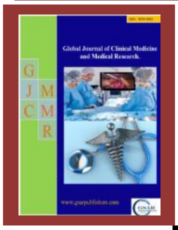

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Impact of Maternal BMI, Blood group and Hemoglobin Genotype on Pregnancy Outcome

By

Bunmi FOLORUNSO-DAVIES[1], Busuyi Kolade AKINOLA[1*], Toluwase Solomon OLAWUYI[1], Modinat Adebukola ADEFISAYO[2]

[1]Department of Human Anatomy, School of Basic Medical Sciences, Federal University of Technology, Akure.
[2]Department of Physiology, School of Basic Medical Sciences, Federal University of Technology, Akure.

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Abstract

Anthropometric and Hematological parameters play a crucial role in assessing health risks, guiding interventions, and evaluating nutritional status. Additionally, negative pregnancy outcomes can have profound effects on both parents and neonates that may require short- or long-term medical intervention. This study investigates the relationship between maternal (Body Mass Index) BMI, blood group, genotype and pregnancy outcomes among parous women.

This retrospective study utilized antenatal and postnatal data from 2018 to 2024, involving 270 parous women aged 18 and above with singleton pregnancies and no pre-existing health conditions. It focused on anthropometric and hematological parameters, including height, weight, blood group, genotype, and BMI. Descriptive and inferential statistical methods (correlation, regression, stratified analysis) were used to assess relationships among variables using SPSS.

Maternal weight positively correlated with neonatal birth weight ($r = 0.151$, $p = 0.013$), while BMI showed a moderate negative correlation with height ($r = –0.494$, $p < 0.001$). Caesarean section (CS) mothers had significantly higher BMI (29.62) than those with spontaneous delivery (25.14) ($p < 0.001$), suggesting a strong BMI-CS link. Blood group showed a small but significant association with delivery mode, whereas genotype did not significantly predict delivery outcomes.

Maternal anthropometric parameters especially BMI and maternal weight play important roles in predicting pregnancy outcomes among parous women. However, blood group and genotype, did not exhibit significant relationships with pregnancy outcomes.

Keywords: *Pregnancy outcomes, Maternal BMI, Blood group, Hemoglobin genotype.*

INTRODUCTION

Anthropometric measures are routinely employed to evaluate health risk, guide medical interventions, and assess both nutritional and general health status (Piqueras *et al*., 2021). A WHO meta-analysis on pregnancy outcomes and maternal anthropometry highlighted the significant predictive value of maternal height, weight, and BMI for specific pregnancy outcomes (Gómez-Carrascosa *et al.*, 2021).

Among these, maternal height has long been considered a key determinant of obstetric outcomes, with distribution patterns varying across geographic and ethnic contexts (Gummadi *et al*., 2024; Toh Adam *et al*., 2012). Likewise, weight gained in excess during a woman's pregnancy period is also associated with adverse pregnancy outcomes (Ramachendran *et al*., 2008). The most widely used metric, body mass index (BMI), defined as weight in kilograms divided by the square of height in meters, serves as a standard tool for estimating body fat (Basraon *et al*., 2015).

In the United Kingdom, several women who experienced death during pregnancy, delivery, or the postpartum period are usually obese or might just be overweight (Thangaratinam *et al*., 2012). Data from the United Kingdom illustrate this concern, where nearly half of maternal deaths occur among women classified as overweight or obese (Thangaratinam *et al*., 2012).

*Corresponding Author: **Bunmi FOLORUNSO-DAVIES**

The global rise in obesity over the last century has thus emerged as a significant public health issue, particularly due to its implications for maternal and neonatal health (Alves *et al*., 2019; Aljahdali *et al*., 2021). Obesity during pregnancy poses risks to both the mother and the baby. For the mother, it increases the chances of developing gestational diabetes and pre-eclampsia, which are serious health issues that can lead to unfavorable conditions for the fetus. Maternal obesity is also associated with fetal macrosomia, characterized by increased fat and fat mass in the neonate, potentially resulting in higher neonatal and maternal morbidity. Also, obesity in women is linked to higher rates of infertility, miscarriages, recurrent pregnancy losses, and lower success rates in assisted reproductive techniques (Kim *et al*., 2023). Obese mothers are more likely to require caesarian sections for delivery (Poston *et al.*, 2016; Muglia *et al*., 2022). These effects, whether short-term or long-term, can have lasting impacts on the overall health of mother and her child (Santangeli *et al*., 2015)

Maternal hematological parameters such as blood group and hemoglobin genotype also provide valuable insights into maternal and fetal health in addition to BMI. The ABO blood group system classifies blood types into four main categories which are A, B, AB, and O (Helmenstine, 2023). ABO blood grouping remains crucial in obstetrics as the primary cause of hemolytic disease of the newborn (HDN). The roles of ABO blood type antigens in the development of malignancies, chronic diseases and infectious diseases have been explored for decades (Chen *et al.*, 2023). The human hemoglobin genotypes include AA, AS, AC, SC and SS. The major concern in genotype compatibility for prospective couples is avoiding sickle cell disease. It is crucial for intending couples to know their genotypes and ensure compatibility before proceeding with marriage (Okoduwa, 2013).

