Statistical Analysis of Maternal Health Factors and Birth Outcomes

Student Name: Vo, Minh Thien An
Student ID: 0543138
Course Name: Business Stats & Data Decision – A
Course ID: 2025FA.BOS.HTM.720.A

Table of Contents

Executive Summary

Using a random sample of 1,174 newborns from the U.S. national birth dataset, this report provides an updated statistical analysis of maternal health practices and their association with delivery outcomes. Three main questions are examined in the analysis: the rate of maternal smoking, maternal age patterns, and the effect of smoking on infant birth weight. Three additional questions look at variations in gestational periods, age-related variations in birth weight, and the connection between pregnancy duration and birth weight.

The results show that the percentage of **mothers who smoke (39.1%)** is much **higher than the previously reported 25%**, that maternal smoking considerably lowers birth weight, and that gestational age continues to be a crucial factor in determining healthy birth outcomes.

Introduction

Public health continues to place a high priority on comprehending the variables that affect birth outcomes. Reduced birth weight and premature delivery have been repeatedly linked to maternal health habits, including smoking during pregnancy.

The following factors are examined in this analysis of a dataset including 1,174 birth records from the United States:

- Birth Weight (oz) – infant's weight at birth
- Gestational Days – duration of pregnancy from conception to birth
- Maternal Age (years) – mother's age at delivery
- Maternal Height (inches) – mother's height during pregnancy
- Maternal Pregnancy Weight (lbs) – weight of the mother during pregnancy
- Maternal Smoker – whether the mother smoked during pregnancy (True/False)

Method

All hypothesis tests were conducted at a significance level of **$\alpha = 0.05$**.

- A **one-sample z-test for proportions** tested whether the maternal smoking rate differs from 25%.
- A **one-sample t-test** evaluated whether mean maternal age differs from 27 years.
- **Two-sample t-tests** (assuming equal variances) were used to compare group means such as birth weights and gestational periods.
- Relationships between continuous variables (e.g., gestational days and birth weight, maternal weight and birth weight) were visualized using scatterplots.

Result

Research Question 1: Maternal Smoking Prevalence

Claim: 25% of mothers smoke during pregnancy.

- Observed proportion: $\hat{p} = 0.391$ (39.1%), n = 1,174
- Standard error under H_0: 0.01264
- $z = 11.15$, $p < 0.0001$
- 95% CI for true proportion: (0.363, 0.419)

Interpretation:
We reject H_0. Compared to 25%, the **smoking rate (39.1%)** is much higher ($p < 0.0001$). This suggests a potential rise in maternal smoking or regional variance and necessitates more robust public health interventions.

