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Nutritional Status Using Mid-Upper Arm Circumference Among Pregnant Women in Flood-Prone and Non-Flood-Prone Communities in Rivers State

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ABSTRACT

Background: *Maternal nutritional status is an important determinant of pregnancy outcomes, particularly in communities experiencing socioeconomic and environmental vulnerabilities. Flooding may disrupt food availability, household livelihoods, and access to healthcare services, potentially increasing nutritional risks among pregnant women. This study assessed nutritional status using mid-upper arm circumference (MUAC) and examined its association with selected maternal characteristics among pregnant women in flood-prone and non-flood-prone communities in Rivers State, Nigeria.*

Methods: *A facility-based cross-sectional study was conducted among 368 pregnant women attending antenatal care in 16 primary healthcare facilities across four local government areas of Rivers State. Participants were recruited through a multistage sampling procedure. Data were collected using a structured questionnaire, MUAC measurements, and hemoglobin assessments. Descriptive statistics and Pearson's chi-square tests were used to examine associations between MUAC-based nutritional status and selected maternal characteristics. Statistical significance was assessed at $p < 0.05$.*

Results: *Of the 368 participants, 187 (50.8%) were classified as having adequate MUAC-based nutritional status, while 181 (49.2%) were classified as having inadequate nutritional status according to the original study criteria. Significant associations were observed between MUAC classification and hemoglobin concentration ($\chi^2 = 12.897$, $p = 0.0016$), educational attainment ($\chi^2 = 17.596$, $p < 0.001$), occupation ($\chi^2 = 9.284$, $p = 0.0257$), and pregnancy trimester ($\chi^2 = 6.661$, $p = 0.0358$). Household income was not significantly associated with MUAC classification ($\chi^2 = 5.776$, $p = 0.0557$). The available results did not provide a direct comparison of MUAC-based nutritional status between flood-prone and non-flood-prone communities.*

Conclusion: *MUAC-based nutritional status was associated with hemoglobin concentration, educational attainment, occupation, and pregnancy trimester among pregnant women attending selected primary healthcare facilities in Rivers State. The findings support the importance of comprehensive nutritional assessment during antenatal care. However, the MUAC classification requires scientific verification, and further analysis is necessary to determine whether maternal nutritional status differs between flood-prone and non-flood-prone communities.*

Keywords: *Maternal nutritional status; Mid-upper arm circumference; Pregnant women; Flood-prone communities; Non-flood-prone communities; Cross-sectional study; Rivers State.*

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Introduction

Maternal nutritional status is an important determinant of pregnancy outcomes and reflects the adequacy of energy and nutrient intake in meeting the physiological demands of pregnancy. Adequate maternal nutrition supports maternal health, fetal growth, and development, whereas undernutrition increases the risk of adverse outcomes, including maternal anemia, fetal growth restriction, and low birth weight [1,2]. Pregnancy is characterized by increased nutritional requirements arising from maternal physiological adaptations, expansion of blood volume, and fetal development. Failure to meet these requirements may compromise maternal nutritional reserves, particularly among women experiencing food insecurity and socioeconomic deprivation [2,3]. Consequently, early identification of nutritional vulnerability is essential for improving maternal health outcomes and guiding appropriate nutritional interventions.

Mid-upper arm circumference (MUAC) is a practical anthropometric indicator commonly used to assess maternal nutritional status, particularly in resource-limited healthcare settings. Its advantages include affordability, ease of measurement, minimal equipment requirements, and suitability for routine nutritional screening during antenatal care [1,4]. MUAC provides an indirect assessment of maternal muscle and subcutaneous fat reserves and may help identify pregnant women at risk of undernutrition. However, the thresholds used to classify maternal undernutrition vary across studies and populations, with commonly applied cut-offs ranging from approximately 21 to 23 cm [1,4]. Wakwoya et al. [1] examined determinants of nutritional status among pregnant women in Ethiopia, highlighting the importance of anthropometric assessment in identifying nutritional vulnerability.

The application of clearly defined and scientifically justified MUAC thresholds is therefore necessary to ensure accurate classification and meaningful interpretation of maternal nutritional status.

Maternal nutritional status is influenced by interacting biological, socioeconomic, dietary, and environmental factors. Previous studies have identified household income, educational attainment, occupation, dietary diversity, household food security, and access to healthcare services as important correlates of maternal nutritional status [1,3,5]. Educational attainment may influence nutritional knowledge, dietary choices, and healthcare-seeking behavior, while household income determines the financial resources available for obtaining sufficient and diverse foods. Similarly, occupational characteristics may affect income stability, food accessibility, and the time available for appropriate maternal care [3,5]. Biological and pregnancy-related factors, including hemoglobin concentration and gestational stage, may also be associated with nutritional status because maternal physiological requirements change throughout pregnancy [2,6]. These relationships highlight the need to examine maternal nutrition within the broader context of socioeconomic conditions and pregnancy-related characteristics.

Environmental conditions may further influence maternal nutritional vulnerability, particularly in communities exposed to recurrent flooding. Flooding is a significant environmental hazard in Nigeria, resulting from factors such as intense rainfall, river overflow, inadequate drainage infrastructure, and settlement in flood-susceptible locations [7,8]. Beyond physical damage to infrastructure and residential areas, flooding can disrupt agricultural production, food distribution, household livelihoods, sanitation systems, and access to essential healthcare services [7,8]. These disruptions may reduce household purchasing power and access to nutritious foods, potentially increasing the risk of inadequate dietary intake among vulnerable populations, including pregnant women. Flood-related displacement and interruptions in antenatal healthcare may also complicate the identification and management of maternal nutritional deficiencies. Nevertheless, the magnitude and direction of these relationships may vary according to household resources, environmental exposure, and the availability of healthcare and social support.