The influence of maternal BMI, blood group and hemoglobin genotype on pregnancy outcome has not been clearly explored hence there is very little information in literature on the predictive value of these maternal parameters on pregnancy outcome (Chen *et al*., 2023).

METHOD

This is a retrospective cohort study. It utilized third-trimester data collected from parous women, with a focus on maternal height, weight, blood group, genotype, and body mass index (BMI). This study utilized maternity cards from 270 women who attended antenatal care and subsequently delivered at the selected hospitals between 2018 and 2024, spanning a period of six years. The primary pregnancy outcomes investigated were birth weight of the newborns and the modes of delivery. Women were categorized into four groups based on their pregnancy BMI (underweight, normal weight, overweight, obese)

Inclusion criteria encompassed women aged 18 years and above, with singleton pregnancies who attended antenatal clinics consistently during all three trimesters and had no pre-existing medical conditions that could potentially influence pregnancy outcomes.

Exclusion criteria included women with multiple gestations (e.g., twins or triplets), those with chronic illnesses such as hypertension, diabetes, asthma, eclampsia, metabolic disorders, or other conditions known to affect pregnancy, as well as those who did not adhere to regular antenatal clinic visits.

The data analysis followed a structured and rigorous approach to examine associations between maternal anthropometric and hematological variables and pregnancy outcomes. All statistical analyses were performed using SPSS. Descriptive statistics summarized the participants' demographic and clinical profiles, while inferential techniques including correlation analysis, multiple regression, and logistic regression were employed to identify significant relationships. Stratified analyses were also conducted to explore associations within specific subgroups based on age, blood group, genotype, and BMI categories.

Ethical approval for the study was granted by the Ondo State Health Research Ethics Committee (OSHREC), under the Ministry of Health, Government of Ondo State, Nigeria. The approval was issued with the ethical clearance number NHREC/18/08/2016.

RESULTS

Table 1: Distribution of Anthropometric parameters among mothers in the study population(n=270)

Parameter	Mean	SD	SE	Median	Min.	Max.
Age	29.71	4.98	0.30	30.00	17.00	42.00
Height (m)	1.66	0.10	0.01	1.65	1.45	1.95
Weight (Kg)	73.35	13.27	0.81	71.00	47.00	130.00
BMI	26.74	5.59	0.34	25.86	16.00	45.61

SD= Standard deviation, SE= Standard error of mean, CI= Confidence interval

This table summarizes anthropometric data for 270 mothers, showing diverse age (17–42 years, avg. 30), height (1.45–1.95m), and weight (47–130kg). The average BMI of 26.74 suggests a predominance of overweight individuals, with a

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wide range (16.00–45.61) indicating both underweight and obesity.

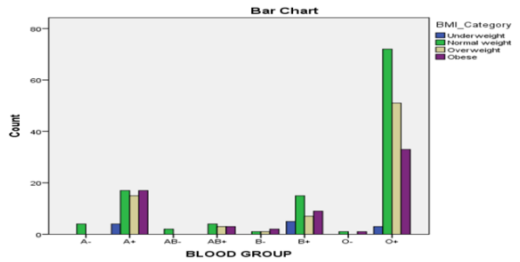
Table 2: Distribution of age, hematological and delivery parameters against BMI categories among mothers in the study population (N=270)

