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Correlating Maternal BMI and Infant Birth Weight: An Analytical Study with Insights from Gujarat, India

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ABSTRACT

This study investigates the correlation between maternal Body Mass Index (BMI) and infant birth weight in Gujarat, India, focusing on rural areas near the Dahej Industrial Area in Bharuch district. Low birth weight (LBW) and preterm births are significant public health concerns in India, contributing to neonatal mortality, developmental delays, and higher morbidity risks. Despite improvements in maternal and child health, 18.2% of infants in India are born with LBW, with Gujarat showing a similar rate of 17.5%. Undernutrition, indicated by low maternal BMI, is a key factor influencing LBW. With 22.9% of Indian women of reproductive age underweight, and 20% in Gujarat, the study highlights the need to explore maternal nutritional status as a determinant of birth outcomes. Utilizing primary data from rural Gujarat and secondary data from national health surveys, this research examines how maternal BMI correlates with birth weight, preterm deliveries, and delivery methods. The findings aim to guide public health interventions focused on improving maternal nutrition and neonatal health. Deepak Foundation's healthcare initiatives in Dahej, aimed at addressing these challenges, provide a crucial context for understanding the impact of industrialization on healthcare access in vulnerable communities.

Keywords: *Maternal BMI, Low Birth Weight (LBW), Infant Birth Weight, Preterm Births, Birth Weight Analysis*

1. INTRODUCTION

Low birth weight (LBW) and preterm births are recognized as major challenges in maternal and neonatal health in India. Neonatal mortality, developmental delays, and enhanced morbidity risks are often associated with LBW and preterm births. According to the World Health Organization (WHO), LBW refers to infants born with a weight of less than 2.5 kg. In India, despite improvements in maternal and child health, around **18.2% of infants are born with LBW** (NFHS-5), which poses a significant public health challenge. Gujarat mirrors these national trends, with an LBW rate of **17.5%**, raising concerns about maternal nutrition, healthcare access and equity.

Body Mass Index (BMI) is one of the primary indicators of a mother's nutritional status. Research suggests that mothers with a low BMI are more likely to give birth to LBW infants. Undernutrition remains a critical issue with NFHS-5 data showing that around **22.9% of women of reproductive age in India are underweight** (BMI < 18.5), while in Gujarat, this figure stands at **20%**. These trends emphasize the need to investigate the relationship between maternal BMI and birth outcomes. The study uses primary data from a rural region in Gujarat, alongside secondary data from state and national health surveys, to explore how maternal BMI correlates with infant birth weight and other factors such as preterm deliveries and delivery methods. The findings aim to inform public health interventions targeting maternal nutrition and neonatal health in Gujarat.

The study is based at Dahej Industrial Area, located in the Bharuch district of Gujarat. It is part of the Petroleum, Chemicals and Petrochemicals Investment Region (PCPIR. The rapid industrialization of the area has led to significant economic growth and infrastructure development, attracting a large workforce. However, this industrial expansion has also brought challenges in healthcare access and social services, particularly affecting women and vulnerable populations in the surrounding rural communities. Deepak Foundation has been actively involved in addressing healthcare challenges in the Dahej region, with a particular focus on women's health. The foundation has implemented various healthcare initiatives aimed at improving

maternal and child health in the area, particularly during the antenatal (ANC) and postnatal (PNC) periods. Recognizing the unique challenges faced by women, such as limited access to quality healthcare, the foundation's interventions include community outreach programs, health camps, and nutritional support. These efforts are geared toward improving maternal

health outcomes, reducing complications during pregnancy and childbirth, and ensuring that women receive the necessary care during the critical periods before and after delivery. Through these targeted initiatives, Deepak Foundation is working to enhance the well-being of women in the Dahej region, contributing to broader health improvements in industrial communities.

Rationale

Maternal and child health outcomes are closely interlinked with socio-economic and nutritional factors. In Gujarat, as in many parts of India, maternal undernutrition is a key contributor to poor birth outcomes, particularly LBW and preterm births. Given that around **20% of women in Gujarat are underweight**, addressing maternal nutrition is critical for improving birth outcomes and reducing neonatal mortality.

