Homework1

Megan Jasek, Charles Kekeh, Rohan, Thakur

Sunday, January 31, 2016

Question 1

```
# Load the dataframe
load(file.path("./data", "birthweight_w271.rdata"))
```

Question 2

```
# Display summary information about the dataframe
print(desc)
```

```
##    variable                          label
## 1    faminc     1988 family income, $1000s
## 2    cigtax   cig. tax in home state, 1988
## 3  cigprice cig. price in home state, 1988
## 4     bwght           birth weight, ounces
## 5  fatheduc           father's yrs of educ
## 6  motheduc           mother's yrs of educ
## 7    parity           birth order of child
## 8      male               =1 if male child
## 9     white                    =1 if white
## 10     cigs  cigs smked per day while preg
## 11   lbwght                  log of bwght
## 12 bwghtlbs           birth weight, pounds
## 13    packs packs smked per day while preg
## 14  lfaminc                   log(faminc)
```

```
print(str(data))
```

```
## 'data.frame':    1388 obs. of  14 variables:
##  $ faminc  : num  13.5 7.5 0.5 15.5 27.5 7.5 65 27.5 27.5 37.5 ...
##  $ cigtax  : num  16.5 16.5 16.5 16.5 16.5 16.5 16.5 16.5 16.5 16.5 ...
##  $ cigprice: num  122 122 122 122 122 ...
##  $ bwght   : num  109 133 129 126 134 118 140 86 121 129 ...
##  $ fatheduc: int  12 6 NA 12 14 12 16 12 12 16 ...
##  $ motheduc: int  12 12 12 12 12 14 14 14 17 18 ...
##  $ parity  : int  1 2 2 2 2 6 2 2 2 2 ...
##  $ male    : int  1 1 0 1 1 1 0 0 0 0 ...
##  $ white   : int  1 0 0 0 1 0 1 0 1 1 ...
##  $ cigs    : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ lbwght  : num  4.69 4.89 4.86 4.84 4.9 ...
##  $ bwghtlbs: num  6.81 8.31 8.06 7.88 8.38 ...
```

```
##  $ packs   : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ lfaminc : num  2.603 2.015 -0.693 2.741 3.314 ...
##  - attr(*, "datalabel")= chr ""
##  - attr(*, "time.stamp")= chr "25 Jun 2011 23:03"
##  - attr(*, "formats")= chr  "%9.0g" "%9.0g" "%9.0g" "%8.0g" ...
##  - attr(*, "types")= int  254 254 254 252 251 251 251 251 251 251 ...
##  - attr(*, "val.labels")= chr  "" "" "" "" ...
##  - attr(*, "var.labels")= chr  "1988 family income, $1000s" "cig. tax in home state, 1988" "cig. pri
##  - attr(*, "version")= int 10
## NULL
```

```
print(summary(data))
```

```
##      faminc          cigtax         cigprice         bwght
##  Min.   : 0.50   Min.   : 2.00   Min.   :103.8   Min.   :  0.0
##  1st Qu.:14.50   1st Qu.:15.00   1st Qu.:122.8   1st Qu.:106.0
##  Median :27.50   Median :20.00   Median :130.8   Median :119.0
##  Mean   :29.03   Mean   :19.55   Mean   :130.6   Mean   :117.9
##  3rd Qu.:37.50   3rd Qu.:26.00   3rd Qu.:137.0   3rd Qu.:132.0
##  Max.   :65.00   Max.   :38.00   Max.   :152.5   Max.   :271.0
##
##     fatheduc        motheduc         parity           male
##  Min.   : 1.00   Min.   : 2.00   Min.   :1.000   Min.   :0.0000
##  1st Qu.:12.00   1st Qu.:12.00   1st Qu.:1.000   1st Qu.:0.0000
##  Median :12.00   Median :12.00   Median :1.000   Median :1.0000
##  Mean   :13.19   Mean   :12.94   Mean   :1.633   Mean   :0.5209
##  3rd Qu.:16.00   3rd Qu.:14.00   3rd Qu.:2.000   3rd Qu.:1.0000
##  Max.   :18.00   Max.   :18.00   Max.   :6.000   Max.   :1.0000
##  NA's   :196     NA's   :1
##      white            cigs           lbwght         bwghtlbs
##  Min.   :0.0000   Min.   : 0.000   Min.   :0.000   Min.   : 0.000
##  1st Qu.:1.0000   1st Qu.: 0.000   1st Qu.:4.663   1st Qu.: 6.625
##  Median :1.0000   Median : 0.000   Median :4.779   Median : 7.438
##  Mean   :0.7846   Mean   : 2.087   Mean   :4.726   Mean   : 7.366
##  3rd Qu.:1.0000   3rd Qu.: 0.000   3rd Qu.:4.883   3rd Qu.: 8.250
##  Max.   :1.0000   Max.   :50.000   Max.   :5.602   Max.   :16.938
##
##      packs           lfaminc
##  Min.   :0.0000   Min.   :-0.6931
##  1st Qu.:0.0000   1st Qu.: 2.6741
##  Median :0.0000   Median : 3.3142
##  Mean   :0.1044   Mean   : 3.0713
##  3rd Qu.:0.0000   3rd Qu.: 3.6243
##  Max.   :2.5000   Max.   : 4.1744
##
```

```
print(stat.desc(data))
```

```
##                    faminc       cigtax     cigprice        bwght
## nbr.val      1.388000e+03 1.388000e+03 1.388000e+03 1.388000e+03
## nbr.null     0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+01
## nbr.na       0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
## min          5.000000e-01 2.000000e+00 1.038000e+02 0.000000e+00
```

```
## max          6.500000e+01 3.800000e+01 1.525000e+02 2.710000e+02
## range        6.450000e+01 3.600000e+01 4.870000e+01 2.710000e+02
## sum          4.028900e+04 2.713950e+04 1.812159e+05 1.635790e+05
## median       2.750000e+01 2.000000e+01 1.308000e+02 1.190000e+02
## mean         2.902666e+01 1.955295e+01 1.305590e+02 1.178523e+02
## SE.mean      5.029888e-01 2.092448e-01 2.749764e-01 6.085627e-01
## CI.mean.0.95 9.867009e-01 4.104705e-01 5.394145e-01 1.193803e+00
## var          3.511608e+02 6.077135e+01 1.049495e+02 5.140438e+02
## std.dev      1.873928e+01 7.795598e+00 1.024448e+01 2.267253e+01
## coef.var     6.455888e-01 3.986916e-01 7.846632e-02 1.923809e-01
##                  fatheduc     motheduc       parity         male
## nbr.val      1.192000e+03 1.387000e+03 1.388000e+03 1.388000e+03
## nbr.null     0.000000e+00 0.000000e+00 0.000000e+00 6.650000e+02
## nbr.na       1.960000e+02 1.000000e+00 0.000000e+00 0.000000e+00
## min          1.000000e+00 2.000000e+00 1.000000e+00 0.000000e+00
## max          1.800000e+01 1.800000e+01 6.000000e+00 1.000000e+00
## range        1.700000e+01 1.600000e+01 5.000000e+00 1.000000e+00
## sum          1.571800e+04 1.794200e+04 2.266000e+03 7.230000e+02
## median       1.200000e+01 1.200000e+01 1.000000e+00 1.000000e+00
## mean         1.318624e+01 1.293583e+01 1.632565e+00 5.208934e-01
## SE.mean      7.953531e-02 6.381773e-02 2.399695e-02 1.341381e-02
## CI.mean.0.95 1.560449e-01 1.251898e-01 4.707424e-02 2.631355e-02
## var          7.540432e+00 5.648838e+00 7.992848e-01 2.497434e-01
## std.dev      2.745985e+00 2.376728e+00 8.940273e-01 4.997433e-01
## coef.var     2.082462e-01 1.837322e-01 5.476213e-01 9.593966e-01
##                     white         cigs       lbwght     bwghtlbs
## nbr.val      1.388000e+03 1388.0000000 1.388000e+03 1.388000e+03
## nbr.null     2.990000e+02 1176.0000000 1.000000e+01 1.000000e+01
## nbr.na       0.000000e+00    0.0000000 0.000000e+00 0.000000e+00
## min          0.000000e+00    0.0000000 0.000000e+00 0.000000e+00
## max          1.000000e+00   50.0000000 5.602119e+00 1.693750e+01
## range        1.000000e+00   50.0000000 5.602119e+00 1.693750e+01
## sum          1.089000e+03 2897.0000000 6.559307e+03 1.022369e+04
## median       1.000000e+00    0.0000000 4.779123e+00 7.437500e+00
## mean         7.845821e-01    2.0871758 4.725725e+00 7.365769e+00
## SE.mean      1.103880e-02    0.1603153 1.195727e-02 3.803517e-02
## CI.mean.0.95 2.165455e-02    0.3144867 2.345628e-02 7.461267e-02
## var          1.691349e-01   35.6730005 1.984510e-01 2.007984e+00
## std.dev      4.112601e-01    5.9726879 4.454784e-01 1.417033e+00
## coef.var     5.241772e-01    2.8616123 9.426668e-02 1.923809e-01
##                     packs       lfaminc
## nbr.val      1.388000e+03 1388.00000000
## nbr.null     1.176000e+03    0.00000000
## nbr.na       0.000000e+00    0.00000000
## min          0.000000e+00   -0.69314718
## max          2.500000e+00    4.17438745
## range        2.500000e+00    4.86753464
## sum          1.448500e+02 4262.92435274
## median       0.000000e+00    3.31418610
## mean         1.043588e-01    3.07127115
## SE.mean      8.015767e-03    0.02464214
## CI.mean.0.95 1.572434e-02    0.04833990
## var          8.918250e-02    0.84284246
## std.dev      2.986344e-01    0.91806452
```

```
## coef.var     2.861612e+00    0.29892005
```

There are 1388 obs. of 14 variables in the data.

