqTotChol = (df3$TotChol - mean(df3$TotChol)) ^ 2
m_sqfull_1 = lm(
  SleepHrsNight ~ TotChol + sqTotChol + Age + Gender + factor(Race1) + BMI +
    BPDiaAve + BPSysAve + AlcoholYear + DaysMentHlthBad + HomeRooms + SexNumPartnLife +
    SexNumPartYear + Poverty,
  df3
)
summary(m_sqfull_1)
```

```
##
## Call:
## lm(formula = SleepHrsNight ~ TotChol + sqTotChol + Age + Gender +
##     factor(Race1) + BMI + BPDiaAve + BPSysAve + AlcoholYear +
##     DaysMentHlthBad + HomeRooms + SexNumPartnLife + SexNumPartYear +
##     Poverty, data = df3)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.8478 -0.8260  0.0405  0.9374  5.4429
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)      6.8577303  0.2238478  30.636  < 2e-16 ***
```

```
## TotChol         -0.0056651  0.0216483  -0.262 0.793577
## sqTotChol        0.0123034  0.0093972   1.309 0.190524
## Age             -0.0106509  0.0019757  -5.391 7.42e-08 ***
## Gender           0.2311086  0.0423940   5.451 5.31e-08 ***
## factor(Race1)2   0.1650502  0.1075454   1.535 0.124938
## factor(Race1)3   0.3997089  0.0941997   4.243 2.25e-05 ***
## factor(Race1)4   0.2850197  0.0702207   4.059 5.03e-05 ***
## factor(Race1)5   0.2847735  0.1016512   2.801 0.005112 **
## BMI             -0.0024955  0.0031888  -0.783 0.433929
## BPDiaAve         0.0018701  0.0021091   0.887 0.375317
## BPSysAve        -0.0022354  0.0017399  -1.285 0.198941
## AlcoholYear      0.0005359  0.0002224   2.410 0.016001 *
## DaysMentHlthBad -0.0279488  0.0025569 -10.931  < 2e-16 ***
## HomeRooms        0.0257677  0.0095196   2.707 0.006823 **
## SexNumPartnLife -0.0011115  0.0003339  -3.329 0.000879 ***
## SexNumPartYear   0.0185336  0.0067981   2.726 0.006434 **
## Poverty          0.0528694  0.0137308   3.850 0.000120 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.255 on 3904 degrees of freedom
## Multiple R-squared:  0.06735,    Adjusted R-squared:  0.06329
## F-statistic: 16.58 on 17 and 3904 DF,  p-value: < 2.2e-16
```

```r
par(mfrow = c(2, 3)) #read more from ?plot.lm
plot(m_sqfull_1, which = 1)
plot(m_sqfull_1, which = 2)
plot(m_sqfull_1, which = 3)
plot(m_sqfull_1, which = 4)
plot(m_sqfull_1, which = 5)
plot(m_sqfull_1, which = 6)
```




```
par(mfrow = c(1, 1)) # reset
```

(4) Diagnosis: 10-fold CV

```
library(caret)
```

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

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

```
splitIndex <-
  createDataPartition(df3$SleepHrsNight, p = 0.7, list = FALSE)
trainData <- df3[splitIndex,]
testData <- df3[-splitIndex,]
predictions <- predict(m_sqfull_1, newdata = testData)
mse <- mean((testData$SleepHrsNight - predictions) ^ 2)
control <-
  trainControl(method = "cv", number = 10)  # 10-fold cross-validation
cv_model <-
  train(
    SleepHrsNight ~ .,
    data = df3,
    method = "lm",
    trControl = control
  )
```