Rivers State, located in the Niger Delta region of Nigeria, contains communities with varying levels of flood susceptibility arising from differences in geographical location, hydrological conditions, settlement patterns, and environmental characteristics [7,8]. Flood-prone communities are generally characterized by greater exposure to flooding hazards, whereas communities classified as non-flood-prone experience comparatively lower levels of flood susceptibility. Njoku et al. [7] identified spatial variations in flood risk and vulnerability across Nigeria, demonstrating the importance of geographical and environmental characteristics in understanding flood exposure. In Rivers State, such differences may have implications for food security, household livelihoods, healthcare accessibility, and maternal nutritional wellbeing. However, classification of communities according to flood susceptibility does not necessarily establish that individual residents have experienced flooding or its associated nutritional consequences.

Although previous studies have investigated the nutritional status of pregnant women and its socioeconomic determinants in Nigeria and other settings [1,5,6,9], evidence specifically examining MUAC-based nutritional status in relation to community flood susceptibility remains limited in the literature considered for this study. Existing research has largely focused on maternal nutritional characteristics without adequately examining how environmental vulnerability may intersect with socioeconomic and pregnancy-related factors. This represents an important area for investigation in Rivers State, where differences in flood susceptibility may coexist with disparities in food accessibility, household income, and healthcare utilization. Understanding these relationships may provide useful evidence for strengthening maternal nutritional screening and identifying populations requiring additional nutritional support.

Therefore, this study aimed to assess nutritional status using MUAC among pregnant women attending selected primary healthcare facilities in flood-prone and non-flood-prone communities in Rivers State, Nigeria. Specifically, the study sought to examine the associations between MUAC-based nutritional status and selected maternal characteristics, including hemoglobin level, educational attainment, occupation, household income, and trimester of pregnancy, while considering differences in community flood susceptibility. The findings are expected to contribute evidence relevant to maternal nutritional assessment and the development of context-appropriate interventions in communities with differing environmental vulnerabilities.

Statement of the problem

Maternal undernutrition remains an important public-health concern, particularly in low-resource settings where socioeconomic inequalities, food insecurity, and limited access to healthcare may compromise nutritional wellbeing during pregnancy. Inadequate maternal nutrition is associated with adverse pregnancy outcomes, including maternal anemia, fetal growth restriction, and low birth weight [1,2]. Although mid-upper arm circumference (MUAC) provides a practical and cost-effective approach to assessing maternal nutritional status, identifying pregnant women at nutritional risk remains essential for guiding timely interventions, particularly in communities experiencing socioeconomic and environmental vulnerabilities [1,4].

In Rivers State, Nigeria, recurrent flooding presents additional challenges to household livelihoods, agricultural activities, food accessibility, and healthcare delivery. Communities with greater flood susceptibility may experience disruptions in food production, household income, transportation, and access to antenatal services, potentially increasing nutritional vulnerability among pregnant women [7,8]. Conversely, communities with comparatively lower flood susceptibility may experience fewer flood-related disruptions, although socioeconomic disadvantage and other determinants of maternal undernutrition may persist. These environmental differences raise important questions about whether maternal nutritional status varies between pregnant women residing in flood-prone and non-flood-prone communities.

Previous studies have identified educational attainment, household income, occupation, dietary practices, and pregnancy-related characteristics as factors associated with maternal nutritional status [1,3,5,6].

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However, the extent to which these characteristics are associated with MUAC-based nutritional status among pregnant women living in communities with differing flood susceptibility in Rivers State remains insufficiently documented in the literature considered for this study. Furthermore, the relationship between community flood susceptibility and maternal nutritional status requires investigation because environmental vulnerability may coexist with socioeconomic inequalities and differences in healthcare accessibility.

The limited availability of context-specific evidence may constrain the development of appropriately targeted maternal nutrition programs for communities experiencing different environmental conditions. Therefore, this study sought to assess MUAC-based nutritional status among pregnant women attending selected primary healthcare facilities in flood-prone and non-flood-prone communities in Rivers State and to examine its associations with hemoglobin level, educational attainment, occupation, household income, and trimester of pregnancy. By examining these characteristics within communities of differing flood susceptibility, the study aimed to provide evidence that may inform maternal nutritional screening, antenatal care, and context-appropriate public-health interventions.

Methodology

Study Design

A descriptive, facility-based cross-sectional study was conducted to assess nutritional status using mid-upper arm circumference (MUAC) among pregnant women attending antenatal care in selected flood-prone and non-flood-prone communities in Rivers State, Nigeria. The design facilitated the assessment of maternal nutritional status and its associations with selected sociodemographic, economic, and pregnancy-related characteristics at a specific point in time. A cross-sectional approach was considered appropriate because it enabled the examination of the distribution of nutritional status and associated characteristics within the study population without manipulating the variables under investigation. However, because exposure and outcome information were collected within the same study period, the design could identify statistical associations but could not establish temporal relationships or causality. The methodological reporting was guided by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for observational studies [10].

Study Area

The study was conducted in four local government areas (LGAs) of Rivers State, Nigeria, namely Ahoada East, Ahoada West, Emohua, and Ikwerre. These LGAs were selected to represent communities with differing levels of flood susceptibility. Ahoada East and Ahoada West were classified as flood-prone, whereas Emohua and Ikwerre were classified as non-flood-prone under the original study's sampling framework. Rivers State is situated within the Niger Delta region, where geographical characteristics, river systems, seasonal rainfall, and environmental conditions contribute to variations in flood susceptibility. Previous studies have documented spatial differences in flood risk and vulnerability across Nigeria, including communities exposed to recurrent flooding and associated environmental disruptions [7,8]. The classification of the selected LGAs was based on the flood-risk categories adopted during the original study.

However, the specific geographical indicators or documentary criteria used to establish these classifications should be identified to ensure that community flood susceptibility is clearly operationalized and reproducible.

Study Population

The study population comprised pregnant women attending antenatal clinics in selected primary healthcare facilities within the four LGAs during the study period. The target population included pregnant women residing in the selected communities who were registered for antenatal services at the participating healthcare facilities. These women were considered appropriate for the study because antenatal clinics provide opportunities for maternal nutritional assessment and the identification of factors associated with nutritional vulnerability during pregnancy. Participation was restricted to women who met the eligibility criteria and voluntarily consented to take part in the study.

