Original Research Article

Nutritional Status of Adolescents in Public and Private Secondary Schools in Asaba, Delta State

ABSTRACT

This study aimed to compare the nutritional status of adolescents in private and public secondary schools in Asaba, Delta State.A cross-sectional analytical design was conducted among 282 adolescents from private day, private boarding and public secondary schools, selected by multistage sampling technique. Anthropometrics measures and socio-demographic characteristics data were collected using pretested questionnaire. Using WHO-reference-2007, height, BMI and weight-for-age were measured for stunting, wasting and underweight respectively and BMI-for-age for overweight and obesity.The collected data were entered in to Microsoft Excel and exported to SPSS for further statistical analysis. Chi-square test at 95% confidence interval (CI) was used to quantify independent variables of nutritional indices.The mean age of the students in public, private day, and private boarding schools were 14.28±2.79, 13.54±2.24, and 14.04±2.53 years, respectively.The prevalence of stunting, thinness, underweight, normal weight and overweight among public school participants was 31, 35, 29, 71, 0% respectively; that of private day school participants was 34, 45, 29, 63, 9%, respectively whereas that of private boarding school participants was 39, 47, 23, 61, 16%, respectively. These differences in the underweight and obesity were statistically significant ($p<0.05$).Statistical analyses revealed significant associations ($p<0.05$) between socioeconomic levels and underweight, highlighting the vulnerability of adolescents from lower socio-economic backgrounds. The influence of poverty on stunting was particularly pronounced within private boarding schools. The result also showed that there was no significant association between thinness, stunting, underweight and eating patterns among adolescents in all school types, however, significant association were observed for overweight.Thus, nutrition interventions to improve nutritional status of the adolescents through providing comprehensive nutritional assessment and counseling services at community, school, and health facility levels, and creating household's income-generating activities are recommended before they reach conception to break the intergenerational cycle effect of malnutrition.

Keywords: Nutritional status; Adolescent; Schools; Malnutrition

UNDER PEER REVIEW

INTRODUCTION

An adolescent is a young person who is typically between the ages of 10 and 19 years old. An adolescent is also a person who is in the stage of development between childhood and adulthood. This stage typically begins with the onset of puberty, which marks the physical and hormonal changes that occur during this period. Adolescence is that period of life in

which an adolescent learns healthy eating pattern which in future leads to healthy nutritional status of an adolescent. An estimated 20% of the total world population are adolescents and 22% of the population inNigeria according to the 2006 census report [1].Adolescents are viewed as a group of people who are at risk of nutritional deficiencies. This is because they are inclined to unhealthy and nutritionally deficient choices, lack of physical activity, and mental stress, which have an impact on their behavior and way of life. Consequently, nutrition plays a vital role in the growth and development of adolescents, during which the establishment of healthy dietary habits and lifestyle practices is of significant importance.

Quality education plays a crucial function in the advancement of the economy, society, and politics. Presently, simply enrolling adolescents in educational institutions is insufficient, the government must guarantee that adolescents achieve fundamental proficiency and abilities required for individual welfare. Educational institutions play a significant role in shaping the child's consciousness and character. Nutrition is also an essential aspect of human well-being, existence, and cognitive growth throughout the complete lifespan [2]. As well, malnutrition is considered a pressing problem that affects the ability of children to learn and could make them perform at a lower level in school [3].

Malnutrition is still prevalent globally with the coexistence of both overnutrition and undernutrition in developed countries affecting people of all ages [4, 5]. Adolescents area vulnerable group for malnutrition and its consequences due to rapid growth and development and changes in dietary habits that may have influenced their nutrient intake [6]. Malnutrition in adolescents occurs in different forms, particularly undernutrition including underweight for age, too short for age(stunted), too thin relative to height (wasted), and functionally deficient in vitamins and minerals [7]. Globally, over 340 million children and adolescents aged 5-19years are overweight and obese [8]. Obesity among children and adolescents isabout one out of 10[1]. Adolescents are at an increased risk for under nutrition in low- and middle-income countries such as Nigeria because of poverty and inadequate food intake.

Adolescents have become more vulnerable to malnutrition due to insufficient attention from health programs and nutrition interventions. Despite being the last chance to prevent undernutrition and break the cycle of malnutrition, they are often considered low-risk for poor health and receive little attention. Nutrition interventions have mainly focused on infants and pregnant/lactating women, leaving out adolescents who have additional nutrient demands for growth and development. This has led to a lack of information on adolescent nutrition, making it difficult for officials to develop appropriate strategies. Lack of physical activity and

UNDER PEER REVIEW

consuming calorie-rich junk food has also caused obesity and other metabolic disorders among adolescents, which has negatively impacted their nutritional status in Nigeria.At the same time, an increasing occurrence of obesity and the chronic diseases associated with it is being witnessed in developed nations among adolescents. In certain developing countries, half of all children and adolescents are unable to reach their full genetic growth potential because of insufficient nutrition, frequent illnesses, and lack of access to healthcare [9]. In developing countries, adolescents experience a dual burden of malnutrition.

The prevalence and pattern of various types of malnutrition such as wasting, stunting, overweight and obesity vary within regions in Nigeria. Abdulkarim*et al*. [10] reported overall prevalence of wasting, stunting, overweight and obesity among school going adolescents, 10–19 years studying in various schools in Abuja Municipal area to be 1.7%, 11.3%, 13.2% and 1.7%, respectively. On the other hand, Kola-Raji*et al*. [1] reported prevalence of stunting, underweight, normal weight, overweight and obesity among adolescents in private school in Ibadan to be 2.5%, 39.3%, 51.9%, 8.0% and 0.8% respectively, whereas that of public-school adolescents was 8.4%, 37.1%, 60.1%, 2.4% and 0.0%. Berhe*et al*. [11] reported the pooled prevalence of stunting and underweight to be 20.7% and 27.5% respectively. The consequences of undernutrition in adolescents include delayed growth, intellectual development, and increased risk of various health problems. Research has shown that factors such as rural/urban differences, socioeconomic status, lifestyle habits, and physical activity levels are associated with malnutrition in adolescents[12].

In many developing nations, efforts to improve nutrition have primarily concentrated on children and women, disregarding adolescents. Meeting the nutritional requirements of adolescents may be a crucial move towards ending the cycle of malnutrition, long-term illnesses, and destitution that passes from one generation to another. Conversely, investigations into the causal factors of malnutrition among adolescents have been conducted in various regions, including Ibadan [1], Abuja [10], Aba [13], Kano [14], Umahia[15], and Calabar[16]. However, it is noteworthy that no analogous studies have been undertaken in Asaba, Delta State.It is important to address the nutritional needs of adolescents as it can accelerate economic development. The objective of this study was to assess the nutritional status of adolescents in public and private secondary schools in Asaba, Delta State.

METHODOLOGY

Research design: The study adopted a cross sectional analytical design.

UNDER PEER REVIEW

Area of the Study: The study was conducted in Asaba, which is the capital city of Delta State in Nigeria. Asaba is situated on the western bank of the Niger River, with an estimated population of 407,126 people. It spans an area of approximately 762 square kilometers (294 sq. miles) in the northern region of Delta State, located between latitude 06o141-6o151N and longitude 06^{o}40E1-6^{o}451E in West Africa. The city is bounded on the east and northeast by the river Niger and on the west by the rolling slopes of the Asaba plateau.

