

Trimester-Specific Variation in Haemoglobin, Body Mass Index, Serum Albumin, Height, Weight, and Blood Pressure among Pregnant Women Attending Antenatal Care at Rivers State University Teaching Hospital, Port Harcourt, Nigeria: A Cross-Sectional Study

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Abstract

Pregnancy is accompanied by progressive physiological, metabolic, haematological and cardiovascular changes that vary across gestation. Antenatal care provides an important opportunity for detecting deviations from expected physiological changes and identifying conditions that may threaten maternal and fetal wellbeing. Although antenatal care coverage is an important measure of maternal-health service utilization, the clinical value of antenatal care depends substantially on the systematic measurement and interpretation of maternal and fetal indicators throughout pregnancy. This study therefore proposes to examine the pattern and clinical significance of selected maternal health indicators across the first, second and third trimesters among pregnant women attending antenatal care at Braithwaite Memorial Hospital, Port Harcourt, Nigeria. Objective: To determine whether selected maternal health indicators differ significantly across pregnancy trimesters and to examine their clinical significance for maternal health surveillance during antenatal care. Methods: A hospital-based analytical cross-sectional study were conducted among pregnant women attending antenatal care at Rivers State University Teaching Hospital (RSUTH) between age bracket (15-45) years, Port Harcourt. Eligible participants were categorized according to gestational age into first trimester (≤ 12 weeks), second trimester ($>12-28$ weeks) and third trimester (>28 weeks). Data were obtained via clinical measurements and review of antenatal records. Selected indicators include maternal age, gestational age, body mass index, weight, blood pressure, pulse rate, haemoglobin/packed cell volume, urine protein, serum albumin where available, and selected. Descriptive statistics was use to summarize participant characteristics and indicator distributions. Differences among trimester groups was examined using appropriate parametric or non-parametric tests, while multivariable regression models were used to assess factors independently associated with abnormal indicator values. Statistical significance was set at $p < 0.05$. Expected significance: The study will provide trimester-specific evidence regarding maternal health indicators and identify indicators that may be particularly useful for routine surveillance and early identification of pregnancy-related abnormalities. Findings support improved antenatal monitoring, risk stratification and clinical decision-making in secondary/tertiary maternal-health settings in Port Harcourt.

Keywords: Pregnancy; Antenatal Care; Maternal Health; Trimester; Blood Pressure; Haemoglobin; Body Mass Index; Maternal Indicators; Port Harcourt; Nigeria.

1. Introduction

The comprehensive health status of women is vital in the socio-economic development of a nation. More so, in the human reproductive phenomenon, women healthiness is second to none. Pregnant women wellness is paramount in enriching maternal, fetal, and societal health (Putri & Lu, 2024). Pregnancy is a dynamic physiological state characterized by progressive alterations in cardiovascular, haematological, metabolic, anthropometric and reproductive functions. Although many changes are normal adaptations to pregnancy, deviations from expected physiological patterns may indicate conditions requiring further assessment or intervention. Consequently, antenatal care is not merely a sequence of clinic visits but an opportunity for continuous assessment of maternal and fetal wellbeing. During pregnancy, many women undergo different stages of physical, social, subjective, physiological and psychological dimensions, as well as cognitive and emotional components (Kara, 2025; Shayeghian et al., 2019; Maggino et al., 2015). These stages are of immense significance to the entire wellbeing of not only the pregnant woman (Shayeghian et al., 2019) but her nucleus and extended family including the society at large in a typical African setting. Pregnant women's health is monitored through trimester specific indicators (healthy blood vessels, blood pressure, steady weight gain or body mass index, among others) (OASH; n.d., BHC, n.d., Shriver, n.d., Bailey, 2024; Rigby et al., 2024) respectively. However, significant changes across trimester encompasses expanding of the abdomen, development of the fetus, and potential discomfort from round ligament pain or stretch marks (Deshpande, 2025; Bernstein et al., 2023; SGH, n.d.). Having a high body mass index (BMI) during pregnancy raises the risk of various health conditions which is not limited to loss of a pregnancy due to miscarriage or stillbirth (Paul, 2024; MCS, n.d.). BMI is a medical screening tool that accounts for the ratio of one's height to that of the body weight to estimate the body fat one is having. It is computed using weight in kilogramme (kg) divided by the square of height in meters (m²) (Oloya & Bibiye, 2023; Table 1.1).

Table 1.1 Description of Body Mass Index (BMI) and Pregnant woman wellness

Description	BMI Score	Healthy Weight Gain Range
Obese	Higher than 29 – 30	Not higher than 7 kg
Overweight	Between 25 – 30	Between 7 – 11 kg
Normal	Between 18.5 – 26	Between 11 – 16 kg
Underweight	Less than 18.5	Between 13 – 18 kg

Source: <https://parenting.firstcry.com/articles/bmi-body-mass-index-and-pregnancy/>

Hemoglobin is an indispensable protein that aid oxygen transport whereas blood pressure is a measure of the force against artery walls. Nevertheless, serum albumin is the main protein in blood plasma that ensures and maintain colloid osmotic pressure and transporting substances (Shimizu, 2023; Luo et al., 2019). Normal serum albumin in pregnancy ranges from 3.1 - 5.1g/100ml as posited by (Cassaza & Yazdi, 2021; Abbassi-Ghanavati & Greer, 2010; Shakhmatova et al., 2000; Giardina et al., 1995). Again, values in second trimester and third trimester could ranges from 2.6 - 4.5 g/100ml and 2.3-4.2 g/100ml respectively (Table 1.2). The World Health Organization (WHO) identifies antenatal care as a core component of maternity care and recommends regular contact with skilled health personnel throughout pregnancy. The current WHO model recommends a minimum of eight antenatal contacts, beginning in the first 12 weeks of gestation, to improve the opportunities for prevention, detection and management of pregnancy complications (WHO, 2016). The clinical value of antenatal care depends partly on the quality and completeness of assessments conducted during these contacts. Recommended assessments include blood pressure, weight and nutritional assessment, laboratory investigations, fetal assessment, screening for infections, assessment for hypertensive disorders, screening for gestational diabetes, and counselling on danger signs and birth preparedness (WHO, 2025).

Most importantly, maternal indicators cannot always be interpreted independently of gestational age. For example, physiological cardiovascular changes during pregnancy mean that blood pressure may change during gestation and subsequently rise toward term.

Table 1.2: Levels of Serum Albumin in Women (Reference Values during Pregnancy)

Unit	Non-pregnant Female	First Trimester	Second Trimester	Third Trimester
g/dL	4.1-5.3	3.1-5.1	2.6-4.5	2.3-4.2
g/L	41-53	31-51	26-45	23-42
Source: Pernatology.com				

A Nigerian longitudinal study reported a decline in blood pressure during the middle trimester followed by progressive increases toward term (NDHS, 2024). Similarly, haematological parameters change during pregnancy because of physiological expansion of plasma volume and other adaptations. A study among pregnant women in Port Harcourt specifically examined haemoglobin, haematocrit and other haematological parameters across the three trimesters, demonstrating the relevance of trimester-specific assessment in this population (Solomon et al., 2019). The significance of individual maternal indicators also extends beyond their numerical values. Blood pressure measurement, for example, is central to the detection of hypertensive disorders of pregnancy. Nigerian research has demonstrated that elevated mid-trimester means arterial blood pressure was associated with subsequent pregnancy-induced hypertension/preeclampsia (Fagbamigbe & Idemudia, 2015) (Figure 1.1). Anaemia is another important maternal-health concern. A Nigerian study involving more than 3,000 antenatal clients found substantial anaemia at booking and demonstrated that antenatal care was associated with correction of anaemia in a considerable proportion of women by term (Osungbade et al., 2008).