Sample Size Determination

The sample size was determined using Cochran's formula for estimating a single population proportion. The calculation was based on an estimated maternal malnutrition prevalence of 36%, as reported in the source cited in the original study protocol [5], a 95% confidence level, and a margin of error of 5%. The formula was expressed as ($n = Z^2p(1-p)/d^2$), where (n) represents the minimum required sample size, (Z) is the standard normal deviate of 1.96 corresponding to a 95% confidence level, (p) is the estimated prevalence of maternal malnutrition (0.36), and (d) is the desired precision (0.05). Substitution of these values yielded a minimum sample size of approximately 354 participants. To account for anticipated non-response, an additional 10% was included, increasing the estimated sample size to approximately 390 participants. The recruitment target was subsequently increased to 400 pregnant women. Of the 400 questionnaires administered, 368 were sufficiently completed and included in the final analysis, representing a response rate of 92.0%. The original sample-size calculation was based on the estimation of a single population proportion and did not explicitly incorporate a design effect for multistage sampling or a separate power calculation for comparisons between flood-prone and non-flood-prone communities.

Sampling Technique

A multistage sampling technique was employed to select the study areas, healthcare facilities, and participants. At the first stage, Rivers West and Rivers East senatorial districts were purposively selected to represent the flood-prone and non-flood-prone study areas, respectively. At the second stage, two LGAs were randomly selected from each senatorial district. Ahoada East and Ahoada West were selected as flood-prone LGAs, while Emohua and Ikwerre were selected as non-flood-prone LGAs. At the third stage, a sampling frame of primary healthcare facilities within the selected LGAs was developed using information obtained from the respective primary healthcare coordinators. Sixteen primary healthcare facilities were subsequently selected through simple random sampling by balloting, with four facilities selected from each LGA. The selected facilities were MPHC Ahoada, Ihuaje, Ula-Ehuda, and Edeoha in Ahoada East; Akinnima, Okarki, Upatabo, and Okogbe in Ahoada West; Ogbakiri, Rumuji, Ndele, and Rumuwehor in Emohua; and Omagwa, Igwuruta, Igwuruta 2, and Aluu in Ikwerre.

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At the fourth stage, proportionate stratified sampling was used to allocate the required number of participants across the selected study areas based on the population information available during sampling. At the final stage, eligible pregnant women attending antenatal services at the selected facilities were recruited consecutively until the allocated sample size for each facility was reached. This approach facilitated recruitment across the selected healthcare facilities, although the final stage was based on consecutive recruitment rather than individual random selection.

Inclusion and Exclusion Criteria

Pregnant women were eligible for inclusion if they resided in one of the selected study communities, were registered for antenatal care at a participating primary healthcare facility, had no chronic medical condition specified in the exclusion criteria, and voluntarily provided informed consent. Women who were not residents of the selected study areas, were not registered for antenatal care at the participating facilities, or declined to participate were excluded. Pregnant women with chronic medical conditions considered likely to affect nutritional status were also excluded, including HIV/AIDS, sickle cell disease, diabetes mellitus, hepatitis B, hypertension, tuberculosis, depression, and chronic liver or kidney disease. The original exclusion criteria additionally identified smoking and alcohol consumption as grounds for exclusion. These criteria were intended to reduce the potential influence of selected pre-existing health conditions and behaviors on the assessment of maternal nutritional status.

Instrument for Data Collection

Data were collected using a researcher-developed structured questionnaire titled Nutritional Status Using Mid-Upper Arm Circumference Among Pregnant Women in Flood-Prone and Non-Flood-Prone Communities in Rivers State Questionnaire. The instrument comprised two sections designed to obtain information relevant to the study objectives. Section A collected sociodemographic information, while Section B assessed selected characteristics potentially associated with maternal nutritional status. The questionnaire was administered through face-to-face interviews to facilitate participation among women with different educational backgrounds. In addition to questionnaire administration, anthropometric and hematological measurements were obtained to assess MUAC-based nutritional status and hemoglobin concentration.

Assessment of Maternal Nutritional Status

Maternal nutritional status was assessed using MUAC measurements obtained by trained personnel. MUAC is a practical anthropometric indicator that provides an indirect assessment of maternal muscle and subcutaneous fat reserves and is particularly useful in resource-limited healthcare settings because it requires minimal equipment and can be obtained relatively quickly [1,11]. The original study documentation indicated that measurements were obtained using a measuring tape whose markings were checked against a reference ruler and compared with a United Nations Children's Fund MUAC tape. Measurements obtained by different personnel were also compared to assess consistency. The original analysis classified MUAC measurements of 25.75–28.10 cm as adequate nutritional status and values outside this interval as inadequate nutritional status. However, the scientific justification for these thresholds was not documented, and the classification differs from commonly applied MUAC screening criteria for maternal undernutrition. Therefore, the final operational definition of MUAC-based nutritional status requires verification against an appropriate published criterion and the original participant-level measurements. In particular, measurements above 28.10 cm should not automatically be interpreted as indicating undernutrition without an appropriate scientific justification.

Assessment of Hemoglobin Concentration

Hemoglobin concentration was measured with the assistance of a licensed medical laboratory scientist using procedures described in the original study documentation. The measurement process reportedly followed the manufacturer's instructions, and repeated measurements were performed to assess consistency. Hemoglobin concentration was included because it is an important indicator used in the assessment of anemia during pregnancy and may be associated with nutritional deficiencies and other maternal health conditions. The original study classified hemoglobin concentrations as normal (≥11 g/dL), mild anemia (9.0–10.9 g/dL), and moderate-to-severe anemia (≤8.9 g/dL). However, the World Health Organization's updated guidance recognizes trimester-specific hemoglobin thresholds for defining anemia during pregnancy, reflecting physiological changes in hemoglobin concentration across gestation [12,13]. Consequently, the original categories should be reviewed against the applicable clinical guidance and the study's measurement protocol. The final manuscript should also specify the type of specimen collected, analytical method, equipment used, and quality-control procedures to ensure reproducibility.