```
cv_model
```

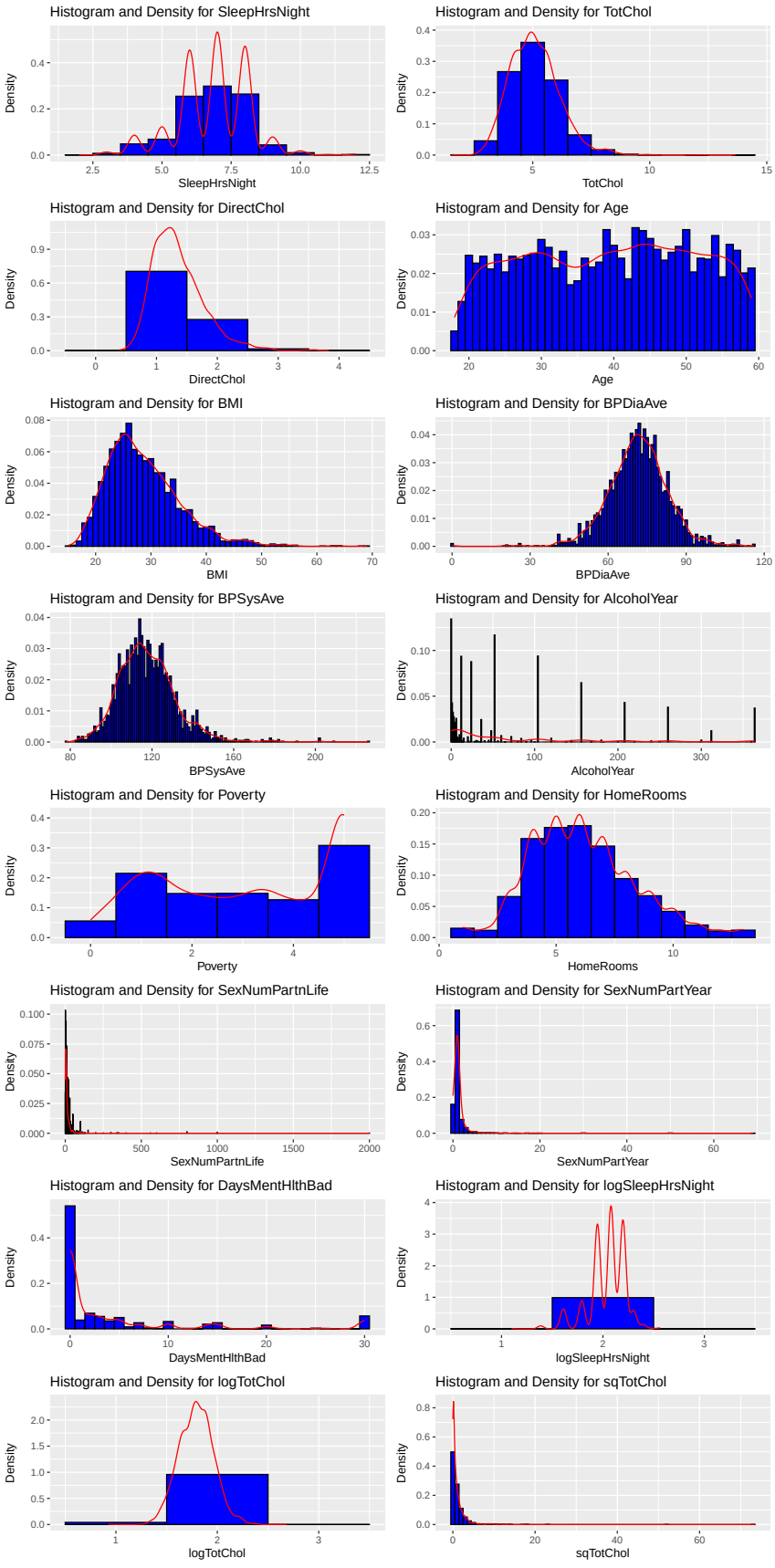
```
## Linear Regression
##
## 3922 samples
##   17 predictor
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 3529, 3529, 3529, 3530, 3530, 3530, ...
## Resampling results:
##
##   RMSE       Rsquared   MAE
##   0.1819272  0.9804423  0.1196029
##
## Tuning parameter 'intercept' was held constant at a value of TRUE
```

```
(cv_results <- cv_model$results)
```

```
##   intercept      RMSE  Rsquared       MAE     RMSESD  RsquaredSD       MAESD
## 1      TRUE 0.1819272 0.9804423 0.1196029 0.03027278 0.005037844 0.007475503
```

(4) Diagnosis: Normality Assumption

```
library(ggplot2)
library(patchwork)
# Initializes an empty patchwork object
plot_list <- list()

# Draw a histogram for each numeric variable (except Race1 and Gender) and add it to the list
for (var in names(df3)) {
  if (is.numeric(df3[[var]]) && !(var %in% c("Race1", "Gender"))) {
    p <- ggplot(df3, aes(x = .data[[var]])) +
      geom_histogram(
        aes(y = after_stat(density)),
        binwidth = 1,
        fill = "blue",
        color = "black"
      ) +
      geom_density(col = "red") +
      ggtitle(paste("Histogram and Density for", var)) +
      xlab(var) +
      ylab("Density")
    plot_list[[length(plot_list) + 1]] <- p
  }
}

# Use patchwork to put all the charts together
combined_plot <- wrap_plots(plot_list, ncol = 2)
print(combined_plot)
```


Histogram and Density for SleepHrsNight
Density
SleepHrsNight
Histogram and Density for TotChol
Density
TotChol
Histogram and Density for DirectChol
Density
DirectChol
Histogram and Density for Age
Density
Age
Histogram and Density for BMI
Density
BMI
Histogram and Density for BPDiaAve
Density
BPDiaAve
Histogram and Density for BPSysAve
Density
BPSysAve
Histogram and Density for AlcoholYear
Density
AlcoholYear
Histogram and Density for Poverty
Density
Poverty
Histogram and Density for HomeRooms
Density
HomeRooms
Histogram and Density for SexNumPartnLife
Density
SexNumPartnLife
Histogram and Density for SexNumPartYear
Density
SexNumPartYear
Histogram and Density for DaysMentHlthBad
Density
DaysMentHlthBad
Histogram and Density for logSleepHrsNight
Density
logSleepHrsNight
Histogram and Density for logTotChol
Density
logTotChol
Histogram and Density for sqTotChol
Density
sqTotChol