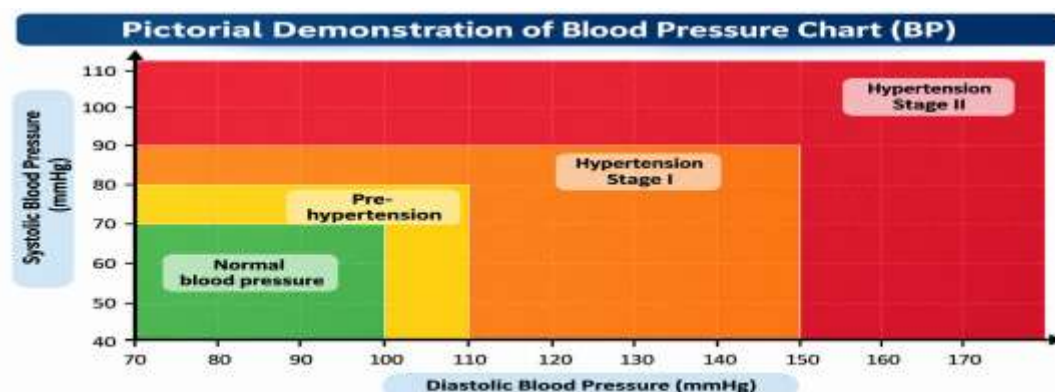


Figure 1.1: Pictorial demonstration of Blood Pressure Chart (BP)
Source: Adapted from Blood Pressure Calculator (n.d.).

The national context further underscores the importance of examining the content of antenatal care rather than simply counting visits. The 2024 Nigeria Demographic and Health Survey reported that 63% of women with a recent live birth received antenatal care from a skilled provider, while 18% initiated ANC during the first trimester and 52% had four or more contacts. Among women who received ANC, 93% had blood pressure measured, 88% had a urine sample taken, 89% had a blood sample taken and 90% had the baby's heartbeat checked (Dapper et al., 2006). These figures demonstrate the importance of measuring not only whether women attend ANC but also whether clinically meaningful indicators are assessed and interpreted.

Previous Nigerian research has also documented gaps in the quality and completeness of antenatal services. For example, a national assessment found that measurement of blood pressure and provision of iron supplementation were common, but other important components were considerably less frequently received (Okonofua et al., 1992). More recent work has continued to identify gaps in detection and management of hypertensive disorders and associated risk factors during antenatal care (Ebeigbe & Gharoro, 2004). The present study therefore focuses on the pattern of selected maternal health indicators across trimesters, rather than treating pregnancy as a uniform physiological state.

2. Problem Statement

Maternal morbidity and mortality remain important public-health concerns in Nigeria. Although antenatal care provides a platform for preventing, detecting and managing pregnancy complications, the effectiveness of ANC depends on timely and appropriate assessment of pregnant women. A major limitation in routine maternal-health monitoring is that individual clinical indicators are sometimes reported without sufficient consideration of gestational age. A blood-pressure measurement, haemoglobin concentration, weight or other indicator may have different clinical meanings depending on the stage of pregnancy. The WHO ANC framework recognizes trimester- and gestational-age-specific interventions. For example, early pregnancy is important for booking, baseline investigations, HIV/syphilis/hepatitis B screening and early ultrasound; blood-pressure assessment continues throughout pregnancy; screening for preeclampsia becomes particularly important after 20 weeks; glucose testing is recommended at approximately 24–28 weeks; and fetal-growth and fundal-height assessment become increasingly relevant later in pregnancy (WHO, 2025). However, there is limited facility-specific evidence describing how routinely measured maternal indicators vary across trimesters among pregnant women receiving ANC in Port Harcourt. This creates several important questions:

1. Do maternal health indicators differ significantly across pregnancy trimesters?
2. Which indicators demonstrate the greatest trimester-related variation?
3. What proportion of women demonstrate potentially abnormal values?
4. Are abnormal indicators associated with maternal characteristics such as age, parity, BMI or gestational age?
5. Can routine indicators be used more effectively for early identification of women requiring closer monitoring?

The absence of such locally generated evidence may limit the ability of health facilities to interpret routine antenatal measurements in a trimester-sensitive manner.

3. Justification of the Study

This study is justified for the following reasons.

1. Clinical importance: Indicators such as blood pressure, haemoglobin, weight, BMI, urine protein and fetal heart rate are relatively inexpensive and feasible components of antenatal assessment.
2. Trimester specificity: Pregnancy-related physiological changes are not static. Examining indicators across trimesters allows clinically meaningful patterns to be identified rather than relying solely on overall averages.
3. Nigerian relevance: The 2024 NDHS demonstrates that although many women receiving ANC undergo blood-pressure, blood and urine assessments, substantial gaps remain in ANC utilization and timing (Dapper et al., 2006).
4. Port Harcourt relevance: Evidence from Port Harcourt has previously demonstrated trimester-related variation in haematological parameters among pregnant women (Salomon et al., 2019). The present study can extend this type of evidence by examining a broader set of routine maternal-health indicators.
5. Health-system relevance: The findings can help clinicians and hospital managers identify indicators that require closer monitoring and determine whether routine ANC assessments are being documented and interpreted consistently.

4. Aim of the Study

The aim of this study is to assess trimester-specific patterns and determine the clinical significance of selected maternal health indicators among pregnant women attending antenatal care at Braithwaite Memorial Hospital, Port Harcourt, Nigeria.

5. Specific Objectives

The study considered the following specific objectives:

1. Determine the distribution of pregnant women according to first, second and third trimester.
2. Assess selected maternal health indicators among pregnant women attending antenatal care
3. Compare maternal anthropometric indicators across the three trimesters.

4. Compare cardiovascular indicators, particularly systolic and diastolic blood pressure across trimesters.
5. Compare haematological indicators, particularly haemoglobin/packed cell volume, across trimesters.
6. Determine Metabolic/nutritional (Serum Albumin) across trimesters of pregnant women.

2.1 Conceptual Framework

The conceptual framework proposes that gestational age is the primary temporal determinant of pregnancy-related physiological adaptation, with trimester serving as a practical classification of advancing pregnancy. Pregnancy produces progressive cardiovascular, anthropometric, haematological and metabolic changes that are necessary to support maternal adaptation and fetal growth. These changes are expected to vary according to gestational stage and therefore should be interpreted in relation to gestational age rather than as isolated measurements (WHO, 2016; Hall et al., 2011). The framework identifies three trimester groups—first, second and third trimester, and links them to selected maternal health indicators, namely (WHO, 2026; Sanghavi et al., 2014, Dapper et al., 2006):

1. Anthropometric: weight and BMI;
2. Cardiovascular: systolic/diastolic blood pressure and pulse rate;
3. Haematological: haemoglobin and packed cell volume (PCV);
4. Metabolic/nutritional: serum albumin
5. Fetal/pregnancy: fetal heart rate and fundal height

These indicators provide measurable manifestations of maternal physiological adaptation. For example, normal pregnancy is associated with increased plasma volume and cardiac output, reduced systemic vascular resistance, and characteristic changes in blood pressure across gestation. Haematological changes likewise accompany plasma-volume expansion, making haemoglobin and PCV relevant indicators for trimester-specific assessment. Evidence from pregnant women in Port Harcourt has also demonstrated trimester-related variation in selected haematological parameters and maternal weight. (Figure 1).