Question 3

```
# Get summary statistics about the birthweight
# variable.
print(summary(data$bwght))
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     0.0   106.0   119.0   117.9   132.0   271.0
```

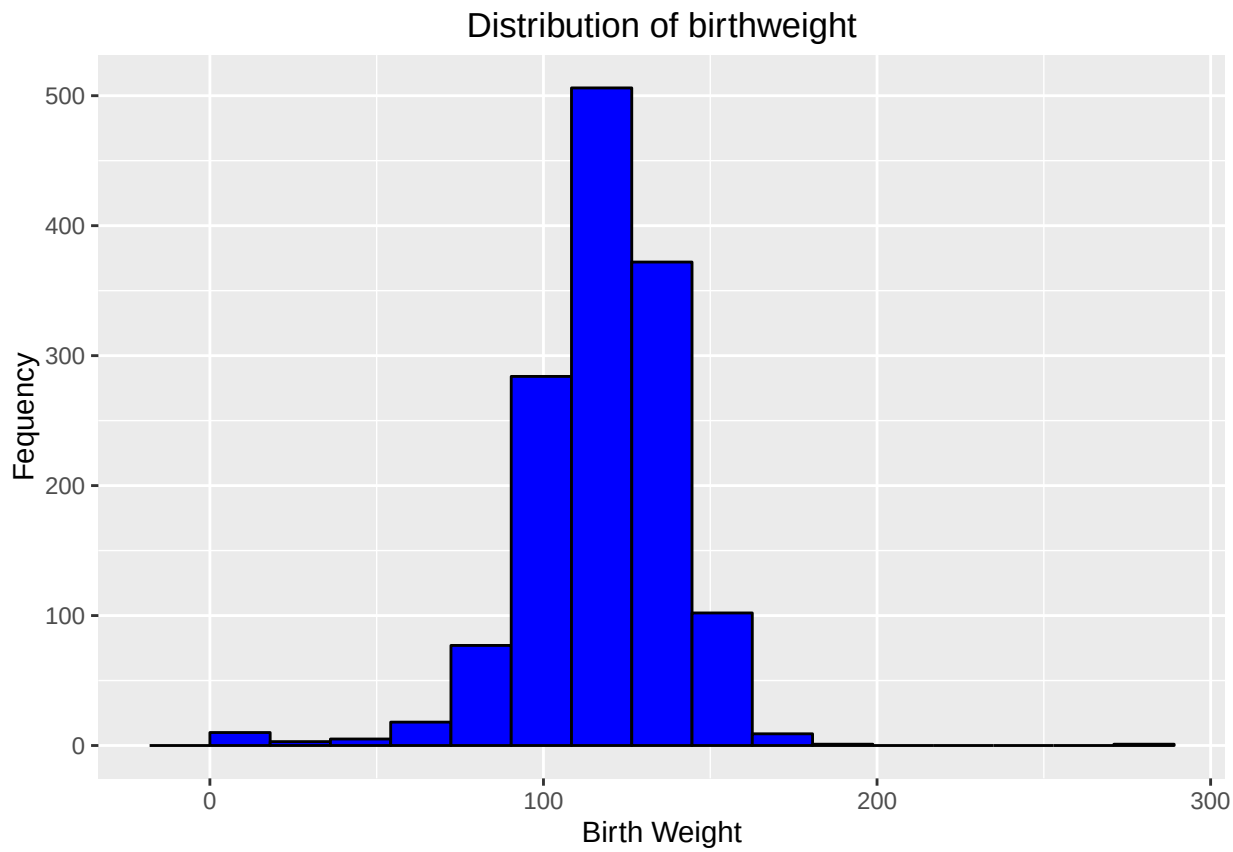
```
print(sum(is.nan(data$bwght)))
```

```
## [1] 0
```

```
print(quantile(data$bwght, probs = c(0.01, 0.05, 0.1,
    0.25, 0.5, 0.75, 0.9, 0.95, 0.99, 1)))
```

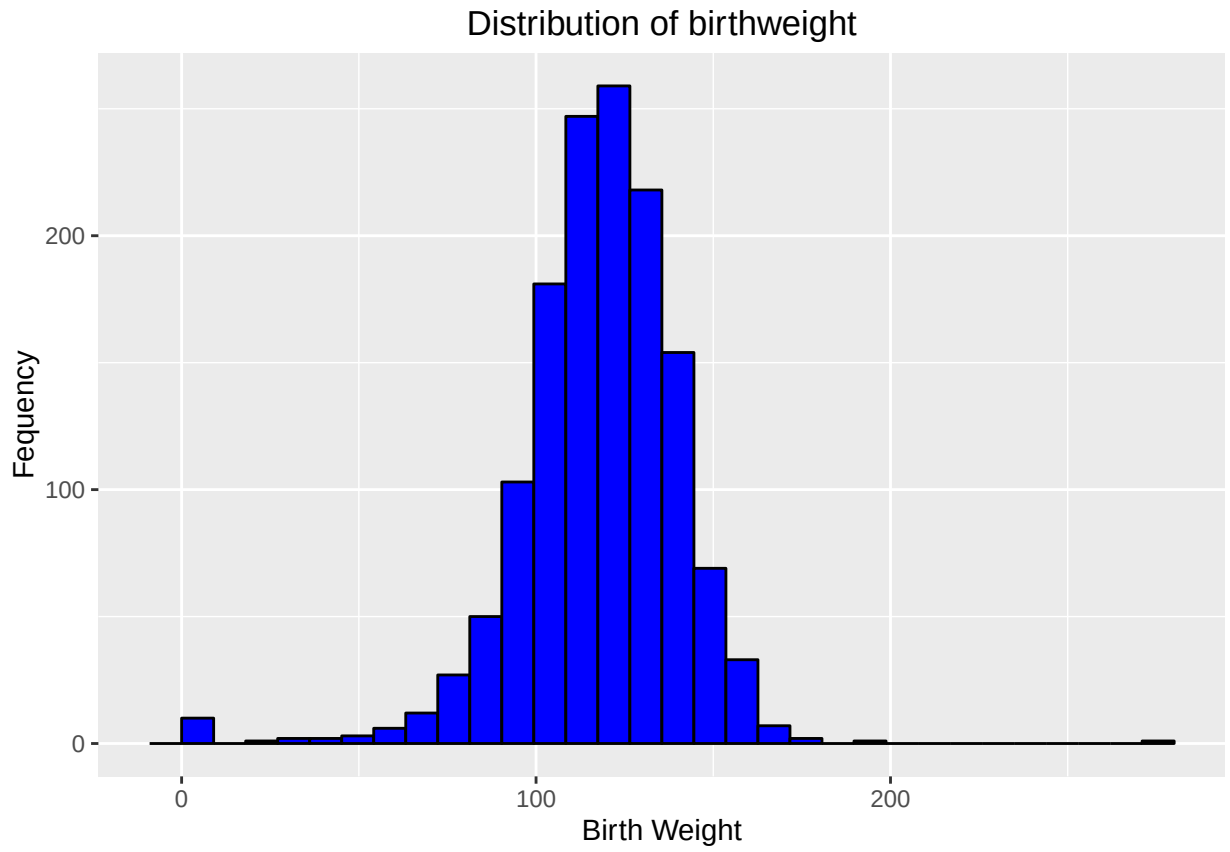
```
##     1%     5%    10%    25%    50%    75%    90%    95%    99%   100%
##  42.35  83.00  93.00 106.00 119.00 132.00 143.00 149.00 160.13 271.00
```

```
# Plot the histogram of bwght at 15 bins
bwght.hist <- ggplot(data, aes(bwght)) + theme(legend.position = "none") +
    geom_histogram(fill = "Blue", colour = "Black",
        binwidth = (range(data$bwght)[2] - range(data$bwght)[1])/15) +
    labs(title = "Distribution of birthweight", x = "Birth Weight",
        y = "Fequency")

plot(bwght.hist)
```