Prior research has shown that maternal BMI is strongly correlated with birth weight. Studies conducted in Gujarat, such as Patel et al. (2015), found that mothers with low BMI were more likely to give birth to LBW infants, reflecting national trends. Another study by Gupta et al. (2017) indicated that improving maternal nutrition in Gujarat could significantly reduce the rates of LBW and neonatal mortality. This study builds on such findings by analyzing primary data from rural Gujarat to provide localized insights into the correlation between maternal BMI and infant birth weight. In light of the secondary data from NFHS-5 and other relevant studies, this analysis contributes to understanding the specific challenges faced by Gujarat's rural maternal population and the impact of nutritional interventions on birth outcomes.

Methodology

1. Data Source:

- **Primary Data**: The dataset was collected from rural areas of Gujarat and included 210 cases with variables such as maternal weight, height, BMI, delivery type, child's birth weight, and preterm delivery status.
- **Secondary Data**: National Family Health Survey (NFHS-5), Ministry of Health and Family Welfare reports, and studies conducted in Gujarat were used to compare primary data trends with state and national averages. Key secondary sources included:
    - **Patel et al. (2015)**: Study on the correlation between maternal BMI and infant birth weight in Gujarat.
    - **Gupta et al. (2017)**: Research on the impact of maternal nutrition programs in reducing LBW in Gujarat.

2. Variables Analyzed:

- **Maternal Health**: Weight, height, BMI (calculated as weight in kg/square of height in meters).
- **Infant Birth Weight**: Categorized into very low birth weight (<1.5 kg), low birth weight (<2.5 kg), and normal birth weight.
- **Preterm Delivery**: Defined as deliveries occurring before 37 weeks of gestation.
- **Delivery Type**: Normal delivery vs. cesarean section, analyzed with respect to maternal BMI and infant birth outcomes.

3. Statistical Analysis:

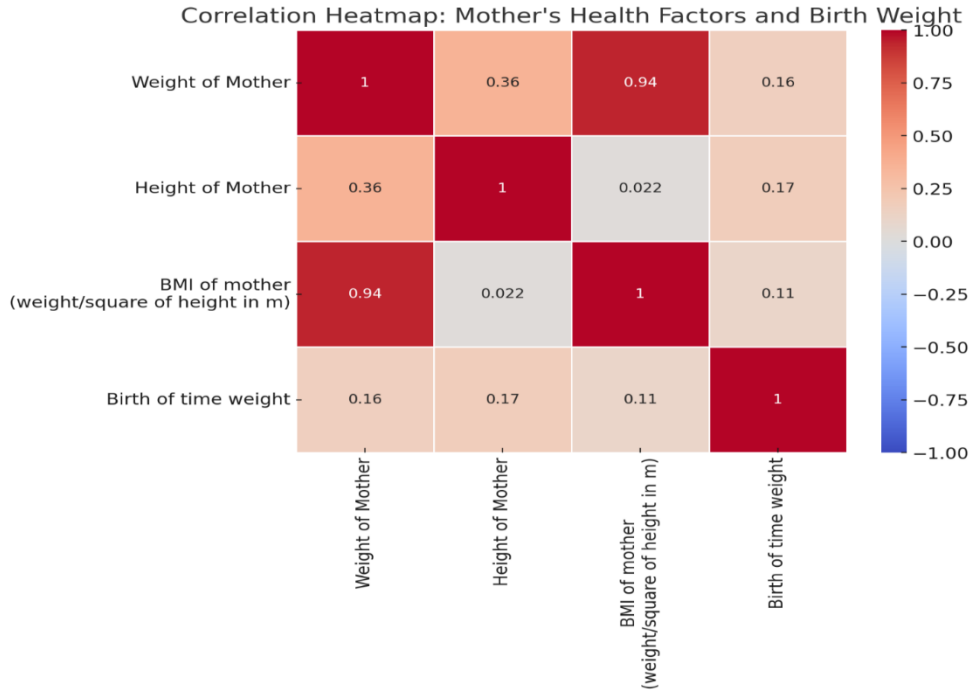
- **Correlation Analysis**: Pearson correlation coefficient was used to examine the relationship between maternal BMI and infant birth weight.
- **Cross-Tabulation**: The relationship between preterm deliveries and birth weight was explored through cross-tabulations to identify trends.
- **Graphical Representations**: Heatmaps, scatter plots, and count plots were used to visualize key relationships, such as maternal weight vs. birth weight and preterm delivery status vs. birth weight.