Study Population: The study population comprised of adolescents in private and public Secondary Schoolsin Asaba that are registered under the ministry of basic and secondary education.

Inclusion criteria included:

i. All private and publicsecondary schools operating in Asaba.

ii. Adolescents within a specific age range, such as 10-19 years old.

iii. All adolescent boys and girls attending private and publicsecondary schools in Asaba.

Exclusion criteria included:

i. Adolescents who are seriously ill.

ii. Schools not registered by the state ministry of education

iii. Adolescents who are unwilling for anthropometric measurements.

iv. Adolescents whose parents refused to give their consent.

Sample and Sampling Technique

Sample Size: The minimum sample size was determined using the formula for comparative designs below [17].

$$N= \frac{[Z\alpha+Z\beta]^2 2p(1-p)}{d^2}$$

Where N= Minimum sample size for each group

Z_{α}= Percentage point of normal distribution corresponding to the two (two sided) significance level. In this case, significance level is 5%, Z_{α}= 1.96

Z_{β}= Power of the test, which is conventionally 80%, Z_{β}= =0.84

p= Population proportion estimated to adolescent malnutrition from previous study which is 26.7% or 0.267[1].

1-p= the variance of the proportions= 1-0.21= 0.71

d= the minimum difference to be detected by the study (20%) = 0.2

Substituting in the formula therefore:

$$N= \frac{[1.96+0.84]^2 2*0.267*0.71}{0.2^2}= \frac{2.972}{0.04}= 74$$

UNDER PEER REVIEW

10% was added to take care of Attrition = 74+8= 82

Furthermore, to enhance the precision of research findings, the researcher decided to augment the sample by including an extra 12 adolescents. It is widely recognized that increasing the sample size improves the accuracy of research findings, a principle supported by established research methodologies.

Sample size = Public school (94) + Private day (94) + Private boarding (94) =282 adolescents.

Sampling Technique

A multistage sampling method was employed in this study.

Stage one:Selection of Secondary Schools: A Comprehensive list of schools registered in the ministry of basic and secondary education was obtained. The list contains a total number of seventy-day secondary schools. This comprise of 13 public schools and 57 private schools. A simple random sampling technique was used. Five schools were selectedfrom the public and fourteen from the private secondary schools (seven day and seven boarding schools, respectively) using balloting method.

Stage Two: Selection of Class arm to be studied

A minimum of 13 students from each private schools and 20 students from public schools were selected from each school. From each of the six classes in each secondary school, simple random sampling technique by balloting was used to select a classarm of students for the study.

Stage Three: Selection of students

A systematic sampling technique was used, four students were required from each selected class arm from the public and private schools. A class list containing the names of every student in the selected class arm was obtained. This formed the sampling frame.

Data Collection Instrument: The study instrument was a semi-structured questionnaire, weighing scale and stadiometer. The instrument was titled "nutritional status of adolescents in private and public secondary schools in Asaba, Delta State". The instrument was developed to cover three (3) sections. Section A: Socio-demographic characteristics; Section B: anthropometric measures and Section C: Factors affecting adolescents' nutritional status.

Scoring and Interpretation of Variables/Outcome Measures

a) **Nutritional Status:** This was obtained using the Body Mass Index (BMI), a measure of body fat based on a person's weight and height. A BMI score of less than 18.5

UNDER PEER REVIEW

indicates underweight, 18.5-24.9 indicates normal weight, 25-29.9 indicates overweight, and over 30 indicates obesity.

b) Prevalence of malnutrition: The prevalence of stunting, wasting and underweightwas calculated by dividing the number of children with stunted growth, wasting, underweight, overweight andobesity by the total number of children in the population being assessed.

c) Types of Malnutrition: A weight-for-height score below -2 standard deviations (-2SD) from the reference median indicates moderate underweight, while a score below -3SD indicates severe underweight.A weight-for-height score below -2 standard deviations (-2SD) from the reference median indicates moderate wasting, while a score below -3SD indicates severe wasting. A height-for-age score below -2 standard deviations (-2SD) from the reference median indicates moderate stunting, while a score below -3SD indicates severe stunting. A weight-for-height score above +1 standard deviation (+1SD) from the reference median indicates overweight, while a score above +2SD indicates obesity [18].

d) **Factors associated with the nutritional status:** Poverty levels of the adolescents was measured by wealth status comprising of dwelling characteristics such as floor material, source of drinking water, type of house, and toilet facilities. Nutritional knowledge of the adolescentswas assessed using objective structured questions on nutrition. The questions assessed their knowledge on nutrition terms of good health, water intake, diet and disease. For a score-based indicator of knowledge, each respondent was given a score based on the number of correct responses provided and ranked from 0-15 points.

For item 1, 5, 6, 7, 8, 11, 14 and 15 each response was scored as follows: “Yes” = 1 point “No” = 0 point. This mean that the sequencing of these items is related to food that the adolescent should eat and be recommended to do. For item 2, 3, 4, 9, 10, 12 and 13 each response was scored as follows: “Yes” = 0 point “No” = 1 point. This mean that the sequencing of these items is related to understanding about nutrition that the adolescents should not eat and not be recommended to do. The criterion of knowledge level was based on the percentage of knowledge score and classified into three groups following Bloom’s criteria [19].

Score 0-8 (<60%) = Poor knowledge

Score 9-12 (60-80%= Moderate knowledge

UNDER PEER REVIEW

Score 13-15 (<80%) = Good knowledge

Reliability of the Instrument: The reliability of the instrument was established using Cronbach Alpha method. A trial test was performed and scores were subjected to Cronbach Alpha statistical reliability test to determine the reliability index of the instrument. The result of the analysis of 0.75 indicated that the instrument was reliable.

Data Collection and Administration: The researcherobtained a letter of introduction from the Head of Department, Community Medicine and Primary Health to the selected schools. Then the researcher also wrote a letter seeking for permission from Delta state ministry of basic and secondary education to carry out theresearch in the selected schools. The researcher administered the questionnaires to the respondents in their class rooms.

Ethical Consideration: Ethical approval for the study was obtained from the Human Research Ethics committee of NnamdiAzikiwe UniversityAwka. Informed consent was obtained freely withoutcoercionfrom respondence and assuring them of respect for the confidentiality of the data obtained from them. The objective of the study was thoroughly explained to them and that they were free to opt-out of the study any time they wished to do so.

Data Analysis: After data collection, data was thoroughly screened, reviewed, compiled and checked for its completeness, consistency and accuracy by the researcher and the data analysis was done as per the objectives of the study. Editing, classifying, coding and entry of data was done using Microsoft Excel and analysis carried out using Statistical Product Service Solution (SPSS) version 23.0. Descriptive analysis such as frequencies, percentage and means were calculated. Categorical variables were presented as frequency and percentages. Association between categorical variables like nutritional status, types of malnutrition and prevalence of malnutrition was determined using Chi-square test of association. Level of significance was determined at p value =0.05.