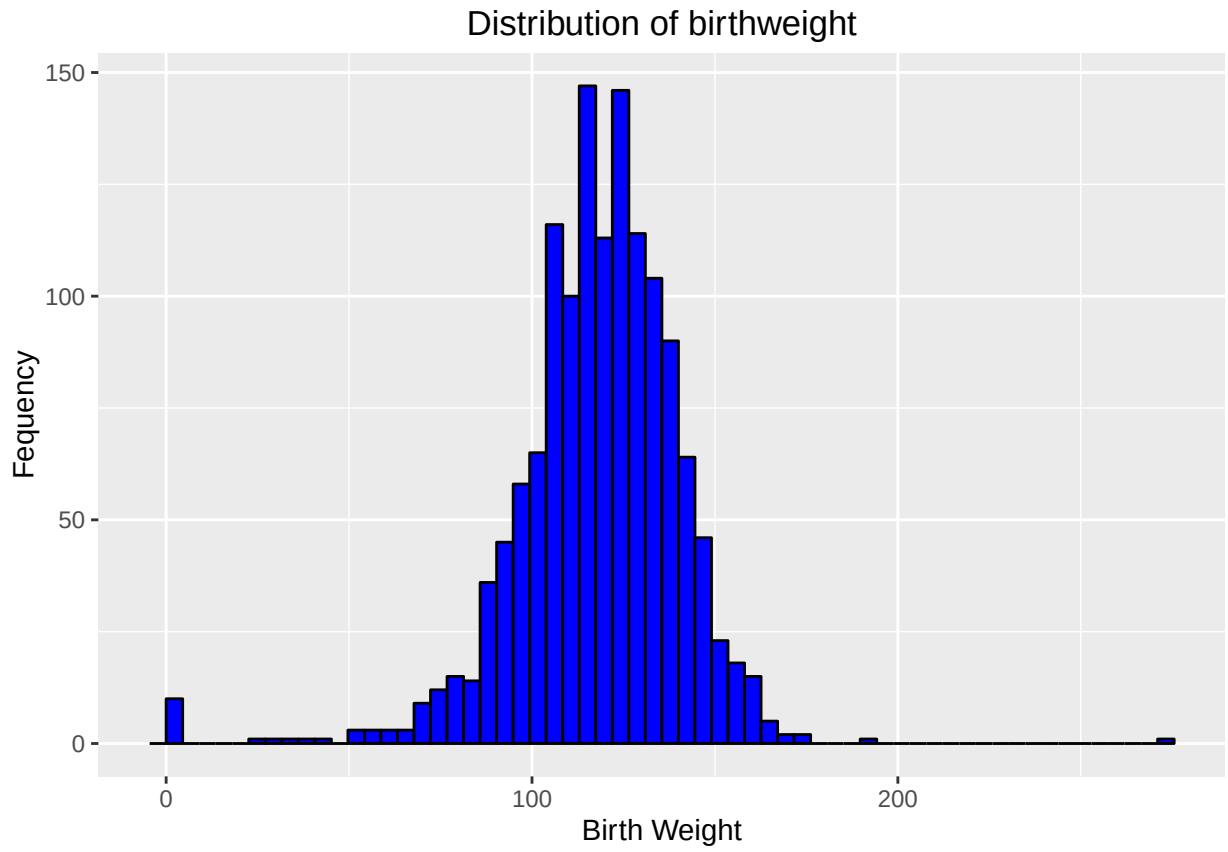



```
# Plot the histogram of bwght at 30 bins
bwght.hist <- ggplot(data, aes(bwght)) + theme(legend.position = "none") +
    geom_histogram(fill = "Blue", colour = "Black") +
    labs(title = "Distribution of birthweight", x = "Birth Weight",
        y = "Fequency")

plot(bwght.hist)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
# Plot the histogram of bwght at 60 bins
bwght.hist <- ggplot(data, aes(bwght)) + theme(legend.position = "none") +
    geom_histogram(fill = "Blue", colour = "Black",
        binwidth = (range(data$bwght)[2] - range(data$bwght)[1])/60) +
    labs(title = "Distribution of birthweight", x = "Birth Weight",
        y = "Fequency")

plot(bwght.hist)
```



Comments on shape of distributions:

As more and more bins are added the shape of the distribution gets smoother.

Data observations:

Below are the outlier observations. There are babies with birthweights of 0 and over 200 ounces.

```
print(sum(data$bwght == 0))
```

```
## [1] 10
```

```
print(data$bwght[data$bwght > 200])
```

```
## [1] 271
```

We should remove the zero baby weights from the data. They probably correspond to data entry issues. We should also remove the single 271 ounces baby observation in the data set. For the purpose of a linear regression, that outlier data point may affect the regression.

Question 4

```
# Get summary statistics about the cigarettes
# smoked variable.
print(summary(data$cigs))
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.000   0.000   0.000   2.087   0.000  50.000
```

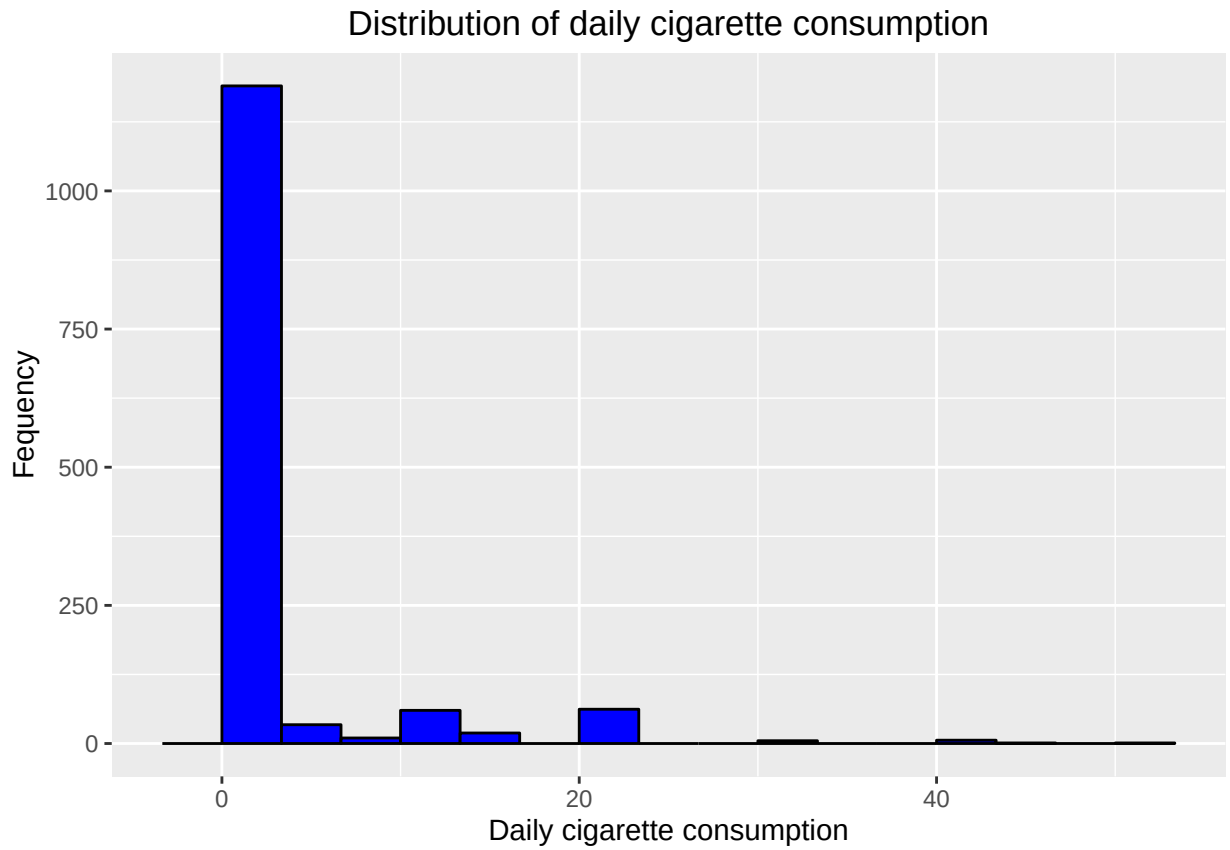
```
print(sum(is.nan(data$cigs)))
```

```
## [1] 0
```

```
print(quantile(data$cigs, probs = c(0.01, 0.05, 0.1,
    0.25, 0.5, 0.75, 0.9, 0.95, 0.99, 1)))
```

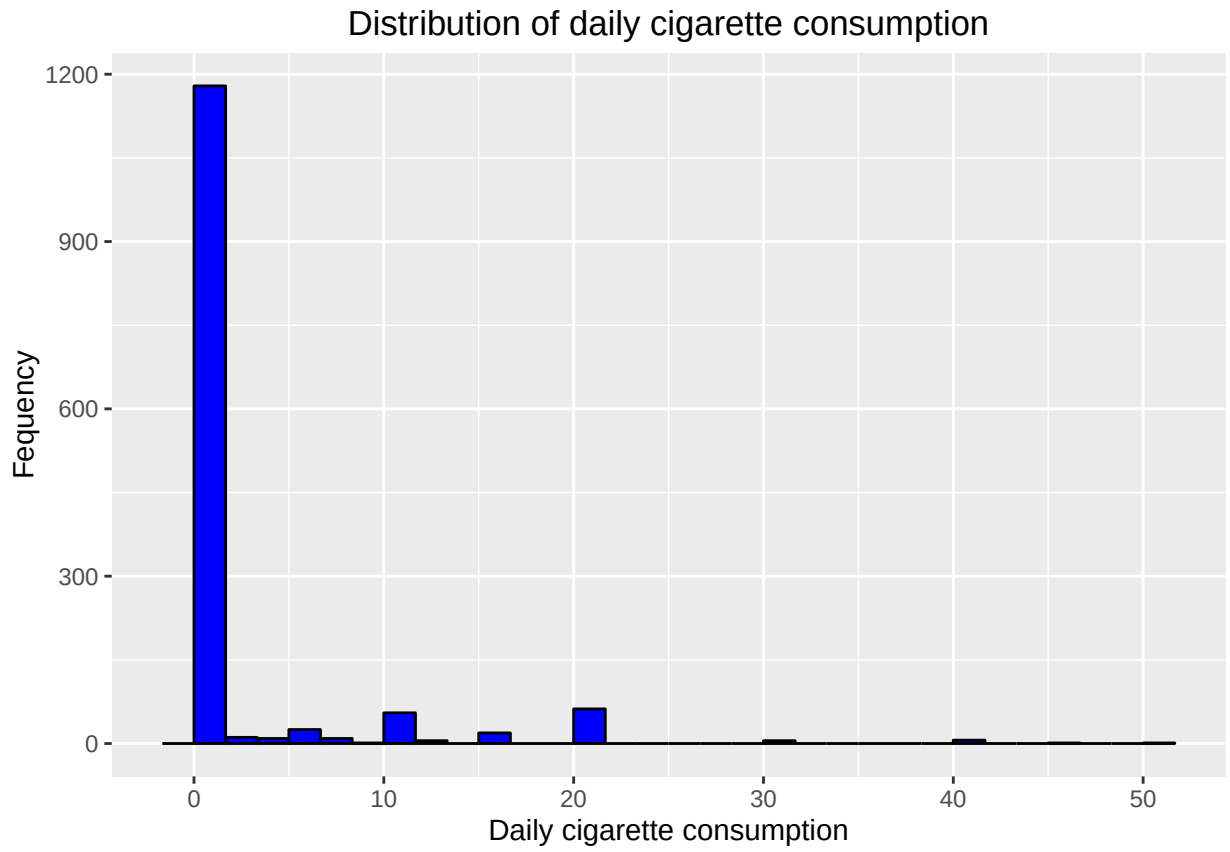
```
##   1%   5%  10%  25%  50%  75%  90%  95%  99% 100%
##    0    0    0    0    0    0   10   20   20   50
```

```
# Plot the histogram of cigs at 15 bins
cigs.hist <- ggplot(data, aes(cigs)) + theme(legend.position = "none") +
    geom_histogram(fill = "Blue", colour = "Black",
        binwidth = (range(data$cigs)[2] - range(data$cigs)[1])/15) +
    labs(title = "Distribution of daily cigarette consumption",
        x = "Daily cigarette consumption", y = "Fequency")

plot(cigs.hist)
```

