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Malnutrition and the Intelligence Quotient of Primary School Pupils in Jos, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors IAA, CJ, SNO and HA designed the study. Authors IAA and CJ designed the protocol. Authors IAA, AOE and MFB contributed to the statistical analysis, the literature review and the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Background: Nigeria has one of the highest burdens of childhood malnutrition, thus, a large number of children are at risk of its far-reaching long term consequences. Although, the detrimental effect of malnutrition on the intellectual capability of children has been well documented, there is still a growing need to assess the extent of this cognitive deficit in our environment. This is with a view to providing a data base that may serve as an impetus for a more proactive attitude, geared towards the prevention of childhood malnutrition in Nigeria, and the West African sub-region in general.
Aim: This study was set up to assess the relationship between the nutritional status of school children and their cognitive function.
Study Design: This was a cross-sectional descriptive study carried out among 407 randomly selected primary school pupils between the ages of six to 12 years in Jos city, Plateau State, Nigeria.
Methodology: A self-administered questionnaire was used to obtain socio-demographic details

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from the parents. Nutritional status was determined by anthropometric methods, while IQ was assessed with Raven's Standard Progressive Matrices (RSPM).
Results: The overall prevalence of malnutrition was 35.4%, with thinness, underweight, stunting, overweight, and obesity accounting for 11.1%, 10.7%, 10.1%, 2.9% and 0.5% respectively. Optimal IQ was recorded among 37.3%, while suboptimal IQ was documented among 62.7% of the pupils. The prevalence of suboptimal intelligence was significantly higher in the stunted and underweight pupils; 83% of the stunted and 80% of the underweight pupils had suboptimal intelligence (p=.005, p=.014 respectively). Furthermore, low socio-economic class was observed to be associated with increased prevalence of suboptimal intelligence among the undernourished children (p<0.001).
Conclusion: The high prevalence of under-nutrition, its association with suboptimal intelligence, as well as the detrimental role of low socio-economic class have been demonstrated in this study. More proactive measures, which should include health education and poverty alleviation, are required towards preventing childhood malnutrition. This will allow children attain their maximum intellectual potentials.

Keywords: Malnutrition; intelligence; school-age; association.

1. INTRODUCTION

Malnutrition can be described as a state of in-balance between nutrient supply and use, causing measurable adverse effects on tissue function [1]. It is broadly categorised into under-nutrition and over-nutrition [2]. Under-nutrition refers to the inadequate intake of nutrients necessary for the optimal mental and physical development, while over-nutrition is the consumption of nutrients in excess of what the body can effectively metabolize [2].

Under-nutrition, which may manifest as stunted growth, underweight, thinness or with varying forms of micronutrient deficiency, is the more common variant of malnutrition in developing countries [3]. In fact, current evidence shows that about 25% of the under-fives in sub-Saharan Africa are undernourished [3].In Nigeria, the prevalence of childhood under-nutrition, especially among under-fives, varies across the different geo-political zones. It ranges from 53% in the North West, to 22% in the South East [4].In Jos, North Central region of Nigeria, the prevalence is 37% [4].Among the school-age group, the prevalence of chronic under-nutrition also differs across the country; It ranges from 52.7% in North Central Nigeria [5], to 0.4% in the South Eastern part of the country [6].

Over the years, the existence of a link between nutrition and the development of a child's brain has been described by researchers [7-12]. It has been shown that cognition, which refers to the method and ways through which individuals acquire and integrate knowledge, is positively influenced by adequate nutrition, especially in the first 2 years of life, when over half of the adult brain mass and cognitive ability is attained [9]. Hence, it can be implied that under-nutrition in early life may impact negatively on the future cognitive potentials.

Intelligence quotient (IQ) is the outcome of a standardized test, designed to assess the cognitive or intellectual capability of an individual [13]. The test takes the age of the subjects into account, as individuals are graded relative to the population at their developmental level [13]. Among the testing tools for IQ determination that exist, Ravens Standard Progressive Matrices (RSPM) has been shown to be culture and language friendly, as it has been found to be useful across different ethnic and geographical backgrounds. Indeed, this test has been earlier standardized and validated for use among Nigerian children [14].

Nutritional status and intelligence are influenced by several factors that include (but not limited to) parents' socio-economic status, family type, parents' literacy level, and family size [4,9,11,12,15]. The impact of these variables on nutrition, and consequently on the child's intelligence remains to be clearly defined in Northern Nigeria. The identification of these potential determinants of nutritional status and hence, the intelligence of children, will help policy makers to develop programmes that can mitigate the impact of under-nutrition on their IQ.

This study thus aimed at describing the relationship between the nutritional status and the IQ of school-age children, as well as identifying the socio-demographic parameters that influence such relationship.

2. MATERIALS AND METHODS

2.1 Study Area

This study was conducted in Jos, the capital city of Plateau State, Nigeria.

2.2 Study Design

This was a descriptive cross-sectional study that involved 10 primary schools, scattered across Jos metropolis.

2.3 Ethical Consideration

Ethical approval was obtained from the Jos University Teaching Hospital research and ethical committee. Approval was sought and obtained from the Local Government Education Authority. Written informed consent was obtained from the parents/guardians, while assent was obtained from the pupils. The study was at no financial cost to the participants.

