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ORIGINAL ARTICLE

ANTHROPOMETRIC INDICES AND PREVALENCE OF IRON DEFICIENCY ANAEMIA AMONG SCHOOL CHILDREN IN DELTA STATE, NIGERIA: AN INTERVENTION STUDY

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Abstract. Background: *Anaemia being a condition of low levels of haemoglobin in the blood is a public health problem that affects approximately 1.3 to 2.2 billion people worldwide.* ***Aim:*** *This study aimed to determine the prevalence of anaemia and its association with anthropometric measurements among school children in Delta State, Nigeria.* ***Materials and Methods:*** *The study was a pretest-postest study of 201 primary school (age 6-12 years) and secondary school (age 13-19 years) respondents randomly selected from primary and secondary schools in the three senatorial districts of Delta State. Eighty-three (41.3%) males and 118 (58.7%) females with a mean age of 12.30 ± 3.14 years were enrolled in the study. The preventive intervention protocol consisted of a single dose of vitamin A, daily vitamin C, weekly vitamin E, and twice weekly ferrous sulphate supplements administered for five weeks. Sociodemographic and anthropometric data were collected. Assessment of anaemia was done by pretest-postest haemoglobin determination.* ***Results:*** *The prevalence of anaemia at baseline was 38.3% and 0% post-intervention. The prevalence of stunting, underweight, and thinness at baseline were 7.0%, 14.3 % and 15.0%, respectively, and post-intervention were 5.5%, 8.7% and 8.5%, respectively. The prevalence of overweight at baseline and post-intervention was 5.0%. The correlation between anaemia and underweight was r = -0.399, p = 0.005. The correlation between anaemia and body mass index was r = -0.234, p < 0.001.* ***Conclusion:*** *Nutritional deficiency could cause anaemia among school children. However, intake of antioxidant vitamins and iron might help to reduce the burden.*

Key words: *anaemia, haemoglobin, malnutrition, nutritional status, vitamins*

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INTRODUCTION

People of all ages, in both industrialized and developing nations, are affected by iron deficiency anaemia (IDA), one of the leading causes of sickness and mortality globally. Anaemia has been a public health problem worldwide from immemorial [1]. According to the World Health Organization (WHO), approximately 1.3 to 2.2 billion people are suffering from anaemia. Anaemia affects 305 million

(25.4%) school-age children [2]. Anaemia is a condition in which the blood is characterized by low levels of haemoglobin as indicated by low quality or quantity of red blood cells [3]. In school children, anaemia impairs cognitive development, school performance and physical growth [4]. According to Dreyfuss et al. [5] the direct causes of anaemia in the population are inadequate dietary iron intake, hookworm infestation and presence of malaria. Similarly, Mikki and Stigum stated that the main cause of anaemia is iron deficiency due to inadequate intake of bioavailable iron from the diet, and other causes include infectious diseases, deficiencies of micronutrients such as folate, vitamin B12, inherited conditions such as thalassaemia and environmental pollutants such as lead [6]. The prevalence of anaemia among school age children was 40% in developing countries, and it is classified as severe public health problem [7]. The problem is alarming in Sub-Saharan African Countries such as Kenya – 48.9%; Mali – 55.8% and Tanzania – 79.6% [7]. Nutritional deficiencies is an important cause of anaemia [3]. Low intake of iron-rich food is a risk factor for stunting [8]. Studies showed that 50% of deaths in children are attributed to malnutrition [9]. In order to reduce the burden of anaemia, daily supplementation was shown to provide the highest dose of iron of any non-parenteral approach, and is a commonly recommended clinical and public health strategy for the prevention and treatment of anaemia [10]. Anthropometric indices are indicators of the nutritional status, and they are based on physical body measurements such as height and weight (in relation to age and sex) [9]. Srivastava et al. [11] and Sumbele et al. [12] classified undernutrition in children into three categories such as stunting (low height-for-age), wasting (low weight-for-height or low BMI for age for children), and underweight (low weight-for-age). Stunting is defined as a low height-for-age for children (too short for his/her age) and it measures the past (chronic) child undernutrition [13]. Body mass index (BMI) is a calculation of a person's weight in relation to height [14]. If the BMI of an individual is under 18.5 kg/m^2, then the person is considered to be underweight. The normal BMI range is 18.5 to 25 kg/m^2. The BMI range for overweight people is 25.0 to 30 kg/m^2. A BMI of 30.0 kg/m^2 or higher is considered obese [14]. A child can be underweight for his/her age because the child is stunted, wasted or both [13]. Children with z-scores < -2 are said to be stunted, wasted or underweight and those < -3 are considered as severely stunted, wasted or underweight.

