Maternal Smoking Effects on Infant Weight

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Abstract

Previous studies have linked infants deaths due to low birth-weights, which typically occurs when mothers smoking during pregnancy. Even though more recent findings indicate that the prematurity of an infant is the leading cause of death, it is still questioned whether low birth-weight is a consequence of maternal smoking. The U.S. Surgeon General has issued concerns regarding the effects of smoking, specifically during pregnancy, but there has been a paradoxical study which revealed infants born to smoking mothers did not have a higher death rate than infants born to non-smoking mothers. Using Mathematica, a statistical analysis was completed to interpret the descriptive statistics of the birth-weight distribution of infants born to smoking and non-smoking mothers. Using the mean, median, standard deviation, skewness, kurtosis, and the histograms, the birth-weight of infants born to smoking mothers is found to resemble a normal distribution while birth-weights of infants born to non-smoking mothers deviate from a normal distribution and have a large peak in the region of the mean. By using statistical methods, it was determined that the majority of the infants born to smoking mothers had a birth-weight less than the upper half of infants born to non-smoking mothers.

Introduction

There has been concern over the past few decades regarding the effects of maternal smoking on the effect on an infant’s health. An infant’s weight, as well as the gestational age, are indicators of the maturity level of an infant. Smoking has been linked to fetal injury, premature birth, and low birth-weights. Previous studies have found maternal smoking has a tendency to reduce the birth-weight of an infant by roughly 5-8 ounces. Typically when babies are born prematurely with low birth-weights, which is often an effect of maternal smoking, there is a much lower survival rate. While that may not be the focus of this statistical analysis, it is important to understand the severity of the research being presented. The majority of previous studies have focused on the connection of maternal smoking and infant prematurity leading to death; however, there has been a lack of research devoted to linking low birth-weights of infants to smoking. It is believed that smoking mothers will birth babies of lower wights than non-smoking mother. The carbon monoxide inhaled from a cigarette will bind with the hemoglobin in the blood and form carboxyhemoglobin. Due to the natural attraction between hemoglobin and carbon monoxide, the amount of oxygen carried by the blood will decrease as it is no longer bonded with hemoglobin. This lack of oxygen will pass through the placenta which draws blood as well, in turn decreasing the weight of a newborn. The Child Health and Development Studies database is used to compare the birth-weights of infants born to smoking mothers compared to those born to non-smoking mothers. Using this data, a conclusion will be made whether a correlation exists between maternal smoking and infant weight.

Methods

This data was imported into Mathematica from the previous study: Child Health and Developmental Studies. This previous study was investigating the main cause of death among infants: prematurity or low birth-weight. That data imported from this study was separated into the birth-weights of infants born to non-smoking mothers and smoking mothers. This is the focal point of comparison for this study; comparing the birth-weights of infants born to non-smoking mother in contrast with the birth-weights of infants born to smoking mother. Using Mathematica, the mean, median, standard deviation, skewness, kurtosis, and five point summary were found for each case. These characteristics of the distribution were used for comparison of the two data sets. The mean of the data sets will provide an average birth-weight of infants which can be used for general comparison amongst infants born to non-smoking and smoking mothers. The median is used when comparing both distributions as whatever lies below the median will be 50% of the data and whatever lies above the median will also be 50% of the data. This was used to compare the discrepancy of birth-weights of infants born to smoking mothers compared to non-smoking mothers. The standard deviation was used to measure the dispersion of the data around the mean for both distributions. The standard deviation would indicate if there is more birth-weights closer to the mean or if the data was spread out. This allows a definitive conclusion to be made about the peakedness and would allow elimination of birth-weights outside of 3 standard deviations, considered outliers.