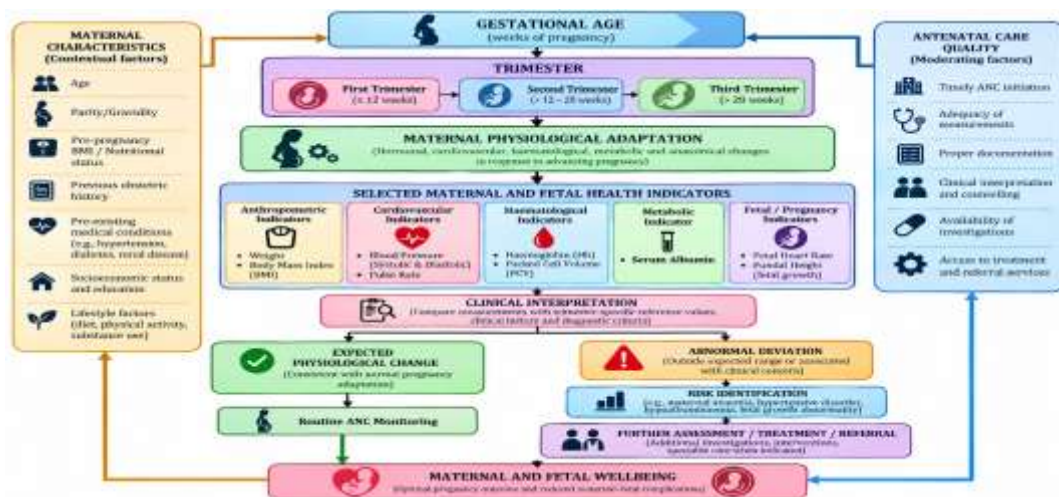


Figure 1. Summarized conceptual framework for trimester-specific assessment of selected maternal health indicators among pregnant women attending antenatal care.

The framework further recognizes that maternal characteristics—including age, parity/gravidity, nutritional status or pre-pregnancy BMI, previous obstetric history and pre-existing medical conditions—may influence observed health indicators and therefore should be considered during analysis. Similarly, quality of antenatal care may modify the pathway through timely ANC initiation, adequacy and accuracy of measurements, proper documentation, clinical interpretation, availability of investigations, and access to treatment or referral. Following measurement, the indicators undergo clinical interpretation, taking into account gestational age, expected physiological changes, maternal

characteristics and relevant clinical criteria. The interpretation leads to two broad pathways: expected physiological change, which supports continued routine ANC monitoring, or abnormal deviation, which may require risk identification, further investigation, treatment, closer monitoring or referral. The ultimate conceptual endpoint is maternal and fetal wellbeing. The framework therefore emphasizes that the clinical value of trimester-specific indicators lies not simply in detecting numerical differences but in determining whether those differences are consistent with normal pregnancy adaptation or suggest potential maternal or fetal risk. This is consistent with WHO's ANC approach, which integrates maternal and fetal assessment, blood-pressure and proteinuria surveillance, haemoglobin testing, and gestational-age-specific interventions throughout pregnancy (WHO, 2016; Hall et al., 2014; Sanghavi et al., 2014).

3.0 Material and Methodology

3.1 Study Design

This study employs a cross-sectional hospital-based analytical study design involving different women at different gestational ages with laboratory-based assessment of selected maternal haematological and biochemical indicators among pregnant women attending antenatal care at Rivers State University Teaching Hospital, Port Harcourt. Maternal health indicators, including haemoglobin, packed cell volume and serum albumin, will be determined using standardized laboratory procedures, while anthropometric, cardiovascular and selected fetal indicators will be assessed using established clinical procedures. Participants were categorized according to gestational age/trimester, and the observed indicators and were compared across the three trimester groups.

3.2 Study Area

Rivers State University Teaching Hospital (RSUTH), formerly Braithwaite Memorial Specialist Hospital, is located on Harley Street in Old Government Residential Area (Old GRA), Port Harcourt, Rivers State, Nigeria. The hospital is situated at approximately 4.7802°N latitude and 7.0142°E longitude. It is a government-owned tertiary health institution providing specialist clinical, diagnostic, maternal-health, teaching and research services. Port Harcourt lies 9m above sea level with a tropical climate, and a substantial rainfall pattern in most months of the year. It also has a short dry season with little effect (Oloya & Bibiye, 2023). The average annual temperature is 26.4°C or 79.5°F with precipitation of about 2708 mm or 106.6 inches per year. The most precipitation occurs in September with an average of 141 mm or 16.3 inches. The driest month is January with 36 mm or 1.4inch rainfall, and warmest month of the year occurs in February, with an average temperature of 26.70 °C or 81.7°F (en.climate-data.org).

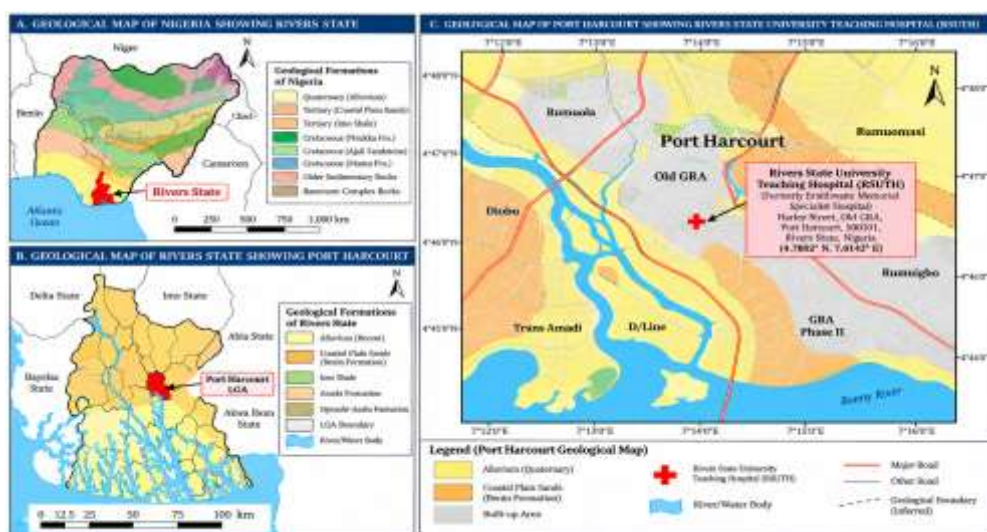


Figure 2: Geological Map showing Rivers State University Teaching Hospital (RSUTH), Port Harcourt, Rivers State, Nigeria.

3.3 Sample Collection and Treatment

Blood samples by means of venipuncture of different pregnant women were sampled at different gestational ages (sixty-four pregnant women) from the Rivers State University Teaching Hospital (RSUTH), Port Harcourt, was carried out using sterile 5ml syringes. In clean plastic tubes, 3ml of blood sample were allowed to clot for 2hrs. It was dislodged with the aid of sterilized broomstick and centrifuged for 5mins. A Pasteur pipette was used to separate yellowish serum into fresh plastic tubes which was used to determining the patient's albumin level. The remaining 2ml of blood was turned into an anticoagulant bottle, and were properly mixed to inhibit clotting. This was used in determining patient's hemoglobin level.

3.3.1 Anthropometric Determination

Weight (kg) and height (m) of each subject were measured using weighing scales and standardized meter. Consequently, the Body Mass Index was computed (BMI) i.e. in kgm^{-2} .

3.3.2 Principle of Determination, Reagents and Procedure of Serum Albumin

Albumin has close affinity with Bromocresol Green (BCG). Thus, when serum or plasma containing albumin reacts with BCG, it forms a characteristic bluish green colour, which is read at wavelength of 628nm in a spectrophotometer. The reagents are 0.01mol/l succinate buffer, pH 4.15, 11.8g of succinate acid, 0.60ml/mol BCG stock solution, 100mg/L sodium azide and 419g of BCG, working buffer per solution, 10.0g/dl stock albumin standard and albumin working standard.