Validity of the Research Instrument

The validity of the questionnaire was assessed through face and content validation by the research supervisors and two subject experts. The reviewers examined the clarity, relevance, and appropriateness of the questionnaire items in relation to the study objectives. Their observations and recommendations were incorporated into the instrument before its final approval. The MUAC measuring tape was checked against a reference ruler and compared with a UNICEF MUAC tape to assess measurement consistency. Measurements obtained by different personnel were also compared. Hemoglobin measurement procedures were assessed according to the manufacturer's instructions, and repeated testing was undertaken as described in the original study documentation.

Reliability of the Research Instrument

The reliability of the questionnaire was assessed through a pilot study involving 40 pregnant women attending a primary healthcare facility outside the selected study facilities. The questionnaire was initially administered to these participants and re-administered after two weeks. Data obtained during the pilot study were analyzed using IBM SPSS Statistics, version 27. Cronbach's alpha was calculated to assess the internal consistency of the questionnaire items, yielding a reported coefficient of 0.83. This value suggests acceptable internal consistency for the items included in the calculation. However, Cronbach's alpha does not independently establish test–retest reliability or construct validity. The original study documentation did not specify the questionnaire items included in the analysis or report a separate test–retest reliability coefficient.

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Procedure for Data Collection

Data collection commenced after the necessary administrative permissions had been obtained from the Rivers State Primary Health Care Board and the relevant healthcare authorities. Six research assistants were recruited and trained to support participant recruitment and questionnaire administration. Before the commencement of fieldwork, the researcher met with healthcare workers and research assistants to explain the objectives of the study, participant recruitment procedures, confidentiality requirements, and the responsibilities of the research team. Eligible pregnant women were approached after receiving routine antenatal services at the selected healthcare facilities. The purpose and procedures of the study were explained, and written informed consent was obtained before participation. For participants who required language assistance, an interpreter facilitated communication and understanding of the study procedures. Questionnaires were administered through face-to-face interactions, and completed questionnaires were retrieved and checked daily for completeness. Following questionnaire administration, MUAC measurements were obtained with the assistance of a nurse, while hemoglobin testing was supported by a licensed medical laboratory scientist. A total of 400 questionnaires were administered, of which 368 were sufficiently completed and retained for statistical analysis, representing a response rate of 92.0%.

Method of Data Analysis

Data were coded, entered, and analyzed using IBM SPSS Statistics, version 27. Descriptive statistics, including frequencies and percentages, were used to summarize participants' characteristics and MUAC-based nutritional status. The original results tables also reported Pearson chi-square statistics, associated p-values, and Cramér's V for associations between nutritional status and selected maternal characteristics, including hemoglobin concentration, educational attainment, occupation, household income, and trimester of pregnancy. Pearson's chi-square test is appropriate for examining associations between categorical variables when its assumptions, including adequate expected cell frequencies, are satisfied. Cramér's V provides an indication of the strength of association between categorical variables. Statistical significance was assessed at a threshold of $p < 0.05$. However, the original frequencies, category definitions, expected cell counts, degrees of freedom, and reported test statistics require verification before the final results can be confirmed. To address the comparative objective, the distribution of MUAC-based nutritional status should also be examined separately among participants from flood-prone and non-flood-prone communities, provided the necessary participant-level information is available. Any observed associations should be interpreted within the limitations of the cross-sectional design and should not be regarded as evidence of causality.

Ethical Considerations

Ethical approval was obtained from the Rivers State University Research, Development and Ethics Committee and the Rivers State Hospitals' Management Board Research, Development and Ethics Committee, with the latter assigned reference number RSHMB/RSHREC/2023/050. Administrative permission was also obtained from the Rivers State Primary Health Care Board and the relevant medical officers and primary healthcare coordinators in the selected LGAs. Participation was voluntary, and written informed consent was obtained from each participant before data collection. Participants were informed about the purpose of the study, the procedures involved, and their right to withdraw at any stage without consequences for their access to healthcare services. Where language assistance was required, an interpreter facilitated the explanation of study procedures and consent information. Confidentiality was maintained by assigning identification codes to questionnaires instead of recording participants' names. Information obtained during the study was treated as confidential and used exclusively for research purposes.

RESULTS

MUA-Based Nutritional Status Among Pregnant Women

A total of 368 pregnant women participated in the study, representing a response rate of 92.0% from the 400 participants initially targeted. Based on the nutritional classification applied in the original analysis, 187 participants (50.8%) were categorized as having adequate MUAC-based nutritional status, while 181 (49.2%) were classified as having inadequate nutritional status. MUAC is an anthropometric indicator used in maternal nutritional assessment, although its interpretation depends on the application of appropriate population-specific or clinically justified thresholds [1,11]. The classifications reported in this study remain provisional pending verification of the MUAC criteria. Table 1 presents the associations between MUAC-based nutritional status and selected maternal characteristics, including hemoglobin concentration, educational attainment, occupation, family income, and pregnancy trimester.

Hemoglobin concentration was significantly associated with MUAC-based nutritional status ($\chi^2 = 12.897$, df = 2, $p = 0.0016$, Cramér's V = 0.187). Among women with normal hemoglobin concentrations, 60.6% were classified as having adequate nutritional status, compared with 42.3% of those with mild anemia and 61.5% of those with moderate-to-severe anemia. Conversely, the proportion classified as having inadequate nutritional status was highest among women with mild anemia (57.7%), followed by those with normal hemoglobin concentrations (39.4%) and moderate-to-severe anemia (38.5%). Although the overall association was statistically significant, the distribution did not demonstrate a consistent increase in inadequate nutritional status with increasing anemia severity. The interpretation of these findings should consider the hemoglobin thresholds used in the study, particularly because contemporary clinical guidance recognizes physiological variations in hemoglobin concentration across pregnancy [12,13].

