Maternal Smoking and Infant Birth Weight

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PART I: Introduction

Our study mainly focuses on analyzing the relationship between a baby's birth weight and its mother's smoking behaviour. Generally, smoking has long been recognized as a factor that may negatively impact babies, which may influence the oxygen supplied to the fetus and be responsible for the reduction in the birth weight. However, there are also studies that show the unexpected finding: ounce for ounce babies of smokers did not have a higher death rate than the babies of non-smokers. Thus, in this report, we will further analyze smoking's influence on baby weight by adopting the data from Child Health and Development Studies (CHDS), which consists of all pregnancies that occurred between 1960 and 1967 among women in the Kaiser Health Plan in Oakland, California.

In this report, we will mainly answer the following questions:

1. What is the difference in weight between babies born to mothers who smoked during pregnancy and those who did not?
2. Is the difference in weight important to the health of the baby?
3. Whether smoking has a negative influence on gestation length that influences babies' birth weights?

After analysis, we can conclude that smoker's baby will tend to have lower birth weight than that of nonsmokers, and low-birth-weight babies tend to have higher illness and mortality rate, but gestation length is not a direct factor caused by smoking behavior that leads to lower birth weight babies.

In Part II, we will use different statistical methods to analyze the data and answer the first two questions. In Part III, we will use advanced analysis to further analyze the data and answer the third question. In Part IV, we will make a conclusion and discuss the limitations and more questions that could be studied on this topic.

PART II: Basic Analysis

2.1 Numerical Comparisons of Birth Weights of Babies of Smoker and Nonsmoker

Methods: Computing numerical summaries of the two groups

1. Mean of Birth Weights
   Smoker: 114.11 ounces
   Nonsmoker: 123.05 ounces
2. Standard Deviation of Birth Weights
   Smoker: 18.10 ounces
   Nonsmoker: 17.40 ounces
3. Median of Birth Weights
   Smoker: 115 ounces
   Nonsmoker: 123 ounces

Analysis:

From the numerical summaries above, babies of nonsmoker mothers tend to have greater birth weights in average and also in median, and the standard deviation of which is smaller than that of babies of smokers', meaning that nonsmoker group has a more concentrated distribution of birth weights than that of the smoker group, so that more babies are borned with higher weights in average.

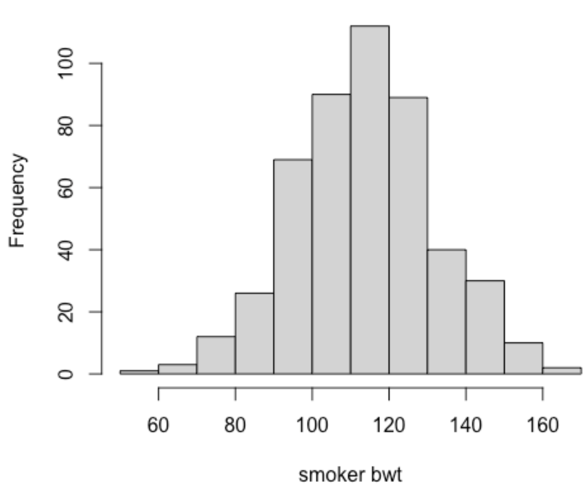
Conclusion:

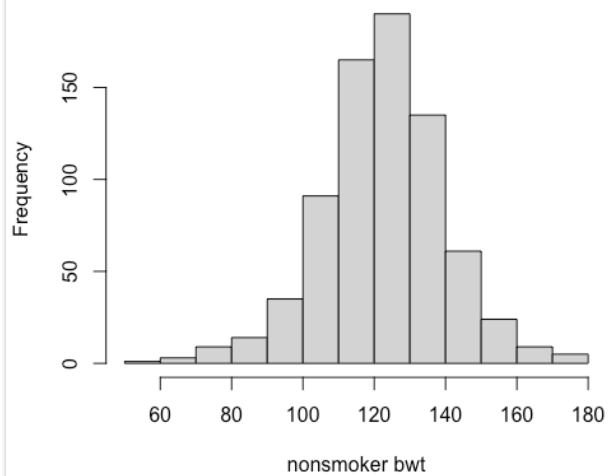
It is reasonable to say that babies of nonsmokers' are borned with greater weights.