The stock albumin standard was diluted appropriately with 50mg/l with 100ml sodium azide to give solutions containing 1.0, 2.0, 3.0, 4.0, 5.0, and 6.0 albumin/100ml and store in refrigerator. 5.0ml of the working dye solution was pipetted into a series of numbered test tubes, one for each of the two-albumin working standard and one for each unknown. 5.0ml of 0.075 molar succinate buffer pH 4.23 was pipetted into similar series of numbered test tubes to serve as blank. 25ml of each standard and each unknown were added to the appropriately numbered tubes in each series. The mixture was thoroughly mixed and allowed to stand for ten minutes at room temperature. Using a spectrophotometer at wavelength of 627nm, the absorbance of the test samples and standard were read. The blank was used to zero the instrument.

Computation: The level of albumin (g/100ml) was calculated as:

$$\frac{\text{Albumin (g/100ml)} \times \text{A Sample} \times \text{Conc. of Standard}}{\text{A Standard}} \dots\dots\dots \text{Equation 1.}$$

Where A = Absorbance; Concentration of standard = 0.060g/ml

3.3.3 Determination, Reagents and Procedure of Haemoglobin

Haemoglobin was determined by the cyanmethemoglobin method using the Drabkin's Solution. 0.2g of Potassium Cyanide (KCN), Sodium bicarbonate (NaHCO_3), 1.0g of Potassium Ferricyanide $\{\text{K}_3\text{Fe}(\text{CN})_6\}$ and 1000ml of distilled H_2O were utilized as reagents. 0.02ml of the whole blood was transferred into 4ml of Drabkin's solution. The sample was allowed to stand for at least 10 mins for colour development, and the absorbance was read at 540nm. The haemoglobin level (g/dl) was deduced from a standard chart.

3.4. Data Analysis

Statistical analyses of the obtained data were performed using IBM SPSS version 25.0 and were used to analyze the Minimum, Maximum, Range, Mean and Standard Error of Mean. Mean Separation using Duncan Multiple Range Test for Weight, Height, Body Mass Index (BMI) and Serum Albumin in Pregnant Women were also carried out.

4.0 Result

4.1 Variation of Haemoglobin, Body Mass Index (BMI) and Serum Albumin of Pregnant Women in Braithwaite Memorial Hospital

There were variations in the level of the discrete indicators (Haemoglobin, Body Mass Index and Serum Albumin). BMI had minimum mean of $21.49(\pm 0.87) \text{ kgm}^{-2}$ and maximum mean of

25.87(± 4.93) kgm^{-2} , HGB had minimum mean of 8.93(± 0.28) kgm^{-2} with a maximum mean of 12.41(± 0.15) kgm^{-2} and SA had minimum mean of 2.73(± 0.03) kgm^{-2} with a maximum mean value of 4.09(± 0.06) kgm^{-2} respectively (Table 4.1).

4.2 Discrete Indicators and Pregnant Women wellness at First Trimester

During the first trimester, BMI had wide variations. Minimum BMI of 2.20 (Kgm^{-2}) occurred at gestation of 3 months with a corresponding haemoglobin of 8.90 g/dl while the maximum BMI

Table 4.1: Descriptive Statistics of Hemoglobin, Body Mass Index and Serum Albumin of Pregnant Women in Braithwaite Memorial Hospital

Parameter	Min	Max	Range	Mean	S. E
BMI(Kgm^{-2})	17.70	28.7.	11.00	23.13	1.70
	16.00	31.90	15.90	24.67	1.05
	14.90	27.20	22.30	23.86	1.50
	20.30	35.70	15.40	25.87	4.93
	10.00	20.40	16.40	21.49	0.87
HGB (g/dl)	7.70	14.20	3.70	9.50	.053
	7.30	10.10	2.80	8.96	0.19
	6.90	10.60	3.70	8.93	0.28
	8.70	9.70	0.50	9.27	0.30
	11.10	13.50	2.40	12.41	0.15
SA(g/100ml)	3.20	3.80	0.60	3.62	0.09
	2.90	3.70	0.80	3.42	0.4
	3.00	3.40	0.40	3.25	0.03
	2.70	2.80	0.10	2.73	0.03
	3.60	4.40	0.80	4.09	0.06

BMI=Body Mass Index, HGB=Hemoglobin, SA=Serum Albumin, Min=Minimum, Max=Maximum, S.E= Standard Error of Mean

of 28.70 (Kgm^{-2}) occurred at 3 months gestational period with a corresponding haemoglobin level of 9.70 g/dl. However, close variation occurred at SA and BP respectively (Table 4.2). Minimum SA of 3.20 g/100ml correspond with 100/60 mmHg BP at gestation of 3 months whereas maximum SA of 3.80 g/100ml correspond with 100/60 mmHg BP (Table 4.2). Furthermore, at gestation of 3 months, highest BMI of 28.7 Kgm^{-2} and HGB of 9.70 g/dl with SA of 3.60 g/100ml had a BP of 100/60 with positive impression of protein in the urine test respectively (Table 4.2).

Table 4.2: Discrete Indicators (BMI, HGB, SA and BP) of Pregnant Women Wellness during the First Trimester

		PARAMETERS			
Gestational (Months)	BMI (Kgm^{-2})	HGB (g/dl)	SA (g/100ml)	BP (mmHg)	Urine (Test)
2	23.50	10.40	3.80	110/60	-
3	2.20	8.90	3.80	100/60	-
3	17.70	7.70	3.20	100/60	-
3	23.60	8.90	3.60	110/60	-
3	28.70	9.70	3.60	100/60	+
3	19.10	11.40	3.70	100/60	-

BMI=Body Mass Index, HGB=Hemoglobin, SA=Serum Albumin, BP=Blood Pressure, (+)=Trace of Protein, (-)=Absent of Protein.

4.3 Discrete Indicators and Pregnant Women wellness at Second Trimester

There were narrow variations of haemoglobin (HGB), serum albumin (SA) and blood pressure (BP) in second trimester with significant gestation in 4, 5, and 6 months while wide variation occurred at the body mass index (BMI) respectively (Table 4.3). At six (6) months gestation, with minimum of BMI of 16.00kgm^{-2} and haemoglobin of 8.50g/dl with a corresponding SA of 3.50g/100ml exhibited a blood pressure of $100/60\text{ mmHg}$ and a trace of protein (TOP) presence in the urine test whereas the maximum body mass index (BMI) of 31.9 Kg m^{-2} was recorded in gestation of 4 months with a corresponding 9.70 g/dl Haemoglobin, 3.60 g/100 serum albumin and $100/60\text{ mmHg}$ of blood pressure respectively (Table 4.3).

4.4 Discrete Indicators and Pregnant Women wellness at Third Trimester

There were narrow variation of serum albumin and haemoglobin across the third trimester. At nine (9) months gestation, the urine test indicated positive (+) i.e., trace of protein (TOP) with a corresponding BMI of 17.80kgm^{-2} , haemoglobin of 10.10g/dl and serum albumin of 3.10g/100ml at a blood pressure of $100/60\text{mmHg}$ respectively (Table 4.4). Minimum BMI of 14.90kg^{-2} and haemoglobin of 9.30g/dl with serum albumin of 3.30g/100ml , and a blood pressure of $30/90\text{mmHg}$ were recorded at seven (7) months gestation with no trace of protein presence in the urine test (Table 4.4). The test of homogeneity in mean variance of the Body Mass Index (BMI) across the pregnant women using the single factor analysis of variance (ANOVA) revealed that at $F(4,59) = 1.321$, $P = 0.273$ and as $P > 0.05$, the result is therefore, exercise no statistically significant evidence of differences among the groups represented in that ANOVA. Haemoglobin: $F = 49.215$, $P < .001$, the result is statistically significant. Again, for serum albumin: $F = 60.776$, $P < .001$, the result is also statistically significant (Table 4.5). Pregnancy involves expected weight gain (pre-pregnancy BMI + gestational weight gain + gestational age). However, the current study contract this possibly due to mild exercise during third trimester and trado-medicals which most pregnant women takes to reduce fetal size and general body fat.