Parameter	Underweight N=12	Normal weight N=116	Overweight N=77	Obese N=65
Age category				
<20	1 (8.3%)	6 (5.2%)	0 (0%)	0 (%)
20-29	6 (50%)	57 (49.1%)	31 (40.3%)	26 (40%)
30-39	5 (41.7%)	51 (44.0%)	44 (57.1%)	39 (60%)
40-49	0 (0%)	2 (1.7%)	2 (2.6%)	0(0%)
Blood group				
A-	0(0%)	4(3.4%)	0(0%)	0(0%)
A+	4(33.3%)	17(14.7%)	15(19.5%)	17(26.2%)
AB-	0(0%)	2(1.7%)	0(0%)	0(0%)
AB+	0(0%)	4(3.4%)	3(3.9%)	3(4.6%)
B-	0(0%)	1(0.9%)	1(1.3%)	2(3.1%)
B+	5(41.7%)	15(12.9%)	7(9.1%)	9(13.8%)
O-	0(0%)	1(0.9%)	0(0%)	1(1.5%)
O+ Genotype	3(25%)	72(62.1%)	51(66.2%)	33(50.8%)
AA	11(91.7%)	92(79.3%)	59(76.6%)	50(76.9%)
AC	0(0%)	2(1.7%)	1(1.3%)	0(0%)
AS	1(8.3%)	22(19%)	17(22.1%)	15(23.1%)
MOD				
CS	0(0%)	4(3.4%)	16(20.8%)	16(24.6%)
SVD	12(100%)	112(96.6%)	61(79.2%)	49(75.4%)
Parity				
Multi	10(83.3%)	74(63.8%)	50(64.9%)	28(43.1%)
Primp	2(16.7%)	42(36.2%)	27(35.1%)	37(56.9%)

*MOD=Mode of delivery, CS=Caesarean section, SVD=Self vaginal delivery, **=frequency(percentage).*

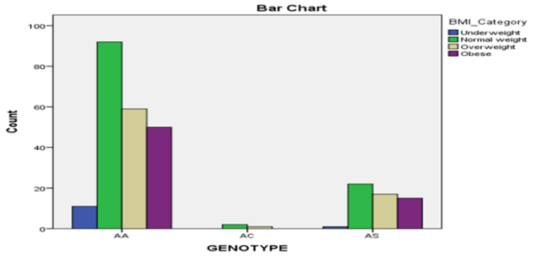
This table links maternal BMI with age, blood group, genotype, delivery method, and parity. Overweight and obese mothers are mostly aged 30–39. Blood group O+ and genotype AA are most prevalent. SVD is the common delivery method, but CS rates rise with higher BMI. Multiparity is typical in lower BMI groups, while primiparity is more frequent among obese mothers—indicating possible associations between BMI and maternal health outcome.

Figure 1: The distribution of BMI across blood groups.



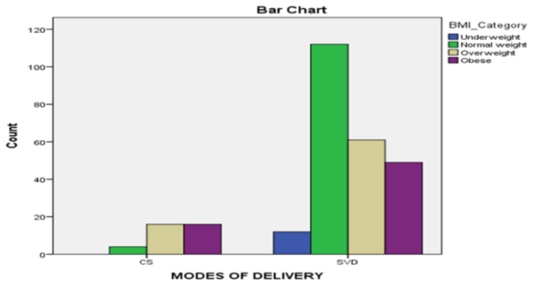
Blood group O+ showed the highest BMI, especially in Normal and Obese ranges; A+ leaned toward obesity. Underweight cases were rare. AB- and B- were least represented.

Figure 2: Distribution of BMI categories among Genotypes



Genotype AA was most common, mainly in Normal and Overweight categories. AS followed a similar pattern. AC was rare. Underweight was low across all genotypes.

Figure 3 Distribution of BMI among different Modes of Delivery



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Spontaneous Vaginal Delivery was more common than Cesarean Section across all BMI ranges, especially Normal. Obesity and Overweight were more prevalent in SVD. Underweight remained low.

Table 3: Distribution of Anthropometric parameters among neonates in the study population(n=270)

Birth weight category	Underweight N=12	Normal weight N=116	Overweight N=77	Obese N=65
Low birth weight (<2.5 Kg)	1(8.3%)	8(6.9%)	6(7.8%)	8(12.3%)
Normal birth weight (2.5 – 4.0Kg)	11(91.7%)	106(91.4%)	68(88.3%)	56(86.2%)
High birth weight (>4.0Kg)	0(0%)	2(1.7%)	3(3.9%)	1(1.5%)

The table provides insight into the anthropometric characteristics of 270 neonates, focusing on their birth weight categories and BMI classifications. The majority of neonates (over 85%) fall within the normal birth weight range (2.5–4.0Kg) across all BMI categories. Low birth weight (, suggesting a possible connection between early obesity risk and lower birth weight. Meanwhile, high birth weight (>4.0Kg) is uncommon, with its highest representation in the Overweight (3.9%) and Normal weight (1.7%) groups. The Underweight neonates are mainly within the normal birth weight range (91.7%), indicating birth weight alone may not be the strongest determinant of neonatal BMI.