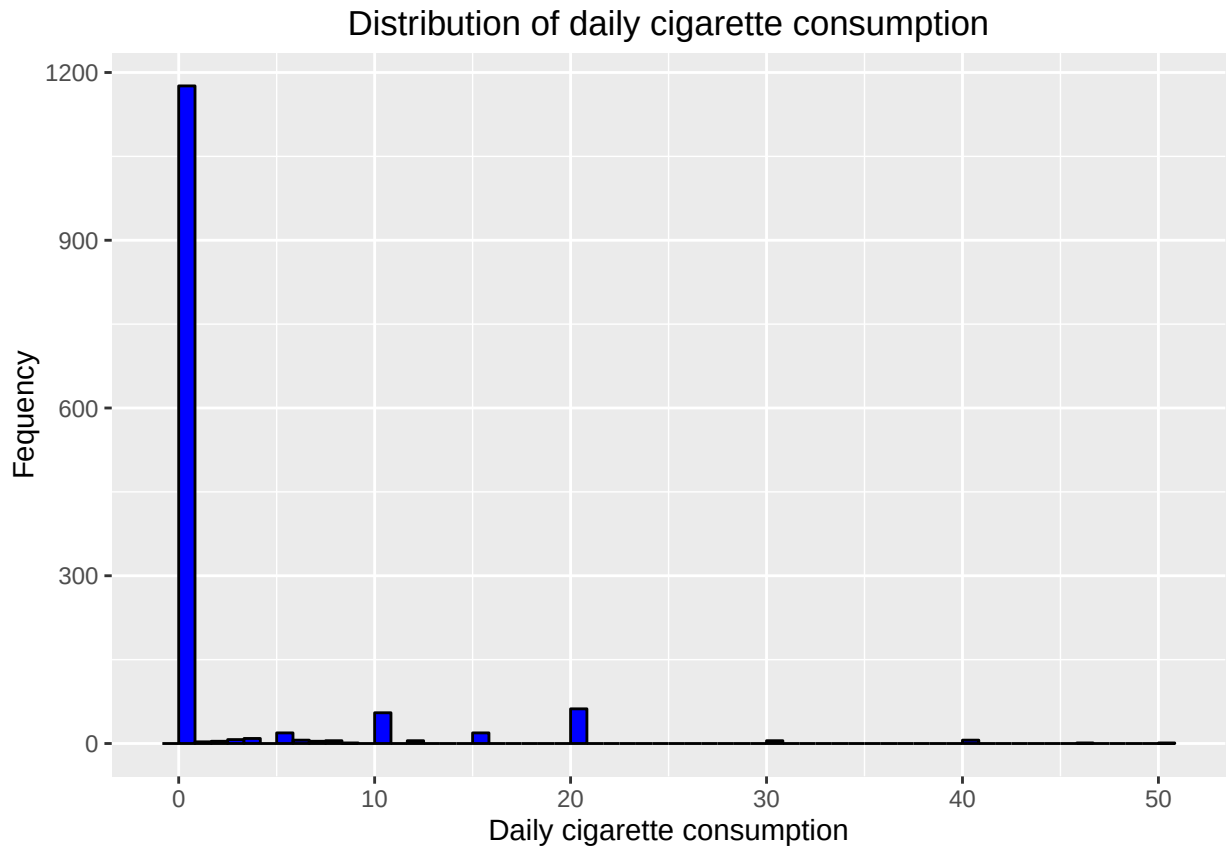



```
# Plot the histogram of cigs at 30 bins
cigs.hist <- ggplot(data, aes(cigs)) + theme(legend.position = "none") +
    geom_histogram(fill = "Blue", colour = "Black") +
    labs(title = "Distribution of daily cigarette consumption",
        x = "Daily cigarette consumption", y = "Fequency")

plot(cigs.hist)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```r
# Plot the histogram of cigs at 60 bins
cigs.hist <- ggplot(data, aes(cigs)) + theme(legend.position = "none") +
    geom_histogram(fill = "Blue", colour = "Black",
        binwidth = (range(data$cigs)[2] - range(data$cigs)[1])/60) +
    labs(title = "Distribution of daily cigarette consumption",
        x = "Daily cigarette consumption", y = "Fequency")

plot(cigs.hist)
```



Comments on shape of distributions:

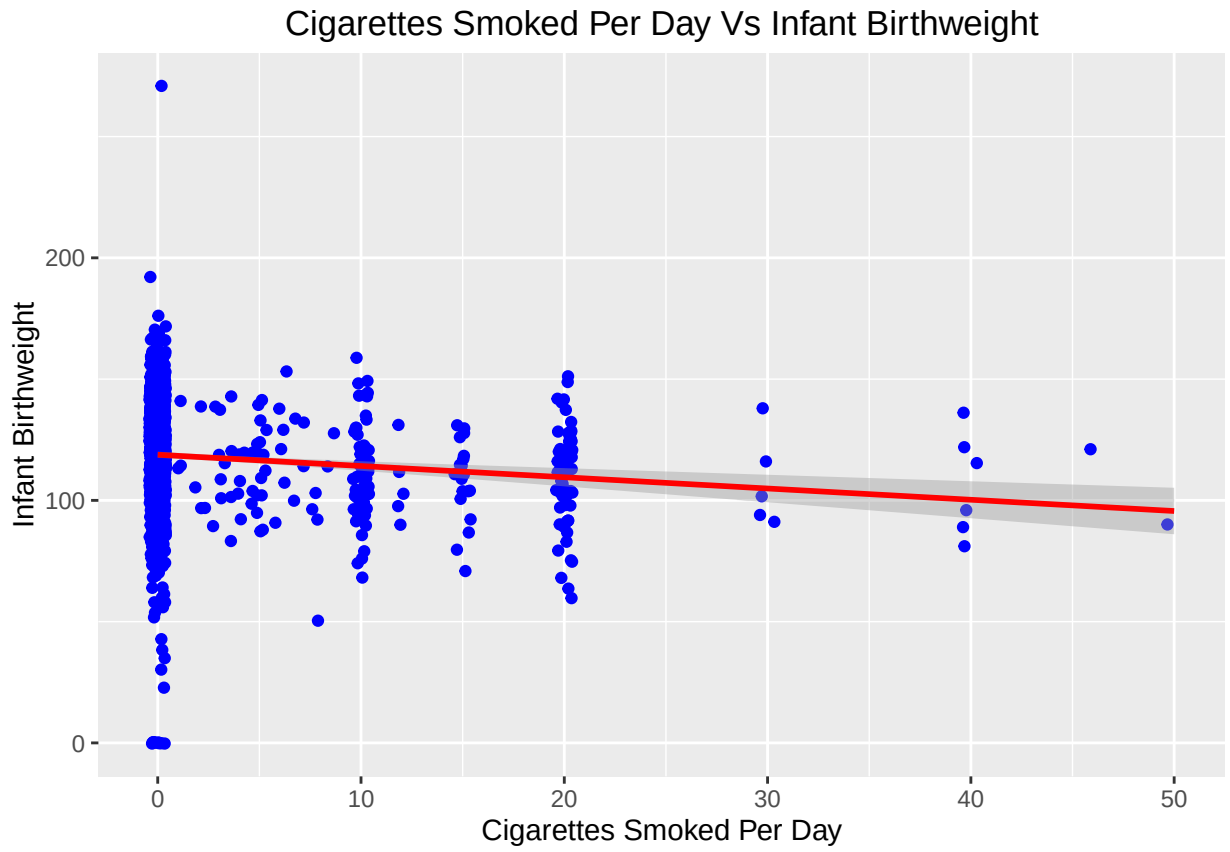
As more and more bins are added, more granularity of the data can be seen.

Data observations:

The histogram for the number of cigarettes smoked is positively skewed with a very high proportion of individuals smoking zero cigarettes per day during their pregnancy. There are no other visible signs of anomalies in the data.

Question 5:

```
# Create a scatterplot of cigarettes smoked per day
# vs baby birthweight
scatter.bwght.cigs <- ggplot(data, aes(cigs, bwght)) +
    geom_point(colour = "Blue", position = "jitter") +
    geom_smooth(method = "lm", colour = "Red") + labs(x = "Cigarettes Smoked Per Day",
    y = "Infant Birthweight", title = "Cigarettes Smoked Per Day Vs Infant Birthweight")
plot(scatter.bwght.cigs)
```



Based on the scatterplot and the fitted lm curve on it, it appears that only a very small amount of the variation of bwght will be explained by cigs. That's because the variation explained in the graph appears to be much lower than the variation of birthweights at any level of daily cigarette consumption in the scatterplot.

