Math 183 - Project 1

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How can mother's smoking behavior affect infant birth weight?

Smoking is a harmful behavior that can cause birth defects, so it is expected that as the number of cigarettes smoked per day for a mother during pregnancy increases, the weight of her baby at birth will decrease. In this project, the two variables will have their distributions and relationship analyzed, and a LS regression model will be generated and tested to demonstrate whether this relationship can be fitted into a linear model.

1. Data Preparation

```
# Data interested to know: infant birth weight vs. mother's smoking behavior
data <- read.csv("Bwghtgrams.csv", header = T)
head(data, n = 2)
```

```
##   faminc cigtax cigprice fatheduc motheduc parity male white cigs   lbwght
## 1   13.5   16.5    122.3       12       12      1    1     1    0 4.691348
## 2    7.5   16.5    122.3        6       12      2    1     0    0 4.890349
##   bwghtlbs packs  lfaminc bwghtgrams
## 1   6.8125     0 2.602690   3090.098
## 2   8.3125     0 2.014903   3770.487
```

```
# Dimension of the original data
dim(data)
```

```
## [1] 1388   14
```

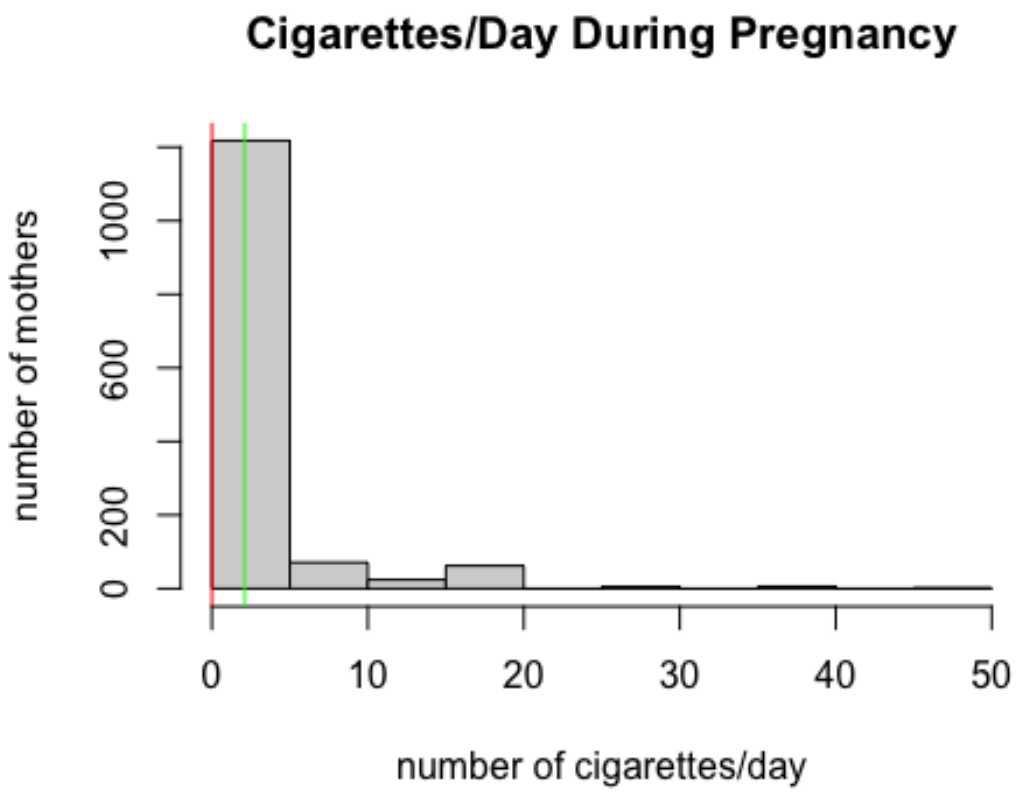
```
# Structure of the original data
str(data)
```

```
## '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 ...
##  $ 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 ...
```