```r
df3 <- data.frame(df3)
library(dplyr)
# Shapiro-Wilk normality test is performed for each numerical variable in df3
results <- sapply(df3, function(x) {
  if (is.numeric(x)) {
    shapiro_test <- shapiro.test(x)
    return(c(shapiro_test$statistic, shapiro_test$p.value))
  } else {
    return(c(NA, NA))
  }
})
# Convert the result to a data box and name the column
results_df <- as.data.frame(t(results))
names(results_df) <- c("W", "p.value")
# Add a variable name as a new column
results_df$Variable <- rownames(results_df)
# Rearrange the order of columns
results_df <- results_df[, c("Variable", "W", "p.value")]
# Calculate the corrected P-value (for example, using Bonferroni correction)
results_df$p.adjusted <-
  p.adjust(results_df$p.value, method = "bonferroni")
print(results_df)
```

```
##                          Variable         W      p.value   p.adjusted
## SleepHrsNight       SleepHrsNight 0.9324408 6.174763e-39 1.111457e-37
## TotChol                   TotChol 0.9724090 7.211614e-27 1.298090e-25
## DirectChol             DirectChol 0.9389239 1.850577e-37 3.331039e-36
## Age                           Age 0.9565820 1.100461e-32 1.980830e-31
## Gender                     Gender 0.6340133 4.238105e-68 7.628589e-67
## Race1                       Race1 0.6732812 7.054979e-66 1.269896e-64
## BMI                           BMI 0.9420252 1.043365e-36 1.878057e-35
## BPDiaAve                 BPDiaAve 0.9787402 8.519951e-24 1.533591e-22
## BPSysAve                 BPSysAve 0.9505758 1.857649e-34 3.343769e-33
## AlcoholYear           AlcoholYear 0.7494486 7.869506e-61 1.416511e-59
## Poverty                   Poverty 0.8916507 3.020524e-46 5.436943e-45
## HomeRooms               HomeRooms 0.9631989 1.707583e-30 3.073650e-29
## SexNumPartnLife   SexNumPartnLife 0.1633647 2.016343e-85 3.629418e-84
## SexNumPartYear     SexNumPartYear 0.2272038 1.134070e-83 2.041325e-82
## DaysMentHlthBad   DaysMentHlthBad 0.6061789 1.487607e-69 2.677692e-68
## logSleepHrsNight logSleepHrsNight 0.8994157 4.724481e-45 8.504065e-44
## logTotChol             logTotChol 0.9966458 1.103791e-07 1.986823e-06
## sqTotChol               sqTotChol 0.4074052 5.946496e-78 1.070369e-76
```

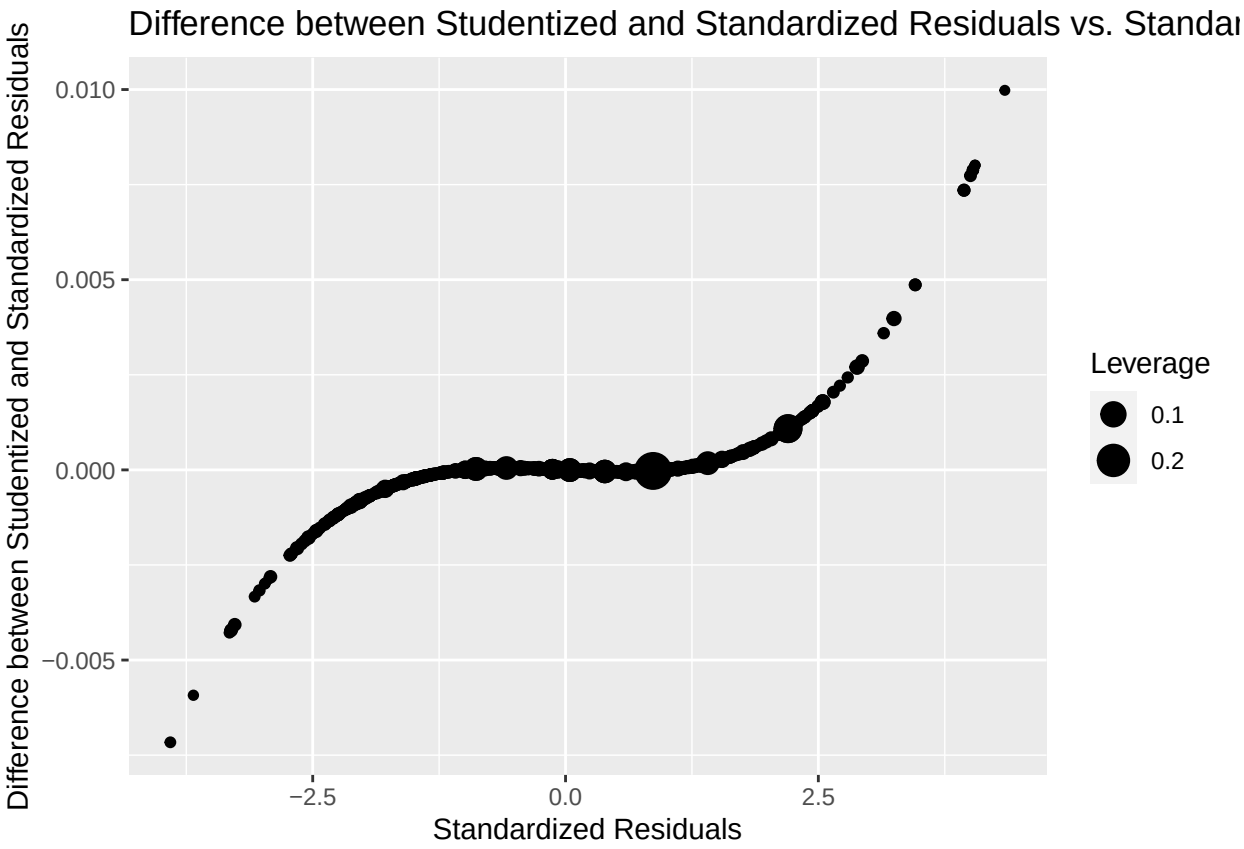
Standardized residuals, Studentized residuals