2.2 Graphical Comparisons of Birth Weights of Babies of Smoker and Nonsmoker

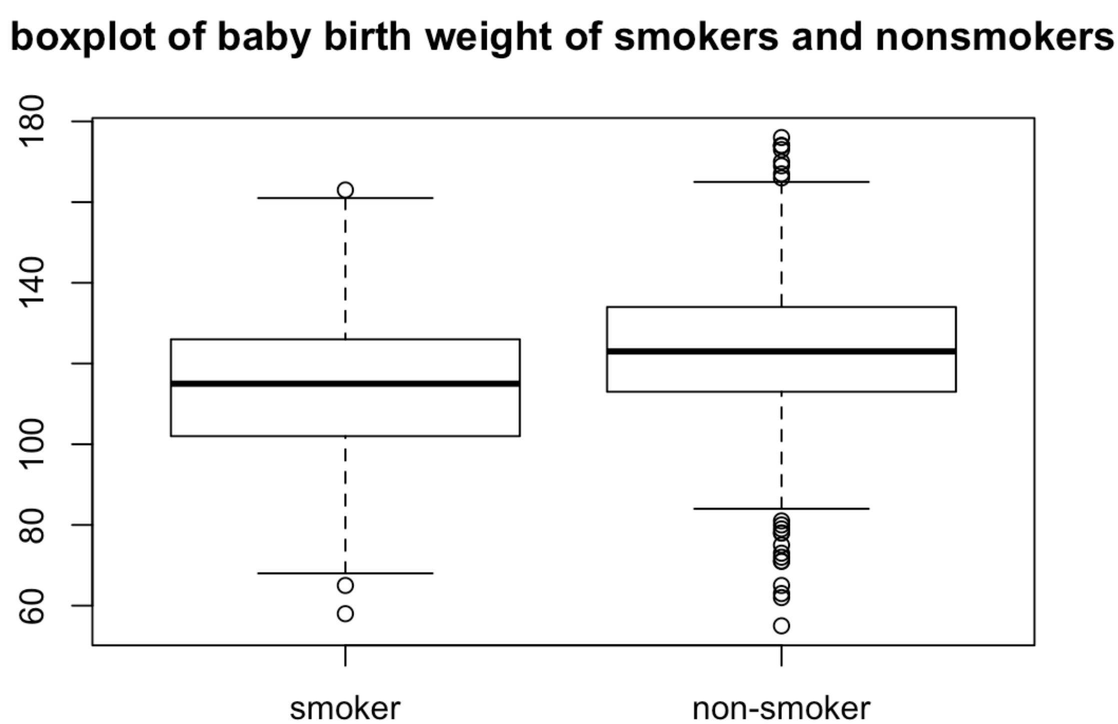
Methods: Histogram, Boxplot

1. Histogram





2. Boxplot



Analysis:

From the two histograms, it can be seen that babies of nonsmokers' have higher frequencies at greater weights ([110, 140]) than that of smokers'. The mode of the smoker group is within 110-120 ounces whereas the mode of the nonsmoker group is within 120-130 ounces, which is a significant difference.

From the two boxplots, the interquartile weights of babies of nonsmokers' is around [112, 130], and that of smokers' is around [101, 128]. Nonsmoker group also includes more greater weight babies (more outliers greater than 160) compared with the smoker group. We can also see that the 25th percentile and 75th percentile of nonsmokers' babies weight are higher than those of smokers' babies weight. Beyond these, the smoker group has smaller lower whisker and upper whisker than the nonsmoker group, which also indicates birth weights are smaller in the smoker group.

Conclusions:

It is reasonable to say that babies of nonsmokers have greater weight distribution than that of smokers based on the plots.