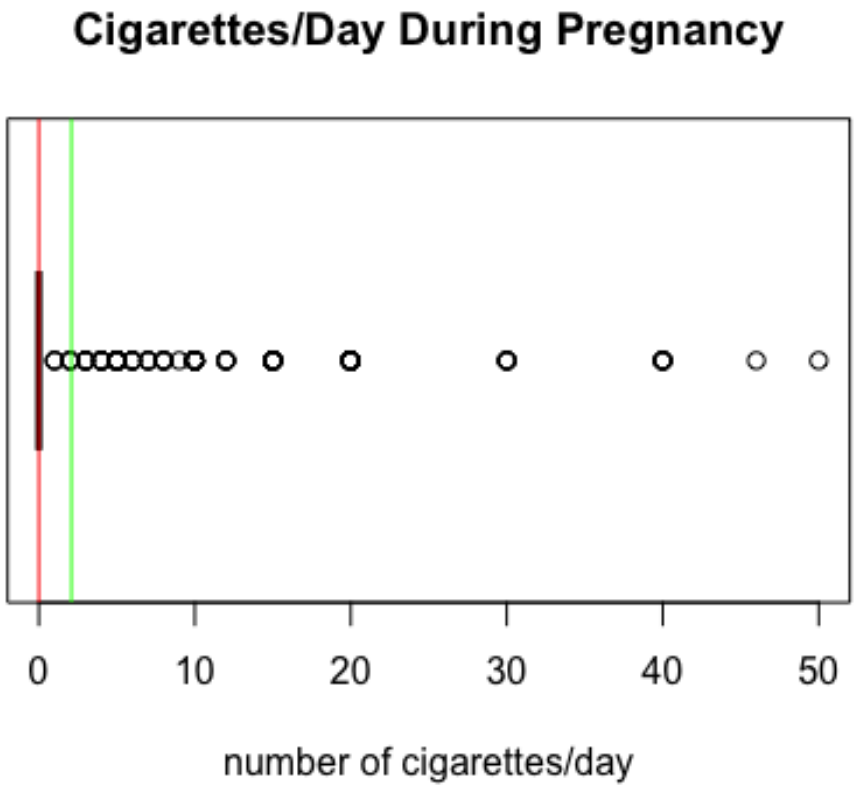
```
##  $ lfaminc   : num  2.603 2.015 -0.693 2.741 3.314 ...
##  $ bwghtgrams: num  3090 3770 3657 3572 3799 ...

# Variables interested to know:
# Independent variable: cigs - number of cigarettes per day that an infant's
mother smoked during pregnancy
cigs <- data$cigs
# Dependent variable: bwghtgrams - infant birth weights in grams
bwghtgrams <- data$bwghtgrams
```

2a. Initial Data Analysis - "cigs"

```
# Structure
str(cigs)

##  int [1:1388] 0 0 0 0 0 0 0 0 0 0 ...

# Statistics
summary(cigs)

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

# Graphical Summary - Histogram
hist(cigs, main = "Cigarettes/Day During Pregnancy", xlab = "number of cigare
ttes/day", ylab = "number of mothers")
abline(v = mean(cigs), col = "green")
abline(v = median(cigs), col = "red")
```




```r
# Graphical Summary - Boxplot
boxplot(cigs, main = "Cigarettes/Day During Pregnancy", xlab = "number of cig
arettes/day", horizontal = T)
abline(v = mean(cigs), col = "green")
abline(v = median(cigs), col = "red")
```



The mean number of cigarettes/day during pregnancy is 2.087, the median is 0.000, the minimum is 0.000, and the maximum is 50.000.

The majority of the mothers don't smoke during pregnancy, but there are also ones who do smoke.

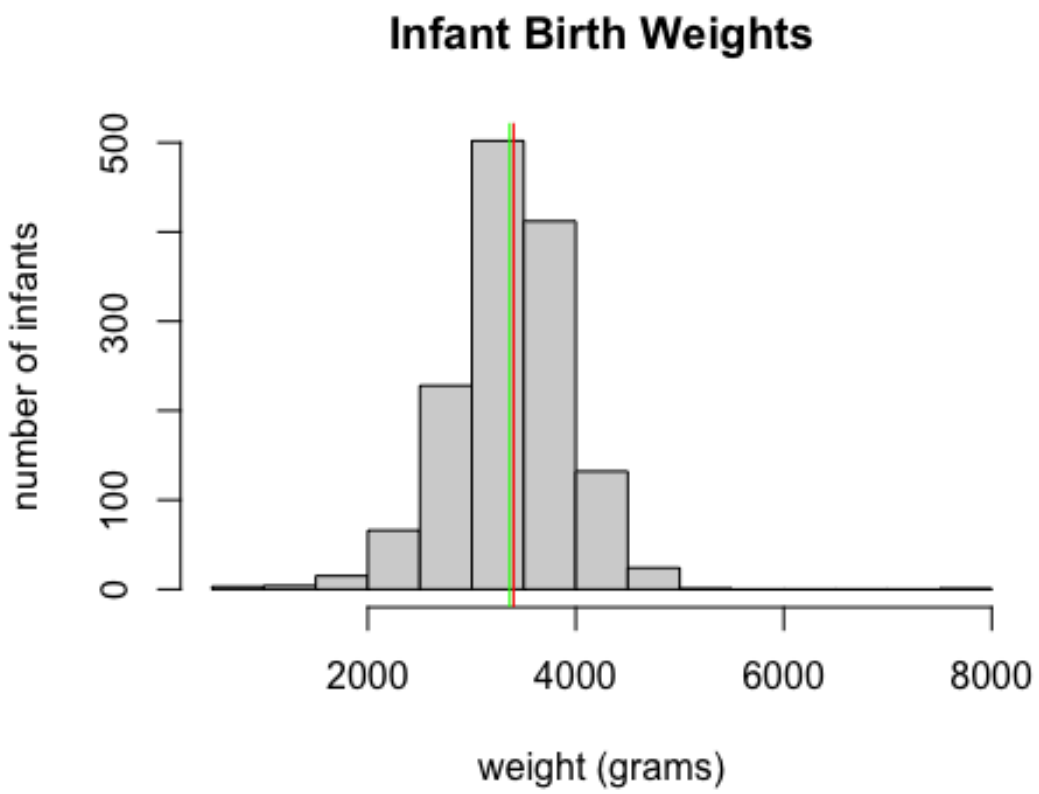
The mean is greater than the median because those who smoke are pulling up the mean.