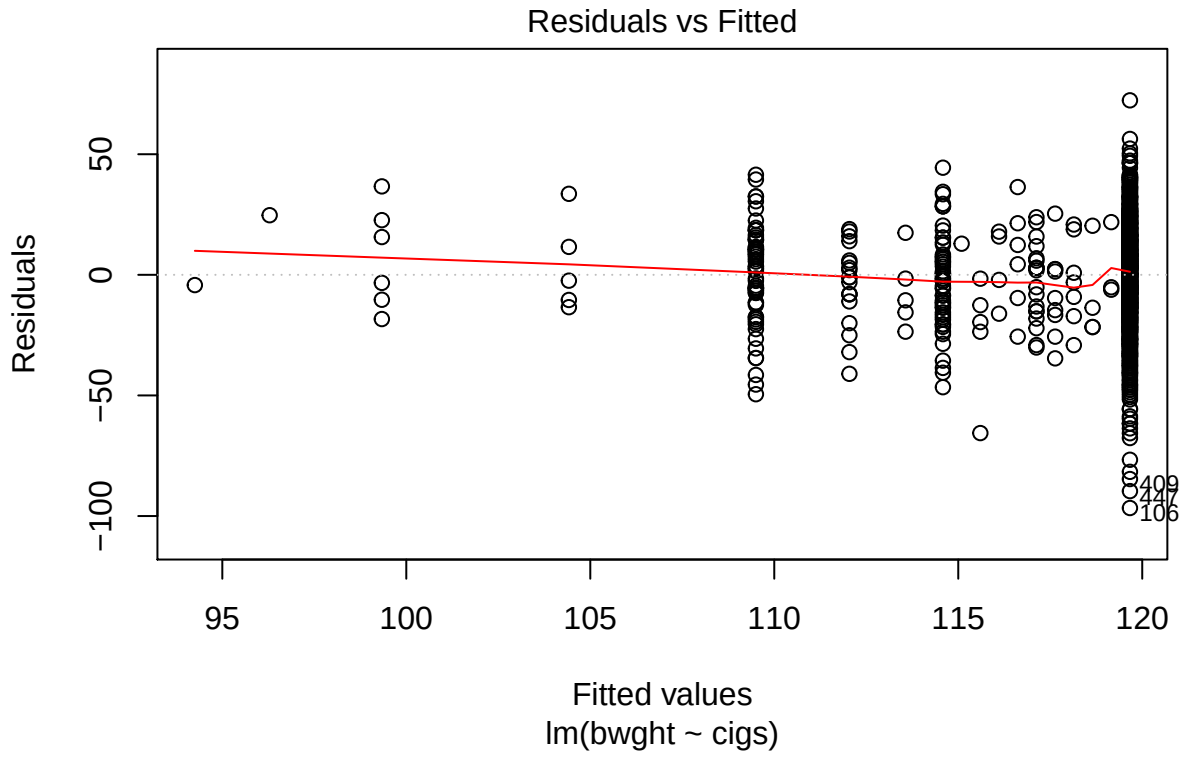
Question 6:

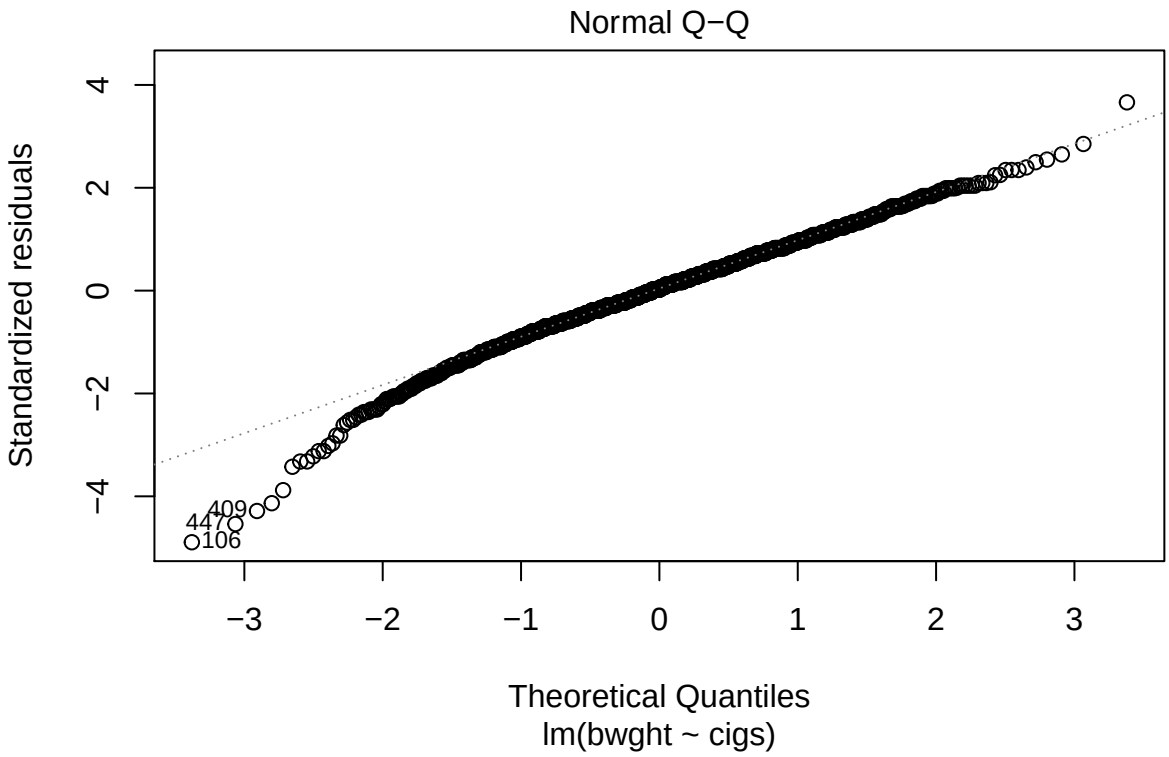
```
# Clean up the data based on previous observations
data <- data[data$bwght != 0 & data$bwght < 200, ]

# Now perform the OLS regression
simple.ols.cigs.bwght <- lm(bwght ~ cigs, data = data)
print(summary.lm(simple.ols.cigs.bwght))
```

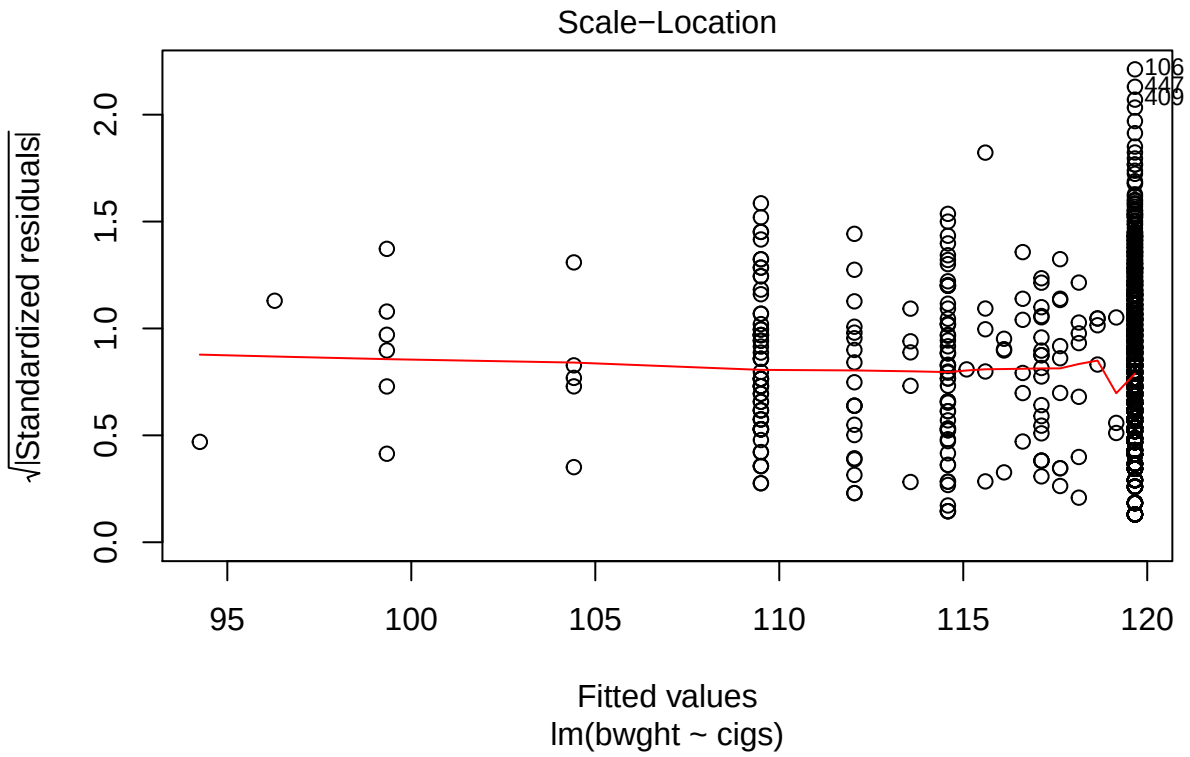
```
##
## Call:
## lm(formula = bwght ~ cigs, data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -96.666 -11.666   0.416  13.334  72.334
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
```