Educational attainment was significantly associated with MUAC-based nutritional status ($\chi^2 = 17.596$, df = 2, $p < 0.001$, Cramér's V = 0.219). Among women with non-formal or primary education, 57.6% were classified as having adequate nutritional status, compared with 29.8% of those with secondary education and 36.8% of those with tertiary education. Inadequate nutritional status was observed among 42.4% of women with non-formal or primary education, 70.2% of those with secondary education, and 63.2% of those with tertiary education. These findings demonstrate differences in the distribution of MUAC-based nutritional status across educational categories, with the highest proportion of inadequate nutritional status observed among women with secondary education.

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Occupation was also significantly associated with MUAC-based nutritional status (χ^2 = 9.284, df = 3, p = 0.0257, Cramér's V = 0.159). Among women engaged in farming or fishing, 47.8% were classified as having adequate nutritional status, compared with 35.7% of formally employed women, 57.5% of women involved in trading or business, and 46.0% of those in other occupations. The proportion classified as having inadequate nutritional status was highest among formally employed women (64.3%), followed by women in other occupations (54.0%), farming or fishing (52.2%), and trading or business (42.5%). Although the association was statistically significant, its magnitude was relatively small, suggesting that occupation alone provided limited information about differences in MUAC classification.

Family income showed variation in MUAC-based nutritional status, although the overall association did not reach statistical significance (χ^2 = 5.776, df = 2, p = 0.0557, Cramér's V = 0.125). Among participants with family incomes above ₦50,000, 57.5% were classified as having adequate nutritional status, compared with 52.7% of those earning ₦10,000–₦50,000 and 39.8% of those earning below ₦10,000. Inadequate nutritional status was most frequently observed among women in the lowest income category (60.2%), compared with 47.3% and 42.5% in the middle- and highest-income categories, respectively. Although the observed pattern suggests differences in nutritional status across income groups, the statistical evidence was insufficient to establish a significant association at the prespecified 5% significance level.

Pregnancy trimester was significantly associated with MUAC-based nutritional status (χ^2 = 6.661, df = 2, p = 0.0358, Cramér's V = 0.135). Adequate nutritional status was observed among 50.0% of women in the first trimester, 58.1% in the second trimester, and 43.7% in the third trimester. Conversely, inadequate nutritional status was observed among 50.0%, 41.9%, and 56.3% of women in the first, second, and third trimesters, respectively. The highest proportion of inadequate nutritional status was observed among women in the third trimester. However, the cross-sectional design does not establish whether advancing gestation contributed to these differences.

Overall, the preliminary findings identified statistically significant associations between MUAC-based nutritional status and hemoglobin concentration, educational attainment, occupation, and pregnancy trimester. Family income showed a possible association that did not reach statistical significance. The observed associations were relatively small in magnitude, as indicated by Cramér's V. These findings require confirmation using the original dataset and a scientifically justified MUAC classification. Furthermore, because the available results do not distinguish between participants residing in flood-prone and non-flood-prone communities, the relationship between community flood susceptibility and maternal nutritional status cannot yet be evaluated.

DISCUSSION

Maternal Nutritional Status Assessed Using Mid-Upper Arm Circumference

This study examined MUAC-based nutritional status and its associations with selected maternal characteristics among 368 pregnant women attending antenatal care in selected flood-prone and non-flood-prone communities in Rivers State, Nigeria.

Based on the original study classification, 50.8% of participants were categorized as having adequate nutritional status, while 49.2% were classified as having inadequate nutritional status. These findings suggest considerable variation in maternal anthropometric measurements within the study population. However, the proportion classified as having inadequate nutritional status should not be interpreted as the prevalence of undernutrition until the MUAC thresholds have been scientifically justified and the original measurements re-evaluated.

Recent evidence supports the usefulness of MUAC as a practical screening tool during pregnancy while emphasizing the importance of appropriate interpretation. Hasan [11], in a 2025 study involving pregnant women in Baghdad, examined MUAC in relation to demographic and nutritional characteristics and reported an association between MUAC and educational attainment. Similarly, Erasmus and colleagues [16] investigated maternal anthropometric measurements among pregnant South African women, highlighting the relevance of MUAC within broader nutritional assessment. A 2026 study by Dias and colleagues [17] further demonstrated that MUAC could assist in screening for maternal underweight and obesity, although different thresholds were required to identify these conditions. Collectively, these studies reinforce the importance of applying clearly defined MUAC criteria rather than interpreting all measurements outside a narrow reference interval as evidence of nutritional inadequacy.

Association Between Hemoglobin Concentration and Nutritional Status

A statistically significant association was observed between hemoglobin concentration and MUAC-based nutritional status (χ^2 = 12.897, p = 0.0016). Nevertheless, the distribution was not consistent with a simple relationship in which increasing anemia severity corresponded to progressively poorer nutritional status. The highest proportion of participants classified as having inadequate MUAC-based nutritional status occurred among women with mild anemia (57.7%), whereas the corresponding proportions were 39.4% among women with normal hemoglobin concentrations and 38.5% among those with moderate-to-severe anemia. The significant association between hemoglobin concentration and MUAC-based nutritional status observed in the present study (χ^2 = 12.897, p = 0.0016) underscores the importance of integrating hematological and anthropometric assessments during antenatal care. However, hemoglobin concentration may be influenced by several nutritional and non-nutritional factors, including micronutrient availability and infectious diseases. In a cross-sectional study conducted in Akinima, Rivers State, Melford et al. [18] reported lower mean packed cell volume among adult females (34.0%) than adult males (45.0%), alongside a high prevalence of malaria. Similarly, Monsi and Melford [19] observed significantly lower serum concentrations of iron, calcium, magnesium, and phosphate among malaria-infected individuals compared with healthy participants. Although neither study specifically investigated pregnant women or MUAC-based nutritional status, their findings provide relevant regional context for understanding the complex interactions between infection, micronutrient status, and hematological characteristics. These observations suggest that hemoglobin findings during pregnancy should be interpreted alongside nutritional assessments and other relevant clinical factors rather than being attributed exclusively to nutritional deficiencies.