It is challenging to identify effective intervention techniques for teenagers due to the lack of information on their nutritional condition, particularly their iron status. Data on the nutritional status of young children under the age of five and older children who had obviously been neglected, including schoolchildren, were provided by the Nigeria Food Consumption and Nutrition Survey [15]. Since minors make up roughly 60% of Nigerian society, it is important to evaluate their nutritional health [1]. This would offer information on the nutritional status and make it easier to develop interventions to reduce nutritional deficiencies in this expanding group, regardless of whether they live in rural or urban regions. Limited studies had been conducted regarding iron deficiency anaemia in Delta State. This study therefore aimed at determining the anthropometric indices and the prevalence of iron deficiency among school children in Delta State, Nigeria. This may add to the body of knowledge and available epidemiological data for school children in Nigeria and other part of the world where there is prevalence of iron deficiency among school children.

MATERIALS AND METHODS

The study was a pretest-postest study of 201 primary school (age 6-12 years) and secondary school (age 13-19 years) respondents randomly selected using purposive and multistage sampling from three public primary and three public secondary schools in the three senatorial districts of Delta State. The selected sample comprises of 67 primary schools and secondary school children each from Warri South LGA (Delta South), Ethiope East LGA (Delta Central) and Ukwuani LGA (Delta North). Baseline and post intervention sociodemographic information were collected using self-administered questionnaires.

Anthropometry assessment of nutritional status

Based on the age, body weight and height, indices such as height-for-age and weight-for-height (body mass index) were used to assess nutritional status [16]. Weights were determined using a portable digital scale to the nearest 0.1 kg with individuals wearing minimal clothing. Height measurements were taken using a calibrated, fixed-base, portable wooden scale to the closest 0.1 cm. Each measurement was carried out three times. All the data were transformed and expressed in Z-scores.

The children were classified using three categories: 'underweight' (low weight-for-age for ages 5-10 years), 'stunting' (low height-for-age for ages 5-19 years) and body mass index (BMI). BMI was classified into thinness (wasting), and overweight or obese.

Height for age (stunted), BMI, and weight for age (underweight) for each child were calculated and compared with WHO reference values as standard [17]. Cut-off point values between ± 2 SD were considered normal [18]. Children with z-scores < -2.00 were said to be underweight, stunted, or thin.

Collection of blood samples

Venous blood (2ml) was collected from each respondent into an EDTA container with disposable sterile syringe after cleaning the skin surface using sterile cotton wool (immersed in 70% alcohol).

Determination of hemoglobin (Hb) concentration

The cyanmethemoglobin method designated by Eiler [19] was adopted for determination of haemoglobin. Two millilitres (2 ml) of haemoglobin reagent were dispensed in test tubes labelled blank, control and test. Ten microliters (10 μl) of blood samples were placed into respective test-tubes and mixed. This was allowed to stand for 3 minutes at room temperature. Two millilitres of standard reagent (contained 60 mg/dl methemoglobin dissolved in cyanmethemoglobin reagent) was placed in the test tube labelled standard. The spectrophotometer was set at 500 nm and then zero with the blank. The absorbance of all tubes were read and recorded.