2.3 Incidence Comparisons of Birth Weights of Babies of Smoker and Nonsmoker

The low-birth-weight babies are babies with birth weights smaller than 2500g (around 88 ounces), and the frequency of low-birth-weight babies of smokers is 36 out of 484 smokers, with the incidental rate of 7.44%, and this is more than that of nonsmokers, with frequency of 22 out of 742 nonsmokers, with incidental rate of 2.96%.

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	2-sample test for equality of proportions with continuity correction

data:  c(22, 36) out of c(742, 484)
X-squared = 12.03, df = 1, p-value = 0.0002617
alternative hypothesis: less
95 percent confidence interval:
 -1.00000000 -0.02089309
sample estimates:
    prop 1     prop 2 
0.02964960 0.07438017 
```

We conduct a two sample proportion test and conclude that the proportion of low-birth-weight in nonsmokers is significantly smaller than that in smokers. However, due to the limited number of samples, the conclusion still has some limitations, so a larger sample size would make our estimation more reliable. Besides, the criteria of low-birth-weight we used is based on a general recognition, and we need to further analyze whether the change of criteria will influence our estimation.

If we redefine the low-birth-weight babies as babies with birth weights smaller than 100 ounces, then the frequency of low-birth-weight babies of smokers is 100 out of 484 smokers, with the incidental rate of 20.66%, and that of nonsmokers is 56 out of 742 nonsmokers, with the incidental rate of 7.55%. There is a more significant difference in incidental rate between the two groups than before.

Therefore, the extent to which the frequencies of babies' low birth weights are different in groups of smokers and nonsmokers also depends on how we define the "low birth weight", since different thresholds may reveal or hide some differences sometimes, but the trend is quite clear that there is a difference of frequency of low birth weights between the two groups in general. Also, as we make the threshold of low-birth-weight babies greater, from smaller than 88 ounces to smaller than 100 ounces, the incidental rate in smoker group increases more significantly than that of nonsmoker group, this indicates that there are many more babies with lower weights in smoker group than in nonsmoker group.

2.4 Asses Differences in Three Types of Comparisons

We find that all three types of comparisons indicate a difference of babies' birth weight between the group of smokers and nonsmokers, with babies in the smoker group having lower birth weights than babies in the nonsmoker group in this sample. This implies that smoking may have association with baby weight in general. Thus, this may serve as an important warning for the danger of smoking during pregnancy.

To further understand this association, we conduct literature research on previous studies regarding this topic. From an article in *PLUS ONE*, the study conducted by Wei Zheng and his fellow researchers shows that "Maternal smoking was significantly associated with low birthweight in all age groups. The strength of the association increased with maternal age."

We also find another research that studies the relationship between maternal smoking and birth weight. The study conducted by Mariana Caricati Kataoka and her fellow researchers finds that "In full-term infants, birth weight decreased as the category of cigarette number per day increased, with a significant weight reduction as of the category 6 to 10 cigarettes per day." This study further analyzes the influence of the number of cigarettes the mother consumed during pregnancy on the birth weight.

In conclusion, our findings in previous studies are consistent with many previous studies on the same topic. Going beyond this finding, low-birth-weight has a negative effect on infant's health. According to the study by Maureen O'Leary on WHO website, mortality was consistently higher for low-birth-weight infants than for non-low-birth-weight infants, and low-birth-weight infants have higher illness rates in the neonatal period. This is an important finding since "despite the surgeon general warning, 15% of pregnant women in 1996 smoked during pregnancy."

PART III: Advanced Analysis

1. First, we will use an advanced analysis method - two sample t-test to demonstrate the significance of the results that we find in question 1 Part II. In Part II 2.2 we can see that two groups follow the normal distribution roughly from the histograms.

   Methods: Two sample t-test on mean

   Analysis:

   H0: The mean birth weight of babies of nonsmokers and smokers are the same

   H1: The mean birth weight of babies of nonsmokers is greater than that of smokers.

   ```
           Welch Two Sample t-test