RESULTS

Demographic Characteristics of the Adolescents

The demographic characteristics of the adolescents are presented in Table 1. A total of 282 adolescents took part in the study. The mean age ± standard deviation (SD) of the study participants in public, private day, and private boarding schools were 14.28±2.79,

UNDER PEER REVIEW

13.54±2.24, and 14.04±2.53 years, respectively. Regarding gender distribution, slightly less than two-fifths, 108 (38.30%), of the participants were males, while the majority, 174 (61.70%), were females. In terms of academic levels, the majority were in JSS3 (72 or 25.53%) and SS1 (73 or 25.89%), followed by 31 (10.99%) in JSS1, 44 (15.60%) in JSS2, 33 (11.70%) in SS2, and 29 (10.28%) in SS3.Regarding religious affiliation, the majority, 226 (80.14%), identified as Christians, 41 (14.54%) as Muslims, and 15 (5.32%) belonged to other religions.

Table 1. Demographic and socioeconomic-related characteristics of school's adolescents in Asaba, Delta State (*n* = 282)

Variables	Public		Private Day		Private Boarding	
	N (94)	%	N (94)	%	N (94)	%
Age						
10 -13	35	37.23	42	44.68	45	47.87
14 – 16	40	42.55	37	39.36	32	34.04
17 – 19	19	20.21	15	15.96	17	18.09
Mean ± SD	14.28±2.79		13.54±2.24		14.04±2.53±2.53	
Sex						
Male	33	35.11	33	35.11	42	44.68
Female	61	64.89	61	64.89	52	55.32
Class						
JSS1	12	12.77	10	10.64	9	9.57
JSS2	9	9.57	16	17.02	19	20.21
JSS3	33	35.11	11	11.70	28	29.79
SS1	19	20.21	36	38.30	18	19.15
SS2	11	11.70	11	11.70	11	11.70
SS3	10	10.64	10	10.64	9	9.57
Religion						
Christian	94	100.00	71	75.53	61	64.89
Islam	-	-	23	24.47	18	19.15
Others	-	-	-	-	15	15.96

Prevalence and types of malnutrition among adolescents in Asaba, Delta State

Table 2 shows the prevalence and types of malnutrition among adolescents in Asaba, Delta State. The prevalence of thinness (BAZ < − 2 SD) among students in public, private day, and private boarding schools was 35%, 45%, and 47%, respectively (p>0.05). Regarding stunting (HAZ < − 2 SD), the overall prevalence rates were 31%, 34%, and 39% for public, private day, and private boarding schools, respectively (p>0.05).Concerning overweight, the prevalence was 8% in private day schools and 16% in private boarding schools, with no overweight recorded in public schools (p<0.000). Notably, obesity was not observed in any of the adolescents across all school types.The prevalence of severe thinness (BAZ < − 3 SD)

UNDER PEER REVIEW

was 2% for both public and private day schools, with none recorded for private boarding schools. The prevalence of severe stunting was 3% and was only observed in public schools ($p<0.000$).In terms of the nutritional status of the adolescents according to the body mass index (BMI), 29% of adolescents from public and private day schools were underweight, respectively, while 23% of adolescents from private boarding schools were underweight ($p=0.030$).

UNDER PEER REVIEW

Table 2. Anthropometric status of study participants of school adolescents in Asaba, Delta State (*N* = 282)

Variables	Categories	Public		Private Day		Private Boarding		*p*-value
		N (94)	%	N (94)	%	N (94)	%	
Height for age (Stunting)	Severe stunting	3	3	-	-	-	-	0.000
	Moderate stunting	26	28	32	34	37	39	0.640
	Not stunted	65	69	62	66	57	61	0.984
BMI (kg/m^2)	Underweight (<18.5kg/m^2)	27	29	27	29	22	23	0.030
	Normal weight (>18.5kg/m^2)	67	71	59	63	57	61	0.823
	Overweight (>25 kg/m^2)	-	-	8	9	15	16	0.000
	Obesity (>30 kg/m^2)	-	-	-	-	-	-	-
Weight for age (thinness)	Severely thin	2	2	2	2	-	-	0.000
	Moderately thin	31	33	40	43	44	47	0.367
	Normal	61	65	52	55	50	53	0.849

UNDER PEER REVIEW

Factors associated with thinness, stunting, underweight and overweight of adolescents

Factors associated with stunting among school adolescents' in Asaba, Delta State

The findings extracted from Tables 3 and 4 offer valuable insights into the factors associated to stunting among school adolescents in Asaba, Delta State. The study examined a range of factors across different types of schools: public, private day, and private boarding.Regarding poverty levels, the chi-square ($\chi 2$) value was found to be 0.203, 1.144 and 7.372 for public, private day and private boarding schools, respectively and p-value=0.203, 0.564 and 0.025 which showed no significant association between stunting and poverty levels among adolescents in public and private day schools. However, a significant association between high poverty levels and stunting was observed in private boarding schools (p=0.025).Socioeconomic levels also emerged as significant factors, with low socioeconomic levels being connected to stunting in private day schools (p=0.004). In terms of nutritional knowledge, the chi-square ($\chi 2$) value was found to be 3.933, 2.011 and 2.051 for public, private day and private boarding schools, respectively and p-value=0.140, 0.366 and 0.359 which showed no significant association between stunting and poverty levels among adolescents in all school types. Similarly, eating patterns did not reveal significant associations with stunting in public and private day schools. Nonetheless, a significant association was noted in private boarding schools (p=0.067).

UNDER PEER REVIEW

Table 3. Factors associated with stunting among school adolescents' in Asaba, Delta State

Factors	Public		Private Day		Private Boarding	
Poverty levels	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
High	2 (2.13%)	6(6.38%)	17(18.09%)	33(35.11%)	10(10.64%)	4(4.26)
Medium	23(24.47%)	49(52.13%)	13(13.83%)	21(22.34%)	2(2.13%)	6(6.38%)
Low	4(4.26%)	10(10.64%)	2(2.13%)	8(8.51%)	25(26.60%)	47(50.00%)
Socioeconomic levels						
High	-	-	6(6.38%)	33(35.11%)	17(18.09%)	33(35.11%)
Medium	16(17.02%)	38(40.43%)	22(23.40%)	22(23.40%)	10(10.64%)	12(12.77%)
Low	13(3.19%)	27(28.72%)	4(4.26%)	7(7.45%)	10(10.64%)	12(12.77%)
Nutritional knowledge						
High	7(7.45%)	22(23.40%)	5(5.32%)	7(7.45%)	2(2.13%)	7(7.45%)
Moderate	15(15.96%)	37(39.36%)	25(12.77%)	45(47.87%)	25(26.60%)	31(32.98%)
Low	7(7.45%)	6(6.38%)	2(2.13%)	10(10.64%)	10(10.64%)	19(20.21%)
Eating pattern						
Excellent	-	2(2.13%)	7(7.45%)	10(10.64%)	12(12.77%)	12(12.77%)
Fair	27(28.72%)	63(67.02%)	17(18.09%)	41(43.62%)	18(19.15%)	28(29.79%)
Poor	2(2.13%)	-	8(8.51%)	11(11.70%)	7(7.45%)	17(18.08%)

UNDER PEER REVIEW

Table 4. Chi-square tests for the association with between poverty levels, socioeconomic status, nutritional knowledge, eating pattern and stunting among school adolescents' in Asaba, Delta State

Factors	Public		Private day		Private boarding	
	χ2	p-value	χ2	p-value	χ2	p-value
Poverty levels	0.203	0.904	1.144	0.564	7.372	0.025
Socioeconomic status	0.089	0.766	11.063	0.040	1.287	0.526
Nutritional knowledge	3.933	0.140	2.011	0.366	2.051	0.359
Eating pattern	5.406	0.067	1.514	0.469	2.184	0.336