```r
# Regular residuals
residual_1 <- fit0$residuals

# Standardized residuals
residual_2 <- rstandard(fit0)

# Studentized residuals
```

```r
residual_3 <- rstudent(fit0)

# Externally studentized residuals
# Note: Externally studentized residuals are the same as studentized residuals in most cases
residual_4 <- rstudent(fit0)

# Creating a data frame to summarize these residuals
residual_summary <- data.frame(
  Residuals = c("Regular", "Standardized", "Studentized", "Externally Studentized"),
  Mean = c(mean(residual_1), mean(residual_2), mean(residual_3), mean(residual_4)),
  SD = c(sd(residual_1), sd(residual_2), sd(residual_3), sd(residual_4)),
  Min = c(min(residual_1), min(residual_2), min(residual_3), min(residual_4)),
  Max = c(max(residual_1), max(residual_2), max(residual_3), max(residual_4))
)

# Display the summary
print(residual_summary)
```

```
##                Residuals          Mean       SD       Min      Max
## 1                Regular -1.149380e-16 1.251851 -4.894975 5.444620
## 2           Standardized  9.976361e-05 1.000389 -3.907567 4.343986
## 3            Studentized  8.874780e-05 1.000738 -3.914730 4.353965
## 4 Externally Studentized  8.874780e-05 1.000738 -3.914730 4.353965
```

```r
# Load necessary library
library(ggplot2)

# Assuming fit0 is your linear model
# fit0 <- lm(SleepMinNight ~ ., data = df3)

# Calculate standardized and studentized residuals
residual_2 <- rstandard(fit0)
residual_3 <- rstudent(fit0)

# Calculate leverage values
leverage_values <- hatvalues(fit0)

# Create a data frame for plotting
plot_data <- data.frame(
  Standardized_Residuals = residual_2,
  Difference = residual_3 - residual_2,
  Leverage = leverage_values
)

# Create the plot
ggplot(plot_data, aes(x = Standardized_Residuals, y = Difference)) +
  geom_point(aes(size = Leverage)) +
  ggtitle("Difference between Studentized and Standardized Residuals vs. Standardized Residuals") +
  xlab("Standardized Residuals") +
  ylab("Difference between Studentized and Standardized Residuals")
```

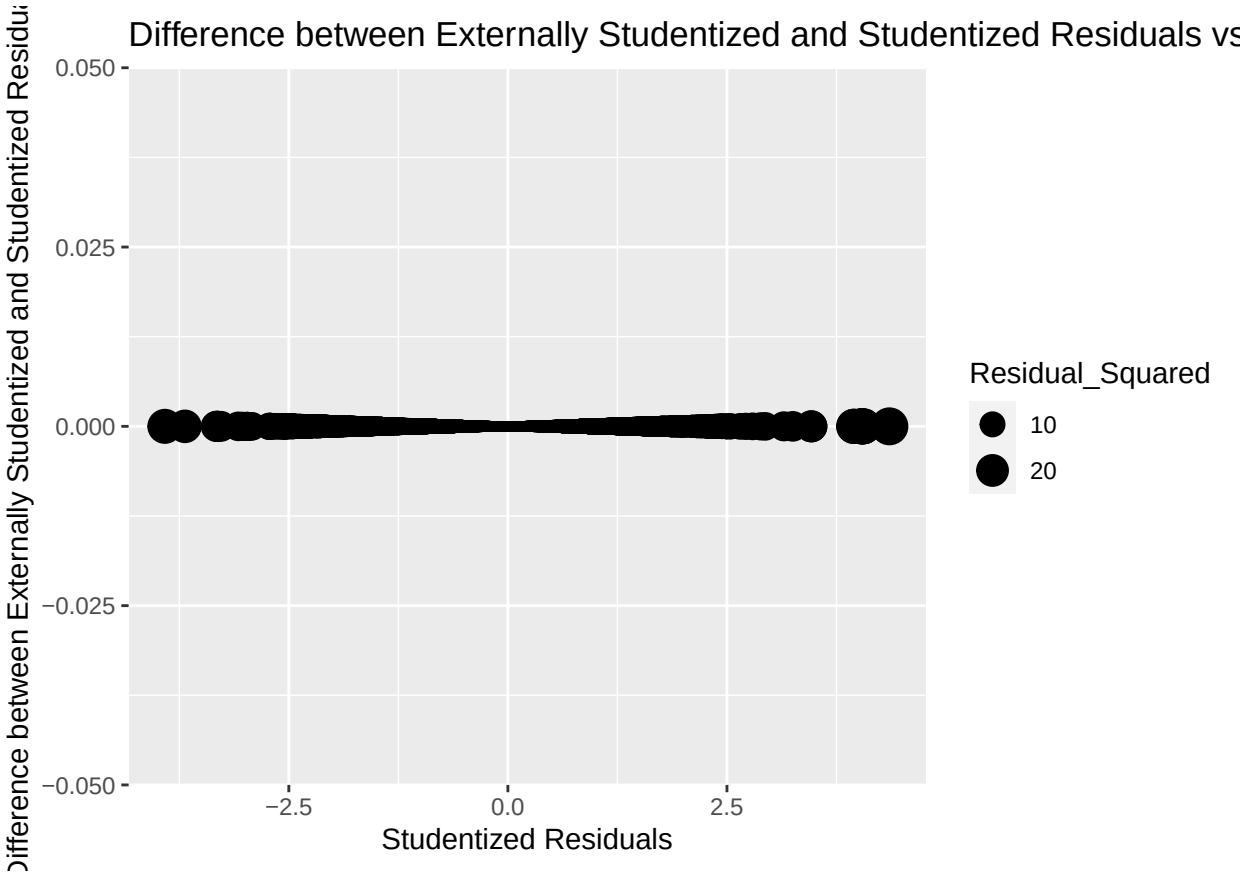