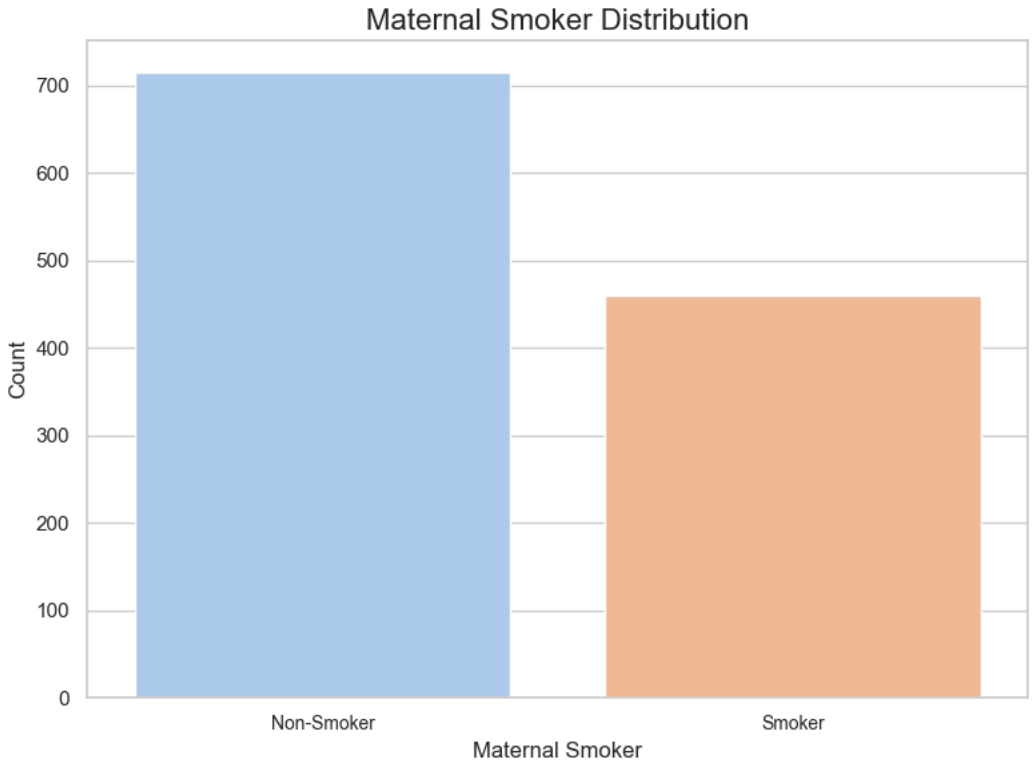

Figure 1: Maternal Smoker Distribution – Bar Chart

Research Question 2: Maternal Age Comparison

Mean maternal age = 27.23 years (SD = 5.82, n = 1,174)
t = 1.34, p = 0.179

Interpretation:
We fail to reject H_0. The national average of 27 years is not substantially different from the sample mean. This indicates the dataset's representativeness in terms of maternal age demographics.