Table 4: Pearson correlation (r) between BMI and maternal weight, height and pregnancy outcome (birth weight)

	Correlation	Maternal wt.	Maternal BMI	Maternal height	Maternal age	Birth weight
Maternal wt.	r	1	0.809 *	0.098	0.093	0.151 *
	p-value		0.000	0.108	0.128	0.013
	N		270	270	270	270
Maternal BMI	r	0.809 *	1	-0.494 *	0.130 *	0.056
	p-value	0.000		0.000	0.033	0.358
	N	270		270	270	270
Maternal height	r	0.098	-0.494 *	1	-0.084	0.117
	p-value	0.108	0.000		0.170	0.054
	N	270	270		270	270
Maternal age	r p-value	0.093 0.128	0.130 * 0.033	-0.084 0.170	1	0.006 0.922
	N	270	270	270		270
Birthweight	r	0.151 *	0.056	0.117	0.006	1
	p-value	0.013	0.358	0.054	0.922	
	N	270	270	270	270	

Maternal wt.= Maternal weight. * = correlation is significant at p<0.05.

In this analysis (n = 270), maternal weight is strongly correlated with BMI (r = 0.809, p < 0.001) and modestly with neonatal birth weight (r = 0.151, p = 0.013). Maternal BMI is moderately negatively correlated with height (r = -0.494, p < 0.001) and weakly positively correlated with age (r = 0.130, p = 0.033). Correlations between height and age, height and birth weight, and age and birth weight are not statistically significant.

Table 5: Grouped comparison between Maternal BMI and Modes of delivery using Paired samples t-test

Parameter	MD	SD	SE	95% CI		t-value	df	Sig. (2-tailed)
				Lower bou	Upper boun			

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				nd	d			
BMI vs. CS	29.62	4.64	0.77	28.05	31.19	38.26	35	0.000
BMI vs. SVD	25.14	5.49	0.36	24.44	25.85	70.03	233	0.000

MD= Mean difference, SD= Standard deviation, SE= Standard error, CI= Confidence interval, CS= Caesarean section, SVD= Self Normal Delivery, df= degree of freedom, p significant at <0.05.

Table 6: compares maternal BMI between Caesarean section (CS) and Spontaneous Vaginal Delivery (SVD) groups using paired t-tests. Mothers in the CS group had a significantly higher mean BMI (29.62 ± 4.64) than those in the SVD group (25.14 ± 5.49), with $p < 0.001$ in both cases. This suggests higher BMI is linked to a greater likelihood of Caesarean delivery.

Table 7: Linear Regression and ANOVA to evaluate the relationship between hematological parameters and mode of delivery (MOD) in the study population

Parameters	R	R^2	R^2%	95% CI		F-statistic	t-value	Df	Sig. (2-tailed)
				Lower bound	Upper bound				
BG vs MOD	0.145	0.021	2.1	-0.037	-0.004	5.738	-2.396	269	0.017
GT vs MOD	0.080	0.006	0.6	-0.017	0.084	1.732	1.316	269	0.189

BG= Blood Group, MOD= Mode of Delivery, GT= Genotype, CI= Confidence interval, df= degree of freedom, p significant at <0.05.

The linear regression analysis shows that the blood group is significantly associated with the mode of delivery, with a small but statistically significant negative relationship (t = –2.396, 95% confidence interval from –0.037 to –0.004, p = 0.017), explaining about 2.1% of the variance. In contrast, the genotype does not significantly predict mode of delivery (t = 1.316, 95% confidence interval from –0.017 to 0.084, p = 0.189), accounting for only 0.6% of the variance

Table 8: Pearson Correlation and ANOVA to evaluate the relationship between hematological parameters and birth weight in the study population

Parameters	R	R^2	R^2%	95% CI		F-statistic	t-value	Df	Sig. (2-tailed)
				Lower bound	Upper bound				
BG vs Bwt.	0.068	0.005	0.5	-0.034	0.009	1.252	-1.119	269	0.264
GT vs Bwt.	0.079	0.006	0.6	-0.022	0.108	1.687	1.299	269	0.195

BG= Blood Group, GT= Genotype, Bwt.=Birth weight, CI= Confidence interval, df= degree of freedom, p significant at <0.05.

The Pearson correlation and Analysis of Variance results indicate that neither blood group nor genotype is significantly associated with neonatal birth weight. Specifically, blood group shows a correlation coefficient (R) of 0.068 with a p-value of 0.264, and genotype shows an R of 0.079 with a p-value of 0.195, explaining only 0.5% and 0.6% of the variance in birth weight, respectively.