```
# Display the plot
print(ggplot)
```

```
## function (data = NULL, mapping = aes(), ..., environment = parent.frame())
## {
##     UseMethod("ggplot")
## }
## <bytecode: 0x2353450>
## <environment: namespace:ggplot2>
```

```
# Load necessary library
library(ggplot2)

# Assuming fit0 is your linear model
# fit0 <- lm(SleepMinNight ~ ., data = df3)

# Calculate studentized and externally studentized residuals
residual_3 <- rstudent(fit0)
residual_4 <- rstudent(fit0)  # Externally studentized residuals are typically the same as studentized

# Regular residuals
residual_1 <- fit0$residuals

# Create a data frame for plotting
plot_data <- data.frame(
  Studentized_Residuals = residual_3,
  Difference = residual_4 - residual_3,
```

```
  Residual_Squared = residual_1^2
)

# Create the plot
ggplot(plot_data, aes(x = Studentized_Residuals, y = Difference)) +
  geom_point(aes(size = Residual_Squared)) +
  ggtitle("Difference between Externally Studentized and Studentized Residuals vs. Studentized Residuals") +
  xlab("Studentized Residuals") +
  ylab("Difference between Externally Studentized and Studentized Residuals")
```

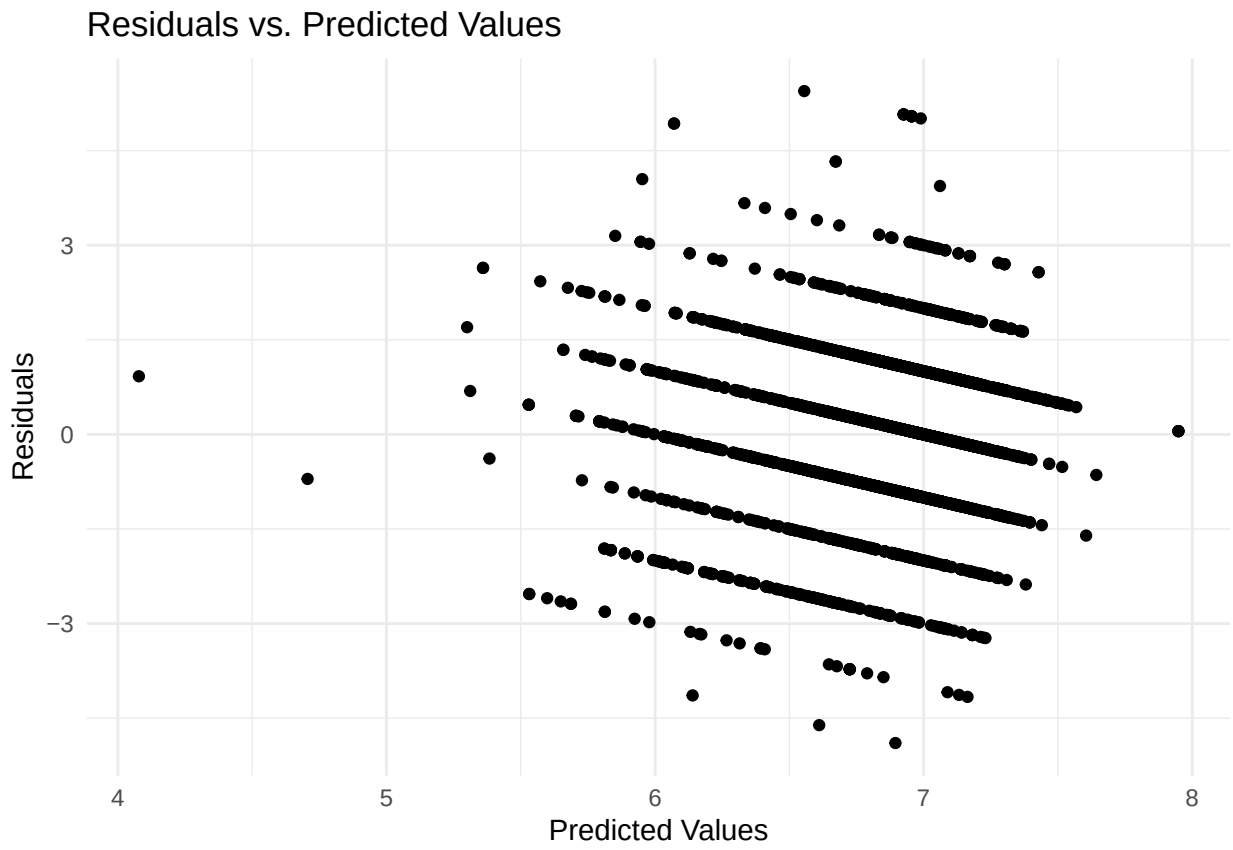