Table 4.3: Discrete Indicators (BMI, HGB, SA and BP) of Pregnant Women Wellness during the Second Trimester

	PARAMETERS				
Gestational (Months)	BMI (Kg m^{-2})	HGB (g/dl)	SA (g/100ml)	BP (mmHg)	Urine (Test)
4	24.50	8.50	3.60	110/60	-
4	31.90	9.70	3.60	100/50	-
4	29.00	9.70	3.40	120/50	-
4	23.90	9.30	3.50	120/60	-
4	19.20	8.50	3.50	100/70	-
4	30.50	9.70	3.70	140/70	-
5	20.80	9.30	3.40	100/70	-
5	28.00	9.30	3.30	120/70	-
5	26.30	9.70	3.40	120/80	-
5	20.50	10.10	3.30	100/60	-
5	17.40	8.50	3.40	110/70	-
5	31.60	9.70	3.20	130/60	-
5	28.10	7.70	3.40	100/40	-
6	27.80	7.70	2.90	100/60	-
6	22.70	7.30	3.40	100/60	-
6	20.70	8.90	3.50	100/60	-
6	16.00	8.50	3.50	100/60	+
6	21.70	8.10	3.50	100/60	-
6	28.10	8.90	3.50	100/60	-
6	24.50	10.10	3.40	130/70	-

BMI=Body Mass Index, HGB=Hemoglobin, SA=Serum Albumin, BP=Blood Pressure, (+)=Trace of Protein, (-)=Absent of Protein.

Table 4.4: Discrete Indicators (BMI, HGB, SA and BP) of Pregnant Women Wellness during the Third Trimester

		PARAMETERS			
Gestational (Months)	BMI (Kgm ⁻²)	HGB (g/dl)	SA (g/100ml)	BP (mmHg)	Urine (Test)
7	25.70	6.30	3.30	80/50	-
7	19.40	6.90	3.20	100/60	-
7	18.10	7.70	3.30	80/60	-
7	14.90	9.30	3.30	130/90	-
7	27.10	9.30	3.00	100/60	+
8	19.50	8.50	3.30	90/50	-
8	37.20	8.10	3.10	100/60	-
8	25.20	8.10	3.30	110/70	-
8	22.10	8.10	3.40	100/60	-
8	32.40	8.10	3.40	100/60	-
9	17.80	10.10	3.10	100/60	+
9	23.90	10.60	3.30	110/60	-
9	26.00	9.80	3.30	100/60	-
9	22.20	10.40	3.20	100/60	-
9	26.40	9.70	3.20	120/70	-

BMI = Body Mass Index, HGB = Hemoglobin, SA = Serum Albumin, BP = Blood Pressure, (+) = Trace of Protein, (-) = Absent of Protein.

5.0 Discussion

Weight is a significant part of women's health and wellbeing during pregnancy. The amount of weight gain during pregnancy can affect the recipient's health as well as the fetal health and development (TW, n.d.). Computationally, weight is a function of Body Mass Index (BMI). The body mass index is a measure that utilizes weight and height to categorize individuals into different weight categories *vis-à-vis* normal, under-weight, overweight, and obese. In pregnant women healthiness, BMI help evaluate maternal health, guide weight loss or gain, and identifies potential risk for both mother and child (Oloya & Bibiye, 2023). A high body mass index can possibly indicate high body fatness (MC, 2023). In the current study, at first trimester, minimum BMI of 19.10kgm⁻² occurred in the third (3) month while in the second trimester, minimum BMI of 17.4 kgm⁻² occurred in the fifth (5) month and in the third trimester, the minimum BMI of 14.90 kgm⁻² occurred in the seventh (7) month respectively.

Table 4.5: ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Weight	Between Groups	2376.875	4	594.219	5.111	.001
	Within Groups	6859.465	59	116.262		
	Total	9236.340	63			
Height	Between Groups	.138	4	.034	3.723	.009
	Within Groups	.545	59	.009		
	Total	.682	63			
BMI	Between Groups	126.567	4	31.642	1.321	.273
	Within Groups	1412.882	59	23.947		
	Total	1539.449	63			
HGB	Between Groups	157.373	4	39.343	49.215	.000
	Within Groups	47.166	59	.799		

	Total	204.539	63			
S. Albumin	Between Groups	9.435	4	2.359	60.776	.000
	Within Groups	2.290	59	.039		
	Total	11.725	63			

This indicates that at first trimester, there is normal and functional BMI defining effective growth and healthiness of the pregnant women including the fetus while at second trimester, there exist a slight underweight, and at the third semester, there was an actual underweight. It is a known fact that maternal underweight is associated with low birthweight and preterm birth, both spontaneous and iatrogenic, but appropriate gestational weight gain may mitigate low body mass index (BMI) (Burnie et al., 2022; CC, n.d.). Insufficient calories and protein can limit maternal weight gain during pregnancy. The observed underweight in this study could be associated with nutritional deficiencies', fatigue, stress or underlying medical conditions such as preeclampsia among others. Pregnancy-related nausea and vomiting, persistent nausea, vomiting, poor appetite or hyperemesis can reduce food intake and cause weight loss. This corroborates with the study of (Burnie et al., 2022) and (Strauss et al., 1990) that although being underweight may be protective against several pre-birth and intrapartum complications, low BMI can be related to underlying organic disease (i.e., medical conditions) and or eating disorders, or there may be modifiable lifestyle factors that should be addressed in pregnancy. The observed low BMI values across some gestational-age groups may reflect pre-pregnancy nutritional status, inadequate gestational weight gain, insufficient dietary intake, pregnancy-related nausea or vomiting, underlying maternal illness, or other socioeconomic and nutritional factors. However, these determinants were not directly assessed in the present study; therefore, causal explanations for the observed BMI patterns cannot be established. Again, the Highest BMI of 28.70 kgm⁻² in the first trimester occurred at third (3) month while at the second trimester, the highest BMI of 31.90 kgm⁻² occurred at the fourth (4) month, and at the third trimester, the highest BMI of 37.20 kgm⁻² occurred at the eight (8) months respectively. According to (Wagner et al., 2025) weight gain during pregnancy or gestational weight gain (GWG) is a hypothetically modifiable risk factor for antagonistic health outcomes, with GWG outside of recommendations being associated with future health risks for the mother and child. The systemic increase of BMI in this study, mostly at eight months signal obesity. However, at the night month, this condition was lowered to 26.40 kgm⁻² which strictly define an overweight. The nexus for these drops in weight which is ideal (depicting wellness) could be associated with routine antenatal check-up and strict adherence to midwife or gynecologist by pregnant women.

Pregnancy is a period of significant changes in women's body, including their haemoglobin levels (PA, 2024; Oloya & Bibiye, 2023). Haemoglobin is a protein initiated in the red blood cells that is accountable for the conveyance of oxygen all over the body (Oloya & Bibiye, 2023). It serves as a modulator of erythrocyte metabolism, oxidation as an onset of erythrocyte senescence and its implication in genetic resistance to malaria, enzymatic activities and interactions with drugs, and as source of physiological active catabolites (Khoigani et al., 2009). During pregnancy, it is expected that expectant mothers maintain an appropriate haemoglobin levels in their blood. The National Institute for Health and Care Excellence (NICE) has developed guidelines to ensure that pregnant women have optimal haemoglobin levels to support the health of both mother and baby (PA, 2024). More so, the guidelines suggest that a haemoglobin level of 11-14g/dL or above is considered normal during pregnancy. However, maintaining adequate haemoglobin levels is vital for healthiness of both mother and developing baby. Low haemoglobin (Anaemia) can lead to impediment such as difficulty in breathing, fatigue, increase risk of preterm birth, etc. Contrary, disproportionately high haemoglobin levels can indicate conditions such as gestational diabetes or preeclampsia (PA, 2024; MC, n.d., Oloya & Bibiye, 2023). The maximum hemoglobin levels in the extant study of 7.70g/dl (First Trimester), 7.30g/dl (Second Trimester) and 6.30g/dl (Third Trimester) at 3months, 6months and 7months correspondingly were significantly low suggesting the intake of iron-rich foods and supplements. The probable cause(s) of this low haemoglobin could be due to preterm premature rupture of membranes later in the pregnancy or iron deficiency consumption. This is in line with the views of (Khoigani et al., 2012; Zhang et al., 2009; Ferguson et al., 2012). respectively.