The distribution of number of cigarettes/day in this sample is right skewed.

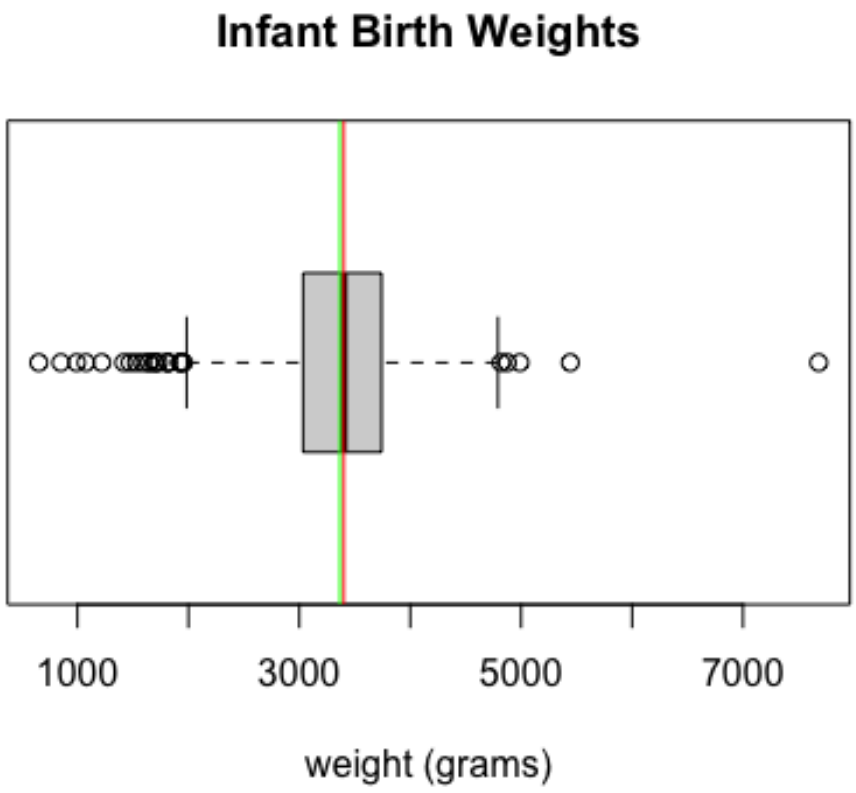
2b. Initial Data Analysis - "bwghtgrams"

```
# Structure
str(bwghtgrams)

##  num [1:1388] 3090 3770 3657 3572 3799 ...

# Statistics
summary(bwghtgrams)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     652    3033    3402    3365    3742    7683

# Graphical Summary - Histogram
hist(bwghtgrams, main = "Infant Birth Weights", xlab = "weight (grams)", ylab
```

```
= "number of infants")
abline(v = mean(bwghtgrams), col = "green")
abline(v = median(bwghtgrams), col = "red")
```




```
# Graphical Summary - Boxplot
boxplot(bwghtgrams, main = "Infant Birth Weights", xlab = "weight (grams)", h
orizontal = T)
abline(v = mean(bwghtgrams), col = "green")
abline(v = median(bwghtgrams), col = "red")
```