Assessment of anaemia

Description criteria for iron deficiency anaemia was defined as a haemoglobin level of less than 120 g/l for male and female children between 6-14 years of age and females over 15 years of age, and less than 130 g/l in boys over 15 years of age according to the WHO definition of anaemia [20].

Intervention therapy

Vitamin A (batch No. 4793539) was supplied by Nutrition International, Canada. Vitamin C (NAFDAC REG NO. 04-1453) was supplied by Emzor Pharmaceutical, Nigeria. Vitamin E (NAFDAC REG NO. A7-4481) was supplied by Healthpath Nature, Nigeria. Ferrous sulphate with NAFDAC REG NO: 04-0371 was manufactured by Leady-Pharama industries Ltd, Ogun State, Nigeria. Each sugar coated tablet of ferrous sulphate contains: dried ferrous sulphate B.P 200 mg (equivalent to 65 mg ferrous iron). The vitamins A, C, E and ferrous sulphate were purchased from a pharmaceutical store in Warri, Delta State. Nigeria. Single dose of 200,000 IU vitamin A was administered. Daily 100 mg of vitamin C, weekly 1000 IU of vitamin E and twice weekly 200 mg of ferrous sulphate supplements were administered for five (5) weeks.

Data analysis

Pretest and post-test data collected were analysed using statistical package for social science (SPSS) version. Level of significance was determined at $p < 0.05$ and the power level has been set at 80%. This study was conducted in conformity with the principles established in the Declaration of Helsinki, and all procedures involving human subjects or patients were approved by the Central Hospital Ethics Committee in Warri, Delta State with protocol number: CHW/ECC VOL 1/243 (approved 16, August, 2021) and Eku Government Hospital, Eku, Delta State with reference number: EBGH/AD/112/REM/V/101 (approved 13, September, 2021). Permission to gain access to primary and secondary schools in the various LGA were obtained from the Local Education Authority (LEA) and Chief Inspector Education (CIE), respectively. Written informed consent was obtained from parents or caregivers of the respondents and assent from each respondent child was sought as well.

RESULTS

Table 1 illustrates the socio-demographic features of the respondents. The results show that 83 (41.3%) of the respondents were male and 118 (58.7%) were female with mean age of 12.30± 3.14 years. A total of 72 respondents (35.8%) were of primary school age (6-12 years), while 129 (64.2%) were of secondary school age (13-19 years). The majority of parental level of education and employment status were secondary schooling (n = 87, 43.3%) and self-employed (n = 139, 69.2%), respectively. The majority of parents (n = 81, 40.3%) received income of less than N30, 000 per month.

Sociodemographic characteristics of anaemia are shown in Table 2. The prevalence of anaemia at baseline was 38.3% (77) and 0.0% post intervention. A total of 27 (13.4%) male and 50 (24.9%) female participants had anaemia. Similarly, 27 (13.4%) of primary and 50 (24.9%) of secondary school respondents had anaemia. Overall, the majority of respondents, 36 (17.9%) and 55 (27.4%) of parents (with secondary school education level and self-employed, respectively), were anaemic. A total of 33 (16.4%) parent respondents with monthly income between N30, 000 and N50, 000 had anaemia. All sociodemographic variables were not significantly associated with anaemia at baseline. Normal haemoglobin level was observed in all anaemic respondents (100%) after intervention.

Table 3 illustrates stunting among respondents. The overall prevalence of stunting was 7.0% and 5.5% for baseline and post intervention, respectively. Males and females have equal prevalence of 3.5%. The secondary age group (13-19 years) had the highest prevalence (6.0%). Respondents whose parents were self-employed with income per month

<N 30,000 had prevalence of 7.0% and 4.0%, respectively. Apart from the educational status of the respondents' parent that was significantly associated with stunting post intervention (p = 0.048, χ^2 = 15.830), other sociodemographic variables were not associated with stunting.

