Original

Assessment of Nutritional Knowledge, Dietary Diversity, and Nutritional Status of Pregnant Adolescents in Bauchi State: A Cross-Sectional Study

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ABSTRACT

Background: Teenage pregnancy poses major nutritional and physiological risks for both mother and fetus. This research evaluated the nutrition knowledge, dietary diversity, and nutritional knowledge of pregnant adolescents in Bauchi State.

Methods: An analytical cross-sectional study design was conducted among 200 pregnant adolescents aged 10-19 years selected from Comprehensive Primary Health Centres in Dambam and Alkaleri through multistage sampling. Nutrition Knowledge was measured using a 20-item validated questionnaire. Dietary diversity was assessed using FAO Minimum Dietary Diversity for Women (MDD-W) questionnaire. Nutritional status was determined using Mid-Upper Arm Circumference (MUAC) while blood samples were analysed for Packed Cell Volume (PCV) and serum Vitamin B_{12}. Data was analysed using Statistical Package for Social Sciences (SPSS v25), Chi-square tested bivariate associations and multivariate logistic regression identified independent predictors at $p<0.05$.

Results: Findings revealed that 66% (n=132) had high nutrition knowledge scores, 53.5% (n=107) achieved adequate dietary diversity (≥5 food groups) and 74.5% (n=149) were undernourished (MUAC <23cm). Most adolescents had adequate Vitamin B_{12} levels (83%, n=166) but 43.5% (n=87) had low-normal PCV (33-35%). Multivariate analysis revealed that pregnant adolescents in Dambam had higher odds of inadequate dietary diversity compared to those in Alkaleri (AOR=1.7, 95% CI: 1.2-2.6, p=0.035). Adolescents from Polygamous families also had higher odds of inadequate dietary diversity compared to monogamous counterparts (AOR=1.8, 95% CI: 1.3-2.5, p=0.036).

Conclusion: Despite high nutrition knowledge among participants, undernutrition remained high highlighting the need for effective strategies addressing both socioeconomic constraints and improved dietary access in the region.

Keywords: Pregnant adolescents, MUAC, Mid-upper arm circumference. MDD-W, Minimum dietary diversity for Women, Nutrition knowledge, Vitamin B12, Bauchi State.

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INTRODUCTION

Maternal nutritional status during pregnancy plays a crucial role in ensuring maternal well-being, optimal fetal growth, and favourable birth outcomes, a role that becomes even more vital during adolescence, a phase of development characterized by rapid physical growth and increased physiological demands, and ongoing cognitive maturation.[1–2] Many societies view pregnancy as a joyful stage of life, as it heralds the birth of a new human being.[3] However, adolescent pregnancy is also widely recognised as a public health and social concern, as these girls face numerous health, social, and psychological challenges, including an increased risk of various health complications such as hypertension, preterm birth, low birth weight, fetal growth restriction, and preeclampsia.[4] Adequate nutrition during this stage is therefore essential for both maternal and fetal health and plays a critical role in determining birth outcomes.[5]

Globally, reports have estimated that approximately 16 million girls between ages 15–19 give birth annually, with Sub-Saharan Africa and Latin America accounting for the largest proportions.[6] Nigeria has one of the largest adolescent populations in Africa with pregnancy rate among this group estimated at 106 per 1,000 girls aged 15-19 years.[7] This public health challenge is particularly prominent in northern Nigeria, including Bauchi State, where early marriage among teenage girls is prevalent. According to reports, 75.1% of women aged 20–24 were married before the age of 18 and 25.3% of girls aged 15–19 have experienced pregnancy.[8-9] Furthermore, this region is characterised by structural and sociocultural factors that increase the risk of undernutrition among adolescent girls. Despite its largely agrarian economy, 73.9% of the population is categorised as multidimensionally poor.[10] Additionally, low female literacy and limited decision-making power among women and girls restrict their ability to make informed dietary and health choices.[11] These factors, combined with early marriage and pregnancy, contribute to high malnutrition rates, with Bauchi State reported to have one of the highest acute malnutrition rates among women and adolescent girls in Nigeria.[12]

Dietary diversity refers to the range of food groups consumed within a specific reference period.[13] The Minimum Dietary Diversity for Women (MDD-W) is an indicator that measures whether women and adolescent girls aged 15-49 years consume a minimum five out of ten class of food and serves as a practical proxy for micronutrient sufficiency as well as diet quality.[13] Despite its importance, only a small fraction of adolescent girls in food-insecure settings like Nigeria, meet the suggested MDD-W threshold of greater than five food groups, thereby heightening the vulnerability of teenage girls to malnutrition, with potential negative consequences for maternal and foetal health[14] While several studies have examined maternal nutrition among adult women, limited studies have specifically focused on pregnant adolescents,[7,15-18] particularly in resource constrained areas such as Bauchi State, where early marriage, high poverty rate, and malnutrition increase vulnerability of girls.