Discussion

This retrospective study focused on parous women with varying heights and weights, classified across different four major BMI categories. It also examined their hematological parameters, including blood group and genotype. The relationship between maternal anthropometric measurements and hematological parameters in relation to pregnancy outcomes was explored. According to Khanna *et al.* 2022 and Nuttall 2015, BMI is a useful metric for classifying individuals as overweight or obese, serving as one of the primary methods for assessing obesity in populations. The average BMI of the women in this study was 26.74,

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suggesting a predominance of overweight individuals. Also, there is a predominance of overweight and obese individuals, particularly among mothers aged 30–39, suggesting that maternal age may play a role in weight distribution.

Sigamani & Gajulapalli, 2022 and Flor *et al.* 2020 estimated the distribution of ABO and Rh (D) blood groups, identifying a strong presence of O+ at approximately 37.67%, with the entire O category comprising 48.9% respectively. Similarly, this research indicates a significant prevalence of blood group O+, accounting for 58.9% across all BMI categories.

The higher prevalence of obesity in blood groups O+ and A+ further highlights possible genetic or environmental factors contributing to weight patterns. Jawed et al., also discovered a similar trend during his studies as most of the participant who were overweight and obese fell into the O+ category.

These findings highlight the strong association between neonatal birth weight and BMI classifications, with the majority of neonates falling within the normal birth weight range. This is quite similar to the study carried out by Singh *et al.,* 2016 and Gupta *et al.*, 2020 which indicates that Maternal BMI may have a relationship with neonatal birth weight. The relatively low prevalence of high birth weight suggests that excessive fetal growth is uncommon within the studied population. Interestingly, the data indicates a slight correlation between low birth weight and obesity, raising questions about potential early-life risk factors that may contribute to later weight-related concerns.

According to Poston *et al.*, 2016; Muglia *et al*., 2022, obese mothers are more likely to require caesarian sections for delivery. However, other maternal characteristics, including age, blood group, genotype, and birth weight, did not show meaningful statistical differences across BMI groups as their p-values were above the 0.05 significance threshold. This suggests that while BMI influences certain maternal outcomes, its relationship with neonatal birth weight may be less direct, hence, a need for additional research to explore other potential contributing factors.

A strong positive correlation between maternal BMI and weight ($p < 0.001$) confirms that higher maternal weight is closely associated with an increased BMI, reinforcing the expected relationship between these two variables. Additionally, maternal weight exhibits a modest yet significant positive correlation with neonatal birth weight ($p = 0.013$), suggesting that maternal weight influences neonatal birthweight. This aligns with existing literature, which links maternal nutritional status and overall body composition to fetal growth outcomes (Etim et al., 2014, Kim et al., 2023)

Conversely**,** maternal BMI and height demonstrate a moderate negative correlation indicating that shorter mothers are more likely to have higher BMI values. This relationship suggests that body proportions contribute significantly to BMI calculations, as shorter individuals with higher weight tend to present as overweight or obese. Furthermore, a small but significant positive correlation is observed between maternal BMI and maternal age ($p = 0.033$).

From the analysis in this study using paired samples t-tests there seem to be a significant difference in maternal BMI between mothers who had gone through Caesarean sections (CS) and those who had Spontaneous Vaginal Deliveries (SVD). This was also similar to report from studies carried out by Chen et al., 2023 and Robbins et al., 2014. Evidently, mothers in CS group had higher mean BMI compared to those in the SVD group, who had **a** lower mean BMI**.** The statistical significance of these differences (**$p < 0.001$**) suggests a strong association between increased maternal BMI and the likelihood of delivering via CS.

Furthermore, when examining the relationship between hematological parameters, anthropometric measurements, and pregnancy outcomes, it was found that blood group categories exhibit **a** small but statistically significant negative relationship with the mode of delivery**.** The results indicate that blood group may have a minor influence on the mode of delivery**.** However, despite its statistical significance, the strength of this association remains relatively weak, suggesting that maternal anthropometric measures play a more substantial role in predicting both the mode of delivery and neonatal weight**.**

Similarly, in this study genotype does not significantly predict delivery mode. This lack of significant association indicates that maternal genotype does not independently influence whether a woman will undergo a Caesarean section (CS) or a Spontaneous Vaginal Delivery (SVD)**.**

CONCLUSION

This study highlights the strong predictive value of maternal BMI and weight in determining pregnancy outcomes. Unlike hematological traits such as blood group and genotype, which showed minimal associations, maternal weight consistently influenced fetal development and delivery methods. These findings support the need for improved maternal health strategies, including early screenings, nutritional guidance, and weight management, to reduce pregnancy risks and promote better neonatal outcomes.

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*Corresponding Author: **Bunmi FOLORUNSO-DAVIES**