Albumin preserves transports hormones and nutrients, fluid balance, and supports tissue repair. With its antioxidant properties, albumin binds harmful molecules, helps defending the body against oxidative stress (Thompson, 2024; Malmström et al., 2016; Geyer et al., 2016; Adkins et al., 2002; Anderson & Anderson, 1977). Naturally, during pregnancy, albumin levels may decrease due to increased blood volume and fluid shifts. Albeit, significant deviations can indicate health challenges such as liver or kidney dysfunction, nutritional deficiencies, or inflammation among others (Thompson, 2024). Serum albumin (SA) measures the amount of albumin in a blood sample. It is an analyte found on the comprehensive metabolic panel (CMP) (Thompson, 2024). In the current study, serum albumin varies from (3.20 - 3.80) g/100ml for the first trimester, (2.90- 3.60) g/100g/ml second trimester and (3.10-4.40) g/100ml third trimester respectively. This indicates significant heterogeneousness among first, second and third trimesters. The implication of this result is that there is no cause of medical attention as values were within the reach of normalcy. Elsewhere in India values were also similar and are within the normal range (Pandey et al., 2019).

Blood pressure is that force applied by the blood against the walls of once arteries as the heart pumps it around the body. It is an imperative aspect of antenatal care since changes in this vital sign can signify potential problems. A healthy blood pressure (BP) during pregnancy is less than 140/90 mmHg according to the American Heart Association (AHA, 2025). Any blood pressure greater than or equal to 140/90 is termed gestational hypertension (GH). However, this, according to American College of Obstetrician and Gynecologist (ACOG) categorized it at stage 2 hypertension (i.e., Systolic 140mmHg or higher or diastolic 90mmHg or higher) (Fletcher & Wallis, 2020). High blood pressure has been implicated with hypertension which is a common disorder affecting 5% to 10% of women during pregnancy, and has been 25% increase during the past 2 decades (CDC, 2024). According to Fletcher & Wallis, (2020) and AHA (2023), normal blood pressure range during pregnancy is less than 120/80mmHg, and that very high or low blood pressure demand medical attention. The current blood pressure varies from (100/60 -110/60) mmHg in the first trimester which is adjudge normal. The second trimester had two variants, first from (100/60 – 130/70) mmHg and second 100/60 - 140/70 mmHg respectively. In the existing condition, 100/60 -130/70 mmHg could be considered normal since it is less than 140/90 but the second condition of 100/60 – 140/70 mmHg where the systolic pressure of 140 mmHg is at a threshold for high blood pressure i.e., gestational hypertension is considered abnormal even though it's diastolic pressure of 70 mmHg is within a healthy range. At the third trimester, a tripod variance occurred. First condition ranged between 100/60 – 120/70 mmHg which could be define as low BP i.e., systolic 100 mmHg and 60 mmHg diastolic (Hypotension) to a normal BP of 120 mmHg systolic with 70 mmHg diastolic. However, in the second condition where the systolic is 130 mmHg and diastolic 90 mmHg is considered a stage one hypertension according to (CDC, 2024). This calls for medical attention, monitoring and management to prevent possible complication such as preeclampsia. The third condition where the blood pressure ranged from 80/50 – 90/50 mmHg is considered low BP (Hypotension) and demand immediate medical attention. The probable cause could be link with heart, anaemia or any underlying medical condition which if not attended to can influence the fetus negatively. Both situations 80/50 mmHg and 90/50mmHg are significantly unfriendly mostly at pregnancy and thus inhibit women wellness but worst still is 80/50 mmHg which request emergency. This corroborates with the study carried by (CDC, 205; ACOG, 2020).

Summary of Findings

1. There exist a normal BMI during the first trimester defining healthiness of mother and fetus.
2. There was a slight underweight in the second trimester which need to be monitored in a bid to retore sound health and wellbeing of mother and child.
3. There was an actual underweight during the third trimester. This calls for a great concern as it could lead to complication if not properly managed.
4. Nonetheless, at the third trimester, the highest BMI of 37.20 kgm^{-2} occurred at the eight (8) months which signify obesity. This indicates future health risk to mother and child.
5. Furthermore, at the ninth (9) month, the systemic increase of BMI 37.20 kgm^{-2} was brought to 26.40 kgm^{-2} which probably could be linked with stern adherence to midwife or Gynecologist counselling during antenatal checkup.
6. Pregnant women who are obese are likely to have future health risk including their child.

7. The haemoglobin of 7.70g/dl (First Trimester), 7.30g/dl (Second Trimester) and 6.30g/dl (Third Trimester) at 3months, 6months and 7months correspondingly were significantly low when compared with the standard (11-14g/dL) put forward by (PA) (2024).
8. The probable cause(s) of this low haemoglobin could be due to preterm premature rupture of membranes later in the pregnancy or iron deficiency consumption.
9. The serum albumin values across the three trimesters were within the normal range (3.1-5.1g/100ml) as posited by Thompson (2024) and Cassaza et al., (2021) respectively.
10. There was BP ranging from 100/60 mmHg – 110/60 mmHg which could be considered normal during pregnancy in the first trimester while in the second and third trimester reveals gestational hypertension (140/70) mmHg and hypotension (80/50 mmHg and 90/50 mmHg) respectively.
11. Normal BP in pregnant women is less than 140/90 mmHg (most acceptable 120/80 mmHg depending on certain conditions) as there was no hypotension (low blood pressure i.e., below 90/60mmHg).

Conclusion

Women wellness during pregnancy is a discrete phenomenon that is sacrosanct in reproductive and family education including socio-cultural environment. Ideally, this period of pregnancy is characterized with significant physical and physiological changes in women's body including their haemoglobin levels. Maintaining adequate haemoglobin levels is vital for wellness of both mother and developing baby. Low haemoglobin (Anaemia) can lead to impediment such as difficulty in breathing, fatigue, increase risk of preterm birth, among others. More so, unreasonably high haemoglobin levels can indicate conditions such as gestational diabetes or preeclampsia. A healthy blood pressure (BP) during pregnancy is less than 140/90 mmHg (Gestational hypertension) according to the American Heart Association (AHA) (2015) but not lower than 90/60mmHg. It has been acknowledged that maternal underweight is associated with low birthweight and preterm birth, both spontaneous and iatrogenic, but appropriate gestational weight gain may mitigate low body mass index. However, Serum albumin measures the amount of albumin in a blood sample. It is an analyte found on the comprehensive metabolic panel. Naturally, during pregnancy, albumin levels may decrease due to increased blood volume and fluid shifts. Albeit, significant deviations can indicate health challenges such as liver or kidney dysfunction, nutritional deficiencies, or inflammation among others.

Recommendation

1. To circumvent anaemia and other complications during pregnancy, intake of iron-rich foods and supplements should be recommended to pregnant women who exhibit low haemoglobin level.
2. Routine antenatal checkup by pregnant women be encouraged in a bid to enhance and promote women wellness during pregnancy in one hand and to ensure early diagnosis, detection and management of perceived complication on the other hand.
3. Prompt medical checkup be encouraged to ease early diagnosis and quick management which are essential to preventing morbidity and mortality associated with preeclampsia.
4. Pregnant women well is also a function of adherence to medical advice (Midwife or Gynecologist, etc.). Thus, they should be encouraged to ensure ultimate compliance to medical advice through-out the three trimesters.
5. There should be homogeneous compliance to medical regulation mostly those pregnant women who are obese in a bid to regulate future health risk to mother and child.