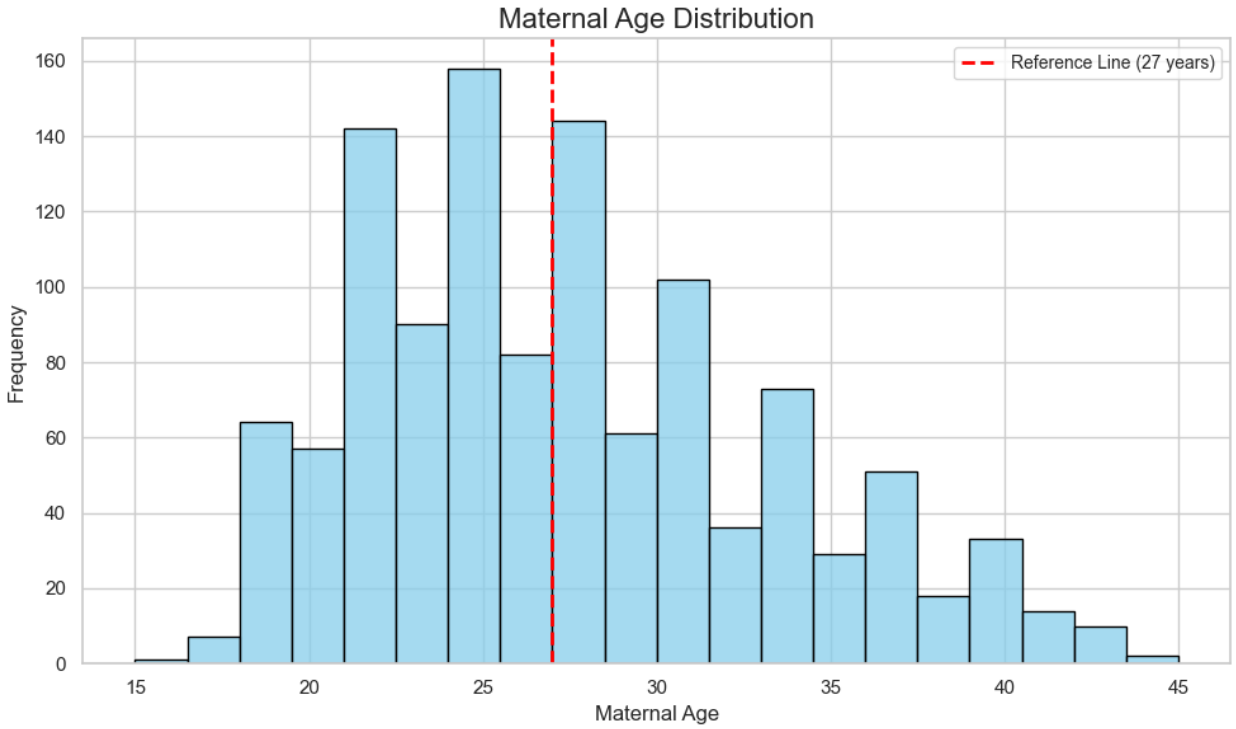

Figure 2: Maternal Age Histogram

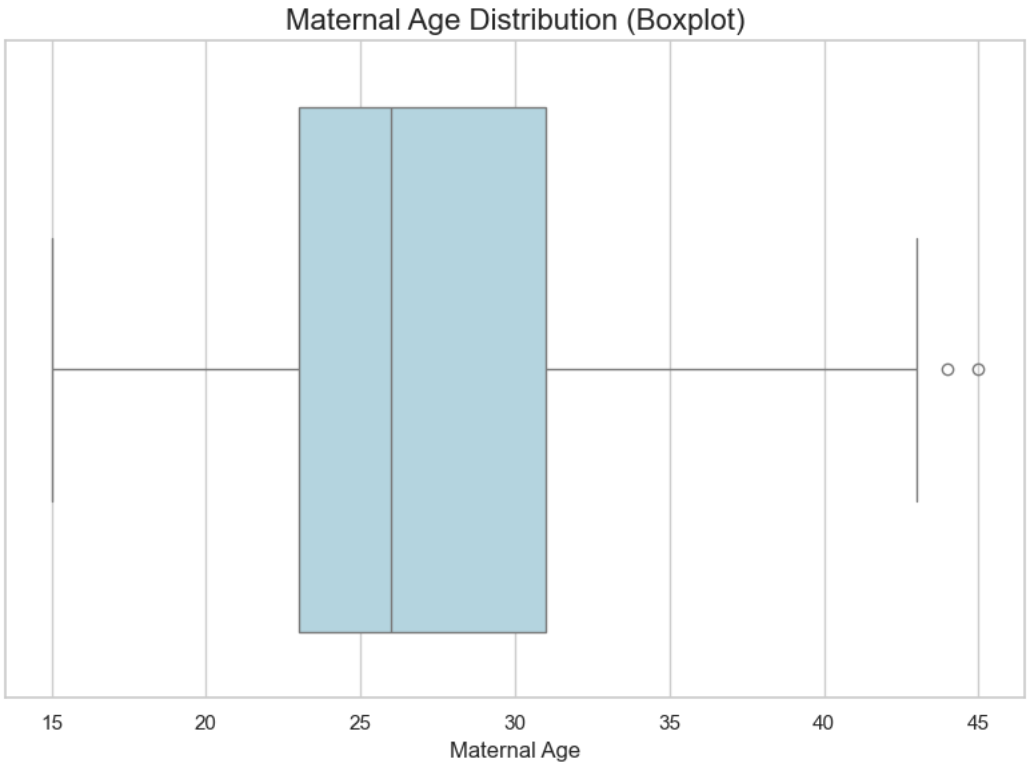

Figure 3: Maternal Age Boxplot

Descriptive Overview of Birth Weight

We first look at the overall distribution before looking at factors that affect birth weight. The sample's birth weights, as shown in Figure 4, have a roughly normal distribution with a center of **120 ounces (7.5 lbs)**, with the majority of infants weighing between 100 and 140 ounces. This distribution covers both preterm and mature births, as well as babies born to moms who smoke and those who do not.