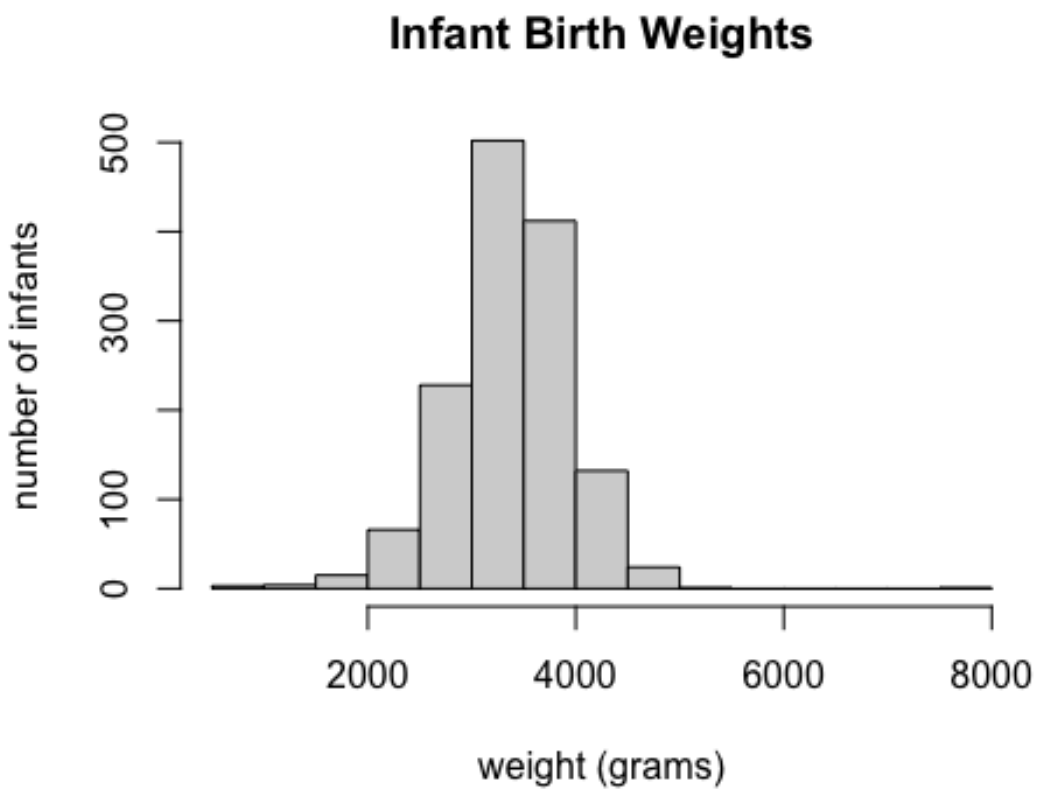
The mean infant birth weight is 3365g, the median is 3402g, the minimum is 652g, and the maximum is 7683g.

The mean and the median are similar.

The distribution of infant birth weight in this sample is approximately Normal.

3. Distribution Analysis

```
# Distribution of infant birth weights
hist(bwghtgrams, main = "Infant Birth Weights", xlab = "weight (grams)", ylab
= "number of infants")
```



Based on the histogram, this distribution is approximately Normal.

By the Central Limit Theorem, the distribution of mean infant birth weight can also be approximately Normal as the size increases.

This sample mean will be replicated and have its distribution analyzed in the following steps.

```
# Random sample generated based on the bwghtgrams data
sample(bwghtgrams, 100, replace = TRUE)
```

```
##   [1] 2579.807 3572.040 2579.807 4507.574 3827.186 3798.836 3798.836 3430.
292
##   [9] 3231.846 2126.214 3572.040 2154.564 3203.496 3685.438 4139.030 4450.
875
##  [17] 2438.059 3486.991 4507.574 4819.419 3061.749 2863.302 3458.642 3260.
195
##  [25] 2579.807 3486.991 3742.137 3628.739 3231.846 3770.487 2749.904 2863.
302
##  [33] 2976.700 3175.146 3118.448 2749.904 3401.943 3373.593 2324.661 4422.
525
##  [41] 3572.040 3515.341 2381.360 3600.389 3940.584 4082.331 3657.088 3373.
593
##  [49] 4110.681 3175.146 3486.991 3401.943 2211.263 3175.146 3742.137 4394.
```