The skewness measures the asymmetry of the birth-weights of infants born to non-smoking and smoking mothers. With a small magnitude of skewness, most of the data will be located evenly and the distribution will be symmetric. The skewness will determine where the majority of data reigns, whether it be above or below the mean. The kurtosis is used in this experimental investigation to determine the characteristic of the distribution. In general, the kurtosis measures the fatness of the tails, and hence the peakedness of the distribution. As the kurtosis approaches 3, the distribution can be modeled as a normal distribution. However, as a distribution deviates from a kurtosis of 3, the distribution can no longer be modeled as normal; if the kurtosis is larger than 3, then the distribution has much longer tails and the majority of the data lies around the mean. Histograms are used as a graphical representation of the distribution and can display the skewness, symmetry and count of each data points in one range. Histograms are used to display the birth-weights of each distribution and demonstrates where the majority of the data in one distribution lies in comparison to the other distribution (Figure 3). By using overlying histograms, a conclusion can be made about the effects of maternal smoking on the birth-weight of infants. The Box-and-Whiskers Plots are used for comparison of the 5-number summary of each set of data and will display the dispersion and outliers of each distribution. A side by side Box-and-Whiskers plot is used to illustrate the difference in median birth-weight for smokers versus non-smokers and the location of the majority of data. Quantile plots provide a mean of measuring the normality of a distribution by comparing the normal-quantile plot to that the distribution of birth-weights of infants born to non-smoking and smoking mothers. By comparing the variation from the normal quantile line, a conclusion can be made regarding how closely a certain distribution models a normal distribution. All of these statistical tests will contribute to making a conclusion of whether babies who were born to mothers who smoke would have lower birth-weights

Results

The average birth-weight of a baby born from a non-smoking mother is larger than that of a smoking mother as shown in Table 1 below. In addition, the median of the non-smoking mother data set was 123 ounces while the median of the smoking mothers data set was 115 ounces. As clearly shown in the overlying smooth histogram curve, the majority of newborns born to smoking mothers had a weight less than the average of newborns born to non-smoking mothers. The standard deviation is used to measure the dispersion of the data points surrounding the mean. The skewness is used to measure the symmetry of the distribution and is used in tandem with the kurtosis to compare distributions to a normal distribution. Both sets of data are negatively skewed. The kurtosis measure the fatness of the tails and the peakedness of the distribution.

Table 1: Descriptive Statistics of Infants Birth-Weight (ounces)
for Smoking and Non-Smoking Mothers

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	Non-Smoking Mothers	Smoking Mothers
Mean	123.	114.1
Median	123	115
Standard Deviation	17.	18.
Skewness	-0.187	-0.0335
Kurtosis	4.04	2.99
Lower Quartile	113	102
Upper Quartile	134	126
Minimum	55	58
Maximum	176	163

Figure 1: Histogram of Birth-Weights for Babies Born to
Non-Smoking Mothers

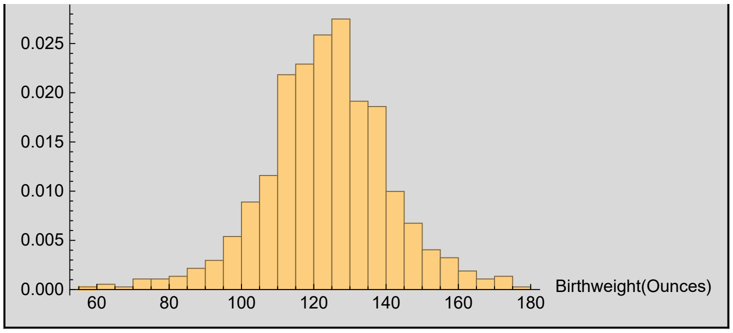


Figure 2: Histogram of Birth-Weights for Babies Born to Smoking Mothers

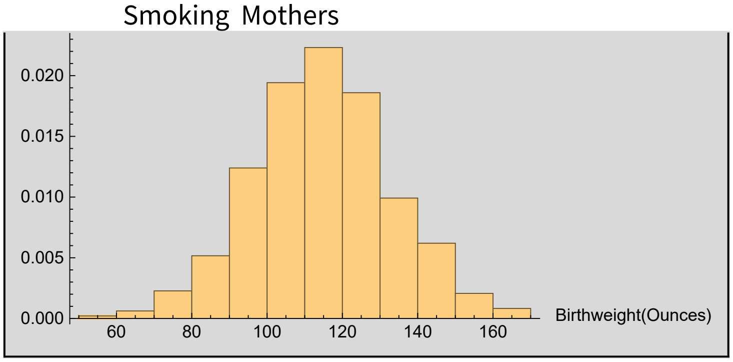
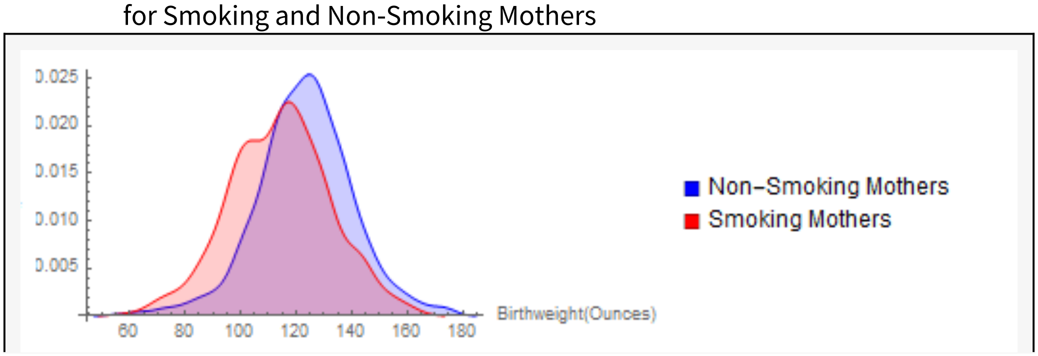