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This non-linear pattern requires cautious interpretation. Hemoglobin concentration and MUAC reflect different aspects of maternal health. Hemoglobin is influenced by iron availability, other micronutrient deficiencies, infection, inflammation, hemoglobin disorders, and physiological changes during pregnancy, whereas MUAC primarily reflects maternal anthropometric reserves. Consequently, the two measurements should not be expected to demonstrate identical patterns in every population. The World Health Organization's updated guidance also recognizes trimester-specific hemoglobin thresholds, reflecting physiological differences in hemoglobin concentration during pregnancy [12]. Pasricha and colleagues [13] further emphasized the importance of appropriate hemoglobin measurement and classification when assessing anemia at individual and population levels.

The unexpected distribution observed in the present study may reflect differences in nutritional characteristics, pregnancy stage, underlying health conditions, or the classification methods applied. However, these explanations remain hypothetical because the available analysis did not adjust for potential confounding variables. Furthermore, the original hemoglobin categories differ from the updated WHO classification, indicating that reanalysis may be necessary before drawing firm conclusions about the relationship between anemia severity and MUAC-based nutritional status.

Association Between Educational Attainment and Nutritional Status

Educational attainment was significantly associated with MUAC-based nutritional status (χ^2 = 17.596, p < 0.001). The proportion of participants classified as having inadequate nutritional status was highest among women with secondary education (70.2%), followed by those with tertiary education (63.2%) and non-formal or primary education (42.4%). This finding indicates that higher educational attainment did not correspond to a consistently more favorable MUAC classification in the study population.

Previous research has identified maternal education as an important characteristic associated with nutritional status during pregnancy. Wakwoya and colleagues [1] investigated determinants of maternal nutritional status in Ethiopia, while Lama and colleagues [3] examined nutritional characteristics among pregnant women attending antenatal care in Nepal. More recently, Hasan [11] reported an association between educational attainment and MUAC among pregnant women in Iraq. These studies support the relevance of educational characteristics in maternal nutritional assessment, although their findings should not be assumed to establish a uniform relationship across populations.

The unexpected pattern observed in the present study may reflect differences in employment conditions, household resources, dietary practices, or other characteristics that were not adequately captured by educational attainment alone. It is also possible that the original MUAC classification influenced the distribution across educational groups. Because the analysis was unadjusted, the findings do not establish education as an independent determinant of maternal nutritional status. Further analysis incorporating socioeconomic and pregnancy-related characteristics would be required to assess whether the observed association persists after accounting for potential confounding.

Association Between Occupation and Nutritional Status

Occupation was significantly associated with MUAC-based nutritional status (χ^2 = 9.284, p = 0.0257), although the magnitude of the association was relatively small. The highest proportion of participants classified as having inadequate nutritional status was observed among formally employed women (64.3%), followed by women in other occupations (54.0%), farming or fishing (52.2%), and trading or business (42.5%). This distribution suggests that occupational categories were associated with differences in MUAC classification, but it does not establish that any particular occupation increased the risk of maternal undernutrition.

Occupation may influence maternal nutritional circumstances through income stability, workload, time available for meal preparation, access to food, and opportunities to attend antenatal services. However, occupational titles alone may not adequately represent these conditions. Previous studies have examined socioeconomic and occupational characteristics in relation to maternal nutritional status in different settings [1,3,5]. The present findings extend this line of investigation to pregnant women attending selected primary healthcare facilities in Rivers State, although direct comparisons should account for differences in study populations, measurement criteria, and socioeconomic contexts.

The relatively high proportion of inadequate MUAC classification among formally employed women warrants further investigation rather than an assumption that formal employment is nutritionally disadvantageous. Differences in age, gestational stage, household composition, dietary intake, and other unmeasured characteristics may have contributed to the observed pattern. Additionally, because occupation was examined using broad categories, variation within occupational groups could not be adequately assessed.

Association Between Household Income and Nutritional Status

Household income was not significantly associated with MUAC-based nutritional status at the conventional 5% significance level (χ^2 = 5.776, p = 0.0557). Nevertheless, the descriptive findings showed that the proportion classified as having inadequate nutritional status was highest among women reporting household incomes below ₦10,000 (60.2%), compared with those earning ₦10,000–₦50,000 (47.3%) and above ₦50,000 (42.5%). This pattern suggests a possible socioeconomic gradient, although the available statistical evidence was insufficient to establish an association at the prespecified significance threshold.

Household income is relevant to maternal nutrition because financial resources can influence food purchasing capacity, dietary diversity, and access to healthcare. Previous investigations have considered household economic circumstances alongside other determinants of maternal nutritional status [1,3,5]. However, income alone may not adequately reflect household food security, particularly where household size, food prices, agricultural production, and dependence on informal livelihoods differ substantially.

The present finding should therefore be interpreted as a non-significant association rather than evidence that income has no relationship with maternal nutrition. The analysis did not account for household size, food expenditure, dietary intake, or other factors that could influence the relationship between reported income and nutritional status.

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In addition, the cross-sectional design prevents conclusions about the direction of any relationship between household economic circumstances and maternal anthropometric measurements.

Association Between Pregnancy Trimester and Nutritional Status

Pregnancy trimester was significantly associated with MUAC-based nutritional status ($\chi^2 = 6.661$, $p = 0.0358$). The proportion classified as having inadequate nutritional status was highest among women in the third trimester (56.3%), followed by those in the first trimester (50.0%) and second trimester (41.9%). Although the association was statistically significant, its magnitude was relatively small, and the distribution did not demonstrate a consistent pattern across successive trimesters.

Maternal nutritional assessment during pregnancy requires consideration of physiological changes and the increasing nutritional demands associated with fetal growth and maternal tissue development. However, MUAC is not a direct measure of dietary adequacy, and its interpretation may be influenced by maternal body composition and the thresholds used to define nutritional categories. Recent anthropometric research among pregnant South African women [16] and the study by Dias and colleagues [17] reinforce the importance of interpreting MUAC within a broader assessment of maternal nutritional status.