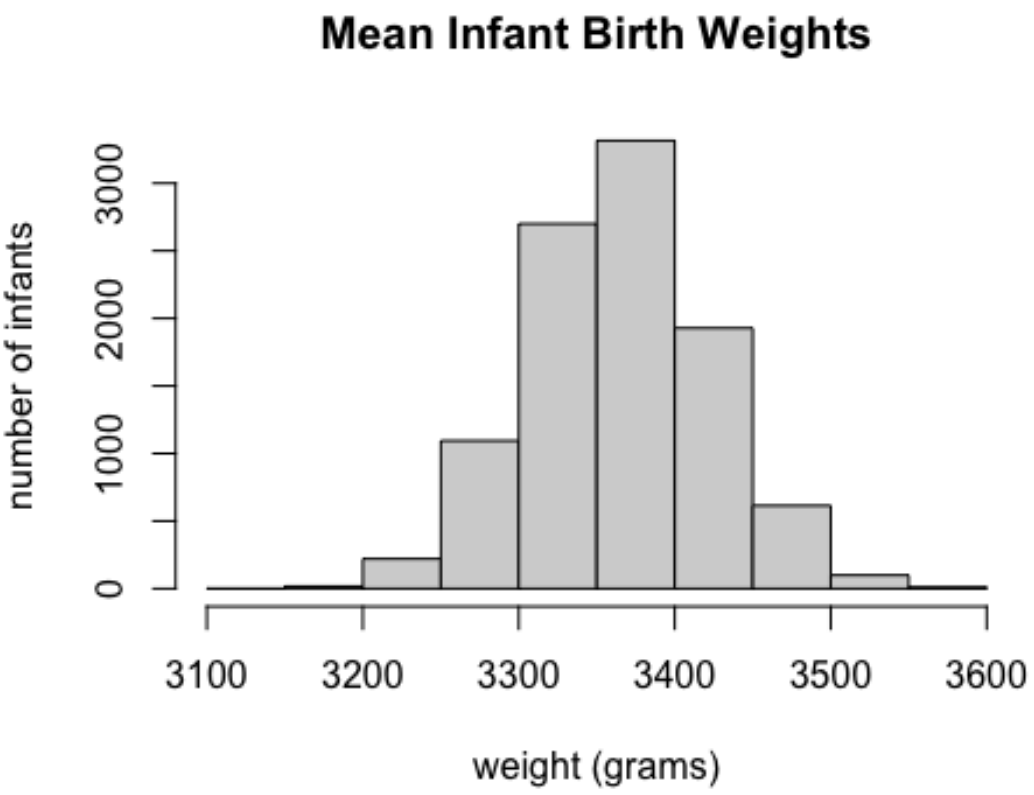
```
176
##  [57] 3628.739 3288.545 3628.739 2920.001 2806.603 3316.894 3713.788 3033.
399
##  [65] 3175.146 3231.846 3288.545 3968.933 3486.991 3288.545 4082.331 3997.
283
##  [73] 2551.457 2636.506 3798.836 4280.778 2636.506 3827.186 3515.341 3798.
836
##  [81] 3855.535 3061.749 1700.971 3515.341 3458.642 4535.924 3770.487 3770.
487
##  [89] 3628.739 3175.146 3033.399 2749.904 3572.040 3316.894 3316.894 2891.
651
##  [97] 3033.399 3260.195 4167.380 3600.389
```

```
# Mean of this random sample
mean(sample(bwghtgrams, 100, replace = TRUE))
```

```
## [1] 3393.154
```

```
# Replicate this mean 10000 times
set.seed(1)
mean_weight <- replicate(10000, mean(sample(bwghtgrams, 100, replace = TRUE))
)
```

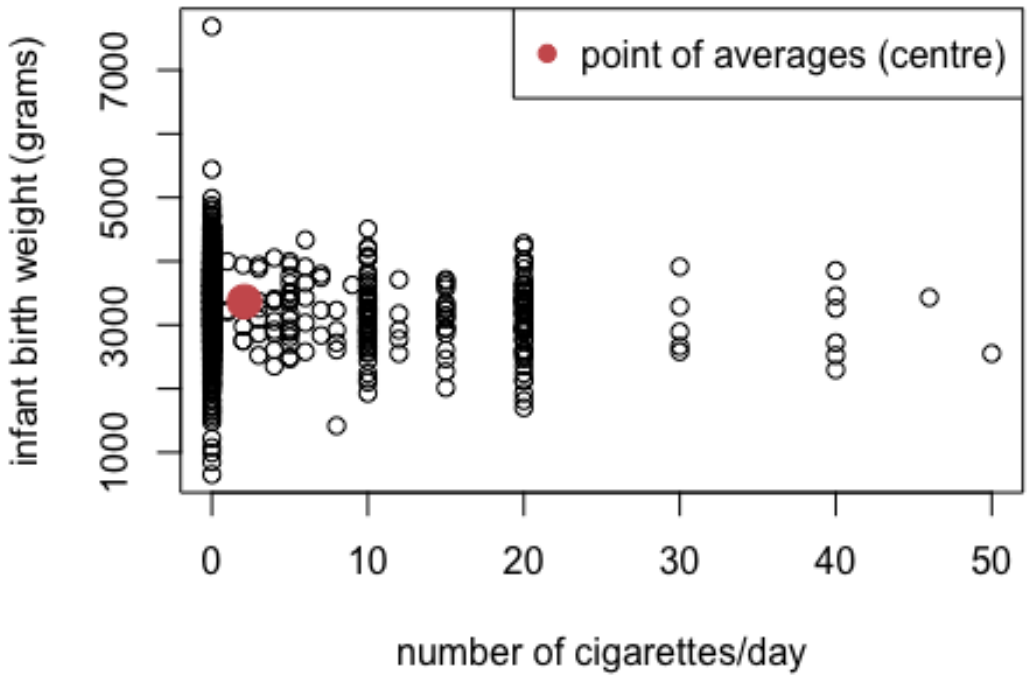
```
# Distribution of replicated sample mean
hist(mean_weight, main = "Mean Infant Birth Weights", xlab = "weight (grams)"
, ylab = "number of infants")
```