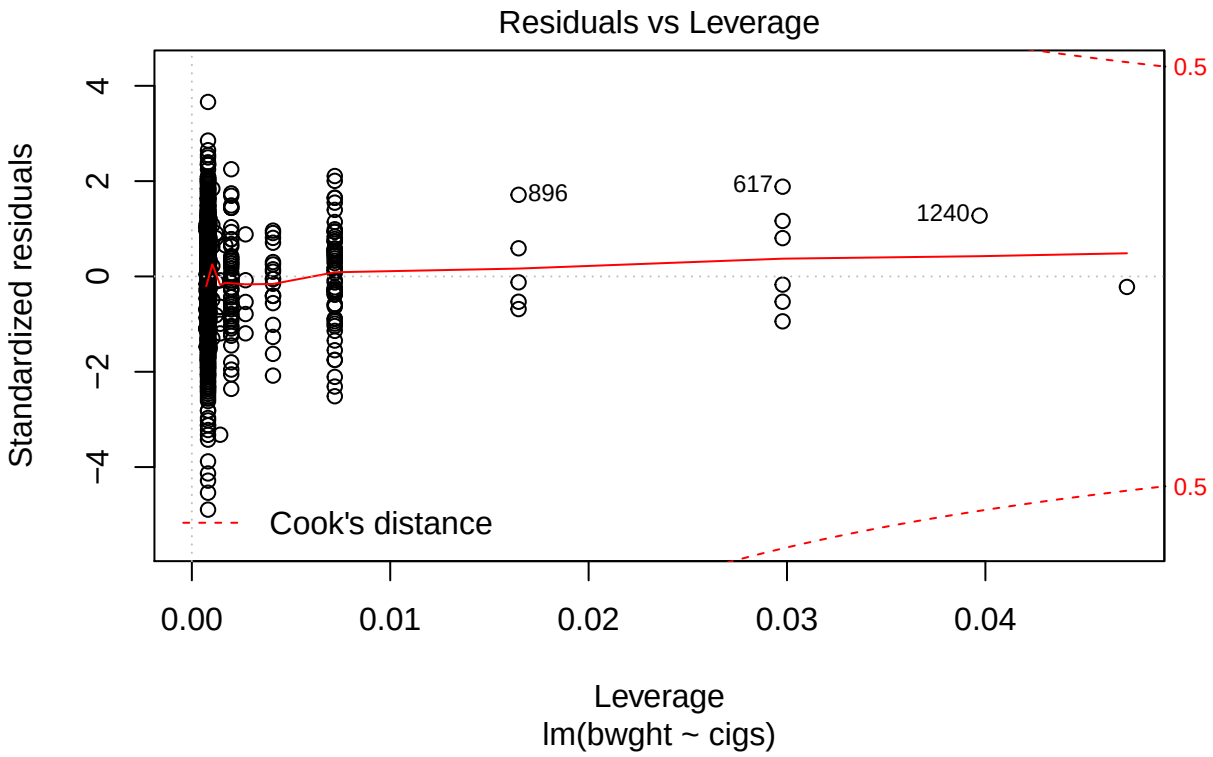
```
## (Intercept) 119.6663     0.5645 211.989  < 2e-16 ***
## cigs         -0.5083     0.0889  -5.717 1.32e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 19.76 on 1375 degrees of freedom
## Multiple R-squared:  0.02322,    Adjusted R-squared:  0.02251
## F-statistic: 32.69 on 1 and 1375 DF,  p-value: 1.324e-08
```

```
plot(simple.ols.cigs.bwght)
```




Normal Q−Q
Standardized residuals
4
2
0
−2
−4
409
447
106
−3
−2
−1
0
1
2
3
Theoretical Quantiles
lm(bwght ~ cigs)


Scale−Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
106
447
409
95
100
105
110
115
120
Fitted values
lm(bwght ~ cigs)



Coefficients:

Intercept: estimate = 119.6663, standard error = 0.5645
cigs: estimate = -0.5083, standard error = 0.0889
The intercept and slope coefficents of the model are statistically significant.

Interpret the Results:

1. Our model null hypothesis is that there is no relationship between the bwght variable and the cigs variable. We are able to reject the null hypothesis since our p-value of the f-statistic of the model is significant at 1.711e-08.
2. Our coefficient null hypothesis is that the coefficient for the cigs variable is 0. We are able to reject the null hypothesis since our p-value of the t-statistic of the cigs variable is significant at 1.32e-08.
3. A change of 1 unit in cigs corresponds to a 0.51 reduction in birthweight. (The model shows a negative coefficient for the variable cigs with a value of -0.508).
4. Practical significance: we have an R-squared value of 0.02322, indicating that 2.32% of the variation in bwght is explained by our model. An R value of 0.152 indicates a relatively small effect size.

Question 7

```r
# Obtain descriptive statistics for the new
# variable
print(summary(data$faminc))
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.50   14.50   27.50   29.02   37.50   65.00
```

```r
print(sum(is.nan(data$faminc)))
```

```
## [1] 0
```

```r
print(quantile(data$faminc, probs = c(0.01, 0.05, 0.1,
    0.25, 0.5, 0.75, 0.9, 0.95, 0.99, 1)))
```

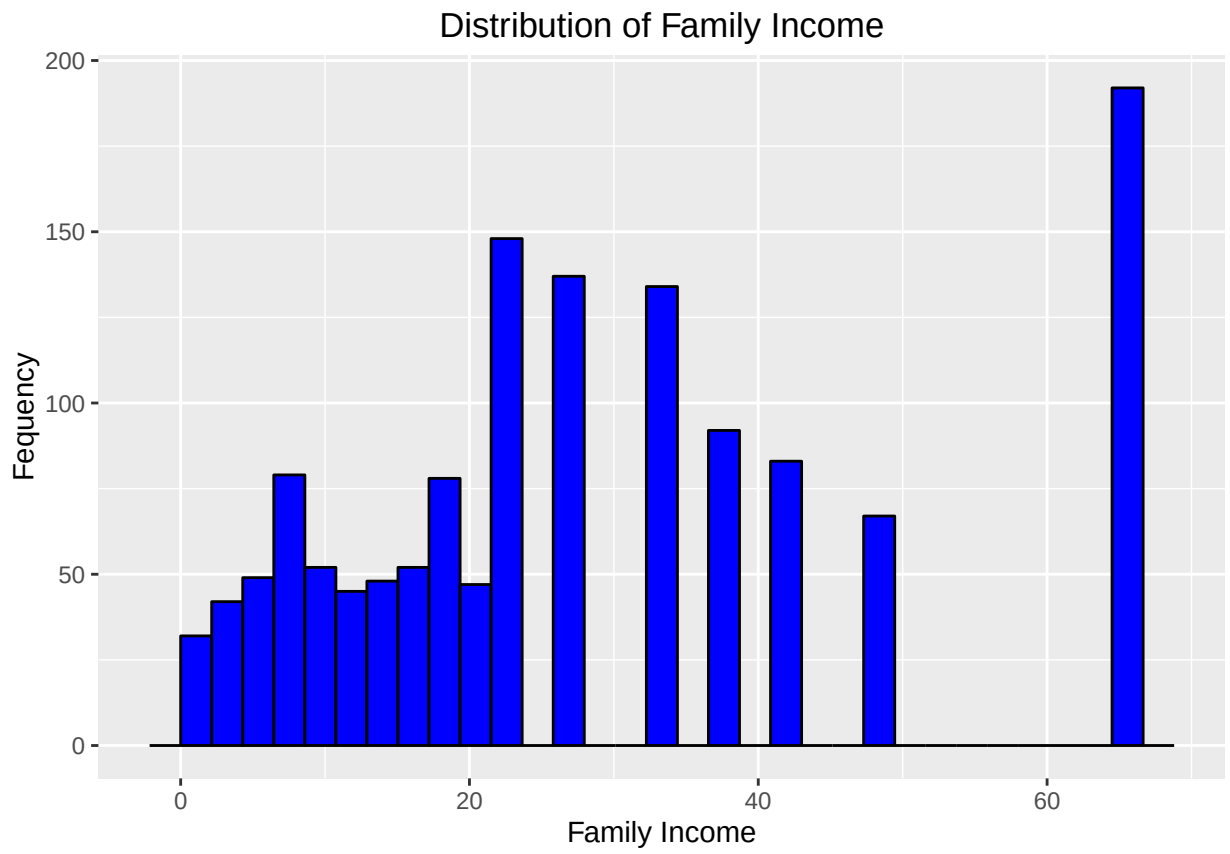
```
##   1%   5%  10%  25%  50%  75%  90%  95%  99% 100%
##  0.5  3.5  6.5 14.5 27.5 37.5 65.0 65.0 65.0 65.0
```

```r
print(stat.desc(data$faminc, basic = FALSE, norm = TRUE))
```

```
##        median          mean       SE.mean  CI.mean.0.95           var
##  2.750000e+01  2.901924e+01  5.064030e-01  9.934054e-01  3.531234e+02
##       std.dev      coef.var      skewness      skew.2SE      kurtosis
##  1.879158e+01  6.475557e-01  6.173813e-01  4.681523e+00 -5.383847e-01
##      kurt.2SE    normtest.W    normtest.p
## -2.042725e+00  9.189733e-01  1.520670e-26
```