Table 1. Socio-demographic characteristics of the respondents

Variable	Frequency (n = 201)	Percentage (%)
Gender		
Male	83	41.3
Female	118	58.7
School Age Group		
Primary School age (6-11 Years)	72	35.8
Secondary School age (12-17 Years)	129	64.2
Parent Educational Status		
No Schooling	11	5.5
Primary Schooling	29	19.9
Secondary Schooling	87	43.3
Tertiary Schooling	72	35.8
Employment Status of Parent		
Unemployed	16	8.0
Employed	29	14.4
Self Employed	139	69.2
No Response	17	8.4
Income Per Month of Parent		
< 30,000	81	40.3
30,000-50,000	72	35.8
51,000-100,000	26	12.9
> 100,000	20	10.0
No Response	2	1.0

Sociodemographic characteristics of underweight respondents are shown in Table 4. The overall prevalence of underweight at baseline and post-intervention were 14.3% and 8.7%, respectively. Only males were underweighted with a prevalence of 14.3%. The majority of respondent's parents with primary school level of education were underweighted with prevalence of 8.2% and 8.7% at baseline and post-intervention. Educational status was associated with underweight at baseline (p = 0.030, χ^2 = 10.940) and post-intervention (p = 0.003, χ^2 = 11.536). Respondents whose parents were self-employed with income per month of <N 30,000 had prevalence of underweight of 14.3% and 10.2%, respectively. Income was significantly associated with underweight at baseline (p = 0.027, χ^2 = 11.716) and post-intervention (p = 0.015, χ2 = 8.303). Association between underweight and gender, and employment status were not statistically significant. Also, association between underweight at baseline and intervention were not statistically significant (p = 0.96, t = -1.701). Mean BMI value at baseline and post-intervention was 17.4318 kg/m^2 ± 3.45551 S.D and 17.6224 kg/m^2 ± 3.20610 S.D, respectively. The association between BMI value at baseline and BMI value post-intervention was statistically significant (p = 0.017, t = -2.413).

The body mass index (BMI) among respondents is illustrated in Table 5, thinness at baseline and post-intervention had overall prevalence of 15.0% and 8.5%, respectively. The prevalence of overweight at baseline and post-intervention was 5.0%. Males (9.5%) were thinner than females (5.5%). Females (3.5%) were more overweight than males (1.5%). Gender was significantly associated with BMI baseline (p = 0.014, χ^2 = 10.361), but was not significantly associated with post-intervention BMI (p = 0.092, χ^2 = 6.364). Respondents in secondary school age group whose parents had tertiary level of education and self-employed were thinner with prevalence of 9.0%, 8.5% and 9.5%, respectively.

DISCUSSION

Anaemia, a leading factor in infant and maternal mortality in the majority of low- and middle-income countries, is also linked to a higher risk of low birth weight, cognitive impairment, increased susceptibility to infection, and delayed physical and mental development, as well as a lower capacity for employment [7]. In this study, 83 (41.3%) of the respondents were male and 118 (58.7%) were female with an overall mean age of 12.30 ± 3.14 years. Respondents in the primary school age group (6-12 years) were 72 (35.8%) and those in the secondary school age group (13-19 years) were 129 (64.2%). Similarly, 87 (43.3%) of the respondents parents had a secondary school level of education while 139 (69.2%) of the respondents parents were self-employed. Furthermore, the study shows that 81 (40.3%) of the respondents parents received income of less than N 30, 000 only per month (Table 1). Since anaemia is linked to morbidity and death, particularly in more vulnerable groups like pre-schoolers and pregnant women, anaemia prevalence data continue to be an important public health indicator [2]. In this study prevalence of anaemia, stunting, underweight and thinness at baseline were 38.3%, 7.0%, 14.3% and 15.0% respectively, and post-intervention prevalence were 0%, 5.5%, 8.7% and 8.5%, respectively (Table 2, 3, 4 and 5). Anaemia prevalence cut-off values for public health significance indicator show that value