This research is grounded on the Social Determinants of Health framework which recognises that our individual health outcomes are shaped by multifaceted interaction of economic, societal and individual elements. Various socio-demographic characteristics such as place of residence and family structure may influence access to diverse foods, health services and decision-making power. These factors in-turn has an effect on individual level characteristics such as nutrition knowledge. However, nutrition knowledge alone may not necessarily translate into improved dietary practices due to structural and economic constraints. These interconnected factors eventually impact dietary diversity and determine the nutritional position of pregnant adolescents. Therefore, this study aimed to assess the nutrition knowledge, dietary diversity, and nutritional status of pregnant adolescents in Bauchi State. Notably, this study introduces a novel approach of combined biochemical and anthropometric assessments, providing a more comprehensive evaluation of pregnant adolescents.

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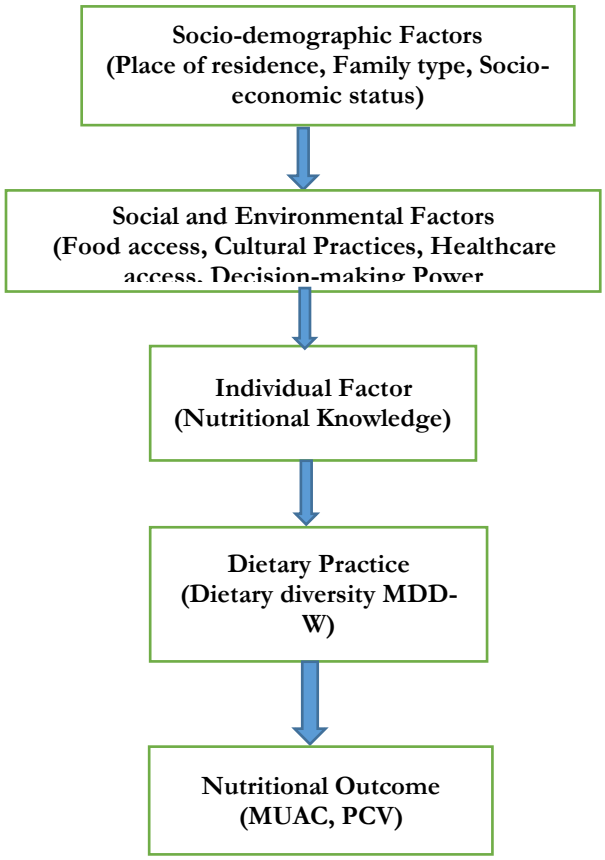

Figure 1: Conceptual Framework illustrating the relationship between socio-demographic, environmental, and individual factors on dietary diversity and nutritional status among pregnant adolescents.

METHODOLOGY

Study Area: The research was carried out in Bauchi State, Nigeria. This region represents 3.2 percent of the country's population. The state is characterized by a predominantly rural population engaged primarily in agriculture and trade. The state has diverse ethnic groups however; it is predominated by the Hausa/Fulani and is made up of 20 Local Government Areas.

Study Design: The research utilised an analytical cross-sectional design.

Study Period: Data was collected between March and June 2025 amongst pregnant adolescent girls in selected comprehensive primary health care centres in Bauchi State.

Study Population: The research targeted pregnant adolescent girls aged between 10 and 19 years.

Study Setting: Comprehensive primary health care centres located in Dambam and Alkaleri LGAs of Bauchi State, North-East Nigeria were chosen as the study setting.

Eligibility Criteria: Participants were qualified to be selected for the research if they were confirmed pregnant, aged 10–19 years, registered for antenatal services in the selected primary health centres in the local government areas, in good state of health with no documented health conditions, as determined by a doctor's clinical assessment and review of antenatal records. This exclusion was essential to lessen confounding effects of disease conditions on nutritional status. Furthermore, it was also mandatory for study participants to be residents of the study area for at least six months prior to the research and willing to provide informed consent (or assent with parental/guardian consent where applicable).

Sampling Technique: A multistage sampling technique was employed to obtain a study sample of pregnant adolescents. It involved three stages; in the first stage, a comprehensive list of all fully operational primary health centres (n = 104) in Bauchi State was obtained from the Bauchi State Primary Healthcare Development Board. From the list given, two comprehensive primary health centres were purposively selected based on records of high antenatal attendance of pregnant adolescents, to ensure adequate access to the target population. In the second stage, pregnant adolescents registered for antenatal care in the selected primary health centres were identified via the facility antenatal registers. The total number of adolescents in the registers were n=280 (Dambam: 143; Alkaleri: 137). Of these, n=35 (Dambam: 20; Alkaleri: 15) did not meet the inclusion criteria, leaving eligible participants for the research to be n=245 (Dambam: 123; Alkaleri: 122).

In stage three, simple random sampling (balloting) was utilised to select respondents based on the proportionate size of eligible participants in each facility. Eligible pregnant adolescents were allocated unique numbers, written on folded slips of paper, placed in a container, and drawn sequentially by a neutral individual until the required quota for each facility is achieved. A total of n=213 participants were selected (107 adolescents from Dambam and 106 from Alkaleri). However, of the selected sample size, 13 were excluded due to refusal of

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consent by spouse/parents and incomplete data leading to a final sample size of 200.