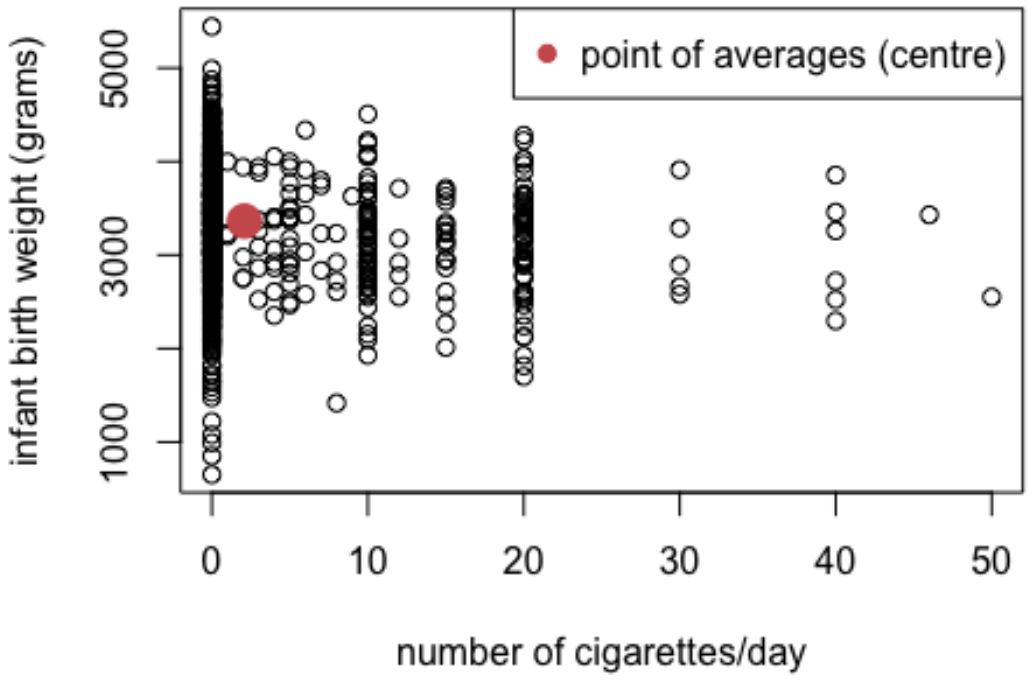
The distribution of the mean also shows a Normal distribution because of the Central Limit Theorem.

4. Regression Model Estimation

```
# Scatter plot of bwghtgrams vs. cigs
plot(cigs, bwghtgrams, xlab = "number of cigarettes/day", ylab = "infant birt
h weight (grams)")
points(mean(cigs), mean(bwghtgrams), col = "indianred", pch = 19, cex = 2)
legend("topright", c("point of averages (centre)"), col = "indianred", pch =
19)
```




```r
# Data cleaning: there seems to be an outlier with an infant birth weight gre
ater than 7000 grams
data2 <- data[data$bwghtgrams<7000,]
cigs <- data2$cigs
bwghtgrams <- data2$bwghtgrams
plot(cigs, bwghtgrams, xlab = "number of cigarettes/day", ylab = "infant birt
h weight (grams)")
points(mean(cigs), mean(bwghtgrams), col = "indianred", pch = 19, cex = 2)
legend("topright", c("point of averages (centre)"), col = "indianred", pch =
19)
```




```
# Correlation coefficient
cor(cigs, bwghtgrams)

## [1] -0.1519832
```

The correlation coefficient is -0.15, so there is a negative correlation between infant birth weight and number of cigarettes during pregnancy.