Table 2. Sociodemographic characteristics of anaemia among respondents

	Anaemia Baseline n = 201 (%)			Anaemia Intervention n = 201 (%)	
Variables	Normal	Anaemic	P-Value+	Normal	P-Value*
Overall prevalence	61.7 (124)	38.3 (77)		100 (201)	
Gender			0.185		
Male	56 (27.9)	27 (13.4)		83 (41.3)	
Female	68 (33.8)	50 (24.9)		118 (58.7)	
Age Group			0.881		
Primary (6-12 years)	45 (22.4)	27 (13.4)		72 (35.8)	
Secondary (13-19 years)	79 (39.3)	50 (24.9)		129 (64.2)	
Educational Status of Parent			0.196		
No Schooling	6 (3)	5 (2.5)		11 (5.5)	
Primary School	23 (11.4)	6 (3)		29 (14.5)	
Secondary School	51 (25.4)	36 (17.9)		87 (43.3)	
Tertiary School	42 (20.9)	30 (14.9)		72 (35.8)	
No Response	2 (1.0)	0 (0)		2 (1.0)	
Employment Status of Parent			0.771		
Unemployed	11 (5.5)	5 (2.5)		16 (8.0)	
Employed	17 (8.5)	12 (6.0)		29 (14.5)	
Self-Employed	84 (41.8)	55 (27.4)		139 (69.2)	
No Response	12 (6.0)	5 (2.5)		17 (8.5)	
Income per Month			0.253#		
< 30,000	55 (27.4)	26 (12.9)		81 (40.3)	
30,000-50,000	39 (19.4)	33 (16.4)		72 (35.8)	
51,000-100,000	14 (7.0)	12 (6.0)		26 (13.0)	
> 100,000	14 (7.0)	6 (3.0)		20 (10.0)	
No Response	2 (1.0)	0 (0)		2 (1.0)	

+Chi Square test, #Fisher's exact test, * No statistics are computed because anaemia intervention is a constant

Table 3. Sociodemographic characteristics by stunting among respondents

	Stunting Baseline n = 201 (%)			Stunting Intervention n = 201 (%)		
Variables	Yes	No	P-Value+	Yes	No	P-Value+
Overall Prevalence	14 (7.0)	187 (93.0)		11 (5.5)	190 (94.5)	
Gender			0.550			0.324
Male	7 (3.5)	76 (37.8)		6 (3)	77 (38.3)	
Female	7 (3.5)	111 (55.2)		5 (2.5)	113 (56.2)	
Age Group			0.172			0.574
primary (6-12 years)	2 (1.0)	70 (34.8)		2 (1.0)	70 (34.8)	
secondary (13-19 years)	12 (6.0)	117 (58.2)		9 (4.5)	120 (59.7)	
Educational Status of Parent			0.190			0.048
No Schooling	0 (0)	11 (5.5)		0 (0)	11 (5.5)	
Primary School	5 (2.5)	24 (11.9)		4 (2.0)	25 (12.4)	
Secondary School	7 (3.5)	80 (39.8)		7 (3.5)	80 (39.8)	
Tertiary School	2 (1.0)	70 (34.8)		0 (0)	72 (35.8)	
No Response	0 (0)	2 (1.0)		0 (0)	2 (1.0)	
Employment Status of Parent			0.383			0.538
Unemployed	0 (0)	16 (8.0)		0 (0)	16 (8.0)	

Employed	0 (0)	29 (14.4)		0 (0)	29 (14.4)	
Self-Employed	14 (7)	125 (62.2)		11 (5.5)	128 (63.7)	
No Response	0 (0)	17 (8.5)		0 (0)	17 (8.5)	
Income per Month			0.345			0.252
< 30,000	8 (4.0)	73 (36.3)		7 (3.5)	74 (36.8)	
30,000-50,000	4 (2.0)	68 (33.8)		2 (1.0)	70 (34.8)	
51,000-100,000	2 (1.0)	24 (12.0)		2 (1.0)	24 (12.0)	
> 100,000	0 (0)	20 (10)		0 (0)	20 (10)	
No Response	0 (0)	2 (1.0)		0 (0)	2 (1.0)	