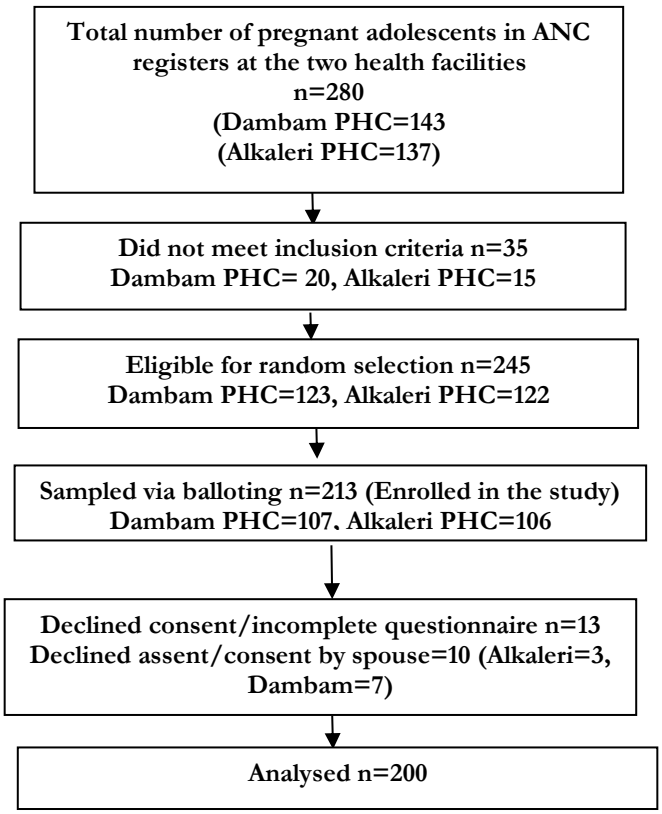

Figure 2: Flow chart showing enrolment and analysis of pregnant adolescent girls in the study.

Variables of the Study

Dependent Variable: Nutritional Knowledge, Minimum Dietary Diversity for Women (MDD-W), Nutritional Status (Mid Upper Arm Circumference), Packed Cell Volume, Serum Vitamin B12

Independent Variables: Socio-demographic Factors such as age, educational status, marital status, place of residence among others.

Sample Size Determination: The sample size was calculated using the formula for prevalence studies.[19]

$$n = \frac{Z^2 p(1-p)}{D^2}$$

The calculation of the sample size was based on prevalence of acute malnutrition among adolescent girls and women in Bauchi state at 13% from a previous study,[12] with adjustments made for a 5% margin of error.

Parameters:

Z=1.96 (95% confidence)
P=0.13 (13% prevalence)
D=0.05 (5% margin of error)

$$= \frac{1.96^2 \times 0.13(0.87)}{0.05^2}$$

$0.13 \times 0.87 = 0.1131$

$$\frac{1.96^2 \times 0.1131}{0.05^2}$$

$$= \frac{0.4345}{0.0025}$$

$=173.8 \approx 174$

To account for the multistage sampling technique and clustering effects arising from the selection of two primary health centres, a modest design effect of 1.1 was applied due to the limited number of clusters:

Deff (1.1) = $174 \times 1.1 = 191.4$

10% adjustment for non-response rate=

$$\frac{191.4}{0.9} = 212.7 \approx 213$$

Data Collection Instruments and Methods: Data collection for the study involved the use of interviewer-administered questionnaires comprising questions on social-demographics, nutrition knowledge, dietary diversity, and health behaviours of the respondents.

Assessment of Subjects Nutrition Knowledge: Respondent's nutrition knowledge were evaluated using a twenty-point questionnaire on key aspects on health and nutrition during pregnancy. The nutrition knowledge scores were categorised as "high" for participants who scored 16 or more marks, "medium" for those who scored 11–15 marks and "low" for those who scored 10 or less out of a total possible score of 20.[18] The questionnaire was forward- and back-translated from English to Hausa by two independent bilingual nutritionists to ensure accuracy and cultural relevance and it was pretested (n=25 pregnant adolescents) in a similar Bauchi LGA. Cronbach's alpha was 0.82, indicating good internal consistency.

Dietary Diversity Assessment of the respondents: Dietary diversity of the study participants was evaluated using the Food and Agriculture Organisation (FAO) Minimum Dietary Diversity for Women (MDD-W) questionnaire.[13] It involved collection of information on all foods and beverages study participants consumed during the previous day and night (In the last 24-hours). Probing techniques was employed by trained research assistants, using open-ended questions such as 'what did you eat yesterday from morning to night? Any soups, fruits, snacks, drinks? Foods were categorized into 10

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groups according to FAO recommendations:[13] (i) all starchy staples, (ii)beans and peas, iii) nuts and seeds, (iv) all dairy, (v) flesh foods, (vi) eggs, (vii) vitamin A-rich dark green leafy vegetables, (viii) other vitamin A-rich vegetables and fruits, (ix) other vegetables, (x) other fruits. Each food group consumed was assigned 1 point, and a 0 score was given if no food from the group was consumed.

The minimum dietary diversity score was calculated by adding the number of food groups consumed. Participants who consumed at least five food groups were classified as having adequate dietary diversity (MDD-W ≥5).[13] Data collection was done between March and June, 2025, a period conforming to the late dry season and the onset of the rainy season.