```
# Display the plot
print(ggplot)
```

```
## function (data = NULL, mapping = aes(), ..., environment = parent.frame())
## {
##     UseMethod("ggplot")
## }
## <bytecode: 0x2353450>
## <environment: namespace:ggplot2>
```

```
# Load necessary library
library(ggplot2)

# Assuming fit0 is your linear model
# fit0 <- lm(SleepMinNight ~ ., data = df3)

# Calculate regular residuals
```

```r
residual_1 <- fit0$residuals

# Get predicted values from the model
predicted_values <- predict(fit0)

# Create the plot
ggplot() +
  geom_point(aes(x = predicted_values, y = residual_1)) +
  ggtitle("Residuals vs. Predicted Values") +
  xlab("Predicted Values") +
  ylab("Residuals") +
  theme_minimal()
```

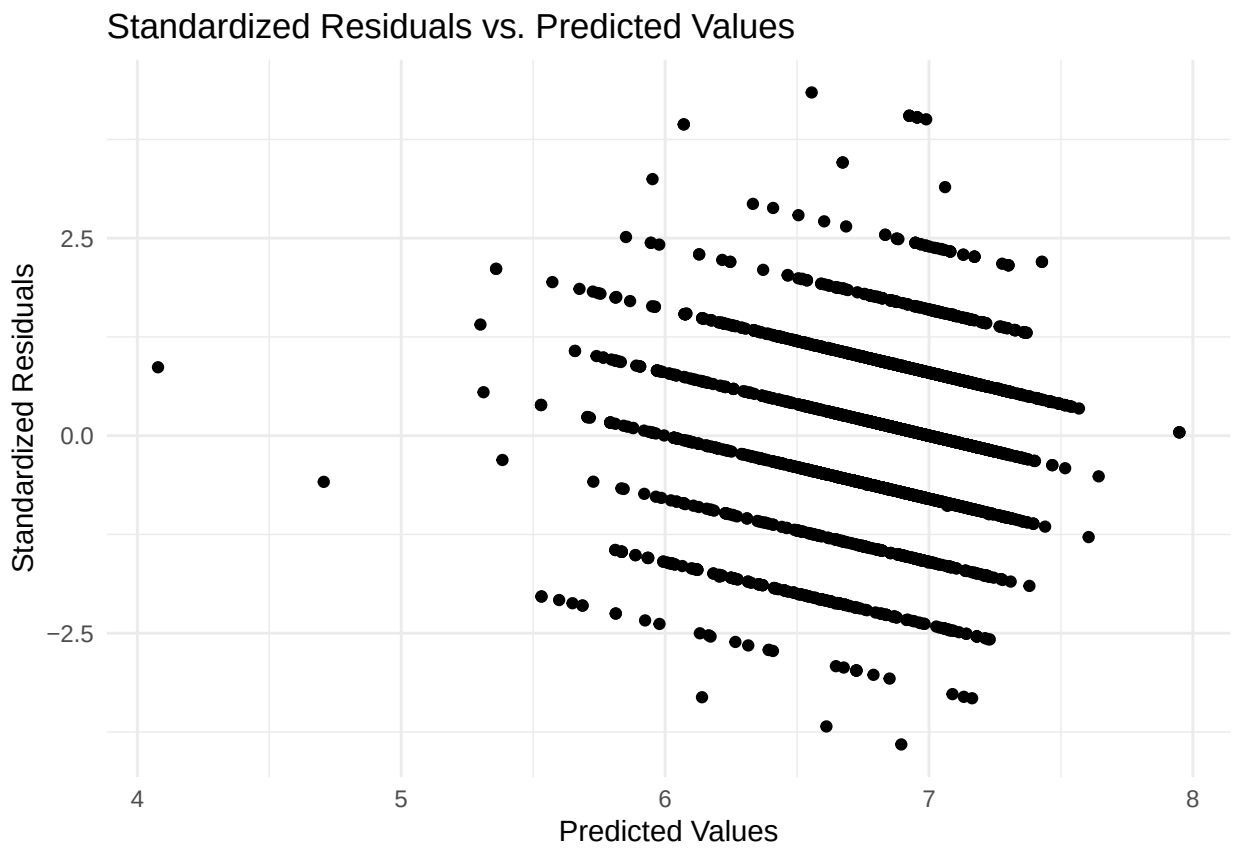