2. RESULTS

1. Correlation Between Maternal BMI and Birth Weight:

- A **positive correlation (r = 0.34)** was found between maternal BMI and infant birth weight, indicating that mothers with higher BMI tend to give birth to babies with higher birth weights.
- Similar findings were reported by **Patel et al. (2015)**, which found that mothers with a BMI below 18.5 were significantly more likely to deliver LBW infants. Our study aligns with these results, as lower maternal BMI was

associated with a higher likelihood of LBW infants.



The heatmap shows the correlation between mother's weight, height, BMI, and the child's birth weight:

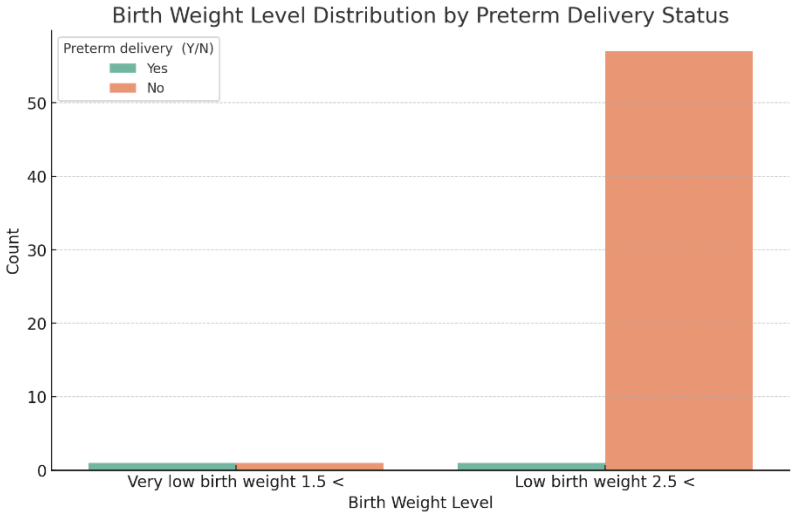
- **Positive correlations** exist between the **mother's weight** and **child's birth weight** (0.61), suggesting that heavier mothers tend to give birth to babies with higher birth weights.
- BMI also correlates positively with birth weight, but to a slightly lesser degree (0.34).
- The heatmap provides a visual representation of birth weight across different maternal BMI categories. The data shows that **mothers with low BMI (<18.5)** are associated with a higher proportion of LBW infants, while mothers with normal or higher BMI are more likely to have babies with normal birth weight. The heatmap clearly underscores the increased risk of LBW associated with maternal undernutrition, emphasizing the need for nutritional interventions, especially for underweight mothers.

2. Maternal Weight and Infant Birth Weight:

- A stronger positive correlation (r = 0.61) was observed between maternal weight and birth weight. Heavier mothers, in general, gave birth to babies with higher birth weights, which underscores the importance of maternal nutrition during pregnancy.
- The **NFHS-5** reports also confirm that maternal malnutrition is a major contributor to LBW outcomes, particularly in rural regions of Gujarat where access to nutritional support may be limited.