Nutritional Status Assessment of the Respondents

Mid-Upper Arm Circumference (MUAC): Mid-Upper Arm Circumference was measured to determine the nutritional status of pregnant adolescent girls. It is an excellent indicator of protein reserves in an individual's body and a thinner arm signifies wasted lean mass (undernutrition).[20] It was measured on the left arm using a non-stretchable MUAC tape (Shakir tape), following documented standard measurement procedures.[20] Measurements were taken at the midpoint between the acromion process of the left scapula and olecranon process of the left ulna with the arm relaxed.[20] The measurement was taken twice by trained research assistants, and the average number recorded when the difference between both measurements was ≤0.2cm. Where the difference exceeded 0.2cm, a third measurement was taken and the average of the two closest values recorded to improve reliability.

Although while no universal consensus on MUAC thresholds exist for pregnant adolescent girls/women, various countries have adopted their own thresholds usually ranging from 21cm-23cm, this study adopted a MUAC threshold of <23cm for undernutrition because of its strong evidence based link to low birth weight in resource limited regions like Africa and its high sensitivity in the identification of nutritional risk irrespective of gestational age.[21-22] Furthermore, this threshold (<23cm) has also been used in a study among pregnant adolescents in Uganda.[16] In addition, a study conducted in the Ashanti Region of Ghana has employed a higher MUAC cutoff by using a threshold of <24cm among pregnant adolescents.[23]

Laboratory Analysis

Biochemical and Haematological Assessment

Serum Vitamin B12 Determination: Serum vitamin B12 levels were determined using an automated electrochemiluminescence immunoassay (ECLIA) on the Roche Cobas e601 analyser (Roche Diagnostics, Germany). 5 mL of venous blood was collected into serum separator tubes. This was allowed to clot at room temperature, and then centrifuged within 2 hours of collection at 1500–2000 rpm for 10 minutes. The separated serum was aliquoted and stored at −20 °C until analysis.

Total serum vitamin B12 was quantified using the Elecsys Vitamin B12 II assay involving three main steps. Step one involved the use of pre-treatment reagents to incubate 15 µL of serum to release bound vitamin B12, step two involved the use of rhutenium labelled intrinsic factor to bind the released B12 and step three involved the use of micro particles and biotinylated B12 to release chemiluminescent emission.[24]

Vitamin B12 was categorised as: <200 pg/mL (deficient), 200–300 pg/mL (borderline), and >300 pg/mL (adequate), in line with NIH guidelines.[25]

The analyser was calibrated using the manufacturer-provided standards (Elecsys CalSet II) with a two-point calibration method, performed per reagent lot. Internal quality control was conducted daily using control sera at varying concentration levels to ensure accuracy and precision of the assay. Results were considered acceptable if they fell within ±2 standard deviations of the established control mean. Any analytical run that failed quality control criteria was repeated.

Packed Cell Volume (PCV) Determination: Blood samples of the study partakers were aseptically collected into ethylenediaminetetraacetic acid (EDTA) bottles. 3mL of venous blood was obtained from each teenager utilising sterile instruments with assistance from trained medical personnel at the selected facilities. Non-heparinized capillary tubes were filled with well-mixed EDTA blood samples, cleaned, sealed, and centrifuged in a haematocrit centrifuge at 10,000 rpm for 5 minutes. The packed cell volume was read using a calibrated haematocrit reader. Duplicate measurements were performed for each sample, and the average value was recorded to improve reliability.[26]

Quality control for determined packed cell volume was done by performing duplicate measurements for each sample, using calibrated haematocrit readers, periodic cross-checking of results with an automated full blood count analyser where available, adhering to standard

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operating procedures for sample handling and centrifugation

Anaemia was classified based on established reference ranges: where anaemia in pregnancy was defined as PCV <33%, with further categorization as 33–35% (low normal) and ≥36% (normal).[27]

Ethical Considerations: Ethical approval for the study was granted by the Health Research and Ethics Committee of Afe Babalola University, Ado-Ekiti **(ABUADHREC/29/01/202/789)** and the Bauchi State Ministry of Health **(**Approval No**: NHREC/TR/BAU-HREC/28/8/2023;** Protocol Reg No**: BSMOH/REC/0137/2024)**. Clearance was obtained from the Bauchi State Primary Health Care Development Board and presented to the community health officer in charge of the selected Comprehensive Primary Health Care Centres to gain access to study sites.

For adolescents under the age of 18 years, written and verbal consent was gotten first from parent/spouse after the study objectives and procedures was carefully explained in their preferred language (Hausa or English) with emphasis on the study being entirely voluntary and that refusal to participate will not affect the adolescent's routine antenatal care. While the Nigerian Constitution recognises those under the age of 18 years as minors, pregnant or married adolescents are regarded as emancipated minors as a result, following the guardian/spousal approval, the evolving autonomy of the minor was considered and an age-appropriate participant assent process was conducted using simple and non-technical language. The researchers explained the study procedures and objectives, reaffirming their right to withdraw at any time regardless of parental/spousal consent. For participants above 18 years, written and verbal consent was obtained from them before the start of the study. To ensure strict confidentiality, no personal names or other identifiers were recorded. Instead, the adolescents were given unique numbers.