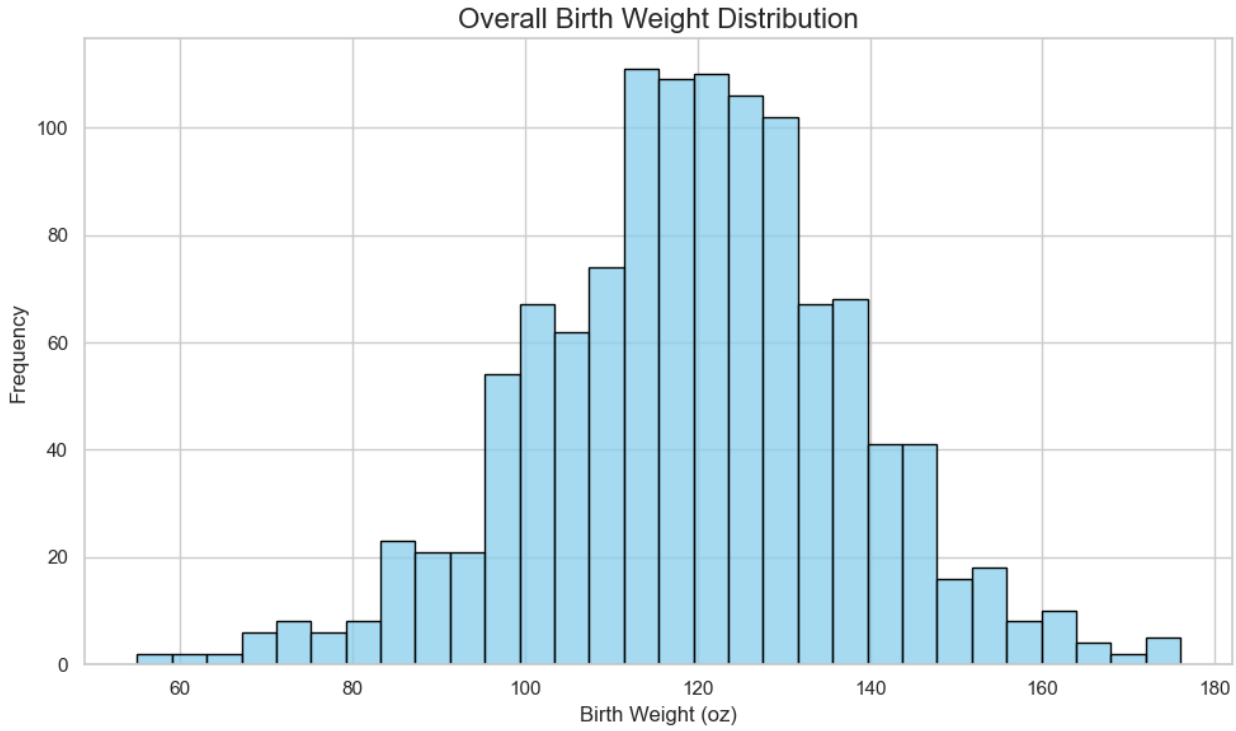

Figure 4: Overall Birth Weight Distribution

Research Question 3: Birth Weight and Maternal Smoking

Group	Mean (oz)	SD	n
Non-smokers	123.09	17.42	715
Smokers	113.82	18.30	459

- Difference = 9.27 oz
- Pooled variance = 315.75, SE = 1.06
- t = 8.72, df = 1,172, p < 0.0001

Interpretation:
The average weight difference between infants born to smokers and non-smokers is **9.27 ounces**. The difference is **statistically and clinically significant** ($p < 0.001$). Smoking cessation programs during pregnancy are crucial since lower birth weight raises the risk of newborn problems.

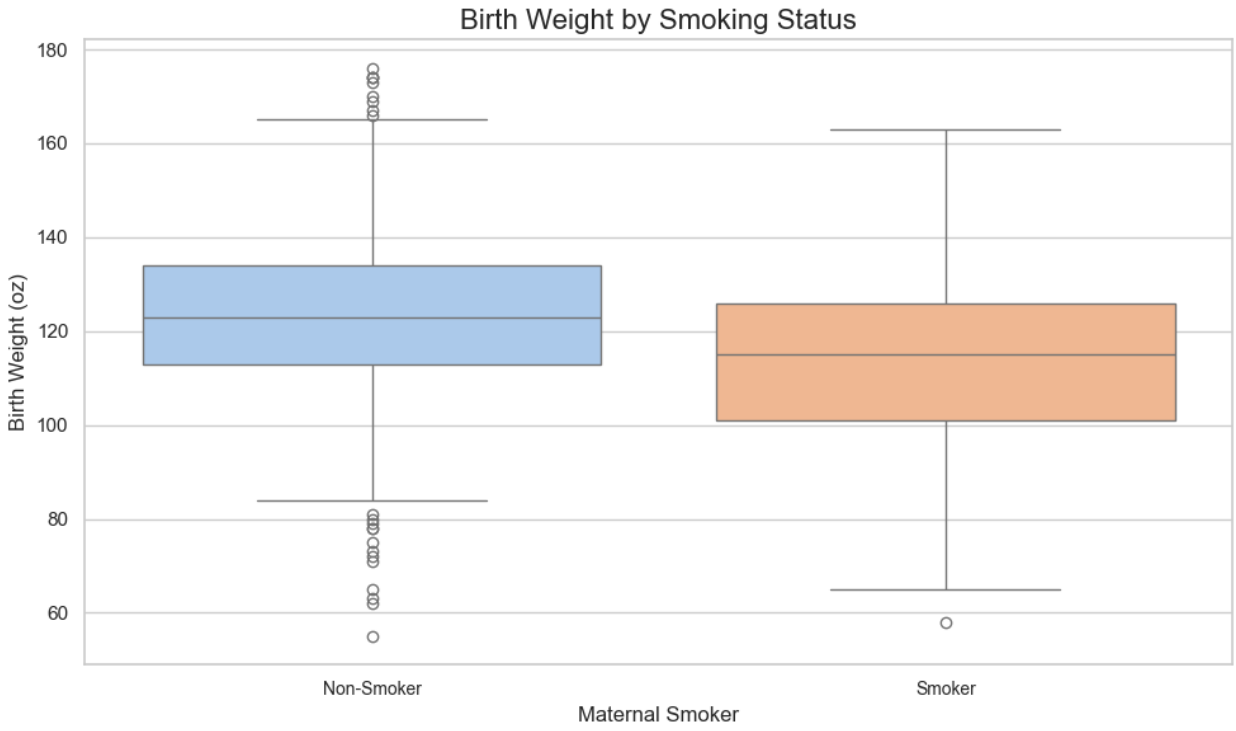

Figure 5: Birth Weight by Smoking Status – Comparative Boxplots

Research Question 4: Gestational Period and Maternal Smoking

Group	Mean (days)	SD
Non-smokers	279.87	16.47
Smokers	277.90	15.20

t = 2.07, p = 0.039

Interpretation:
Smokers typically have gestational periods that are two days shorter than those of non-smokers. Although clinically insignificant, the outcome is statistically significant. Smoking may somewhat reduce the length of pregnancy, but this effect is negligible in comparison to its significant impact on birth weight.