```r
# Display the plot
print(ggplot)
```

```
## function (data = NULL, mapping = aes(), ..., environment = parent.frame())
## {
##     UseMethod("ggplot")
## }
## <bytecode: 0x2353450>
## <environment: namespace:ggplot2>
```

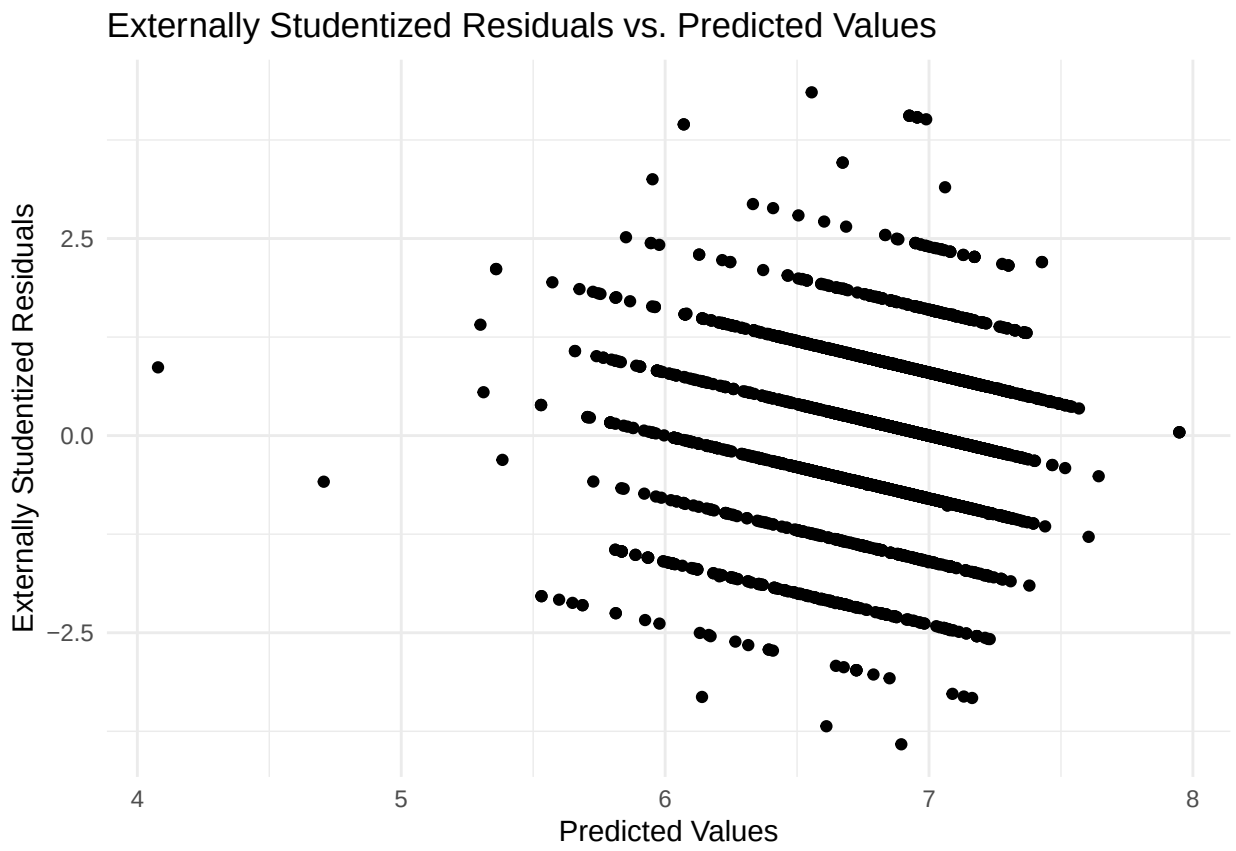
```r
# Load necessary library
library(ggplot2)

# Assuming fit0 is your linear model
```

```r
# fit0 <- lm(SleepMinNight ~ ., data = df3)

# Calculate different types of residuals
residual_2 <- rstandard(fit0)
residual_3 <- rstudent(fit0)
residual_4 <- rstudent(fit0)  # Externally studentized residuals

# Get predicted values from the model
predicted_values <- predict(fit0)

# Plot for Standardized Residuals
ggplot() +
  geom_point(aes(x = predicted_values, y = residual_2)) +
  ggtitle("Standardized Residuals vs. Predicted Values") +
  xlab("Predicted Values") +
  ylab("Standardized Residuals") +
  theme_minimal()
```




```r
# Plot for Studentized Residuals
ggplot() +
  geom_point(aes(x = predicted_values, y = residual_3)) +
  ggtitle("Studentized Residuals vs. Predicted Values") +
  xlab("Predicted Values") +
  ylab("Studentized Residuals") +
  theme_minimal()
```


```
# Plot for Externally Studentized Residuals
ggplot() +
  geom_point(aes(x = predicted_values, y = residual_4)) +
  ggtitle("Externally Studentized Residuals vs. Predicted Values") +
  xlab("Predicted Values") +
  ylab("Externally Studentized Residuals") +
  theme_minimal()
```



(5) Model Selection