***Statistical analysis*:** Data was gathered, coded, and analysed using the Statistical Package for the Social Sciences (SPSS) version 25 software. Descriptive statistics, including absolute numbers and simple percentages, were employed to describe categorical variables. Bivariate associations were tested using the Pearson Chi-square test; for variable with small cell count, categories were collapsed or Fishers Exact Test was conducted to ensure validity of the statistical test. Multivariate logistic regression was used to identify independent predictors of inadequate dietary diversity, adjusting for confounders (age, education, monthly income, place of residence, family type, and marital status), with results reported as Adjusted Odds ratios (AOR) and 95% confidence intervals (CI). Statistical Significance was set at $p<0.05$.

RESULTS

Socio-Demographic Characteristics of the Respondents:

Table 1 below presents the socio-demographic characteristics of the respondents. A total of 200 pregnant adolescents participated in the study. The age distribution revealed that slightly more than half of the respondents 102 (51.0%) were aged 18–19 years, while 98 (49.0%) were aged 14–17 years.

Most participants, 130 (65.0%), had no children, while 55 (27.5%) had one child and 15 (7.5%) had two children. The majority of respondents 180 (90.0%) were married. In terms of educational attainment, half of the respondents 100 (50.0%) had primary education, 60 (30.0%) had secondary education, and 40 (20.0%) had nursery/elementary education.

Regarding occupation, more than half of the respondents 120 (60.0%) were artisans/traders, 35 (17.5%) were farmers, 25 (12.5%) were students, and 20 (10.0%) were unemployed. Two thirds of the respondents132 (66.0%) were from polygamous households.

With respect to income, 136 (68%) reported a monthly income of less than ₦20,000. Study participants were evenly distributed across the two study locations (Alkaleri: 100, 50.0%; Dambam: 100, 50.0%).

In terms of religion, more than half 112 (56.0%) practiced Islam, 63 (31.5%) practiced Christianity, and 25 (12.5%) practiced traditional religion.

Nutritional Knowledge of Pregnant Adolescents

Figure 3 below represents the nutritional knowledge of pregnant adolescents. More than half of the pregnant adolescents 132(66.0%) demonstrated high nutrition knowledge scores, 56(28.0%) had medium scores, while a small proportion 12(6%) had low scores.

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Figure 3: Nutritional knowledge of the Pregnant Adolescents

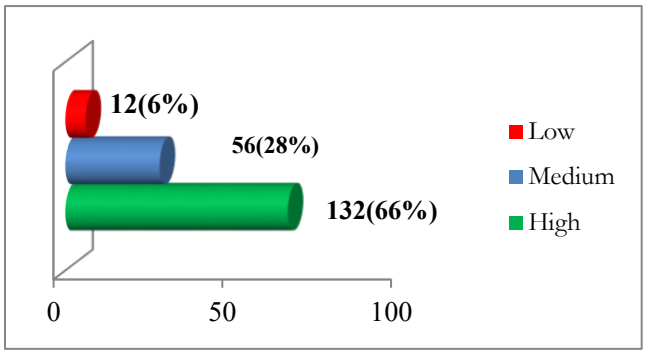

Table 1: Socio-demographic Characteristics of the Respondents (n=200)

Variable	Frequency (%)
Age (Years)	
14-17	98 (49.0)
18-19	102 (51.0)
Number of Children	
None	130 (65.0)
1	55 (27.5)
2	15 (7.50)
Place of Residence	
Alkaleri	100 (50.0)
Dambam	100 (50.0)
Marital Status	
Single	20 (10.0)
Married	180 (90.0)
Religion	
Christianity	63 (31.5)
Islam	112 (56.0)
Traditional Religion	25 (12.5)
Educational Status	
Secondary	60 (30.0)
Primary	100 (50.0)
Nursery	40 (20.0)
Family Type	
Monogamy	68 (34.0)
Polygamy	132(66.0)
Occupation	
Unemployed	20 (10.0)
Student	25 (12.5)
Farmer	35 (17.5)
Artisan/Traders	120 (60.0)
Monthly Income (₦)	
< 20,000	136 (68.0)
20,000 - 49,999	41 (20.5)
50,000 - 100,000	12 (6.0)
> 100,000	11 (5.5)

Minimum Dietary Diversity of the Pregnant Adolescents

Figure 4 below shows the minimum dietary diversity of the pregnant adolescent girls. Among the 200 pregnant adolescents, more than half 107(53.5%) met the minimum dietary diversity threshold (MDD-W ≥5) whereas, 93(46.5%) had low dietary diversity (consuming foods from fewer than five food groups).