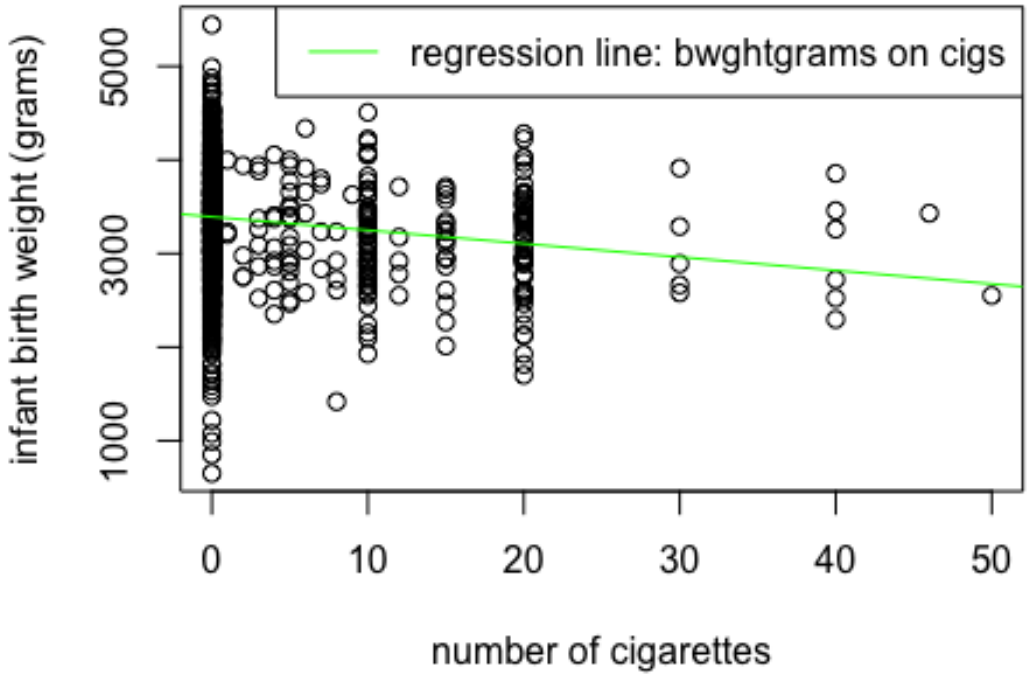
However, this value is close to 0, which means the the correlation is not strong.

```
# Linear model
lm(bwghtgrams~cigs)

##
## Call:
## lm(formula = bwghtgrams ~ cigs)
##
## Coefficients:
## (Intercept)         cigs
##     3392.01       -14.38

# Linear model regression line
model <- lm(bwghtgrams~cigs)
model$coeff
```

```
## (Intercept)        cigs
##   3392.0072    -14.3842
```

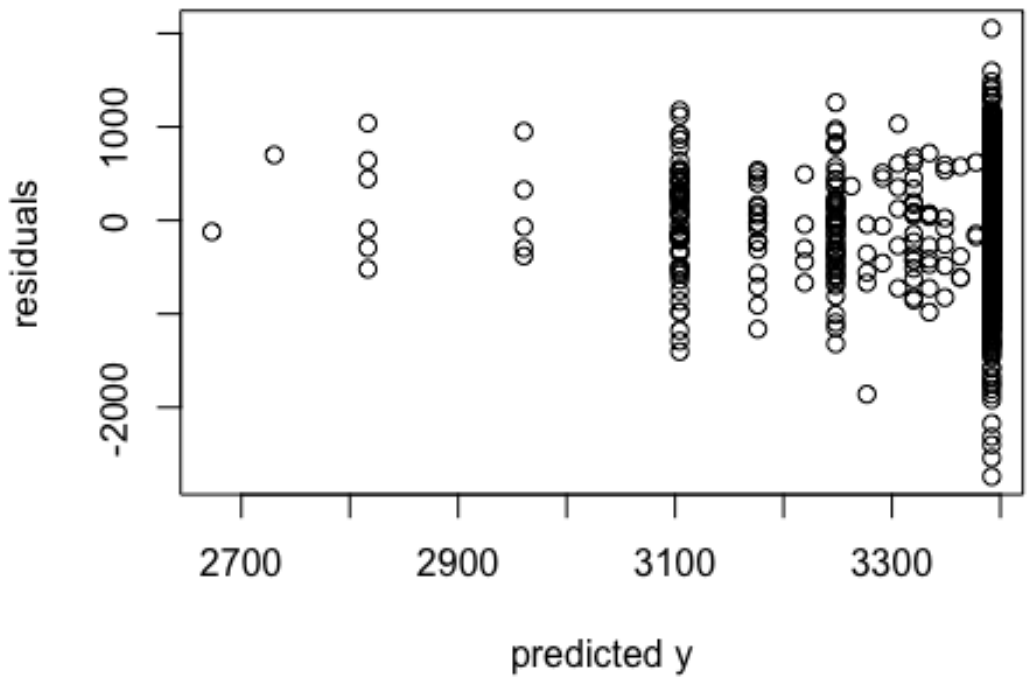
The estimated linear model should have a regression line of bwghtgrams = -14.3842 * cigs + 3392.0072.

```
# Plot with regression line
plot(cigs, bwghtgrams, xlab = "number of cigarettes", ylab = "infant birth weight (grams)")
abline(lm(bwghtgrams~cigs), col = "green")
legend("topright", c("regression line: bwghtgrams on cigs"), col = "green", lty = 1)
```