```
step(fit0)
```

```
## Start:  AIC=1796.94
## SleepHrsNight ~ TotChol + DirectChol + Age + Gender + Race1 +
##     BMI + BPDiaAve + BPSysAve + AlcoholYear + Poverty + HomeRooms +
##     SexNumPartnLife + SexNumPartYear + DaysMentHlthBad
##
##                    Df Sum of Sq    RSS    AIC
## - TotChol           1     0.387 6145.1 1795.2
## - BPDiaAve          1     1.147 6145.9 1795.7
## - BPSysAve          1     2.270 6147.0 1796.4
## - BMI               1     2.872 6147.6 1796.8
## <none>                          6144.7 1796.9
## - DirectChol        1     3.700 6148.4 1797.3
## - AlcoholYear       1    11.211 6155.9 1802.1
## - SexNumPartYear    1    12.425 6157.1 1802.9
## - HomeRooms         1    12.586 6157.3 1803.0
## - SexNumPartnLife   1    17.677 6162.4 1806.2
## - Poverty           1    24.042 6168.8 1810.3
## - Race1             4    33.645 6178.4 1810.4
## - Age               1    46.071 6190.8 1824.2
## - Gender            1    49.306 6194.0 1826.3
```

```
## - DaysMentHlthBad  1   187.449 6332.2 1912.8
##
## Step:  AIC=1798.4
## SleepHrsNight ~ DirectChol + Age + Gender + Race1 + BMI + BPDiaAve +
##     BPSysAve + AlcoholYear + Poverty + HomeRooms + SexNumPartnLife +
##     SexNumPartYear + DaysMentHlthBad

##
## Call:
## lm(formula = SleepHrsNight ~ DirectChol + Age + Gender + Race1 +
##     BMI + BPDiaAve + BPSysAve + AlcoholYear + Poverty + HomeRooms +
##     SexNumPartnLife + SexNumPartYear + DaysMentHlthBad, data = df3)
##
## Coefficients:
##     (Intercept)       DirectChol              Age           Gender
##       7.0066602       -0.0868565       -0.0103630        0.2492065
##           Race1              BMI         BPDiaAve         BPSysAve
##       0.0709518       -0.0045456        0.0017997       -0.0021224
##     AlcoholYear          Poverty        HomeRooms  SexNumPartnLife
##       0.0005835        0.0485063        0.0262798       -0.0011571
##  SexNumPartYear  DaysMentHlthBad
##       0.0185115       -0.0283090
```

```
library(olsrr)
```

```
##
## Attaching package: 'olsrr'

## The following object is masked from 'package:datasets':
##
##     rivers
```

```
ols_step_forward_p(fit0,penter=0.1,details=F)
```

```
##
##                                 Selection Summary
## ------------------------------------------------------------------------------------
##         Variable                          Adj.
## Step        Entered        R-Square    R-Square      C(p)          AIC          RMSE
## ------------------------------------------------------------------------------------
##    1    DaysMentHlthBad      0.0319      0.0316    135.1234    13044.1166    1.2757
##    2    Gender               0.0401      0.0396    102.7354    13012.6991    1.2704
##    3    Race1                0.0454      0.0446     82.6655    12993.1011    1.2671
##    4    Age                  0.0512      0.0502     60.3184    12971.1357    1.2634
##    5    Poverty              0.0570      0.0558     38.1552    12949.2058    1.2597
##    6    SexNumPartnLife      0.0591      0.0577     31.1607    12942.2607    1.2584
##    7    SexNumPartYear       0.0610      0.0593     25.1899    12936.3166    1.2573
##    8    HomeRooms            0.0628      0.0609     19.7213    12930.8583    1.2563
##    9    AlcoholYear          0.0641      0.0619     16.4559    12927.5917    1.2556
## ------------------------------------------------------------------------------------
```

```
ols_step_forward_p(fit0,penter=0.05,details=F)
```

```
##
##                                 Selection Summary
## ------------------------------------------------------------------------------------
##         Variable                          Adj.
```

```
## Step        Entered         R-Square    R-Square      C(p)         AIC          RMSE
## ----------------------------------------------------------------------------------
##    1    DaysMentHlthBad      0.0319      0.0316    135.1234    13044.1166    1.2757
##    2    Gender               0.0401      0.0396    102.7354    13012.6991    1.2704
##    3    Race1                0.0454      0.0446     82.6655    12993.1011    1.2671
##    4    Age                  0.0512      0.0502     60.3184    12971.1357    1.2634
##    5    Poverty              0.0570      0.0558     38.1552    12949.2058    1.2597
##    6    SexNumPartnLife      0.0591      0.0577     31.1607    12942.2607    1.2584
##    7    SexNumPartYear       0.0610      0.0593     25.1899    12936.3166    1.2573
##    8    HomeRooms            0.0628      0.0609     19.7213    12930.8583    1.2563
##    9    AlcoholYear          0.0641      0.0619     16.4559    12927.5917    1.2556
## ----------------------------------------------------------------------------------
```

```
ols_mallows_cp(model =m_logfull_1, fullmodel =m_full)  # Mallows' Cp
```

```
## [1] -3821.538
```

```
ols_mallows_cp(model =m_logfull_2, fullmodel =m_full)  # Mallows' Cp
```

```
## [1] 11.05159
```

```
ols_mallows_cp(model =m_sqfull_1, fullmodel =m_full)  # Mallows' Cp
```

```
## [1] 11.28616
```