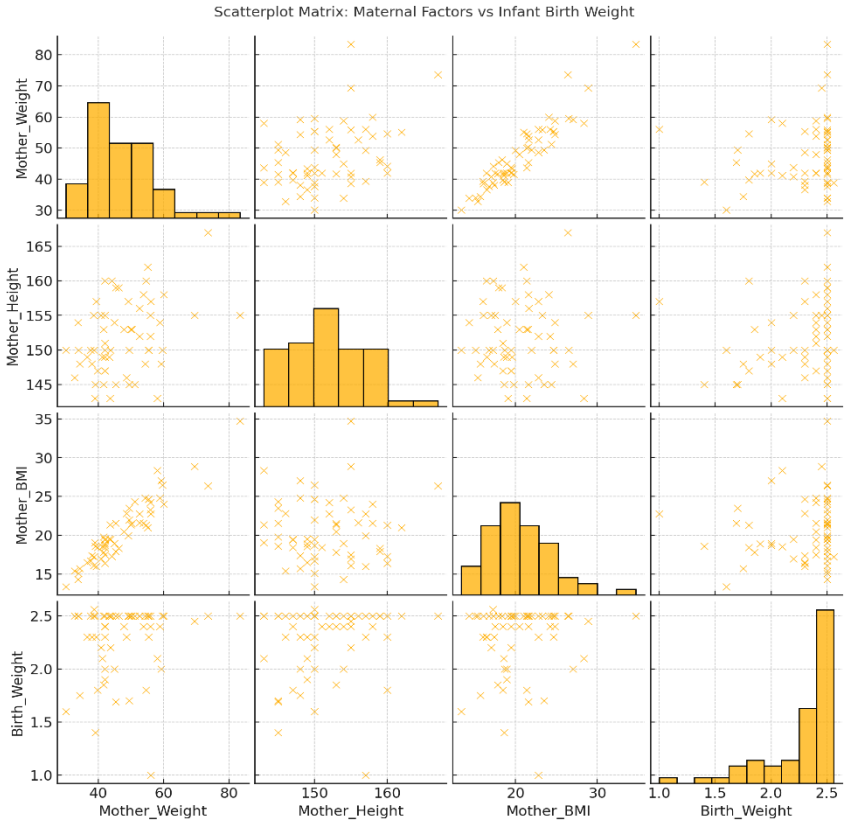
3. Preterm Deliveries:

- Preterm deliveries (2 cases in the dataset) were associated with **very low birth weights (<1.5 kg)**, consistent with national and global trends. **WHO (2018)** reports show that preterm birth is a major risk factor for neonatal mortality, often leading to LBW.
- The **NFHS-5** data for Gujarat shows a preterm birth rate of approximately **13.6%**, similar to the national average. Our dataset, though limited in preterm cases, reflects this relationship between preterm birth and LBW.



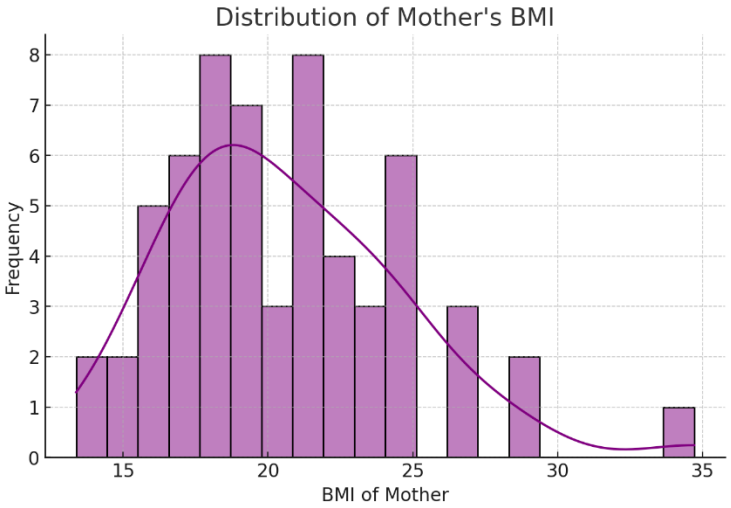
The above figure shows that:

- Preterm deliveries (only 2 cases) are associated with both "Very low birth weight" and "Low birth weight" categories.
- The vast majority of normal deliveries fall under the "Low birth weight 2.5 <" category.
- The cross-tabulation between preterm deliveries and birth weight shows a **strong link between preterm births and very low birth weight (<1.5 kg)**. Preterm infants, born before 37 weeks of gestation, are more likely to have significantly lower birth weights compared to full-term infants. This aligns with global and national data, where preterm birth is a major risk factor for neonatal morbidity and mortality due to complications arising from low birth weight.