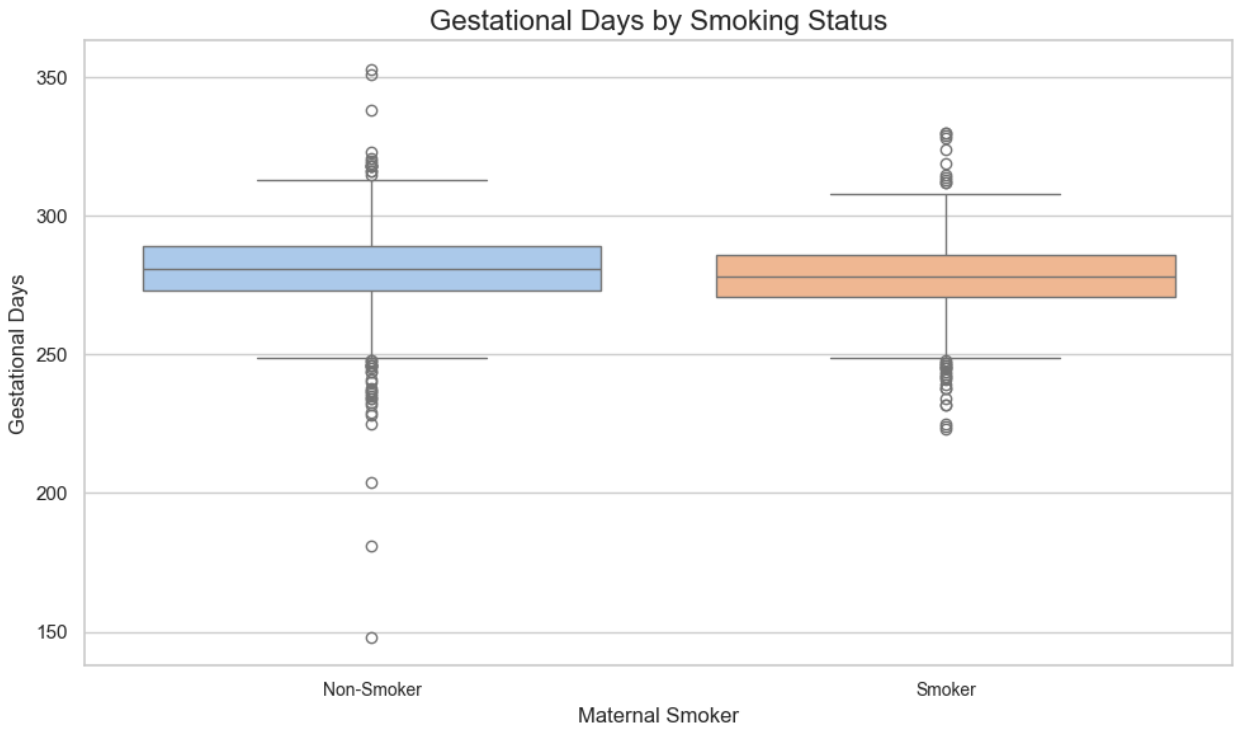

Figure 6: Gestational Days by Smoking Status – Comparative Boxplots

Research Question 5: Maternal Age Groups and Birth Weight

(Younger < 25 vs. Older ≥ 30)

Result: No statistically significant difference in mean birth weights ($p > 0.3$).

Interpretation: Age alone does not appear to determine birth weight. Both younger and older mothers can achieve similar outcomes with appropriate prenatal care and healthy behaviors.