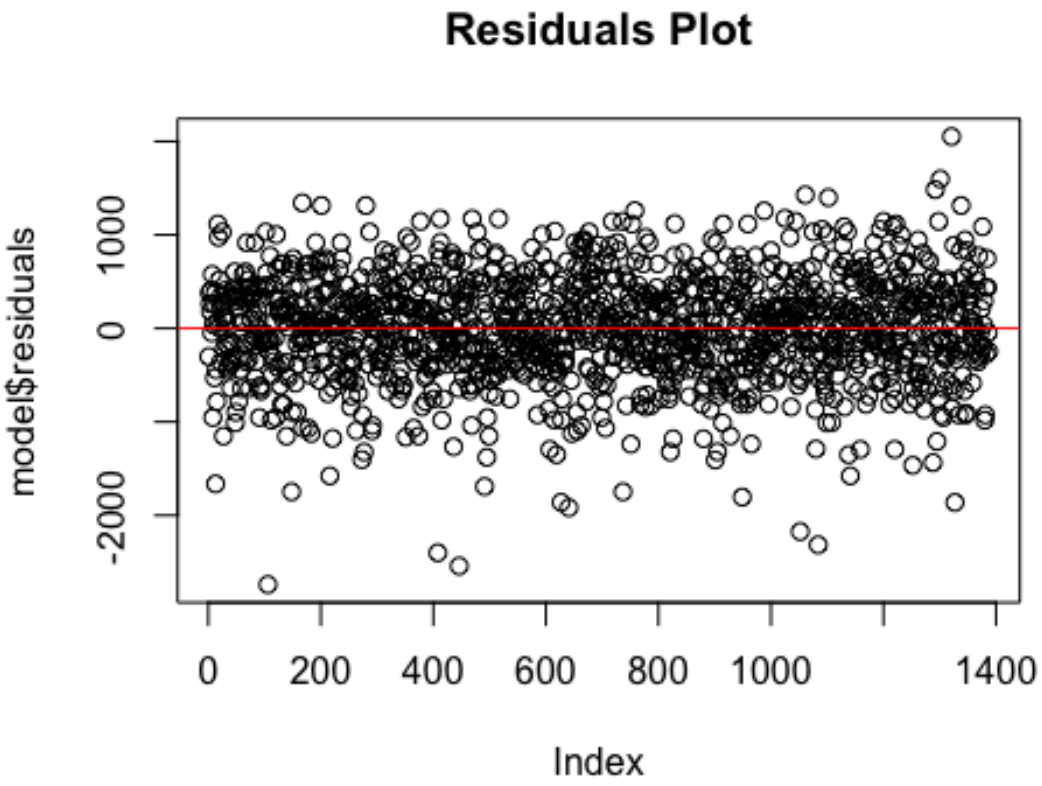


5. Regression Model Testing

```
# Residuals vs. predicted y
preds <- predict(model)
resids <- residuals(model)
plot(preds, resids, xlab = "predicted y", ylab = "residuals")
```




```r
# Residual plot
plot(model$residuals, main = "Residuals Plot")
abline(h = 0, col = "red")
```



Classic linear regression model assumptions:

1) Linear in parameters: bwghtgrams is linearly related to cigs by bwghtgrams = -14.3842 * cigs + 3392.0072.

2) Random sampling: It is assumed that the mothers and the infants are randomly chosen from the population.

3) Sample variation: The independent variable, which is the number of cigarettes smoked during pregnancy, is not a constant value.

4) Zero condition mean: There seems to be a relationship between residuals and predicted y such that as the predicted y gets larger, the variance of the residuals also gets larger.

5) Homoscedasticity: The residual plot shows no pattern, so the variance of the model is constant.

The classical linear regression model assumptions are not all satisfied because as the predicted y gets larger, the variance of the residuals also gets larger. Therefore, a linear regression model is not an appropriate model for the relationship between infant birth weight and number of cigarettes smoked during pregnancy.

6. Conclusions

Solely based on the data provided, several conclusions can be made:

1) Infant birth weight is negatively correlated with number of cigarettes/day during pregnancy, but the correlation is not strong. This means that smoking can make some contributions to a decreased birth weight.

2) The linear model is not an appropriate model for the samples data.

3) The infant birth weights is more Normally distributed.

7. Interpretations

These conclusion are expected because of several reasons:

1) In the data provided, the number of mothers who smoke is much smaller that of mothers who do not smoke, so there is not enough data to effectively measure the effect of smoking.

2) Smoking is not the only factor that can affect infant birth weight, some other factors such as diet, genetic characteristics, emotions, etc. all have the potential to affect infant birth weight.

8. Future Thoughts

Some adjustments can be made for future estimations:

1) More samples can be drawn, especially samples from mothers who smoke during pregnancy.

2) Try to minimize the effects of other factors, which means making them be controls instead of variables.

Some words to say…

Even though this sample did not effectively demonstrate the harmful effect of smoking, mothers should still be aware that smoking is harmful and should avoid this behavior. Smoking is just bad :(