The higher proportion of inadequate MUAC classification among women in the third trimester may reflect differences in baseline nutritional status, maternal characteristics, or other unmeasured factors. However, because participants were assessed at a single point in time rather than followed throughout pregnancy, the findings cannot demonstrate changes in MUAC within individual women as pregnancy progressed. Longitudinal research would be needed to investigate such changes.

Flood Susceptibility and Maternal Nutritional Vulnerability

The inclusion of flood-prone and non-flood-prone communities was an important feature of the study design because environmental vulnerability may influence the circumstances in which pregnant women obtain food, maintain livelihoods, and access healthcare. Previous research has documented geographical variation in flood risk and the broader consequences of flooding in Nigeria [7,8]. These findings provide a contextual basis for examining maternal nutritional status in communities with differing flood susceptibility.

Flooding may affect maternal nutritional circumstances through several interconnected pathways, including agricultural disruption, reduced household income, damage to transportation infrastructure, interruptions in food distribution, and difficulties accessing healthcare services. Nevertheless, the extent to which these mechanisms operate depends on household resources, local infrastructure, social support, and the severity and duration of flooding. Consequently, residence in a flood-prone community should not automatically be interpreted as evidence of individual flood exposure or food insecurity.

Although the present study recruited pregnant women from communities classified as flood-prone and non-flood-prone, the available results do not report MUAC-based nutritional status separately for the two groups. It is therefore not possible to determine whether nutritional status differed significantly according to community flood susceptibility.

Similarly, the existing findings cannot establish whether flooding modified the associations between socioeconomic characteristics and maternal nutritional status. A group-specific analysis is required to address the principal comparative objective of the study. Until that analysis is completed, conclusions concerning differences between flood-prone and non-flood-prone communities should remain limited.

Public Health Implications

The findings highlight the potential value of incorporating maternal anthropometric screening into routine antenatal services, particularly in communities experiencing socioeconomic and environmental vulnerabilities. MUAC offers a relatively simple approach to identifying women who may require further nutritional assessment, although its effectiveness depends on appropriate measurement procedures and scientifically justified interpretation criteria [11,16,17]. Combining MUAC assessment with hemoglobin testing, dietary evaluation, and relevant socioeconomic information may provide a more comprehensive understanding of maternal nutritional vulnerability.

The observed associations with hemoglobin concentration, educational attainment, occupation, and pregnancy trimester suggest that maternal nutritional screening should consider multiple characteristics rather than relying on a single socioeconomic indicator. However, the present findings do not establish which factors independently predict nutritional status or whether interventions directed at these characteristics would improve pregnancy outcomes. Additional research incorporating validated MUAC thresholds, dietary assessments, and multivariable statistical analyses would help clarify these relationships.

Strengths and Limitations of the Study

An important strength of this study was the inclusion of pregnant women attending multiple primary healthcare facilities across four LGAs in Rivers State. The study also combined questionnaire-based information with anthropometric and hemoglobin measurements, allowing several maternal characteristics to be examined in relation to MUAC-based nutritional status.

Nevertheless, several limitations should be acknowledged. First, the cross-sectional design prevented the establishment of temporal relationships or causality. Second, the facility-based recruitment strategy excluded pregnant women who did not attend the selected antenatal clinics, potentially limiting the representativeness of the sample. Third, some socioeconomic information was self-reported and may have been affected by recall or reporting bias. Fourth, the original MUAC classification requires scientific justification, and the hemoglobin categories require review against current clinical guidance. Fifth, the available analysis did not adjust for potential confounding variables, including maternal age, dietary intake, household food security, and other relevant characteristics. Sixth, the sampling design involved multiple healthcare facilities, but the reported statistical analysis did not explicitly account for potential clustering. Finally, the absence of group-specific results prevented a direct assessment of differences between flood-prone and non-flood-prone communities.

Summary of the Discussion

The study identified preliminary associations between MUAC-based nutritional status and hemoglobin concentration,

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educational attainment, occupation, and pregnancy trimester among pregnant women attending selected primary healthcare facilities in Rivers State. Household income showed a descriptive gradient but did not reach statistical significance. The observed relationships were generally small in magnitude and should not be interpreted as causal. Although the study was designed to include communities with differing flood susceptibility, the available results do not establish whether maternal nutritional status differed between these communities. Verification of the MUAC classification and further analysis of the original dataset are therefore necessary before definitive conclusions can be drawn.

Maternal Nutritional Status Using Mid-Upper Arm Circumference — Rivers State, Nigeria

Table 1: Distribution of MUAC classification by maternal characteristics (N = 368)

Characteristic	Category	Adequate*	Inadequate*	Total
Haemoglobin concentration	Normal	43	28	71
	Mild anaemia	85	116	201
	Moderate/severe anaemia	59	37	96
Educational attainment	No formal/primary	152	112	264
	Secondary	14	33	47
	Tertiary	21	36	57
Occupation	Farming/fishing	33	36	69
	Employed	20	36	56
	Trading	111	82	193
	Others	23	27	50
Household income	Above STUVUUU	46	34	80
	SCUVUUAESTUVUUU	108	97	205
	Below SCUVUUU	33	50	83
Pregnancy trimester	First	25	25	50
	Second	93	67	160
	Third	69	89	158
Total		187	181	368

**MUAC categories reproduce the original study classification and remain provisional pending verification of scientifically appropriate thresholds. Counts are drawn from the previously shared manuscript tables; they have not been checked against participant-level data.*

Table 2: Pearson chi-square tests of association with MUAC classification

Characteristic		df	p-value	Interpretation A = 0.05)
Haemoglobin concentration	12.897	2	0.00158	Significant
Educational attainment	17.596	2	0.00015	Significant
Occupation	9.284	3	0.02574	Significant
Household income	5.776	2	0.05569	Not significant
Pregnancy trimester	6.661	2	0.03578	Significant

Notes

Pearson chi-square statistics were recalculated from the aggregate cell counts displayed in Table 1. The overall counts are 187/368 (50.8%) in the original "adequate" category and 181/368 (49.2%) in the original "inadequate" category. The household-income association is not statistically significant at $p < 0.05$. The occupational grand total of 298 previously reported as adequate was erroneous; the consistent total is 187.