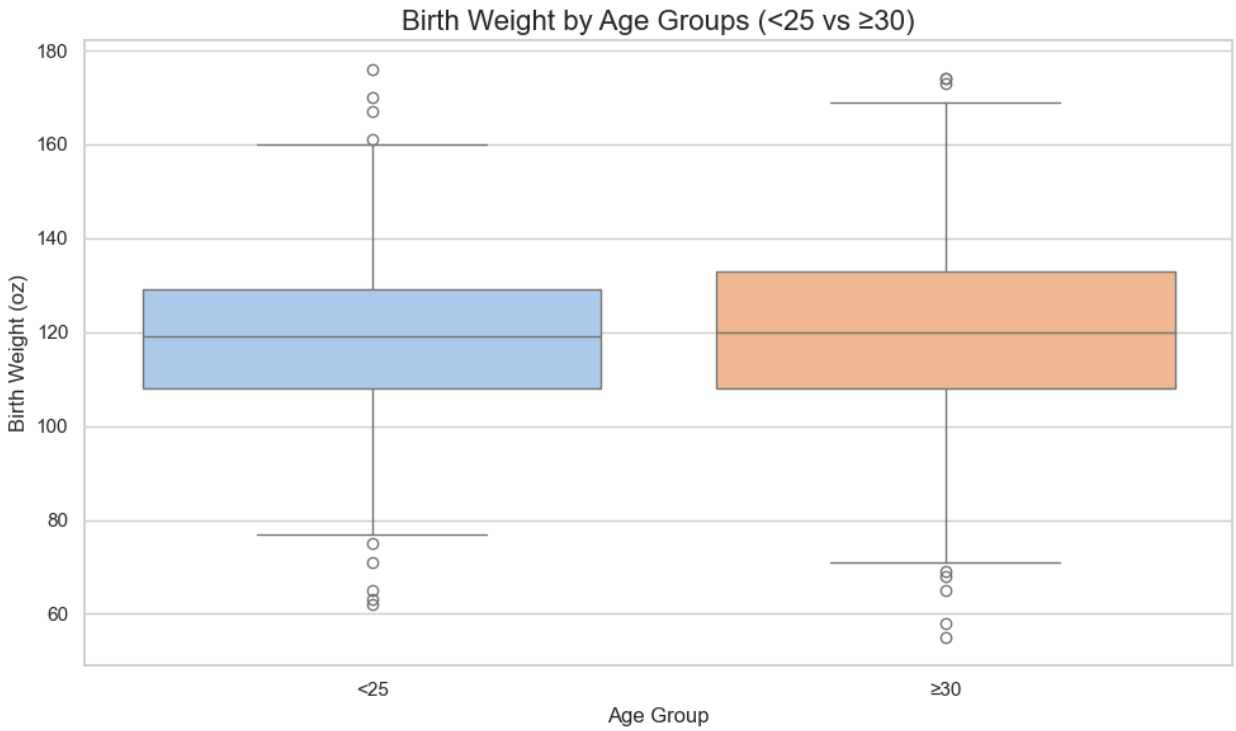

Figure 7: Birth Weight by Age Groups – Comparative Boxplots

Research Question 6: Gestational Period and Birth Weight

Group	Mean (oz)	n
Pre-term (<280 days)	112.60	570
Full-term (>= 280 days)	125.94	604

- Difference = 13.34 oz
- $t = -13.34$, $p < 0.0001$

Interpretation:
The average weight difference between full-term and pre-term babies is **13.3 ounces**. Gestational length is a crucial predictor of healthy birth weight, as seen by this considerable and statistically significant difference ($p < 0.0001$).