+Fisher's exact test

Table 4. Sociodemographic characteristics of underweight among respondents

	Underweight Baseline n = 49 (%)			Underweight Intervention n = 46 (%)		
Variables	Yes	No	P-Value+	Yes	No	P-Value+
Overall Prevalence	29 (14.3)	172 (85.7)		17 (8.7)	184 (91.3)	
Gender			0.121			0.144
Male	7 (14.3)	24 (49.0)		4 (8.7)	24 (52.2)	
Female	0 (0)	18 (36.7)		0 (0)	18 (39.1)	
Age Group			a			a
primary (6-10 years)	7 (14.3)	42 (85.7)		4 (8.7)	42 (91.3)	
secondary (13-19 years)	-	-		-	-	
Educational Status of Parent			0.030			0.003
No Schooling	1 (2.0)	4 (8.2)		0 (0)	5 (10.9)	
Primary School	4 (8.2)	8 (16.3)		4 (8.7)	5 (10.9)	
Secondary School	0 (0)	5 (10.2)		0 (0)	5 (10.9)	
Tertiary School	2 (4.1)	25 (51.0)		0 (0)	27 (58.7)	
Employment Status of Parent			0.746			0.752
Unemployed	0 (0)	2 (4.1)		0 (0)	6 (13.0)	
Employed	0 (0)	6 (12.2)		4 (8.7)	27 (58.7)	
Self-Employed	7 (14.3)	25 (51.0)		0 (0)	9 (19.6)	
No Response	0 (0)	9 (18.4)				
Income per Month			0.027			0.015
< 30,000	5 (10.2)	10 (20.4)		4 (8.7)	9 (19.6)	
30,000-50,000	2 (4.1)	22 (44.9)		0 (0)	23 (50)	
51,000-100,000	0 (0)	8 (16.3)		0 (0)	8 (17.4)	
> 100,000	0 (0)	2 (4.1)		0 (0)	2 (4.3)	

+Fisher's exact test, aNo statistics are computed because underweight was a constant

< 5% shows no public health problem, 5-19% displays mild public health problem, 20-39% demonstrate moderate public health problem, and ≥ 40% illustrates severe public health problem [2,7]. In this investigation, the prevalence of anaemia may be classified as moderate public health problem. The result of this study is similar to the prevalence of anaemia among primary school children in Lagos, Nigeria which was reported to be 38.1%, [21] and that of the study done by Assefa et al. [7] among school children in Ethiopia whose prevalence was 37.6%, and 38% in Ghana [22]. The result obtained in this work was higher than the prevalence of anaemia in school children of which 5% was reported in Norway [23] and the United States [24], 3% in Canada,[10] and 11.6% in Saudi Arabia [25]. On the contrary, it is lower than the prevalence of 72%, [26] and 69%, [27] among children in India and Jordon, respectively, due to the report of high prevalence of

Table 5. Sociodemographic characteristics by body mass index (BMI) among respondents