Conflict Of Interest

Authors have declared that there is no conflict of interests.

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Reference

- Abbassi-Ghanavati, M. & Greer, L. G. (2010). Reference table of normal laboratory values in uncomplicated pregnancies. In: Williams Obstetrics, 23rd ed, Cunningham FG, Leveno K.J., Bloom, S., Hauth, J. C., Rouse, D. J., Spong, C. Y. (Eds), McGraw-Hill, New York 2010.

- ACOG Practice Bulletin (2020). Gestational Hypertension and Preeclampsia, *Obstet Gynecol.* 222, 135(6), e237-e260.
- Adkins, J. N. et al. (2002). "Toward a human blood serum proteome: analysis by multidimensional separation coupled with mass spectrometry". *Molecular & Cellular Proteomics.* 1 (12): 947–955. doi:10.1074/mcp.M200066-MCP200.
- Anderson, N. L. Anderson, N. G. (1977). "High Resolution Two-Dimensional Electrophoresis of Human Plasma Proteins". *Proceedings of the National Academy of Sciences.* 74 (12): 5421–5425. doi:10.1073/pnas.74.12.5421.
- Bailey, L. (2024). Changes in your body during pregnancy: First Trimester. Retrieved online dated 20th August, 2025 from <https://familydoctor.org/changes-in-your-body-during-pregnancy-first-trimester/>
- Bernstein, M., Afshar, Y. & Han, C. S. (2023). Preconception Care: In the Continuum of Women's Healthcare. *Handbook of GynecologySpringer Nature Link.* 39–61. Retrieved online dated 20th August, 2025 from https://link.springer.com/rwe/10.1007/978-3-031-14881-11_18.
- Burnie, R., Golob, E. & Clarke, S. (2022). Pregnancy in underweight women: implications, management and outcomes. *TOG The Obstetrician and Gynecologist.* Accessed 23/11/2024
- Cassaza, L. & Yazdi, P. (2021). Albumin: Function & Associated Diseases, Selfcode Lab. Retrieved online dated 9 April, 2023. <https://labs.selfdecode.com/blog/albumin/>
- CDC (2024). High Blood Pressure During Pregnancy. Retrieved online dated 4th September, 2025 from <https://www.cdc.gov/high-blood-pressure/about/high-blood-pressure-during-pregnancy.html>
- (AHA) American Heart Association (2025). Blood Pressure and Pregnancy. Retrieved online dated 4th September, 2025. <https://www.goredforwomen.org/en/know-your-risk/pregnancy-and-maternal-health/pregnancy-and-common-heart-conditions/blood-pressure-and-pregnancy#:>
- (BHC) Better Health Channel (n.d.). Pregnancy - signs and symptoms. Retrieved online dated 20th August 2025 from <https://www.betterhealth.vic.gov.au/health/healthyliving/pregnancy-signs-and-symptoms>
- (CC) Cleveland Clinic (n.d.). What is body mass index (BMI)? Retrieved online dated 20th August, 2025 from <https://my.clevelandclinic.org/health/articles/9464-body-mass-index-bmi>
- Collins, H. E., Alexander, B. T., Care, A. S., Davenport, M. H., Davidge, S. T., Eghbali, M., Giussani, D., Hoes, M. F., Julian, C. G. et al., (2024). Guidelines for assessing maternal cardiovascular physiology during pregnancy and postpartum, *American Journal of Physiology - Heart and Circulatory Physiology*; 327(1):H191–H220. doi: 10.1152/ajpheart.00055.2024
- Dapper, D. V. B., Ibe, C. J. & Nwauche, C. A. (2006). Haematological values in pregnant women in Port Harcourt, Nigeria., *Niger J Med*, 15(3):237-40. doi: 10.4314/njm.v15i3.37220.
- Deshpande, S. (2025). Early Pregnancy Symptoms You Need to Know. <https://sahyadrihospital.com/videos/early-pregnancy-symptoms-you-need-to-know/>
- Ferguson, S. E., Smith, G. N., Salenieks, M. E., Windrim, R., Walker, M. C. (2002). Preterm premature rupture of membranes. Nutritional and socioeconomic factors. *Obstet Gynecol.*,100(6):1250–6. doi:10.1016/s0029-7844(02)02380-3.
- Fletcher, J. & Wallis, M. (2020). Normal blood pressure during pregnancy. Retrieved online dated 4thSeptember, 2025 from [medicalnewstoday.com](https://www.medicalnewstoday.com)
- Geyer, P. E., Kulak, N. A., Pichler, G., Holdt, L. M., Teupser, D. & Mann, M. (2016). "Plasma Proteome Profiling to Assess Human Health and Disease". *Cell Syst.* 2 (3): 185–95. doi:10.1016/j.cels.2016.02.015.
- Ebeigbe, P.N. & Gharoro, E. P. (2004). A raised mid-trimester means arterial blood pressure: is it predictive of pregnancy induced hypertension in Nigerian pregnant women, *Niger Postgrad Med J*, 11(4):294-7.
- Fagbamigbe, A. F. & Idemudia, E. S. (2015). Assessment of quality of antenatal care services in Nigeria: evidence from a population-based survey, *Springer Nature: Reprod Health*, 12(88). doi: 10.1186/s12978-015-0081-0.
- Giardina, B., Messina, I. Scatena, R and Castagnola, M. (1995). The multiple functions of hemoglobin, *Crit Rev Biochem Mol Biol*, 30(3):165-96. doi: 10.3109/10409239509085142.