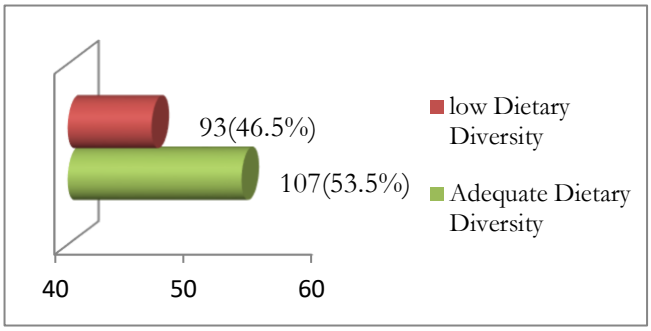

Figure 4: Minimum Dietary Diversity of the Pregnant Adolescents

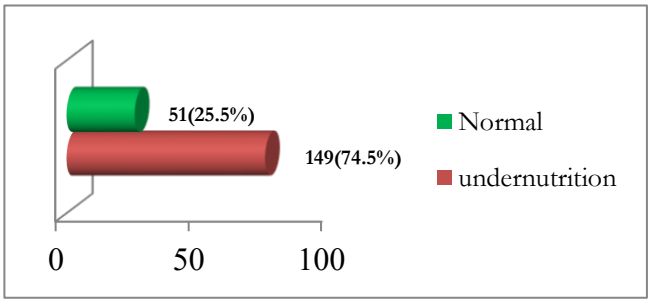

Figure 5: Nutritional Status of the Respondents

Nutritional Status of the Respondents

Figure 5 below represents the nutritional status of the pregnant adolescent girls based on mid-upper arm circumference (MUAC). A substantial proportion 149(74.5%) of the pregnant adolescents were classified as undernourished, while 51(25.5%) had normal nutritional status.

Health Behaviours Related to Supplement Use among Respondents

Table 2 summarizes the health behaviours of the pregnant adolescents related to supplement Majority of the respondents 180(90.0%) reported consuming supplements during pregnancy with more than half 134(67.0%) taking Iron-Folic Acid (IFA) Supplement while a few 46(23.0) consuming multiple micronutrient supplement (MMS).

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Table 2: Health Behaviours Related to Supplement Use among Respondents

Variables	Frequency	Percentage
Supplement Consumption during pregnancy		
Yes	180	90.0
No	20	10.0
Type of Supplements Taken		
None	20	10.0
IFA	134	67.0
MMS	46	23.0

IFA= Iron-Folic Acid; MMS=Multiple Micronutrient Supplements

Biochemical and Haematological Indicators of the pregnant adolescents

Table 3 below summarizes the biochemical and haematological indicators of the pregnant adolescents. While more than half 104(52.0%) of the pregnant adolescents maintained normal packed cell volume (PCV), 87(43.5%) were clustered within the low-normal PCV category. Regarding micronutrient status, majority of the adolescents 166(83.0%) exhibited adequate serum Vitamin B12 levels while 27(13.5%) had borderline serum Vitamin B12 deficiency.

Table 3: Biochemical and Haematological Indicators of the pregnant adolescents

Variables	Freq	Percent
Packed Cell Volume (PCV)		
Anaemia (<33%)	9	4.5
Low normal (33-35%)	87	43.5
Normal (≥36%)	104	52.0
Serum Vitamin B_{12}		
Definite deficiency (<200pg/mL)	7	3.5
Borderline (200-300pg/mL)	27	13.5
Adequate (>300pg/mL)	166	83

pg/mL=picograms per millilitre

Association between Socio-Demographic Characteristics and Minimum Dietary Diversity of Respondents

Table 4 summarizes the associations between socio-demographic characteristics and minimum dietary diversity of the respondents. The analysis revealed significant associations between minimum dietary diversity and several other socio-demographic factors including: place of residence (X^2 =31.16, p<0.001), religion (X^2 =15.04, p=0.020), marital status (p=0.038, fisher's exact test), occupation (X^2 =24.16, p=<0.001), educational status (X^2 =28.61, p=<0.001), monthly income (X^2 =4.10, p=0.043), family type (X^2=6.33, p=0.012) and number of children (X^2=6.19, p=0.013)

Predictors of Inadequate Dietary Diversity among Study Participants

Table 5 below presents the predictors of inadequate dietary diversity among the study participants. Multivariate logistic regression identified two independent predictors: place of residence and family type. Adolescents in Dambam had 1.7-fold higher odds of inadequate dietary diversity compared to adolescents in Alkaleri (AOR=1.7, 95% CI: 1.2-2.6, p=0.035). Similarly, those in polygamous households had 1.8 higher odds of inadequate dietary diversity compared to monogamous households (AOR=1.8, 95% CI: 1.3-2.5, p=0.036).

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Table 4: Association between Socio-demographic Characteristics and Minimum Dietary Diversity of Respondents