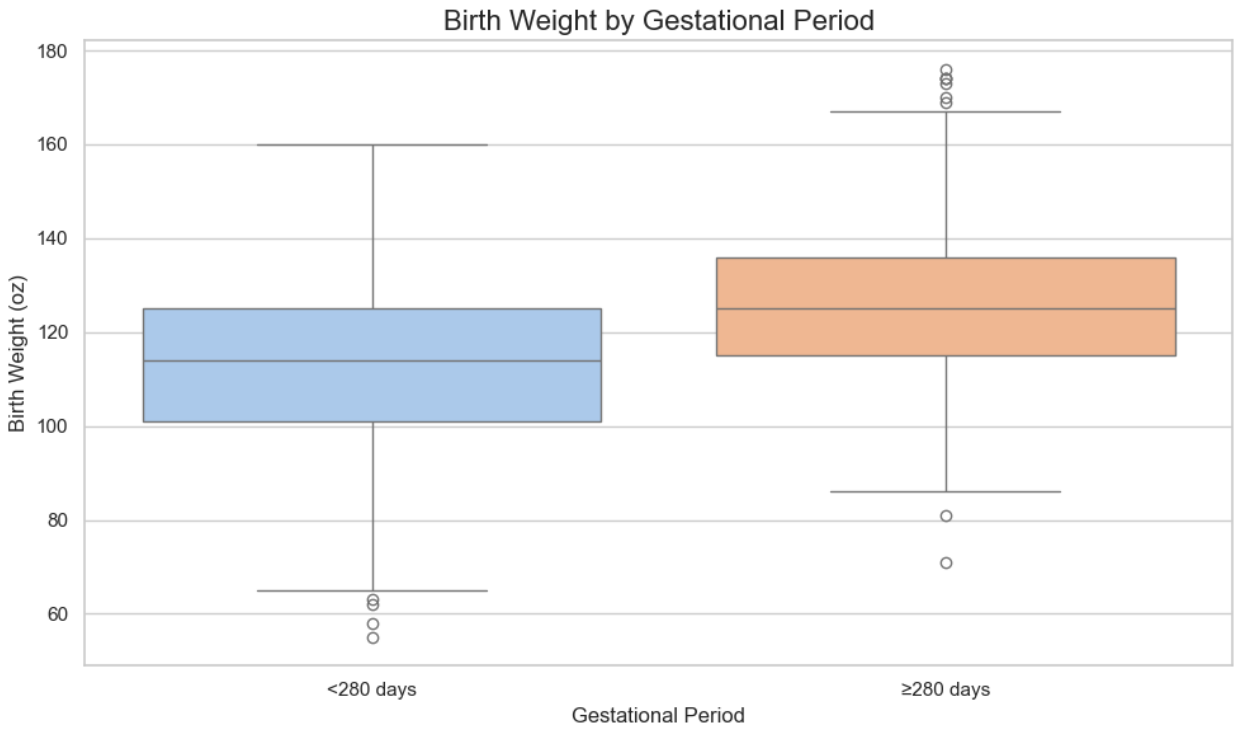

Figure 8: Birth Weight by Gestational Period – Boxplots

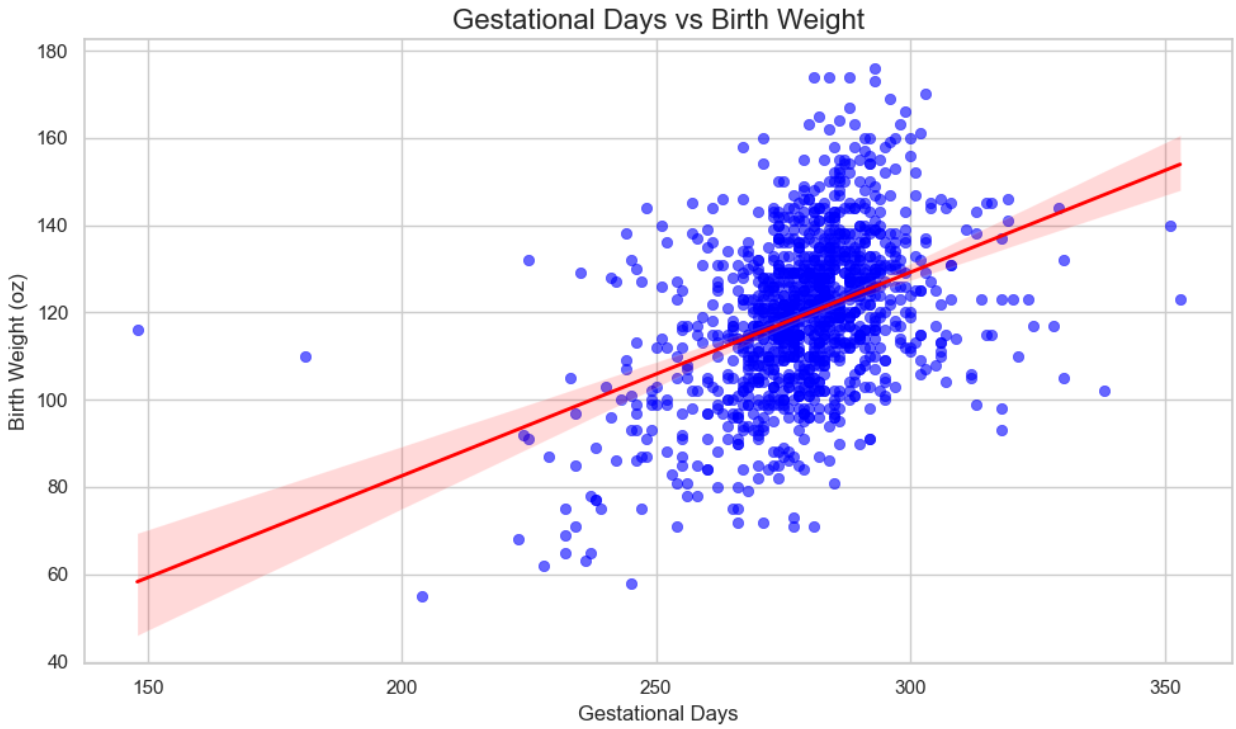

Figure 9: Gestational Days vs. Birth Weight – Scatterplot

Additional Analysis: Maternal Pregnancy Weight and Birth Weight

A supplementary scatterplot was generated to explore the relationship between **maternal pregnancy weight (lbs)** and **infant birth weight (oz)**.