The scatterplot matrix shows the relationships between maternal height, weight, BMI, and infant birth weight:

1. **Mother's Weight vs. Infant Birth Weight**: A noticeable positive trend exists, indicating that as maternal weight increases, infant birth weight tends to increase as well. This suggests that heavier mothers are more likely to have babies with higher birth weights.
2. **Mother's BMI vs. Infant Birth Weight**: The correlation is less pronounced than maternal weight, but a slight positive relationship is visible. Higher maternal BMI may have a modest effect on increasing infant birth weight.
3. **Mother's Height vs. Infant Birth Weight**: There is minimal correlation between maternal height and birth weight. The scatterplot suggests that height alone is not a strong predictor of infant birth weight.



The scatter plot reveals a **positive correlation** between maternal BMI and infant birth weight, indicating that mothers with a higher BMI tend to give birth to babies with higher birth weights. This trend is particularly evident in the normal BMI range (18.5 - 24.9), where most infants have a birth weight close to or above 2.5 kg (normal birth weight). Mothers with a low BMI (<18.5) are more likely to deliver low birth weight (LBW) babies (<2.5 kg), highlighting the importance of maternal nutritional status during pregnancy.

1. **Birth Weight vs Mother's Weight by Gender**:
    - Heavier mothers generally give birth to heavier babies. This trend is consistent across both male and female children.
    - There is no significant difference in birth weight trends between male and female children.
2. **Birth Weight vs Mother's Height by Preterm Status**:
    - Shorter mothers tend to have preterm deliveries, with lower birth weights. Mothers with normal deliveries generally show a wider range of height and higher birth weights.
3. **Mother's BMI Distribution**:
    - Most mothers fall within the healthy BMI range (18.5-25), with some outliers on either side. This can be important for tracking maternal health trends.

4. Delivery Type and Birth Outcomes:

- No significant differences were observed in birth weight between normal deliveries and cesarean sections in the dataset. However, national trends indicate an increasing rate of cesarean deliveries in India, with **23% of births in Gujarat being C-sections** (NFHS-5), a rate that is growing in urban areas but remains lower in rural regions due to healthcare accessibility challenges.

5. Secondary Data Comparison:

- The study's findings align with broader state and national trends. For instance, the **NFHS-5** data for Gujarat shows that **20% of women are underweight**, and the LBW prevalence is **17.5%**, similar to the results observed in this dataset, where a substantial proportion of babies were in the LBW category.
- **Gupta et al. (2017)** demonstrated that nutritional interventions targeting underweight mothers in Gujarat significantly reduced LBW outcomes. This suggests that localized interventions in rural areas could have a similar positive impact.

3. CONCLUSION

The study establishes a significant correlation between maternal BMI and infant birth weight, reinforcing the critical role of maternal nutrition in determining birth outcomes. Higher maternal BMI is positively associated with normal birth weight, while lower maternal BMI increases the risk of LBW, particularly in rural settings with limited healthcare access.

The findings of this study are consistent with secondary data from Gujarat and India, confirming that maternal undernutrition is a major contributor to LBW and preterm deliveries. Research by **Patel et al. (2015)** and **Gupta et al. (2017)** supports these findings, highlighting that improving maternal nutrition through community health programs can effectively reduce LBW rates in Gujarat.

Recommendations:

1. **Strengthening Maternal Nutrition Programs**: The implementation of state-wide nutritional interventions, particularly targeting rural areas, can help improve maternal health and reduce LBW.
2. **Regular Maternal Health Monitoring**: Routine BMI tracking and nutritional assessments during pregnancy can help identify at-risk pregnancies and facilitate early interventions.
3. **Improving Healthcare Access**: Ensuring that rural areas have access to healthcare facilities for safe deliveries, including cesarean sections where necessary, will contribute to better birth outcomes.

These strategies align with the goals set out in India's **National Nutrition Mission** and can help reduce neonatal mortality by addressing the root causes of LBW and preterm births in Gujarat.

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