Variables	Minimum Dietary Diversity				
	Low DD Frequency (%)	Adequate DD Frequency (%)	Total Frequency (%)	X^2(df)	P-value
Age				5.66 (1)	**0.230**
14 – 17 years	37(18.5)	61(30.5)	98(49.0)		
18 - 19 years	57(28.5)	45(22.5)	102(51.0)		
Number of Children				6.19 (1)	**0.013***
None	53(26.5)	77(38.5)	130(65.0)		
≥1	40(20)	30(15)	70(35.0)		
Place of Residence				31.16 (1)	**<0.001***
Alkaleri	65(32.5)	35(17.5)	100(50.0)		
Dambam	28(14.0)	72(36.0)	100(50.0)		
Religion				15.04 (1)	**0.020***
Islam	59(29.5)	53(26.5)	112(56.0)		
Christianity	36(18.0)	52(26.0)	88(44.0)		
Marital Status[a]				18.77 (1)	**0.038*(fishers exact test)**
Single	2(1.0)	18(9.0)	20(10.0)		
Married	75(37.5)	105(52.5)	180(90.0)		
Educational Status				28.61 (1)	**<0.001***
≥Secondary	36(18.0)	64(32.0)	100(50.0)		
≤Primary	70(35.0)	30(15.0)	100(50.0)		
Occupation				24.16 (1)	**<0.001***
Unemployed	30(15.0)	40(20.0)	70(35.0)		
Employed	50(25.0)	80(40.0)	130(65.0)		
Family Type				6.33 (1)	**0.012***
Monogamy	20(10.0)	48(24.0)	68 (34.0)		
Polygamy	70(35.0)	62(31.0)	132 (66.0)		
Monthly income (₦)				4.10 (1)	**0.043***
< 50,000	60(30.0)	30(15.0)	90(45.0)		
≥50,000	50(25.0)	60(30.0)	110(55.0)		

**p<0.05, X^2= Chi Square, df=degree of freedom, [a] P-value calculated using Fishers Exact Test due to small cell frequency*

Table 5: Predictors of Inadequate Dietary Diversity among Study Participants

Variables	Category	COR (95% CI)	p	AOR (95%CI)	p
Place of Residence	Alkaleri	1.0 (Ref)	-	1.0 (Ref)	-
	Dambam	**1.7 (1.1-2.5)**	**0.009***	**1.7 (1.2-2.6)**	**0.035***
Age (Years)	14–17	1.0 (Ref)	-	1.0 (Ref)	-
	18–20	1.3 (0.6–2.8)	0.443	1.2 (0.5–2.5)	0.714
Educational Status	≤Primary	1.0 (Ref)	-	1.0 (Ref)	-
	≥Secondary	0.8 (0.4–1.6)	0.592	0.9 (0.4–1.9)	0.802
Monthly Income	<(₦)50,000	1.0 (Ref)	-	1.0 (Ref)	-
	≥(₦)50,000	1.3 (0.6–2.2)	0.733	1.3 (0.8–2.2)	0.816
Marital Status	Single	1.0 (Ref)	-	1.0 (Ref)	-
	Married	1.4 (0.9–2.2)	0.166	1.3 (0.8–2.2)	0.291
Occupation	Unemployed	1.0 (Ref)	-	1.0 (Ref)	-
	Employed	1.2 (0.9–1.6)	0.172	1.1 (0.8–2.0)	0.333
Religion	Islam	1.0 (Ref)	-	1.0 (Ref)	-
	Christianity	1.0 (0.7–1.5)	0.938	1.0 (0.6–1.5)	0.928
Number of Children	None	1.0 (Ref)	-	1.0 (Ref)	-
	≥1	1.6 (1.0–2.3)	0.053	1.5 (0.9–2.4)	0.218
Family Type	Monogamous	1.0 (Ref)	-	1.0 (Ref)	-
	Polygamous	**1.6 (1.2–2.3)**	**0.044***	**1.8 (1.3–2.5)**	**0.036***

=significant at p<0.05; COR = Crude Odds Ratio; AOR = Adjusted Odds Ratio

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DISCUSSION

This study evaluated the nutritional knowledge, dietary diversity, and nutritional status of pregnant adolescents in Bauchi State. The findings revealed that over half of the respondents were undernourished based on mid-upper arm circumference (MUAC). Although slightly half of the adolescents met the Minimum Dietary Diversity for Women (MDD-W) threshold, a considerable proportion did not, Nutrition knowledge levels were relatively high among respondents. Most adolescents had adequate vitamin B_{12} levels, while slightly above half had normal packed cell volume (PCV) values, a substantial proportion had low-normal PCV levels.

The observed prevalence of acute malnutrition based on MUAC observed in this study (74.5%) assessed using the mid-upper arm circumference (MUAC) markedly surpasses rates reported in comparable studies from other countries, including Uganda (21%, <23cm),[16] Iraq (3.4%, ≤23cm),[28] Ethiopia (26.4%, <22cm),[29] and Ghana (27.8%, <24cm)[23] among pregnant adolescents. These disparities can be attributed to differences in socioeconomic conditions, dietary practices, and access to nutrition and health services across locations. In addition, the lack of a universal MUAC threshold for identifying maternal undernutrition contributes to inconsistencies in reported results as cut-offs ranging from 21cm-24cm are commonly being used.[21-22] This study adopted a more conservative threshold of <23cm due to evidence of its high sensitivity in the identifying individuals at risk of malnutrition that other restrictive thresholds might exclude.[22] Furthermore, the high prevalence of undernutrition also captures the nutritional emergency in this region as estimates from recent reports have revealed a 120% escalation in admissions due to undernutrition in Bauchi State in comparison to the previous years.[30] UNICEF reports further reveals that the number of undernourished adolescents in Nigeria increased from approximately 5.6 million in 2018 to 7.3 million in 2021, highlighting the growing burden of adolescent malnutrition in Nigeria specifically in Northern states such as Bauchi.[31]