   data:  df$bwt[df$smoke == 0] and df$bwt[df$smoke == 1]
   t = 8.5813, df = 1003.2, p-value < 2.2e-16
   alternative hypothesis: true difference in means is greater than 0
   95 percent confidence interval:
    7.222928      Inf
   sample estimates:
   mean of x mean of y
    123.0472  114.1095
   ```

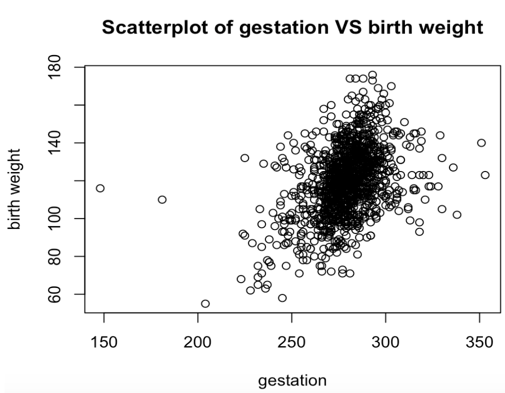
   Conclusion:

   From the t-test above, we can see that the p-value is smaller than 0.05, which means that the mean weight of nonsmokers' babies is significantly greater than the mean weight of smokers' babies.

2. To further understand why there's a difference in baby birth weight between groups of nonsmokers and smokers, we make a hypothesis that smoking has a negative influence on gestation length which would influence the baby birth weight.

   Method: Chi-square test, scatterplot, and two sample t-test

   a. Scatterplot between gestation and birth weight



b. Chi-square test on independence of gestation length and birth weight

   H0: Gestation and birth weight are independent.

   H1: Gestation and birth weight are not independent.

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	Pearson's Chi-squared test

data:  df_clean$gestation and df_clean$bwt
X-squared = 18617, df = 11024, p-value < 2.2e-16
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c. Two-sample t-test on gestation length of smokers and nonsmokers

   H0: The mean gestation of babies of nonsmokers and smokers are the same.

   H1: The mean gestation of babies of nonsmokers is greater than that of smokers.

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	Welch Two Sample t-test

data:  df$gestation[df$smoke == 0] and df$gestation[df$smoke == 1]
t = 1.1705, df = 1153.3, p-value = 0.121
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
 -2.018546       Inf
sample estimates:
mean of x mean of y 
 288.9057  283.9380 
```

Analysis:

From the scatterplot, we can see a positive association between gestation length and birth weight, which means mothers with longer gestation tend to have babies with greater birth weights. The chi-square test also shows that gestation length and birth weights are not independent.

However, from the two sample t-test, we can see that the p-value is larger than 0.05, which means the difference of gestation length between smokers and nonsmokers is not significant on 95% confidence level.

Conclusion:

From the tests and analysis above, we can conclude that gestation has a positive association with birth weight, but we cannot conclude that smoking makes a difference in the gestation based on our sample data.

PART IV: Conclusion

Conclusion summary:

In Part II, we have shown that babies' birth weight is related to the smoking behaviors of their mothers using three types of comparisons, and the results of which are matched in the sense that mothers who smoke during pregnancy tend to have lower birth weight babies than mothers who do not. This answers our question that smoking behaviors of mothers during pregnancy is more likely to influence babies' birth weight negatively, and this is important to the health of the baby according to our research on relevant studies, since low-birth-weight babies tend to have higher illness and mortality rate normally.

In Part III, we found out that length of gestation has a positive association with birth weight, which may serve as a potential factor that influences the birth weight of babies. However, the difference in it may not be caused by the smoking behaviors of mothers according to our test, and so length of gestation may not be the direct factor that explains the difference in the birth weights of babies between two groups.

Discussion:

Our research still has some limitations. First of all, our data only consists of 1236 observations, which is too small to have a conclusion that could generalize to the whole population. Secondly, our data comes from all pregnancies that occurred between 1960 and 1967 among women in the Kaiser Health Plan in Oakland, California. It's not a randomly selected sample, and only contains data from a single cities' health plan, so there may be bias on age, race as well as family background, and we cannot generalize this result to all women in the US without further data collection.

There are still future questions to study. For example, how would the influence of maternal smoking vary in mothers from different age groups? Will the mothers' weight or height have a greater influence on babies' weight? These questions need to be answered by more data and research.

Reference

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