A flood-prone versus non-flood-prone comparison table cannot be produced from the available counts. The original MUAC measurements and community-group data are needed to validate classification and perform that analysis.

Conclusion

This study assessed nutritional status using mid-upper arm circumference (MUAC) among pregnant women attending selected primary healthcare facilities in flood-prone and non-flood-prone communities in Rivers State, Nigeria. Based on the original nutritional classification, 50.8% of the participants were categorized as having adequate nutritional status, while 49.2% were classified as having inadequate nutritional status.

However, these proportions require confirmation using scientifically justified MUAC thresholds before they can be interpreted as estimates of maternal undernutrition.

The findings revealed statistically significant associations between MUAC-based nutritional status and hemoglobin concentration, educational attainment, occupation, and pregnancy trimester. In contrast, the association between household income and nutritional status did not reach statistical significance at the 5% level, although the descriptive findings indicated a higher proportion of inadequate MUAC classification among women in the lowest income category. The observed associations were generally small in magnitude, suggesting that maternal nutritional status may be related to multiple characteristics rather than any single socioeconomic or pregnancy-related factor.

Although the study included pregnant women residing in communities classified as flood-prone and non-flood-prone, the available results did not provide separate estimates of MUAC-based nutritional status for these groups. Consequently, the study cannot establish whether maternal nutritional status differed significantly according to community flood susceptibility. Further analysis of the original dataset is necessary to address this central comparative objective.

The study highlights the importance of comprehensive maternal nutritional assessment during antenatal care. The findings suggest that MUAC measurements, when interpreted using appropriate criteria, may contribute to identifying pregnant women who require additional nutritional evaluation and support. Nevertheless, the cross-sectional design, unadjusted statistical analyses, and unresolved measurement classification issues limit the conclusions that can be drawn. The findings should therefore be interpreted as preliminary associations rather than evidence of causal relationships.

Recommendations

Based on the findings of this study, routine maternal nutritional assessment should be strengthened across primary healthcare facilities in Rivers State. Healthcare professionals providing antenatal services should be encouraged to incorporate MUAC measurements into broader nutritional screening procedures using scientifically justified thresholds. Such screening should be complemented by appropriate clinical assessment, dietary evaluation, and hemoglobin testing to support the early identification of pregnant women requiring nutritional interventions. Recent evidence supports the usefulness of MUAC in maternal nutritional assessment, while contemporary clinical guidance emphasizes the importance of appropriate hemoglobin classification during pregnancy.

Maternal nutrition education should also be strengthened during antenatal visits, with particular attention to dietary diversity, adequate food intake, and the nutritional requirements of pregnancy. Educational interventions should be accessible to women across different educational and occupational backgrounds rather than assuming that formal educational attainment necessarily corresponds to better nutritional outcomes. Nutrition counselling should be adapted to the circumstances of individual women and households, including their food purchasing capacity, occupational responsibilities, and access to available food resources.

Primary healthcare programs should consider the potential nutritional vulnerabilities of pregnant women living in communities exposed to recurrent flooding.

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Although the present study did not establish differences in nutritional status between flood-prone and non-flood-prone communities, previous research has documented the wider consequences of flooding in Nigeria. Evidence from disaster-affected populations has also highlighted the importance of maternal food security during environmental emergencies. Accordingly, maternal health planning in flood-prone communities should consider continuity of antenatal services, access to nutritional counselling, and appropriate referral mechanisms during periods of environmental disruption. These measures should be guided by local needs assessments rather than an assumption that all women living in flood-prone communities experience the same level of nutritional risk.

Healthcare professionals should ensure that anemia screening and management follow current clinical recommendations. Hemoglobin measurements should be interpreted using appropriate pregnancy-specific thresholds, and women identified with anemia should receive further clinical assessment and management according to established guidelines. The updated World Health Organization guidance and recent recommendations from the International Federation of Gynecology and Obstetrics provide relevant frameworks for improving anemia assessment and maternal care.

Further research should examine maternal nutritional status in relation to community flood susceptibility using clearly defined exposure classifications and validated MUAC thresholds. Future studies should include dietary intake, household food security, maternal age, parity, gestational age, and other potential confounding factors. Larger community-based studies involving women who do not routinely attend antenatal clinics would improve the representativeness of the evidence. Longitudinal research would also be valuable for examining changes in maternal nutritional status throughout pregnancy and assessing the potential effects of environmental disruptions on maternal health.

Finally, the original study dataset should be reanalyzed to verify MUAC classifications, correct inconsistencies in the reported frequencies, and determine whether statistically significant differences exist between flood-prone and non-flood-prone communities. Where the data permit, multivariable analysis should be considered to assess whether the observed associations persist after adjustment for relevant maternal characteristics. These steps would strengthen the validity of the findings and improve their usefulness for maternal nutrition programs and public-health planning in Rivers State.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. Strengthening Maternal Nutritional Assessment: Healthcare providers should incorporate routine hemoglobin screening and mid-upper arm circumference (MUAC) measurements into antenatal care to facilitate the early identification of anemia and nutritional deficiencies among pregnant women. Appropriate nutritional counselling, further assessment, and timely interventions should be provided when necessary to improve maternal nutritional wellbeing.

2. Promoting Maternal Nutrition and Socioeconomic Support: Government agencies, healthcare institutions, and relevant organizations should strengthen maternal nutrition programs by integrating nutrition education, dietary counselling, and targeted socioeconomic support for vulnerable pregnant women. These interventions should consider differences in household income and occupational circumstances to improve access to adequate and balanced diets throughout pregnancy.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

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