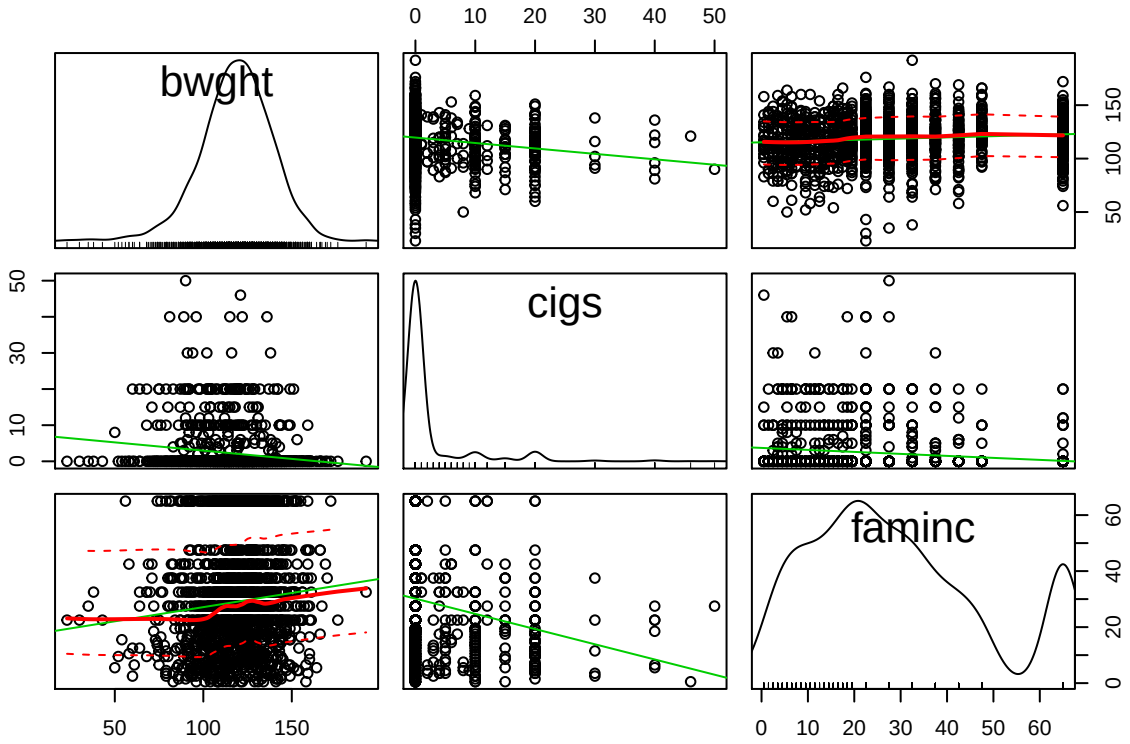
```r
# Plot the histogram of faminc at 30 bins
faminc.hist <- ggplot(data, aes(faminc)) + theme(legend.position = "none") +
    geom_histogram(fill = "Blue", colour = "Black") +
    labs(title = "Distribution of Family Income", x = "Family Income",
        y = "Fequency")

plot(faminc.hist)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
# Produce a scatterplot of bwght, cigs and faminc
scatterplotMatrix(~bwght + cigs + faminc, data = data)
```

```
## Warning in smoother(x, y, col = col[2], log.x = FALSE, log.y = FALSE,
## spread = spread, : could not fit smooth

## Warning in smoother(x, y, col = col[2], log.x = FALSE, log.y = FALSE,
## spread = spread, : could not fit smooth

## Warning in smoother(x, y, col = col[2], log.x = FALSE, log.y = FALSE,
## spread = spread, : could not fit smooth

## Warning in smoother(x, y, col = col[2], log.x = FALSE, log.y = FALSE,
## spread = spread, : could not fit smooth
```



Data observations:

In the famiily income variable, it seems that while all values below 20 were collected as exact values, values above may have been collected as ranges. For example, respondents may have ticked boxes such as 20-25, 25-20, 30-35, etc., and in the final variable it seems the data is represented as the mean of the range. It also seems strange that 65 is so far above the rest of the values. It seems that values above a certain number have been denoted as 65. While this is not ideal, we will proceed with these values as our observations.

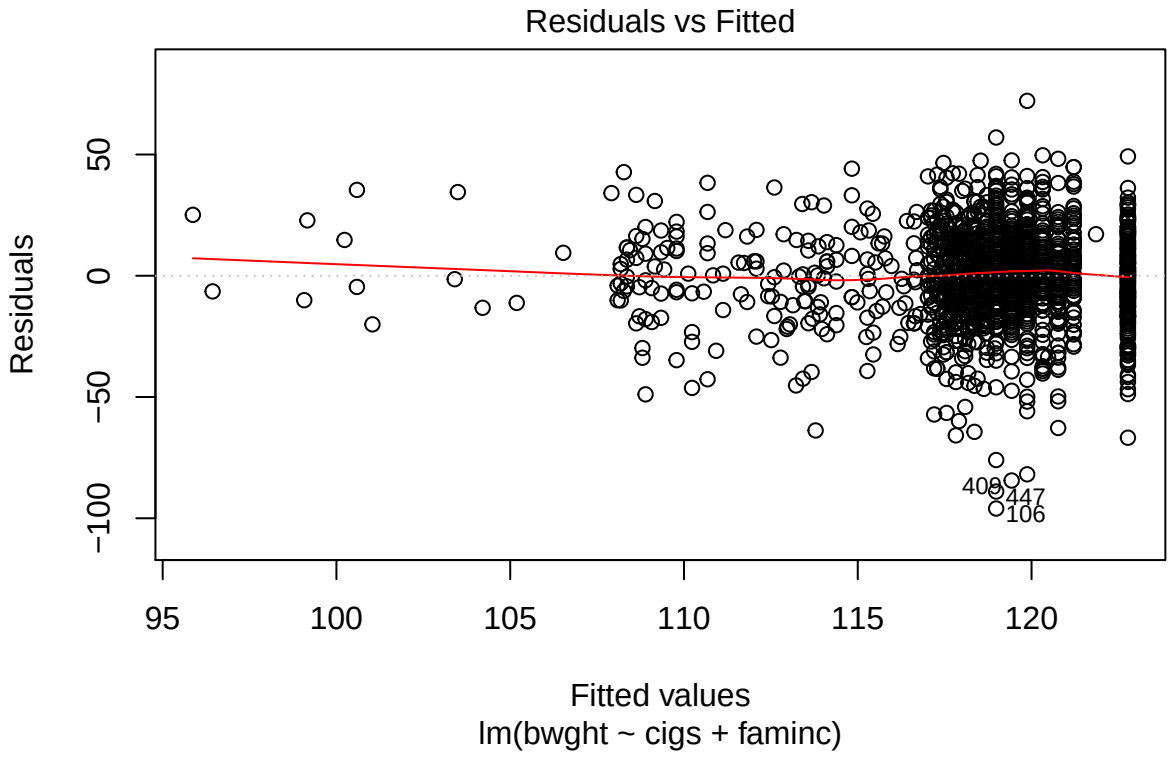
Question 8:

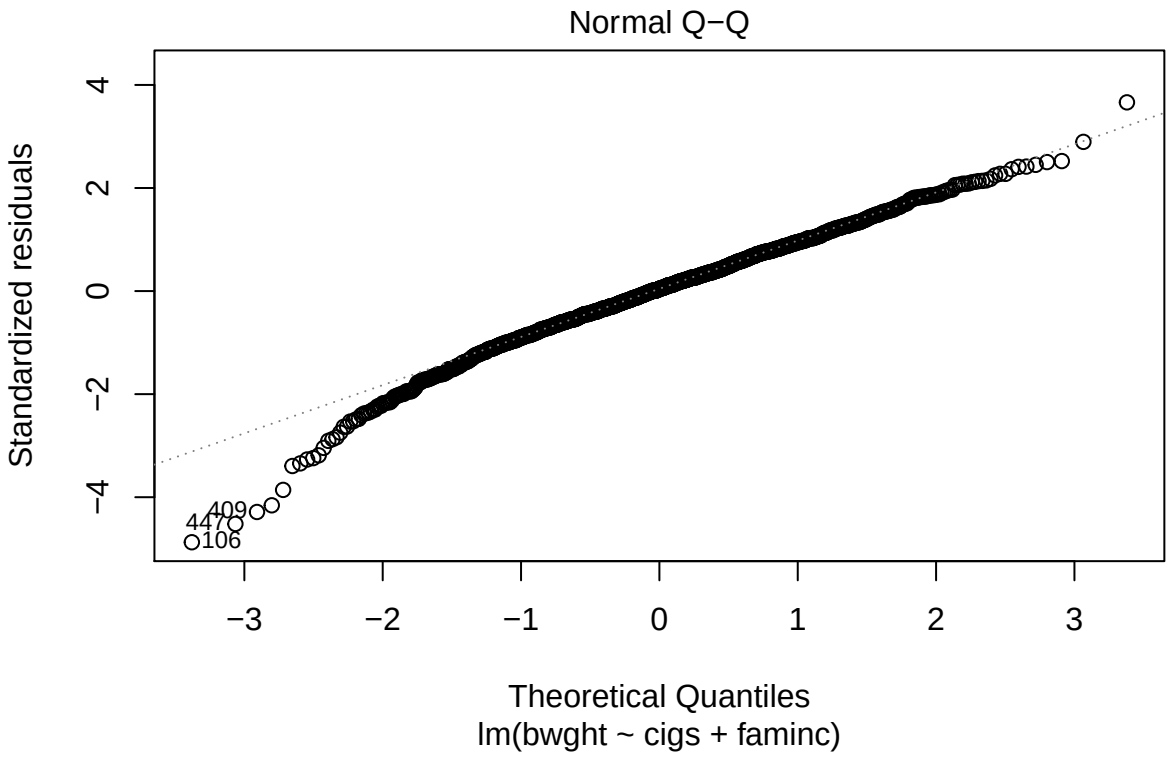
```
# Introduce a new independent variable to the model
multiple.ols.cigs.faminc.bwght <- lm(bwght ~ cigs +
    faminc, data = data)
print(summary.lm(multiple.ols.cigs.faminc.bwght))
```