Factors associated with Thinness among school adolescents' in Asaba, Delta State

The findings, as presented in Table 4, illuminate the factors connected with thinness among school adolescents in Asaba, Delta State. The study investigated various factors across three types of schools: public, private day, and private boarding.Regarding poverty levels, the chi-square (χ2) value was found to be 3.624, 2.165 and 11.042 for public, private day and private boarding schools, respectively and p-value=0.163, 0.339 and 0.040 which showed no significant association between thinness and poverty levels among adolescents in public and private day schools. However, within private boarding schools, a significant association between high poverty levels and thinness was observed (p=0.004).Socioeconomic levels also demonstrated a significant association with thinness, as low socioeconomic levels were correlated with thinness in public schools (p=0.066). In terms of nutritional knowledge, no significant associations were found across the school types. The chi-square (χ2) value was found to be 0.913, 4.261 and 2.240 for public, private day and private boarding schools, respectively and p-value=0.633, 0.119 and 0.326 which showed no significant association between thinness and nutritional knowledge among adolescents in all school types. Regarding eating pattern, the chi-square (χ2) value was found to be 4.796, 4.976 and 0.913 for public, private day and private boarding schools, respectively and p-value=0.091, 0.083 and 0.634 which showed no significant association between thinness and eating patterns among adolescents in all school types.

UNDER PEER REVIEW

Table 5. Factors associated with thinness among school adolescents' in Asaba, Delta State

Factors	Public		Private Day		Private Boarding	
Poverty levels	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
High	4(4.26%)	4(4.26%)	23(24.47%)	27(12.77%)	12(12.77%)	2(2.13%)
Medium	27(28.72%)	45(47.87%)	12(12.77%)	22(23.40%)	4(4.26%)	4(4.26%)
Low	2(2.13%)	12(12.77%)	6(6.38%)	4(4.26%)	27(12.77%)	45(47.87%)
Socioeconomic levels						
High	-	-	27(28.72%)	12(12.77%)	23(24.47%)	27(28.72%)
Medium	15(15.96%)	39(41.49%)	21(22.34%)	23(24.47%)	8(8.51%)	14(14.89%)
Low	18(19.15%)	22(23.40%)	5(5.32%)	6(6.38%)	12(12.77%)	10(10.64%)
Nutritional knowledge						
High	9(9.56%)	20(21.28%)	5(5.32%)	7(7.45%)	5(5.32%)	4(426%)
Moderate	18(19.15%)	34(36.17%)	34(36.17%)	34(36.17%)	28(29.79%)	28(29.79%)
Low	6(6.38%)	7(7.45%)	2(2.13%)	10(10.64%)	10(10.64%)	19(20.21%)
Eating pattern						
Excellent	-	2(2.13%)	8(8.51%)	9(9.56%)	12(12.77%)	12(12.77%)
Fair	31(32.98%)	59(62.77%)	29(30.85%)	29(30.85%)	22(23.40%)	24(25.53%)
Poor	2(2.13%)	-	4(4.26%)	15(15.96%)	9(9.56%)	15(15.96%)

UNDER PEER REVIEW

Table 6. Chi-square tests for the association with between poverty levels, socioeconomic status, nutritional knowledge, eating pattern and thinness among school adolescents' in Asaba, Delta State

Factors	Public		Private day		Private boarding	
	χ2	p-value	χ2	p-value	χ2	p-value
Poverty levels	3.624	0.163	2.165	0.339	11.042	0.040
Socioeconomic status	2.992	0.084	4.492	0.106	1.468	0.480
Nutritional knowledge	0.913	0.633	4.261	0.119	2.240	0.326
Eating pattern	4.796	0.091	4.976	0.083	0.913	0.634

Factors associated with Underweight among school adolescents' in Asaba, Delta State

Tables7 and 8 shows the factors associated with adolescent underweight in Asaba, Delta State. Regarding poverty levels,the chi-square (χ2) value was found to be 9.104, 8.322 and 7.724 for public, private day and private boarding schools, respectively and p-value=0.001, 0.004 and 0.023 which showed a significant association between underweight and poverty levels among adolescents in all school types. Furthermore, a significant association was established between socioeconomic levels and underweight in all schools. The chi-square (χ2) value was found to be 9.451, 6.941 and 10.431 for public, private day and private boarding schools, respectively and p-value=0.001, 0.032 and 0.001.In terms of nutritional knowledge, no significant associations were found across the school types. The chi-square (χ2) value was found to be 1.731, 2.043 and 2.211 for public, private day and private boarding schools, respectively and p-value=0.167, 0.302 and 0.302. On the other hand, a significant statistical association was observed pertaining to eating patterns and underweight across public (p=0.020), private day (p=0.050), and private boarding (p<0.001) schools.

UNDER PEER REVIEW

Table 7. Factors associated with underweight among school adolescents' in Asaba, Delta State

Factors	Public		Private day		Private Boarding	
Poverty levels	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
High	2(2.13%)	18(19.15%)	13(13.83%)	40(42.55%)	6(6.38%)	16(17.02%)
Medium	27(28.72%)	47(50.00%)	6(6.38%)	17(18.09%)	-	-
Low	-	-	4(4.26%)	14(14.89%)	16(17.02%)	56(59.57%)
Socioeconomic levels						
High	-	-	6(6.38%)	19(20.21%)	12(12.77%)	51(54.26%)
Medium	19(20.21%)	36(38.30%)	15(15.96%)	42(44.68%)	6(6.38%)	12(12.77%)
Low	10(10.64%)	29(30.85%)	2(2.13%)	10(10.64%)	4(4.26%)	9(9.57%)
Nutritional knowledge						
High	11(11.70%)	21(22.34%)	5(5.32%)	16(17.02%)	-	-
Moderate	12(12.77%)	29(30.85%)	14(14.89%)	46(48.94%)	14(14.89%)	53(56.38%)
Low	6(6.38%)	15(15.96%)	4(4.26%)	9(9.57%)	8(8.51%)	19(20.21%)
Eating pattern						
Excellent	-	-	4(4.26%)	11(11.70%)	4(4.26%)	14(14.89%)
Fair	27(28.72%)	52(55.32%)	15(15.96%)	47(50.00%)	14(14.89%)	45(47.87%)
Poor	2(2.13%)	13(13.83%)	4(4.26%)	13(13.83%)	4(4.26%)	13(13.83%)

UNDER PEER REVIEW

Table 8. Chi-square tests for the association with between poverty levels, socioeconomic status, nutritional knowledge, eating pattern and underweight among school adolescents' in Asaba, Delta State

Factors	Public		Private day		Private boarding	
	χ2	p-value	χ2	p-value	χ2	p-value
Poverty levels	9.104	0.001	8.322	0.004	7.724	0.023
Socioeconomic status	9.451	0.001	6.941	0.032	10.431	0.001
Nutritional knowledge	1.731	0.167	2.043	0.302	2.211	0.302
Eating pattern	6.348	0.020	4.976	0.050	9.631	0.001

Factors associated with overweight among school adolescents' in Asaba, Delta State

Tables9 shows the factors associated with adolescent overweight in Asaba, Delta State. Regarding poverty levels, the chi-square (χ2) value was found to be 10.233 and 9.213 for private day and private boarding schools, respectively and p-value=0.001 and 0.003 which showed that there was an association between poverty levels and the occurrence of overweight.