Figure 3: Overlayed Smooth Histograms of Infants Birth-Weight (ounces) for Smoking and Non-Smoking Mothers



Both sets of data are negatively skewed, meaning there are more outliers below the mean than above the mean. The data from the birth-weights of infants born to non-smoking mothers has more outliers which is likely to happen when a large distribution is used. Since the distribution from the birth-weight of infants born to non-smoking mothers is more condensed around the median, there is a smaller interquartile range as shown in Figure 4 below. However, this leads to longer tails for this distribution and hence a larger kurtosis, deviating from a normal distribution. On the other hand, the distribution of the birth-weights of infants born to smoking mothers has very little skewness and a kurtosis of approximately 3. Therefore we can assume a normal distribution for this data set. The quantile plots were used to justify previous discoveries made based on the kurtosis and skewness of the distribution.

Figure 4: Box-and-Whiskers Plot of Infants Birth-Weight (ounces)
for Smoking and Non-Smoking Mothers

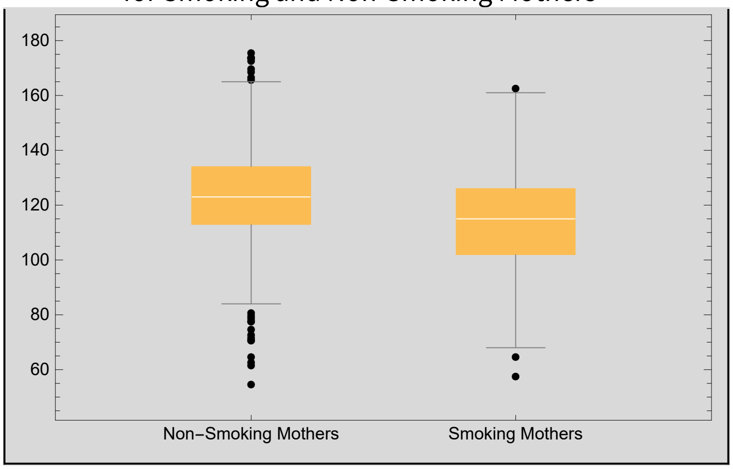


Figure 5: Quantile Plot for Birth-Weights of Babies Born to
Non-Smoking Mothers

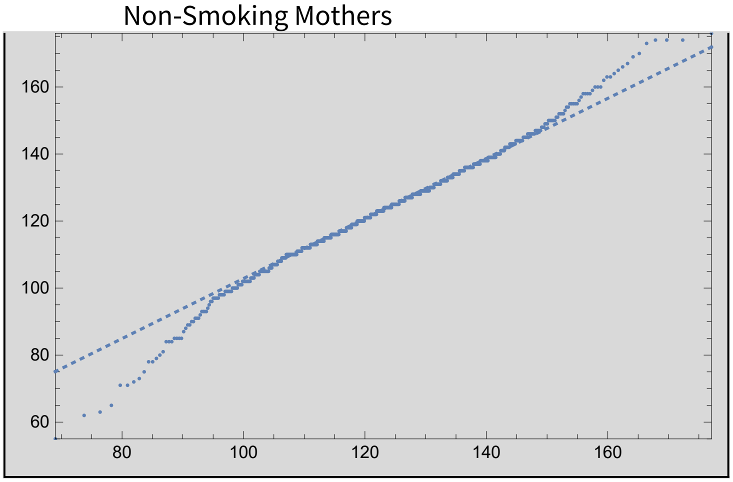
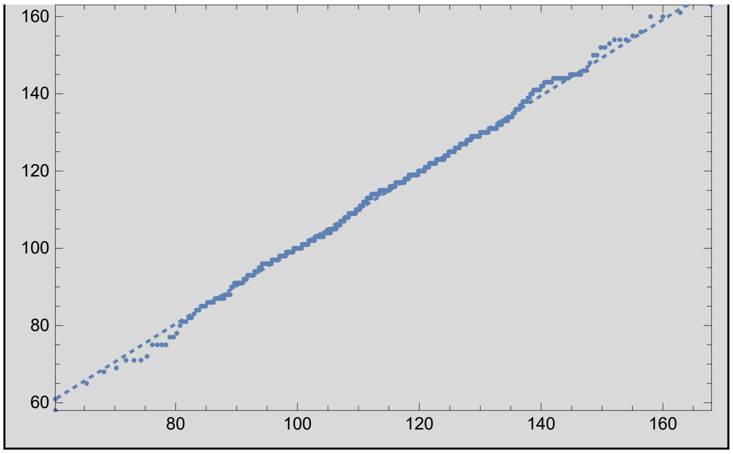


Figure 6: Quantile Plot for Birth-Weights of Babies Born to
Smoking Mothers



Discussion & Conclusion

Non-smoking mothers generally produce heavier babies than smoking mothers according to the results from this study. While both data sets had similar distributions, the birth-weight of infants born to non-smoking mothers, on average, had a birth-wight of approximately 123 ounces while infants born to smoking mothers had an average birth-weight of 115 ounces. While it is not the focus of this report, this finding is believed to be attributed to the lack of oxygen delivered to babies born to smoking mothers. Increased levels of carboxyhemoglobin restricts the amount of oxygen that can be carried by the blood, therefore leading to a underdeveloped newborn.