Observation:

The scatterplot shows little correlation between the weight of the mother during pregnancy and the weight of the baby at birth, which defies early predictions. The association is quite weak and has significant scatter over the data range, despite the regression line's moderate positive slope. This implies that the weight of the mother during pregnancy is not a reliable indicator of the weight of the newborn. Maternal weight seems to have very little independent impact on delivery outcomes, in contrast to gestational duration, which shows a strong, obvious link. Birth outcomes are much more influenced by other factors, such as the length of gestation, the mother's smoking status, general health, genetics, and the quality of prenatal nutrition (rather than the amount of weight).

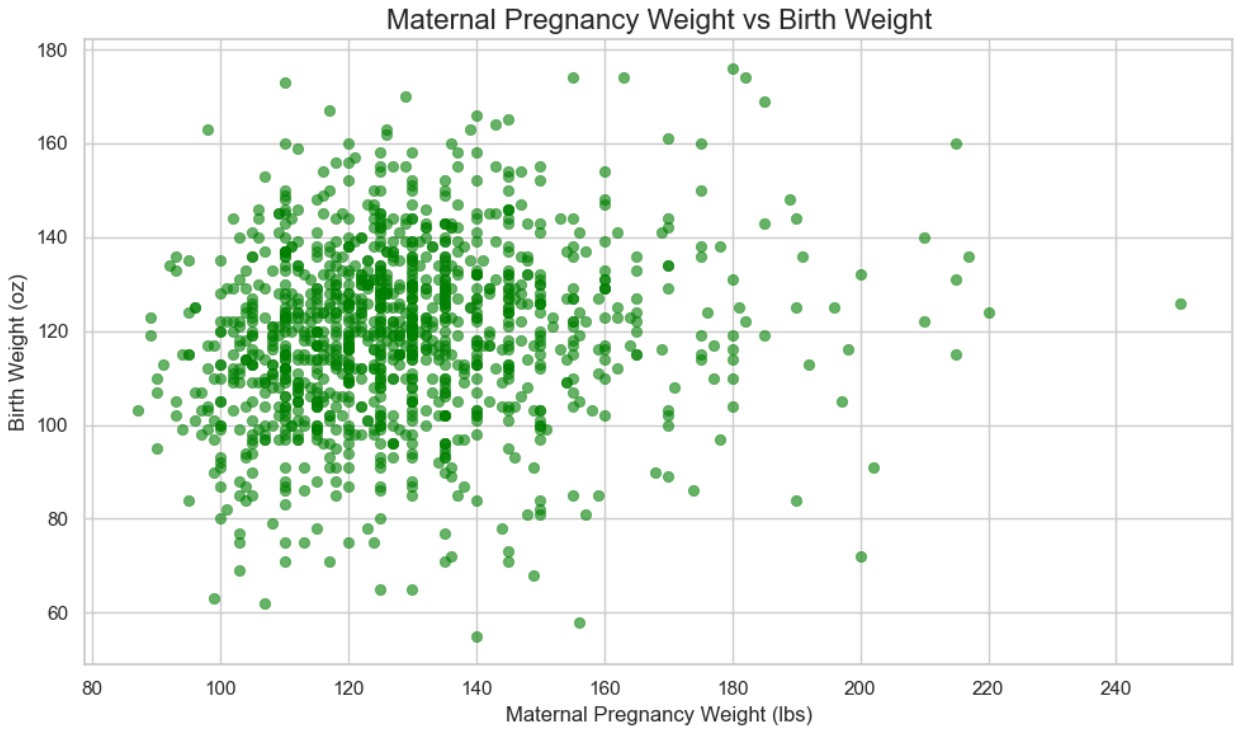

Figure 10: Maternal Pregnancy Weight vs. Birth Weight – Scatterplot

Discussion

This comprehensive analysis identifies several key findings:

- **Smoking prevalence (39.1%)** is significantly higher than past national estimates.
- **Maternal smoking** is strongly linked to lower infant birth weight and a slightly shorter gestational period.
- **Gestational age** remains the single most powerful predictor of birth weight.

- **Maternal age** alone does not significantly affect outcomes.
- **Maternal pregnancy weight** shows a positive association with infant weight, highlighting the broader importance of prenatal nutrition and health.

The combination of behavioral, demographic, and biological factors demonstrates the complexity of maternal and infant health and underscores the continued need for public health programs addressing modifiable risks like smoking.

Conclusions and Recommendations

- **Smoking cessation** should be an essential component of prenatal care.
- **Public health education** should focus on the effects of smoking and the benefits of healthy maternal nutrition.
- **Prevention of preterm birth** should remain a top priority.
- **Future research** should incorporate smoking intensity, nutrition, socioeconomic status, and longitudinal outcomes for a fuller understanding of maternal-infant health dynamics.