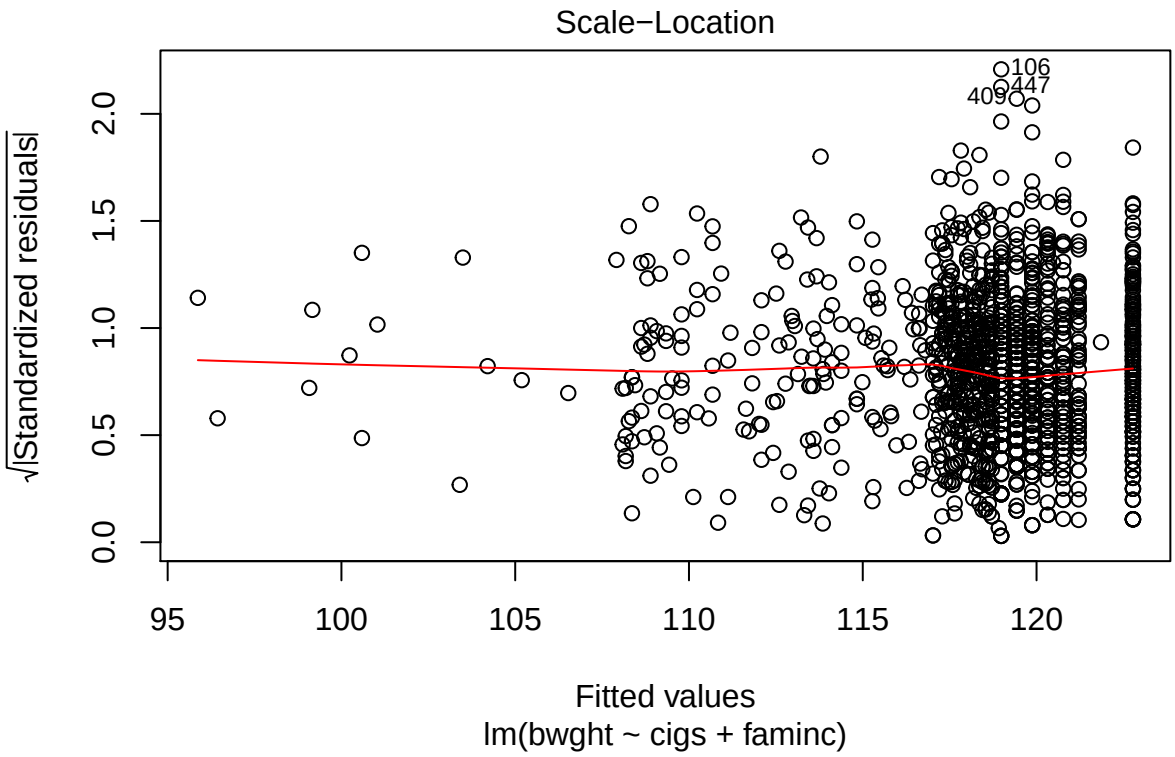
```
##
## Call:
## lm(formula = bwght ~ cigs + faminc, data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -95.983 -11.537   0.824  13.298  72.125
```

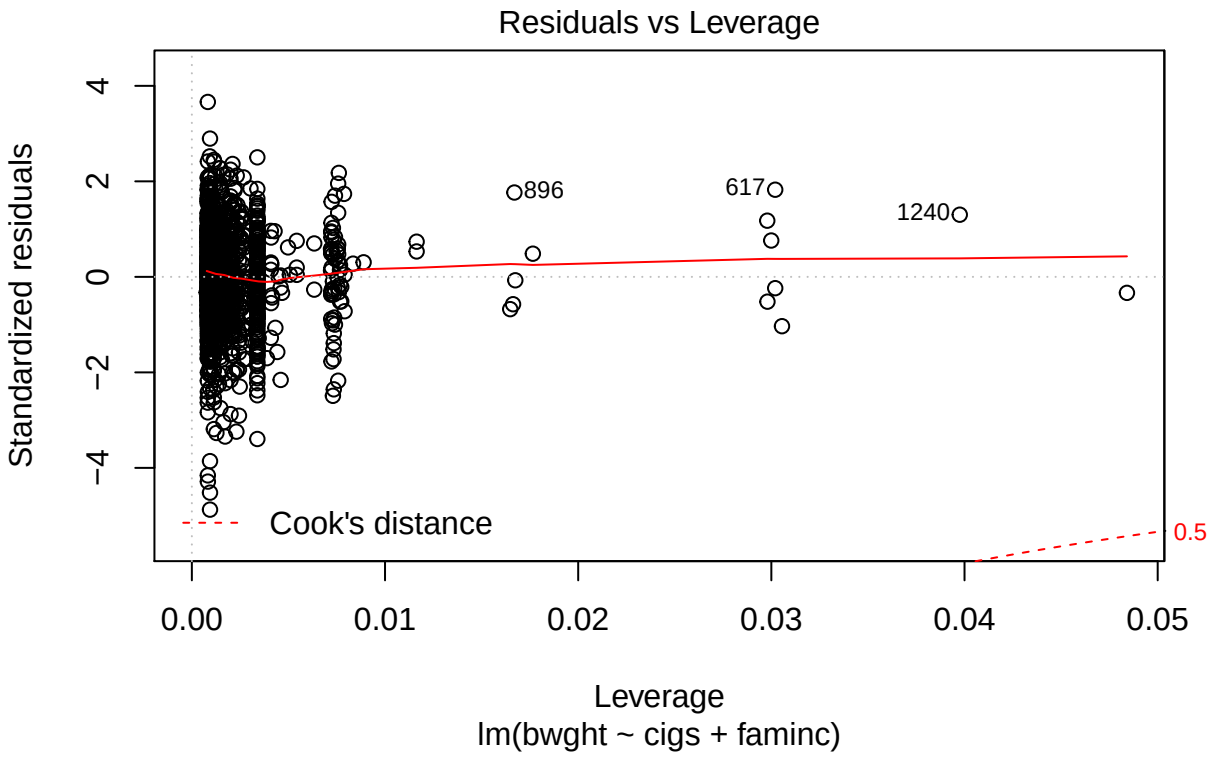
```
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 116.97540    1.03242 113.302  < 2e-16 ***
## cigs         -0.45981    0.08998  -5.110 3.67e-07 ***
## faminc        0.08921    0.02870   3.109  0.00192 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 19.7 on 1374 degrees of freedom
## Multiple R-squared:  0.03004,    Adjusted R-squared:  0.02863
## F-statistic: 21.28 on 2 and 1374 DF,  p-value: 7.916e-10
```

```
plot(multiple.ols.cigs.faminc.bwght)
```




Normal Q−Q
Standardized residuals
4
2
0
−2
−4
409
447
106
−3
−2
−1
0
1
2
3
Theoretical Quantiles
lm(bwght ~ cigs + faminc)


Scale−Location
106
447
409
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
95
100
105
110
115
120
Fitted values
lm(bwght ~ cigs + faminc)



Coefficients:

Intercept: estimate = 116.97540, standard error = 1.03242
cigs: estimate = -0.45981, standard error = 0.08998
faminc: estimate = 0.08921, standard error = 0.02870
The intercept and slope coefficents of the model are statistically significant.

Interpret the Results:

1. Our model null hypothesis is that there is no relationship between the bwght variable and the cigs and faminc variables. We are able to reject the null hypothesis since our p-value of the f-statistic of the model is significant at 7.916e-10.
2. Our coefficient null hypothesis is that the coefficients for the cigs variable and faminc variable are 0. We are able to reject the null hypothesis since our p-value of the t-statistic of the cigs variable is significant at 3.67e-07 and our p-value of the t-statistic of the faminc variable is significant at 0.00192.
3. A change of 1 unit in cigs corresponds to a 0.46 reduction in birthweight. (The model shows a negative coefficient for the variable cigs with a value of -0.45981). A change of 1 unit in faminc corresponds to a 0.09 increase in birthweight. (The model shows a positive coefficient for the variable faminc with a value of 0.08921).
4. Practical significance: we have an R-squared value of 0.03004, indicating that 3.00% of the variation in bwght is explained by our model. An R value of 0.173 indicates a relatively small effect size.

Question 9

In multiple regression, the coefficient on cigs means that for every additional cigarette smoked per day by the pregnant mother, leaving the income variable constant, the birth weight decreases by 0.460 ounces.

In simple regression, we saw that this coefficient was also negative and had a value of -0.508. In this case, the coefficient on cigs meant that for every additional cigarette smoked per day, indepedent of any other condition of the mother, the birth weight was reduced by 0.508 ounces.

In the multiple regression, the variance explained by the faminc variable was captured in the residuals of the simple model and partially also in the coefficent of the cigs variable as we can suspect there is some correlation between the two variables.

Therefore, the introduction of the additional variable faminc has reduced the contribution of the cigs variable to the birth weight. We can hypothesise that there is some correlation between the number of cigarettes smoked per day and the family income, where mothers with higher family income have better health habits and therefore smoke less. And introducing the family income variable thus takes away some of the variance explanation previously captured by the cigs variable.

Question 10

The more negative cigs coefficient is that of the simpel model. It's value is -0.508 compared to the -0.46 value for the multiple regression model. Our explaination for the difference as stated in Question 9 is that there is a correlation between the cigs variable and the faminc variable.