BMI Baseline n = 201 (%)					BMI Intervention n = 201 (%)			
Variables	Thinness	Normal	Over-weight	P-Value+	Thinness	Normal	Over-weight	P-Value+
Overall Prevalence	30(15.0)	161 (80.1)	10 (5.0)		17 (8.5)	174 (86.5)	10 (5.0)	
Gender				0.014				0.092
Male	19 (9.5)	61 (30.3)	3 (1.5)		9 (4.5)	71 (35.3)	3 (1.5)	
Female	11 (5.5)	100 (49.8)	7 (3.5)		8 (4.0)	103 (51.2)	7 (3.5)	
Age Group				0.600				0.418
Primary (6-12 years)	12 (6.0)	55 (27.4)	5 (2.5)		8 (4.0)	59 (29.4)	5 (2.5)	
Secondary (13-19 years)	18 (9.0)	106 (52.7)	5 (2.5)		9 (4.5)	115 (57.2)	5 (2.5)	
Educational Status of Parent				0.270				0.146
No Schooling	2 (1.0)	9 (4.5)	0 (0)		3 (1.5)	8 (4.0)	0 (0)	
Primary School	4 (2.0)	23 (11.4)	2 (1.0)		2 (1.0)	25 (12.4)	2 (1.0)	
Secondary School	7 (3.5)	77 (38.3)	3 (1.5)		6 (3.0)	78 (38.8)	3 (1.5)	
Tertiary School	17 (8.5)	50 (24.9)	5 (2.5)		6 (3.0)	61 (30.3)	5 (2.5)	
No Response	0 (0)	2 (1.0)	0 (0)		0 (0)	2 (1.0)	0 (0)	
Employment Status of Parent				0.025				< 0.001
Unemployed	0 (0)	12 (6.0)	1 (0.5)		3 (1.5)	12 (6.0)	1 (0.5)	
Employed	1 (0.5)	26 (12.9)	2 (1.0)		2 (1.0)	25 (12.4)	2 (1.0)	
Self-Employed	19 (9.5)	113 (56.2)	7 (3.5)		7 (3.5)	125 (62.2)	7 (3.5)	
No Response	7 (3.5)	10 (5.0)	0 (0)		5 (2.5)	12 (6.0)	0 (0)	
Income per Month				0.168				0.893
< 30,000	10 (5.0)	66 (32.8)	5 (2.5)		7 (3.5)	69 (34.3)	5 (2.5)	
30,000-50,000	10 (5.0)	59 (29.4)	3 (1.5)		7 (3.5)	62 (30.8)	3 (1.5)	
51,000-100,000	2 (1.0)	22 (10.9)	2 (1.0)		3 (1.5)	21 (10.4)	2 (1.0)	
> 100,000	8 (4.0)	12 (6.0)	0 (0)		0 (0)	20 (10.0)	0 (0)	
No Response	0 (0)	2 (1.0)	0 (0)		0 (0)	2 (1.0)	0 (0)	

+Fisher's exact test

infectious diseases and the low bioavailability of iron caused by the nature of their diet which is low in heme iron [28], as well as 79.6% in Tanzania, [29] and 82.6% in Abia State, Nigeria [30].

Combinations of vitamins, such as vitamin A, which can improve haematological indicators and increase the effectiveness of iron supplementation, can all help patients with anaemia due to iron deficiency and boosts antioxidant status. [31, 32]. Vitamin E is a potent fat-soluble vitamin with numerous antioxidant and non-antioxidant properties that help to stabilize cellular membranes. Vitamin C increases the absorption of dietary iron. Anaemia is caused by the body's diminished ability to produce haemoglobin and circulating erythrocytes as a result of depleted iron reserves. However, taking an iron supplement like ferrous sulphate may help to reduce anaemia due to iron deficiency [33].

There was a strong significant negative correlation between anaemia and underweight ($r = -0.399$, $p = 0.005$), and also between anaemia and BMI ($r = -0.234$, $p < 0.001$). This result ascertain the report that nutritional deficiencies is an important cause of anaemia in the world and in sub-Saharan Africa.[3]. In study done by Ifebajo et al. [34] haemoglobin level were found to be positively correlated with their BMI ($r = 0.289$, $P > 0.05$). This study also showed that iron supplementation reduced anaemia from 38.3% to 0%. Similarly, in another study, iron supplementation was shown to reduce the risk of anaemia by 50% and the risk of iron deficiency by 79%. [10]. The prevalence of anaemia was lower in males (27%) than in females (50%). This might be because menstruating females lose more iron and females over the age of 36 tend to eat less calories [35]. Numerous studies also demonstrated the advantages of iron supplementation for women who were iron deficient in order to enhance physical performance [36, 37].