- Hall, M. E., George, E. M. & Granger, J. P. (2011). The Heart During Pregnancy, *Rev Esp Cardiol*, 64(11):1045–1050. doi: 10.1016/j.recesp.2011.07.009
- Hartung, S. (2025). What is the normal blood pressure range during each trimester of pregnancy? Eureka Health Medical Group. Retrieved online dated 5th September, 2025 from <https://www.eurekahealth.com/resources/normal-blood-pressure-range-during-pregnancy-by-trimester-en>; <https://doi.org/10.1111/tog.12792>
- Kara, P. (2025). Determinants of well-being in pregnancy: the impact of sociodemographic and obstetric variables and maternal health literacy, cross sectional study. *BMC Pregnancy and Childbirth* 25, 524 (2025). <https://doi.org/10.1186/s12884-025-07654-5> BMC
- Khoigani, M. G., Goli, S. & HasanZadeh, A. (2012) The relationship of hemoglobin and hematocrit in the first and second half of pregnancy with pregnancy outcome. *Iran J Nurs Midwifery Res*, 17(2), S165–S170.
- Luo, H., Fu, Y., You, C., Liu, C. & Xu, F. (2019). Comparison of admission serum albumin and hemoglobin as predictors of outcome in children with moderate to severe traumatic brain injury: A retrospective study *Medicine (Baltimore)*. 1; 98(44):e17806. doi: 10.1097/MD.00000000000017806
- Maggino F. (2015). Assessing the subjective wellbeing of nations. In: Glatzer W, Camfield L, Møller V, Rojas M, editors. *Global handbook of quality of life*. Springer, 803 – 22.
- Malmström, E., Kilsgård, O., Hauri, S., Smeds, E., Herwald, H., Malmström, L. & Malmström, J. (2016). "Large-scale inference of protein tissue origin in gram-positive sepsis plasma using quantitative targeted proteomics". *Nat Commun*. 7(10261). doi:10.1038/ncomms10261.
- (MC) Mayo Clinic (2023). Healthy weight, Nutrition and physical activity. Center for Disease Control and Prevention. Retrieved online dated 10 April, 2023. <https://www.mayoclinic.org/healthy-lifestyle/pregnancy-week-by-week/in-depth/>
- (MCS) Mayo Clinic Staff (n.d.). 3rd trimester pregnancy: What to expect. Retrieved online dated 20th August, 2025 from <https://www.mayoclinic.org/healthy-lifestyle/pregnancy->
- Mojinyinola, J. (2011). Influence of maternal health literacy on healthy pregnancy and pregnancy outcomes of women attending public hospitals in Ibadan, Oyo State, Nigeria. *Afr Res Rev.*, 5(3):28–39. <https://doi.org/10.4314/afrrev.v5i3.67336>.
- NDHS (Nigerian Democratic and Health Survey) (2024). Nigerian Democratic and Health Survey Summary. Accessed dated 12/09/2026 from https://dhsprogram.com/pubs/pdf/SR294/SR294.pdf?utm_source=chatgpt.com
- Okonofua, F. E., Balogun, J. A., Amiengheme, N.A. & O'Brien, S. P. (1992). Blood pressure changes during pregnancy in Nigerian women, *Int J Cardiol*, 37(3):373-9., doi: 10.1016/0167-5273(92)90269-9.
- Osungbade, K., Oginni, S. & Olumide, A. (2008). Content of antenatal care services in secondary health care facilities in Nigeria: implication for quality of maternal health care, *Int J Qual Health Care*, 20(5):346-51. doi: 10.1093/intqhc/mzn026
- OASH (n.d.). Office on Women's Health: Stages of pregnancy. Retrieved online dated 20th August 2025 from <https://womenshealth.gov/pregnancy/youre-pregnant-now-what/stages-pregnancy>
- Oloya, C. G. & Bibiye, A.A. S. (2023). Estimation of Serum Albumin in Pregnant Women in Braithwaite Memorial Hospital, Rivers State, South- South Nigeria, *International Journal of Biochemistry, Bioinformatics, and Biotechnology Studies*, 8(1), 17-30. Doi: <https://doi.org/10.37745/ijbbbs.15/vol8n11730>
- Pandey, P. K., Kumar, A., Deepak, A. D., Kumar, V., Goel, S. & Kumar, N. (2019). Assessment of Serum Albumin Levels in Pregnant Hypertensive Women at a Tertiary Care Teaching Centre, *Int J Med Res Prof*, 5(3), 308-30. DOI:10.21276/ijmrp.2019.5.3.071
- (PA) Pregnancy Archive (2024). NICE Guidelines for Managing Hemoglobin Levels during Pregnancy, admin-science - Health Categories Blog. Retrieved online dated 3rd September, 2025 from <https://pregnancyarchive.com/blog/nice-guidelines-for-managing-hemoglobin-levels-during-pregnancy#>:
- Paul, Ishita (2024). 2 Week Pregnancy Symptoms Before Missed Period. Retrieved online dated 20th August, 2025 from <https://www.prideivf.com/blog/2-week-pregnancy-symptoms-before-missed-period/#>

- Putri, A. P. & Lu, Y. Y. (2024). Maternal health literacy in pregnant women: a concept analysis. *Matern Child Health J.*; 28:1272–82. <https://doi.org/10.1007/s10995-024-03945->
- Putri, A. P., Ady, Irawan A. M. & Lu, Y. Y. (2023). Development of maternal health literacy measurements: a scoping review. *IJNHS.*; 6(2):154–64. <https://doi.org/10.35654/ijnhs.v6i2.706>.
- Rigby, F. B., Talavera, F. Legro, R. S. (2024). Common Pregnancy Complaints and Questions. *Medscape*. Retrieved online dated 20th August, 2025 from <https://emedicine.medscape.com/article/259724-overview>
- Salomon, A., Ishaku, S., Kirk, K. R., Warren, C. E. (2019). Detecting and managing hypertensive disorders in pregnancy: a cross-sectional analysis of the quality of antenatal care in Nigeria, *BMC Health Serv Res*, 19(1): 411, doi: 10.1186/s12913-019-4217-8.
- Sanghavi, M., & Rutherford, J. D. (2014). The heart during pregnancy. *Cardiology Clinics*, 32(1), 1–10
- Shakhmatova, E. I., Osipova, N. A. & Natochin, Y. V. (2000). Changes in osmolality and blood serum ion concentrations in pregnancy. *Human Physiology*; 26:92.
- Shayeghian, Z., Amiri, P., Vahedi-Notash, G., Karimi, M. & Azizi F. (2019). Validity and reliability of the Iranian version of the short form social wellbeing scale in a general urban population. *Iran J Public Health*, 48(8), 1478–87.
- Shimizu, Y., Hayakawa, H., Honda, E., Sasaki, N., Takada, M., Okada, T., Ohira, T. & Kiyama, M. (2023). Association between serum albumin levels and height loss in Japanese workers: a retrospective study. *J Physiol Anthropol* 42, 21 (2023). <https://doi.org/10.1186/s40101-023-00338-z>
- Shriver, E. K. (n.d.). Pregnancy. National Institute of Child Health and Human Development. Retrieved online dated 20th August, 2025 from <https://www.nichd.nih.gov/health/topics/factsheets/pregnancy>
- Strauss, R. S. & Dietz, W. H. (1999). Low Maternal Weight Gain in the Second or Third Trimester Increases the Risk for Intrauterine Growth Retardation. *The Journal of Nutrition*, 9(5), 988-993. <https://doi.org/10.1093/jn/129.5.988>
- Suhrabi, Z. & Taghizadeh, Z. (2020). Development and psychometric properties of maternal health literacy inventory in pregnancy. *PLOS ONE.*, 15(6):e0234305. <https://doi.org/10.1371/journal.pone.0234305>.
- (SGH) Saudi German Health (n.d.). Early Signs of Pregnancy: What to Look For. Retrieved online dated 20th August, 2025 from [https://saudigermanhealth.com/en/medical-](https://saudigermanhealth.com/en/medical-blog/early-signs-pregnancy-what-look#:~:text=) blog/early-signs-pregnancy-what-look#:~:text=
- Thompson, S. (2024). Functional maternity. Retrieved online dated 4th September, 2025 from (TW) The women's (n.d.). Weight and pregnancy. The Royal Women Hospital, Victoria, Australia. Retrieved online dated 2nd of September, 2025 from file:///C:/Users/User/Downloads/Weight%20and%20pregnancy%20_%20The%20Royal%20Women's%20Hospital.html <https://www.functionalmaternity.com/prenatallabs/albumin#/>
- Wagner, K. A., Chen, Z., Hinkle, S. N., Gleason, J. L., Lee, W., Grobman, W. A., Owen, J., Newman, R. B., Skupski, D. W., He, D., Sherman, S., Gore-Langton, R. E., Zhang, C. Grewal, J. & Grantz, K. L. (2025). Relationship between Gestational Weight Gain with Fetal Body Composition and Organ Volumes in the NICHD Fetal 3D Study: A Prospective Pregnancy Cohort. *The American Journal of Clinical Nutrition*, 121(2), 367- 375. <https://doi.org/10.1016/j.ajcnut.2024.12.007s>
- Wang, C., Lin, L., Su, R. Zhu, W., Wei, Y., Yan, J., Feng, H., Li, B., Li, S and Yang, H. (2018). Pregnancy and Childbirth, *BMC*, 18(263). [https://bmcpregnancychildbirth.biomedcentral.com/articles/10.1186/s12884-018-](https://bmcpregnancychildbirth.biomedcentral.com/articles/10.1186/s12884-018-1800-7) 1800-7 week-by-week/in-depth/pregnancy/art-20046767
- Zhang, Q., Ananth, C. V., Li, Z., Smulian, J. C. (2009). Maternal anaemia and preterm birth: a prospective cohort study. *Int J Epidemiol.*; 38(5):1380–9. doi: 10.1093/ije/dyp243.