National nutrition reports have identify Bauchi State as having one of the highest burdens of acute malnutrition among girls and women 15-49 years of age in Nigeria, with a prevalence of approximately 13%.[12] A recent systematic review on adolescent nutrition in Nigeria reported consistently higher rates of malnutrition in the North compared to the southern states, reflecting a greater nutritional vulnerability among this population.[32] Similarly, a survey in Northwest Nigeria also reported critically high levels of malnutrition in this region, with the prevalence of acute malnutrition doubling within one year period.[33] Contextual factors such as limited household decision making power for adolescent girls coupled with unequal household food allocation favouring males, further exacerbate this vulnerability.[34] Prevailing gender norms often prioritize the dietary needs of males in the household based on perceived farm labour contributions and larger body size.[34]

Although, clinical results for anaemia and vitamin B12 deficiency were low among the adolescents, a substantial proportion clustered within the low-normal PCV range raising significant clinical concerns. This marginal status places the pregnant adolescent girls at high risk of developing anaemia thus aligning with the high anthropometric undernutrition. Research conducted in East Africa reported a pooled anaemia prevalence up to 61% among pregnant adolescents, with varying degrees of severity.[35] Pregnant adolescents are especially vulnerable to iron deficiency due to competing nutrient demands between maternal growth and foetal development. However, these biochemical indices do not provide a comprehensive assessment of micronutrient adequacy. Furthermore, laboratory values within normal ranges may not reflect optimal nutritional status, particularly where supplementation may temporarily mask deficiencies without addressing underlying dietary inadequacies.

A considerable number of the pregnant adolescents in the study demonstrated good nutrition knowledge. With levels in this study higher than a South-western study among pregnant adolescents which reported good knowledge scores of 46.2%.[18] Despite this, the high knowledge did not translate into improved dietary diversity or nutritional outcomes. Only slightly above half achieved adequate dietary diversity and the majority were undernourished. This highlights a knowledge-practice gap suggesting that nutrition knowledge only may be insufficient to influence dietary practices in this population. Structural, cultural, financial, and environmental constraints may limit the ability of these teenagers to apply nutritional knowledge in practice. These factors support the social determinants of health framework, which stresses that health behaviours and outcomes of individuals are shaped not only by individual knowledge but also by socioeconomic conditions, gender norms, household power dynamics, and access to food and services.[36]

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Place of residence and family type were independent predictors of inadequate dietary diversity. Adolescents residing in Dambam had higher odds of inadequate dietary diversity, due to several factors such as limited market access, seasonal food availability, and lower household income.[37] In addition, adolescents from polygamous households experience greater competition for available resources potentially leading to reduced dietary diversity.[38]

Several limitations have been observed in this study that should be acknowledged. The cross-sectional design limits the ability to establish causal relationships between nutrition knowledge, dietary practices, and nutritional status because exposures and outcomes were evaluated at a single time point in the study.

The selection of pregnant adolescents from selected primary health centres of Bauchi State introduced selection bias thus limiting the generalisability of the findings.

Dietary intake was assessed through self-report, which may be subject to recall bias. There is also the potential for social desirability bias, where can respondents report behaviours perceived as favourable, such as consumption of a wide variety of foods or adherence to supplementation.

Dietary diversity and nutrition knowledge were assessed using questionnaire-based tools, which may not capture factual dietary practices introducing measurement bias. Furthermore, seasonal variations in food availability and consumption patterns have the ability to influence dietary diversity since data was collected at a single time point (seasonal bias).

The limited range of biochemical indicators assessed does not comprehensively reflect the overall micronutrient status of pregnant adolescent girls.

Further research should be conducted to understand changes in dietary intake and nutritional status throughout pregnancy. Furthermore, more micronutrient biomarkers should be studied because this would provide a more comprehensive evaluation of maternal nutritional status.

CONCLUSION

This study contributes to the limited evidence on nutritional status of pregnant adolescents in Northern Nigeria through the incorporation of a comprehensive assessment that includes nutrition knowledge, dietary diversity, anthropometric and biochemical indicators. Despite relatively high nutrition knowledge levels, a substantial proportion of study participants had inadequate dietary diversity and a high prevalence of undernutrition, highlighting a significant knowledge–practice gap. These findings highlight the need for integrated maternal nutrition approaches that support adolescent mothers. Efforts should go beyond health education to prioritizing improvement in access to affordable, locally available nutrient-dense foods, strengthening adolescent-friendly antenatal services and enhancing context-specific dietary counselling. Clinically, routine nutritional screening during antenatal care should be a top priority and simple anthropometric tools such as MUAC should be used for early identification and management of malnutrition.

Declarations

Authors' Contributions: OUCN conceptualized the study, designed the methodology, collected and analysed the data, and drafted the manuscript. AK provided overall critical guidance on study design, and substantial revision of the manuscript. AI provided methodological support and technical input during data analysis and manuscript review. GMP contributed to data collection, literature review, and initial drafting of the results section. AEO assisted with data entry, proofreading, and final manuscript formatting. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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