Asignificant association was also identified between socioeconomic levels and overweight within private day (p=0.023) and private boarding (p<0.001) schools. Adolescents stemming from lower socioeconomic backgrounds exhibited higher odds of being overweight in comparison to those with higher and medium socioeconomic backgrounds.

Furthermore, the study highlights a statistically significant association between nutritional knowledge and overweight within private day (p=0.004) and private boarding (p=0.020) schools. Adolescents possessing poor nutritional knowledge demonstrated greater odds of being overweight when compared to those with limited nutritional knowledge, as opposed to individuals with moderate and high nutritional knowledge. Regarding eating patterns,the chi-square (χ2) value was found to be 8.011 and 9.305 for private day and private boarding schools, respectively and p-value=0.005 and 0.002 which showed that there was an association between eating patterns and the occurrence of overweight. Adolescents with inadequate eating patterns were more prone to experiencing overweight compared to their peers with fair and moderate eating patterns.

UNDER PEER REVIEW

Table 9. Factors associated with overweight among school adolescents' in Asaba, Delta State

Factors	Public		Private Day				Private Boarding			
Poverty levels	**Yes**	**No**	**Yes**	**No**	**χ2**	**P-value**	**Yes**	**No**	**χ2**	**P-value**
High	-	-	4	45	10.233	0.001	-	-	9.213	0.003
Medium	-	-	4	41			2	22		
Low	-	-	-	-			13	57		
Socioeconomic levels					9.102	0.023			11.212	0.001
High	-	-	4	35			11	54		
Medium	-	-	2	22			2	12		
Low	-	-	2	29			2	13		
Nutritional knowledge					9.751	0.004			10.543	0.020
High	-	-	-	-			-	-		
Moderate	-	-	4	44			8	42		
Low	-	-	4	42			7	37		
Eating pattern					8.011	0.005			9.305	0.002
Excellent	-	-	-	-			2	21		
Fair	-	-	6	51			10	33		
Poor	-	-	2	35			3	25		

DISCUSSIONS

From the results of this study, the percentage of stunting in public schools, private boarding and private day were found to be 31%, 32% and 37%, respectively. The percentage of stunting was higher in the private boarding schools and lower in the public schools, however, no significant ($p>0.05$) relationship existed. The overall average percentage of stunting across all participants was reported as 34.8%. This prevalence of stunting is slightly lower than that reported by Esimai and Ojofeitimi[20] among the adolescents in Port Harcourt (36.3%). This prevalenceis higher than that of Nwoke*et al*. [13], who reported stunting prevalence of 7% and 25% among adolescent boys in private and public schools, respectively in Aba, Abia State. This stark contrast highlights the considerable disparities in adolescent nutritional status even within the same country. This could be attributed to regional variations in socio-economic conditions, dietary patterns, cultural practices, and healthcare access, reaffirming the need for targeted interventions tailored to specific contexts.The higher prevalence of stunting in privateboarding schools suggests chronic under-nutrition, which might result in slowing the metabolic process of maturation [21].This could be due to the living environment

UNDER PEER REVIEW

which could influence dietary habits. Adolescents living away from home might have fewer opportunities to make healthy food choices due to limited control over their diets. Lack of parental oversight on dietary choices could lead to less balanced diets and potentially contribute to stunting.

The prevalence of thinness in public schools, private boarding schools, and private day schools was identified as 35%, 43%, and 47%, respectively. Similarly, the occurrence of thinness was greater in private boarding schools and lower in public schools; however, no statistically significant relationship was observed ($p>0.05$). Factors such as limited physical activity, sedentary behaviours, and sleep patterns in boarding schools might influence metabolic rates and energy expenditure, potentially leading to thinness. The overall average percentage of thinness across all participants was documented as 42.2%. This prevalence is comparatively lower when contrasted with the findings ofEjike*et al*. [15]reporting 24.2% prevalence among adolescent boysin the eastern region of Nigeria. Furthermore, the prevalence reported here falls below the rate of 60.6% reported by Mijinyawa*et al*. [14] for adolescents in Kano.This substantial difference emphasizes the diverse nutritional challenges faced by adolescents across different regions within the same country. Socio-economic factors, cultural practices, and regional disparities likely contribute to these variations in prevalence rates.

The occurrence of being underweight in public schools, private boarding schools, and private day schools was identified as 29%, 29%, and 23%, respectively. The prevalence of underweight was higher in private day and public schools, and lower in private boarding schools ($p<0.030$). The overall average percentage of overweight among all participants was recorded as 28.7%. This prevalence is comparatively lower when contrasted with the prevalence of 39.3% reported by Kaji-Raji*et al*. [1] in both private and public boarding secondary schools in Ibadan. However, it is slightly higher than the prevalence of 21% reported by Nwoke*et al*. (2017) for adolescents in Aba, Abia State.The findings of this study also diverge from those of Kaji-Raji*et al*. [1], who reported a higher prevalence of underweight in public schools than in private schools. This discrepancy was attributed to inadequate social and healthcare services within the country.Several factors could potentially contribute to the observed higher prevalence of underweight among adolescents in public schools compared to their counterparts in private boarding schools, as revealed by this study. These factors encompass socio-economic conditions, access to nutrition, healthcare disparities, and environmental influences.

UNDER PEER REVIEW

The percentage of adolescents who had normal weight in the public-school category was 71% while that of private day and boarding schools were 63% and 61%, respectively. These values were higher than the prevalence of 51.9% and 60% reported by Kola-Raji*et al*. [1] for adolescents in private and public schools in Ibadan. The result showed that the prevalence of normal weight among adolescents in the public schools was higher than that of adolescents in the private day and boarding schools which agreed with the findings of Kola-Raji*et al*. [1]. The prevalence of being overweight in private boarding schools and private day schools was recorded as 9% and 16%, respectively, while none of the adolescents in public schools were found to be overweight. Several factors could help elucidate why adolescents in public schools exhibited a lower prevalence of overweight. Public schools often cater to a more diverse socio-economic demographic, encompassing a range of income levels. Adolescents in these schools might have limited access to discretionary income, which could potentially translate into a diet that is relatively simpler and less reliant on energy-dense foods. This economic constraint might contribute to a lower likelihood of overweight.The prevalence of overweight displayed a significant difference ($p<0.001$), with private boarding schools exhibiting a higher prevalence compared to private day schools. Private boarding schools often encompass an all-encompassing residential setting where adolescents spend extended periods away from home. The controlled environment of boarding schools can impact dietary choices, access to physical activity, and exposure to various lifestyle factors. The higher prevalence of overweight in private boarding schools could be attributed to factors such as limited opportunities for outdoor activities, a higher likelihood of sedentary behaviours, and a cafeteria-style meal system that may offer fewer nutritious food options compared to private day schools.Socio-economic conditions also play a pivotal role. Private boarding schools typically cater to students from more affluent backgrounds. The potential availability of discretionary income might lead to increased consumption of energy-dense, nutrient-poor foods, contributing to higher rates of overweight. Additionally, the presence of amenities that promote a sedentary lifestyle, such as televisions and video games in boarding facilities, might contribute to reduced physical activity levels, further exacerbating the risk of overweight.The overall average percentage of overweight among all participants was registered as 8.2%. In comparison, this prevalence is relatively lower when juxtaposed with the prevalence rates of 13.2% reported by Abdulkarim*et al*. [10] among adolescents in secondary schools in the Abuja Municipal area, and 11.4% among adolescents in secondary schools in Calabar as reported by Ene-Obong*et al*. [16]. These variations could be attributed

UNDER PEER REVIEW

to factors such as regional disparities in dietary habits, lifestyle, and socio-economic conditions.A study conducted by Musa *et al*. (2012) in Benue similarly indicated a prevalence of overweight at 9.7%, which aligns with the prevalence obtained in this study. Notably, none of the adolescents were classified as obese.This finding might reflect an encouraging trend, but a holistic view necessitates considering the potential implications of overweight on the long-term health trajectories of adolescents.