This study is in consonance with the study done in Alexandria, Egypt among adolescents males and females having prevalence of 26.4% and 28.8%, [38] as well as 24.2% (males) and 33.0% (females) in Lagos, Nigeria [34]. This is contrary to the report in a survey conducted in 2009 which showed that males were more anaemic than females in which prevalence of anaemia for males and females were 35.6% and 26.0%, respectively [39]. An iron shortage can also be caused by inadequate dietary intake, increased systemic iron requirements, such as during pregnancy, and impaired iron absorption, such as in celiac disease [40]. Due to the increased bioavailability of iron in breast milk compared to cow's milk, an iron shortage can also be caused by insufficient iron consumption, poor absorption, or blood loss [41,42].

In this study, the overall prevalence (Table 3-5) of stunting, underweight and thinness or wasting (BMI) were 7.0%, 14.3% and 15.0%, respectively. This study revealed that stunted children had higher chances of developing anaemia than normal children. The mechanism of insulin-like growth factor 1 (IGF1), transferrin (Tf), and changes in ghrelin and insulin hormone response may help to explain it. These factors may have contributed to the decrease in growth hormone (GH) and IGF-1 secretion [43]. The current result is consistent with other research carried out elsewhere [44]. The most likely cause of both stunting and childhood anaemia is malnutrition, which shares a common causal pathway with inadequate dietary diversity and feeding children four times each day. The second rationale is that nutritional deficiencies may lower immunity, increase the risk of recurring infections, and hence limit iron storage. Low nutritional status is linked to lowered immunity, therefore infections and intestinal infestations have additive effects of micronutrient deficiencies for inducing anaemia in addition to the deficiency of micronutrients necessary for erythropoiesis [45]. A lack of micronutrients including folic acid, vitamin B12, and iron, which are necessary for the synthesis of haemoglobin and DNA during the creation of erythrocytes, makes anaemia more likely to develop in malnourished children [13]

This result was similar to the result of the study done among school children in Saudi Arabia in which stunting, underweight and thinness or wasting affected 12.2%, 14.2% and 13.8%, respectively [25]. The results in this study were higher than the results reported in the study by Tsuyuoka et al. in which prevalence of stunting, underweight and thinness (BMI) were 5.4%, 4.4% and 2.5%, respectively [46] Stunting in this study was 7% in both males and females, and it was lower than the result shown among school children in Lagos, Nigeria with prevalence of 12.7% and 18.2% for males and females, respectively [34] Also, this study showed that males were more underweight (7.0%) compared to females (0%) (Table 4) unlike the study of Ifebayo et al.[34] in which 27.3% of the female and 23.0% of the male were underweight. This might be because boys need more calories than girls for growth and development, making them more susceptible to malnutrition. [46].

The degree of parental education has previously been noted as a crucial variable predicting result in children's health [25]. Children with sickle cell disease living in low-resource settings are more likely to have severe anaemia when the head of the family has a poor educational standing, which serves as a proxy for poverty [25]. This study showed that as parental education rose, the prevalence of iron deficiency anaemia decreased. With regard to the educational level of the parents, this was insignificant. On the contrary, study done by Tayel and Ezzat [37] showed that anaemia was significantly associated with low parental educational level. The majority of parent respondents with primary school level of education were underweighted with prevalence of 8.2% and 8.7% at baseline and post-intervention, respectively (Table 5). This result was in consonance with the study conducted in Indonesia which showed that the students who have healthy weight with mother who have middle and high educational level have higher prevalence than those who have mother with lower educational level [46].

CONCLUSION

This study has ascertained that anaemia, stunting, underweight and wasting are significant public health problems among primary and secondary school children in Delta State. According to the WHO/UNICEF classification, anaemia prevalence in this study is categorized as a moderate public health issue. Although, females were more anaemic than males, males were thinner than females. The majority of children whose parent had primary school level of education were underweighted.

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