Amongst the babies born to non-smoking mothers, 50% had a weight less than 123 ounces; that is the median was 123 ounces while the average was 123.047 ounces. Since the mean was slightly smaller than the median, it is assumed the majority of the data will lie above the mean, but there will be some outliers far below the mean contributing to the negative skewness of this data set. The resulting skewness of the non-smoking mothers data set proves the majority of the data lies above the mean, however there are some points that lie far below the mean that may contribute to a larger average birth-weight. This can be visualized in the Box-and Whiskers plot; there are far more outliers that fall below the first quartile than above the third quartile therefore contributing to a lower mean than median. In addition, the minimum value of the babies born to non-smoking mothers was 55 ounces which is much farther away from the mean than the maximum birth-weight of 176 ounces. Bringing attention the extremes also draws the question about the dispersion of this data set. For infants born to non-smoking mothers, the standard deviation is approximately 17.4. For a normal distribution, this means roughly 68% of the data would fall within one standard deviation of the mean. However, it will soon be demonstrated that this is not a normal distribution. Instead, the standard deviation demonstrates how much the data varies around the location of the mean. To measure the variation of the data set of the birth-weight of infants born to non-smoking from a normal distribution, the kurtosis is used. Since the kurtosis of this data set was rather high and not close to the kurtosis of a normal distribution (which is

3) it can be concluded that the birth-weight of babies born to non-smoking mothers has large tails, meaning there are a lot of birth-weights in the general area of the mean. This leads to a large peak which is demonstrated in the histogram displayed in Figure 1. Another way to demonstrate the deviation of the birth-weights of babies born to non-smoking mothers from a normal distribution is through the quantile plot. The data for non-smoking mothers departures from normality as can be seen in the quantile plots. As shown in Figure 5, the data deviates from the straight line(indicating a normal distribution). As the tails of the distribution deviate from the normal distribution, represent by the straight line, it can be confirmed that near this distribution deviates from a normal distribution due to the tails not following the normal distribution line.