The results pertaining to the association between poverty levels and stunting are noteworthy. Despite high poverty levels being prevalent, the data does not indicate significant associations with stunting across all three school types. This implies that, in the context of this study, the influence of high poverty levels on stunting might not be uniform across different types of schools. However, it is important to highlight a significant association between high poverty levels and stunting specifically in private boarding schools. This finding suggests that the impact of poverty on stunting might be more pronounced within the private boarding school environment.Socioeconomic levels emerged as a significant factor in this study. Low socioeconomic levels were found to be linked to stunting among students attending private day schools. This finding agrees with the study of Jonah *et al*. [23] who reported that families with low socioeconomic levels (poor families) are at a much higher risk of having stunted child than high socioeconomic families. However, Santosa*et al*. [24] reported that family socioeconomics was not significant in determining maternal factors that cause stunting in children. The association between family socioeconomic status and child stunting might vary depending on the life stage being examined.The geographical location, cultural practices, economic conditions, and healthcare systems within which the studies were conducted might differ significantly. These variations can impact the prevalence of stunting and the factors contributing to it.This highlights the role of socioeconomic factors in contributing to stunting, particularly within the private day school setting. The significance of this association underscores the need for targeted interventions to address socioeconomic disparities that might contribute to stunting among adolescents in these schools. The study of nutritional knowledge and its relation to stunting yielded interesting results. While no significant associations were identified across the various school types, it is important to acknowledge that this finding might suggest a more consistent level of nutritional awareness among students regardless of school type. This could potentially indicate a positive aspect of the education system's effectiveness in imparting nutritional knowledge to adolescents.

UNDER PEER REVIEW

Examining the impact of poverty levels on thinness, the data revealed intriguing patterns. While high poverty levels did not exhibit significant associations with thinness across all school types collectively, a distinctive outcome emerged within the realm of private boarding schools. Notably, a significant association between high poverty levels and thinness was observed specifically within private boarding schools. This finding implies that the influence of poverty on thinness might vary across different school settings, with private boarding schools demonstrating a heightened vulnerability of thinness among students facing high poverty levels.Socioeconomic levels also demonstrated intriguing trends in relation to thinness. A significant association was observed between low socioeconomic levels and thinness in public schools. This suggests that socioeconomic disparities could be contributing to the prevalence of thinness among students in public school environments. Although the association did not reach statistical significance. Exploring the role of nutritional knowledge in relation to thinness, the study did not find significant associations across the various school types. However, a significant association was noted in private day schools. This result indicates the possibility of a subtle connection between nutritional knowledge and thinness specifically within the context of private day schools. Similarly, the findings of eating patterns and their association with thinness yielded noteworthy insights. Although significant associations were not detected in public and private boarding schools, a significant association was identified in public schools. This indicates that eating patterns might play a role in thinness among students in public schools.

The findings of poverty levels and their impact on underweight prevalence yielded particularly noteworthy results. Across all school types, the presence of significant associations between poverty levels and underweight was evident. Adolescents hailing from lower poverty levels exhibited an increased vulnerability to underweight in stark contrast to those from higher and medium poverty levels. This finding underscores the pervasive influence of socioeconomic disparities on underweight prevalence, transcending school types.Socioeconomic levels emerged as another pivotal factor influencing underweight among school adolescents. Adolescents originating from lower socioeconomic backgrounds demonstrated a heightened likelihood of underweight compared to their counterparts from higher and medium socioeconomic backgrounds. The results of this study align with that Farooq *et al*. [25] who reported that the family's wealth index quintile was significantly associated with underweight status of children in Punjab. Similarly, Galgamuwa*et al*. [26] reported that living in small houses, large number of family members, low monthly income

UNDER PEER REVIEW

and maternal employment were significantly associated with undernutrition among school children. This result underscores the importance of addressing socioeconomic inequalities in combating underweight across diverse educational settings.

Based on the findings of the chi square analysis of the data, no significant association was observed between nutritional knowledge and underweight. In actuality, the nutritional status of adolescents was predominantly within the normal range, while their nutrition knowledge was deemed satisfactory. These two sets of data appeared to exhibit a linear trend, yet no direct causal association was established. It should be noted that possessing sound nutrition knowledge does not consistently result in making nutritious dietary choices; this aspect is also influenced by habits and purchasing power capabilities.A prior study indicated that there was a lack of significant association between nutrition knowledge and nutritional status among junior high school students in the KerjoSubdistrict of Karanganyar District [28]. Veronika *et al*. [28] also reported that there was no significant association between nutrition knowledge and nutritional status. It was underscored that nutrition knowledge played a pivotal role in shaping the food preferences and choices of the subjects. The reason behind the absence of a link between nutritional status and knowledge is likely due to the indirect impact of knowledge on nutritional intake, which contrasts with the more direct influence it exerts on status [29].Furthermore, adolescents with suboptimal eating patterns were found to be at a heightened likelihood of encountering underweight compared to peers with fair and moderate eating patterns. This highlights the role of dietary habits in shaping the prevalence of underweight across different school environments.

The presence of significant statistical association, particularly within private day and private boarding schools, indicates that adolescents with lower poverty levels are more susceptible to overweight compared to their peers from higher and medium poverty levels. This emphasizes the importance of considering economic disparities when addressing overweight in these school environments.Similarly, the study highlights the substantial influence of socioeconomic levels on the likelihood of overweight within private day and private boarding schools. The statistically significant connection observed within private day and private boarding schools signifies that adolescents from lower socioeconomic backgrounds face elevated odds of being overweight compared to those with higher and medium socioeconomic backgrounds. This result underscores the need for targeted interventions to address socioeconomic factors in combating overweight among students.These findings agree well with the study of Hoebel*et al*. [30] who reported that the prevalence of overweight and

UNDER PEER REVIEW

obesity was highest among girls and boys from families of low SES.Overweight in adolescence are a worldwide health problem. Overweight represent one of the most important public health challenges in terms of noncommunicable diseases in the 21stcentury [31]. The relationship between overweight or obesity and socioeconomic status (SES) in adolescence has long been known internationally and shows that not all population groups are affected with equal frequency [32]. Chen *et al*. [33] also discovered that children from more privileged socioeconomic backgrounds, living in urban or suburban settings with higher levels of paternal education and family income, exhibited a higher prevalence of overweight in comparison to those from less advantaged backgrounds. Nevertheless, this outcome stands in contrast to the findings reported by Liang [34], necessitating further investigation to authenticate the current outcomes.Liu *et al*. [35] identified a significant protective interaction effect between paternal education and household wealth in relation to the risk of obesity among girls. However, they did not detect a significant disparity in the prevalence of childhood obesity across various levels of household wealth. This discrepancy from our results highlights an inconsistency. The dissimilar impacts of socioeconomic status on overweight, as observed in the aforementioned studies, might arise from variations in classification criteria, representation areas, and sample sizes.This study employed meticulous classification criteria (comprising three levels) to define parental poverty and socioeconomic status. This meticulous approach implies that the outcomes of the present study could be more dependable than those of previous research, addressing the potential limitations of earlier studies.

Furthermore, the study elucidates the role of nutritional knowledge in relation to overweight. The statistically significant association identified within private day and private boarding ($p=0.020$) schools underscores that adolescents possessing poor nutritional knowledge are more prone to being overweight, in contrast to individuals with limited nutritional knowledge, moderate nutritional knowledge, or high nutritional knowledge. These findings agree well with the study of Wang *et al*. [36] who reported that improving the dietary knowledge level of children and adolescents was associated with decreased risk of overweight and obesity.This finding accentuates the importance of promoting nutritional education as a potential strategy to mitigate overweight risks in these school settings.The period of adolescence is a critical phase encompassing both growth and the acquisition of knowledge, along with the development of healthy habits [37]. The promotion and acquisition of dietary knowledge hold particular significance for the well-being of children

UNDER PEER REVIEW

and adolescents [38]. Failing to comprehend dietary knowledge can adversely impact dietary behaviours and impede healthy growth. Earlier research has indicated an association between the level of dietary knowledge among children or adolescents and the occurrence of overweight.A Polish study comprising 1,515 children and adolescents aged 6–18 years demonstrated that an insufficient understanding of dietary matters was linked to a high percentage of obese or overweight children. This, in turn, could elevate the risk of cardiovascular diseases in adulthood [39].

The statistically significant associations unveiled within private day and private boarding schools for overweight highlight that adolescents with inadequate eating patterns face higher susceptibility to overweight compared to their counterparts with fair and moderate eating patterns. The findings agree with the study of Cutler *et al*. [40] who reported that higher adherence to dietary patterns loading heavily on vegetables was associated with lower risk of overweight/obese weight status in older and younger girls, whereas higher adherence to a 'sweet & salty snack food' pattern was associated with lower risk in older and younger boys. Yang *et al*. [41] also found significant statistical associations between dietary patterns and childhood overweight/obesity in Asian adolescents. Similarly, Mu *et al*. [42]reported that a prudent/healthy dietary pattern may decrease overweight/obesity risk, while a western/unhealthy dietary pattern may increase overweight/obesity risk. In a review of 30 cross-sectional studies, a diet rich in fruits and vegetables were inversely associated with BMI and a diet rich in meat and fat was positively associated with BMI [43].This emphasizes the role of dietary habits in contributing to overweight among students in these schools.

CONCLUSION

This study unveiled the prevalence rates of thinness, stunting, underweight, and overweight among adolescents as 42.2%, 34.8%, 28.7%, and 8.2%, respectively. Across different school types, public schools had a stunting prevalence of 31%, private day schools exhibited 32%, and private boarding schools showed the highest prevalence at 37%. The prevalence of overweight was absent in public schools, 16% in private day schools, and a noteworthy 9% in private boarding schools. Regarding thinness, public schools reported 35%, private day schools had 43%, and private boarding schools had the highest prevalence at 47%. Similar trends were seen in underweight, with public schools at 29%, private day schools at 23%, and private boarding schools at 29%.Significant differences in overweight and underweight were observed among the three school types, whereas no associations were found for stunting and thinness.This study highlights thinness and stunting as significant public health concerns

UNDER PEER REVIEW

(defined by WHO criteria). It underscores the complex links between poverty and stunting, especially in private boarding schools. Socio-economic factors impact thinness, highlighting adolescents from lower socio-economic backgrounds' vulnerability to underweight. Nutritional knowledge significantly influences overweight within private day and boarding schools, emphasizing its role. The study highlights the potential impact of nutritional knowledge on these conditions and the importance of eating patterns in underweight vulnerability.Collaborating with educational boards and health authorities, schools should introduce structured physical activity sessions and engaging extracurricular activities. This encourages regular exercise, maintaining healthy body weights, and reducing obesity risk among adolescents in the study area.

REFERENCES

[1] Kola-Raji BA, Balogun MR,Odugbemi TO. A comparativestudy of nutritional status of adolescents from selected private and public boardingsecondary schools in Ibadan, South Western Nigeria.*Journal of Tropical Medicine*, 2017;19:49-55.

[2] EndalewB, Muche M,Tadesse S. Assessment of food security situation in Ethiopia: a review. *Asian J Agric Res*., 2015; 9(2):55–68.

[3] Asmare AA,Agmas YA. Determinants of coexistence of stunting, wasting, and underweight among children under five years in the Gambia; evidence from 2019/20 Gambian demographic health survey: application of multivariate binary logistic regression model. *BMC Public Health*2022; 22: 1621. https://doi.org/10.1186/s12889-022-14000-3.

[4] BuhlA. Meeting nutritional needs through school feeding: a snapshot of four African nations," Report, University of Washington, Seattle, WA, USA, 2010.

[5] Fanzo F. The Nutrition Challenge in Sub-Saharan Africa, UNDP—Regional Bureau for Africa—Working Paper, New York, NY, USA, 2012.

[6] Christian P, Smith ER. "Adolescent under nutrition: global burden, physiology, and nutritional risks," *Annals of Nutrition and Metabolism*, 2018; 72(4): 316-328.

[7] World Health Organization. Essential nutrition actions; improving maternal, newborn, infant and young child health and nutrition, 2012.

[8] World Health Organization. Obesity and Overweight, WHO, Geneva, Switzerland, 2020, https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.

Comment [UP1]: This reference is a bit old. Nutrition is a fast evolving field and there is a lot of studies don, so its is easy to get latest references

Comment [UP2]: More than 10 years old

UNDER PEER REVIEW

[9] Rode S. Prevalence of Malnutrition among Adolescent: The Socio-Economic Issues and Challenges in Mumbai Metropolitan Region. *Global Journal of Human-Social Science*, 2015; 15(8):13-22.

[10] Abdulkarim AA, Otuneye AT, Ahmed P,ShattimaDR. Adolescent malnutrition: Prevalence and pattern in Abuja Municipal Area Council, Nigeria. *Nigerian Journal Pediatrics*, 2014; 41(2):99–103.

[11] Berhe K, Kidanemariam A, Gebremariam G,Gebremariam A. Prevalence and associated factors of adolescent undernutrition in Ethiopia: a systematic review and meta-analysis. *BMC Nutr*2019; 5: 49. https://doi.org/10.1186/s40795-019-0309-4

[12] Kotian SK, Kumar SG, Kotian SS. Prevalence and determinants of overweight and obesity among adolescent school children in Karnataka, India. *Indian Journal of Community Medicine*, 2010; 35: 176-178.

[13] Nwoke EA, Nkoro NV, Ibe SNO, Nwufo RC,Nwokoro. Comparative study of nutritional status of adolescents attending public and private secondary schools in Aba, Abia State, Nigeria. *European Journal of Biomedical and Pharmaceutical sciences*, 2017; 4(2): 37-45.

[14] Mijinyawa MS, Yusuf SM, Gezawa ID, Musa BM,Uloko AE. Prevalence of thinness among adolescents in Kano, Northwestern Nigeria. *Nigerian Journal of Basic and Clinical Sciences*, 2014; 11(1): 24-29.