For the data generated from birth-weight of babies born to smoking mothers, there is a slight difference in the characteristic of the distribution. While the average birth-weight of infants born to smoking mothers was roughly 114 ounces, this data demonstrates that more than 50% of smoking mothers had newborns with a weight less than 115 ounces. Since the mean of the smoking mothers data is less than the median, we can assume that this data is slightly skewed. As a matter of fact, the skewness for smoking mothers proved that this data set has some extremities in the birth-weight distribution below the mean which lower the mean. This can be validated by the Box-and-Whisker Plot (Figure 4) as there are more outliers in the lower portion of this distribution causing the data to be negatively skewed. A standard deviation of 18.09 indicates that the points are more dispersed from the mean region. Since the standard deviation of the birth-weight data for non-smoking mothers was less than the standard deviation of the birth-weight data for smoking mothers, the data from the non-smoking mothers will have a larger collection of data points in the region of the mean. We can justify this conclusion by checking the kurtosis of each distribution. The kurtosis for the the birth-weight of babies born to non-smoking mothers should be larger than 3 since the smaller standard deviation led to an assumption of a larger peak; in fact, there are more data values around the mean and this happens to be the case with a kurtosis of approximately 4 for this data set. The kurtosis for the birth-weights of babies born to smoking mothers is 2.998, roughly 3. Therefore, the distribution for birth-weight of infants born to smoking mothers can be assumed to be the same as that of a normal distribution. By assuming a normal distribution for the birth-weights of infants born to smoking mothers, which is justified, the empirical rule can be applied; therefore roughly 68% of the birth-weights of the infants born to smoking mothers recorded (329 infants) weigh in the range of 96.0111-132.2 ounces. Similarly, using the empirical rule, 95% of the data lies in within 2 standard deviations of the mean and 99.7% of the data lies within 3 standard deviations of the mean. The quantile plot for the birth-weights of infants born to smoking mothers (Figure 6) fits on the straight line representing a normal distribution.

The average birth-weight of a baby born from a non-smoking mother is larger than that of a smoking mother. In addition, the median of the non-smoking mother data set was 123 ounces while the median of the smoking mothers data set was 115 ounces. As clearly shown in the overlying smooth histogram curve, the majority of newborns born to smoking mothers had a weight less than the average of newborns born to non-smoking mothers.The distribution of birth-weights for infants born to smoking mothers can be approximated as a normal distribution, the birth-weights for infants born to non-smoking mothers has a larger peak around therefore a larger kurtosis. While a low birth weight may not be the leading cause of death amongst infants, the data eludes that the birth-weight will be lower if the mother has smoked during pregnancy.

One potential source of bias in this data was that different ethnic groups were not incorporated in this study as they were not likely to be represented in a prepaid medical program. In addition, the educational level and average income of couples taken in this sample is larger than the respective average in California. This discrepancy amongst the average birth-weight of infants born to non-smoking mothers in this sample compared with the average birth-weight of infants born to non-smoking mothers across California may be contributed to the under representation of the indigenous community. It seems sensible that infants born to non-smoking mothers in a necessitous community would weigh less than a infant born to a mother in a wealthier community. While this may also translate for infants born to smoking mothers, a study would need to be done to prove that the average birth-weight of infants born to non-smoking mothers from this new sample would still be similar to the average of birth-weight of the original noninclusive sample and therefore the current conclusion could then be validated.

It should be noted that the correlation of smoking to low birth weight does not necessarily prove causation for several reasons. Other factors may be impacting the low birth weight of infants born to mothers who smoke. For example, it may be assumed that women who smoke have poorer overall health and are less likely to take care of themselves in terms of eating right, exercising, and being generally less health conscious. Factors such as these could limit the applicability of the findings.Measures of overall health of the mother which includes not just smoking, but obesity, underlying illness, lack of exercise, poor nutrition, and so on may make the results more generalizable. Also, the study did not consider how often women smoke (packs per day/week) and how long they have been smoking. Clearly, smoking is a health risk, however, if other factors were included in the study, the results may have been stronger.

Further, all mothers in this study were enrolled in the Kaiser Plan, therefore, they were all being monitored medically and getting an equal level of prenatal care. In other words, all mothers had been receiving medical intervention during their pregnancy. Future studies may be more generalizable if women across different health care models or plans were included in the sample population. As stated in the report, women in the Kaiser Plan sought medical care early in their pregnancy. This may explain the unexpected results regarding the fact that there was not a difference in the death rates of newborns between the smoker and non-smoker groups. It is possible that seeking early medical care may offset the more severe effects of smoking on death rates while, however, not offsetting the more subtle effects of lower oxygen supply on low birth weights. These points do seem to warrant further study of these factors.

References

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