[15] Ejike CE, Onyemairo JN,Onukogu IA. Co-existence of child and adolescent obesity and thinness in a city in Nigeria: Comparison of results derived from different reference standards. *Int J NutrPharmacolNeurol Dis*., 2013; 3: 276-281.

[16] Ene-Obong H, Ibeanu V, Onuoha N,Ejekwu A. Prevalence of overweight, obesity and thinness among urban school-aged children and adolescents in Southern Nigeria.*Food Nutrition Bulletin*,2012; 33(4): 242-250.

[17] Kirkwood BR, Sterne JA. (2003) Calculation of Required Sample Size. In Essential Medical Statistics, Blackwell Science, Oxford, 2003; 420-421.

[18] WHO. *Guideline: Implementing Effective Actions for Improving Adolescent Nutrition.* Geneva: World Health Organization (2018).

[19] Macías FY,Glasauer P. Food and Agriculture Organization of the United Nations. Guidelines for Assessing Nutrition-Related Knowledge, Attitudes and Practices. Food and Agriculture Organization of the United Nations, Rome, 2014. http://books.google.com/books?id=SJB40wU72scC

Comment [UP3]: Refer to newer edition

UNDER PEER REVIEW

[20] Esimai OA,Ojofeitimi EO. Nutrition and Health Status of Adolescents in a Private Secondary School in Port Harcourt.*Health Science Journal*, 2015; 9(5); 4.

[21] WHO. WHO discussion paper on adolescent nutrition: Nutrition in adolescence: Issues and challenges for the health sector 2005; www.who.int/childadolescent-health/new publication/ accessed 7/7/2018.

[22] Musa DI, Toriola AL, Monyeki MA,Lawal B. Prevalence of childhood and adolescent overweight and obesity in Benue State, Nigeria. *Trop Med Int Health*, 2012; 17:1369-1375

[23] Jonah CMP,Sambu WC, May JD. A comparative analysis of socioeconomic inequities in stunting: a case of three middle-income African countries. *Arch Public Health.*,2018; 76:77.

[24] Santosa A, NovandaArif E, Abdul Ghoni D. Effect of maternal and child factors on stunting: partial least squares structural equation modeling. ClinExpPediatr. 2022;65(2):90-97.

[25] FarooqR, Khan H, Khan, MA, Aslam M. Socioeconomic and demographic factors determining the underweight prevalence among children under-five in Punjab. *BMC Public Health*, 2020; 20: 1817. https://doi.org/10.1186/s12889-020-09675-5

[26] Galgamuwa LS, Iddawela D, Dharmaratne SD, Galgamuwa GLS. Nutritional status and correlated socio-economic factors among preschool and school children in plantation communities, Sri Lanka. *BMC Public Health*, 2017; 17: 377. https://doi.org/10.1186/s12889-017-4311-y

[27] Erpridawati DD, HubunganPengetahuanTentangGiziDengan Status GiziSiswa SMP Di KecamatanKerjoKabupatenKaranganyar. The relationship between knowledge about nutrition and nutritional status of junior high school students in Kerjo District, Karanganyar Regency)].[Thesis in Indonesian]. Surakarta: Faculty of Medicine, University of Muhammadiyah; 2012.

[28] Veronika AP, Puspitawati T,Fitriani A. Associations between nutrition knowledge, protein-energy intake and nutritional status of adolescents. *J Public Health Res*., 2021; 10(2):2239. doi: 10.4081/jphr.2021.2239.

[29] Heriyana N. [GambaranPengetahuanGizidan Status giziRemajaSiwa/I (Overview of nutritional knowledge and nutritional status of adolescent Siwa/I)].[Book in Indonesian]. Jambi: Faculty of Medicine and Health Sciences, Jambi University; 2013.

[30] Hoebel J, Waldhauer J, Blume M, Schienkiewitz A. Socioeconomic Status, Overweight, and Obesity in Childhood and Adolescence—Secular Trends From the Nationwide German Kiggs Study. *DtschArztebl Int*. 2022;119(49):839-845. doi: 10.3238/arztebl.m2022.0326.

[31] NCD Risk Factor Collaboration. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet*.,2017; 390:2627–2642.

[32] Chung A, Backholer K, Wong E, Palermo C, Keating C,Peeters A. Trends in child and adolescent obesity prevalence in economically advanced countries according to socioeconomic position: a systematic review. *Obes Rev*., 2016; 17:276–295.

[33] Chen J, Luo S, Liang X, Luo Y, Li R. The relationship between socioeconomic status and childhood overweight/obesity is linked through paternal obesity and dietary intake: a cross-sectional study in Chongqing, China. *Environ Health Prev Med.*, 2021; 26: 56. https://doi.org/10.1186/s12199-021-00973-x

[34] Liang Y, Qi Y. Developmental trajectories of adolescent overweight/obesity in China: socio-economic status correlates and health consequences. *Public Health*.,2020; 185:246–53. https://doi.org/10.1016/j.puhe.2020.05.013.

[35] Liu Y, Ma Y, Jiang N, Song S, Fan Q, Wen D. Interaction between Parental Education and Household Wealth on Children's Obesity Risk. *Int J Environ Res Public Health*.,2018; 15(8). https://doi.org/10.3390/ijerph15081754.

[36] Wang L, Zhuang J, Zhang H, Lu W. Association between dietary knowledge and overweight/obesity in Chinese children and adolescents aged 8–18 years: a cross-sectional study. *BMC Pediatr*, 2022; 22: 558.https://doi.org/10.1186/s12887-022-03618-2

[37] Bozbulut R, Ertaş-Öztürk Y, Döğer E, Bideci A,Köksal E. Increased Obesity Awareness and Adherence to Healthy Lifestyle-Diet Reduce Metabolic Syndrome Risk in Overweight Children. *J Am CollNutr*., 2020; 39:432–437.

[38] Weihrauch-Bluher S,Wiegand S. Risk Factors and Implications of Childhood Obesity. *CurrObes Rep*., 2018; 7:254–259.

[39] Stankiewicz M, Pieszko M, Sliwinska A, Malgorzewicz S, Wierucki L, Zdrojewski T.*et al*. Obesity and diet awareness among Polish children and adolescents in small towns and villages. *Cent Eur J Public Health*.,2014; 22:12–16.

[40] Cutler GJ, Flood A, Hannan PJ, Slavin JL,Neumark-Sztainer D. Association between major patterns of dietary intake and weight status in adolescents. *Br J Nutr*., 2012; 108(2):349-356. doi: 10.1017/S0007114511005435.

[41] Yang WY, Williams LT, Collins C, Siew SweeCW. The relationship between dietary patterns and overweight and obesity in children of Asian developing countries: A Systematic Review. *JBI Library of Systematic Reviews*, 2012; 10(58):4568-4599.

[42] Mu M, Xu LF, Hu D, Wu J, Bai MJ. Dietary Patterns and Overweight/Obesity: A Review Article. *Iran J Public Health*., 2017; 46(7):869-876.

[43] Bouchard-Mercier A, Paradis, AM, Godin G, et al. Associations between dietary patterns and ldl peak particle diameter: A cross-sectional study. *J Am CollNutr*, 2010; 29:630–637.

UNDER PEER REVIEW