2.4 Inclusion Criteria

Healthy school children between the ages of six to twelve years, whose parents gave consent to participate in the study.

2.5 Exclusion Criteria

Children with neurological diseases, as well as any chronically or acutely ill child.

2.6 Sample Size

The minimum sample size was determined using Cochran's sample size formula for categorical data at alpha level of 0.05 and power of 95% [16]. Therefore, the minimum sample size was 382.

2.7 Sampling Technique

Five public and 5 private schools in Jos metropolis were selected randomly. The number of pupils recruited from each school was based on proportionate sampling.

At each school, the pupils were recruited from all the six grades. The number recruited from each grade was also determined by the proportionate sampling method.

A list of all the pupils in each grade was subsequently made and the pupils that took part in the study were eventually selected by using systematic sampling technique. The sampling interval was determined by dividing the total number of pupils in each grade by the number of pupils to be selected from the grade.

2.8 Data Collection and Study Protocol

A pilot study was carried out using 10% of the targeted sample size, in a school that was not involved in the main study. This allowed the research team to pre-test the research tools and also to get properly acquainted with the study protocol. No major changes were made to the research materials following the pilot study.

Questionnaires were given to the pupils to take home to their parents for completion, and these were returned to the schools on the following day. The questionnaires obtained information on medical and social indices, such as family size, parental educational and socio-economic status (using the system suggested by Olusanya et al. [17]).

The procedure for answering the RSPM was carefully explained with a blown up image of the first 2 pages of the booklet, as stated in the manual [18]. The pupils started answering the questions at the same time and the research assistants were on-hand to attend to those that still needed clarification.

Height was measured using a stadiometer to the nearest 0.1 cm and the weight in kilogram was measured and read to the nearest 0.1 kg [19]. The axillary temperature was measured using a clinical thermometer. Pallor and hydration status were also assessed. The study was conducted between the hours of 7 a.m and 9 a.m in the various schools.

2.9 Data Analysis

Out of the 420 pupils recruited, 407 were considered in the final analysis. The remaining 13 were exempted because they either did not fill the questionnaires properly or failed to complete the IQ tests. All data generated were processed and analysed using the EPI info statistical software 3.5.4.

Nutritional assessment software (Nutstat v 3.5.1: WHO/NCHS growth references) was used to determine the weight-for-age, body mass index and height-for-age z-scores (WAZ, BMIZ and HAZ, respectively). The reference z-scores for stunting, underweight and thinness were: HAZ <

-2SD, WAZ < -2SD, BMIZ < -2SD while the reference z-score for overweight and obesity were BMIZ > +2SD and >+3SD respectively. The intelligence test was marked and the scores generated were expressed as grades (I-V), according to standardized scoring scheme. These were subsequently categorised into optimal (Grades I-III) and suboptimal intelligence (Grades IV and V).

Students' t-test was used to establish the association between continuous variables while the chi-square test was used to establish the association between categorical variables. Logistic regression analysis was used to determine the association between the independent and the dependent variables.

The strength of association was estimated using odds ratios (OR) and the corresponding 95% confidence intervals (CI). The level of significance for the chi square test and students' t-test was <0.05.

3. RESULTS

3.1 Socio-demographic Characteristics

Table 1 shows the demographic characteristics of the subjects. A total of 407 pupils that fulfilled the recruitment criteria eventually completed the study. The mean age of the subjects was 9.3±1.8 years, and the male to female (M:F) ratio was 1:1.1. About 56% of the pupils attended private schools.

3.2 Socio-economic Characteristics and School Type

The parents' socio-economic and educational characteristics based on school type are represented in Table 2. Seventy-one percent of the fathers and 63% of the mothers had at least primary level of education. More pupils in privately-owned schools had educated fathers (77%), compared to government owned schools (67%); this difference was significant (p< 0.001).

The majority of the subjects (52%) belonged to the lower socio-economic class and, 62% of the subjects in the lower class were enrolled in public schools. In contrast, 92% of the subjects in the upper socio-economic class were enrolled in privately owned schools. These observations were significant (p < 0.001).

3.3 Nutritional Status

As shown in Table 3, the nutritional status z-scores did not differ significantly between the male and female pupils. In addition, pupils in public schools were significantly lighter (WAZ) and shorter (HAZ) for their ages, compared to their peers in private schools.

3.4 Prevalence of Malnutrition Based on Age, Gender and School Type

While the overall prevalence of malnutrition was 35.4%, overweight malnutrition accounted for 2.9%, while 0.5% of the subjects were obese (See Table 4). There was a higher prevalence of overweight among male subjects, though this was not significant (p=0.576) (See Table 5). It is also noteworthy, that most (83%) of the overweight pupils and the only 2 obese pupils attended private schools (See Table 6).

With regard to under-nutrition, the prevalence of stunting, underweight and thinness were 10.1%, 10.7% and 11.1% respectively (See Table 4). In addition, males had a higher prevalence of

Table 1. Characteristics of subjects by sex

Variable	Male N=193 (%)	Female N=214 (%)	Total N=407 (%)	x^2	*p*-value
School					
Public	86(48.3)	92(51.7)	178(43.7)		
Private	107(46.7)	122(53.3)	229(56.3)	0.102	0.750
Age (years)					
6	14(46.7)	16(53.3)	30(7.4)		
7	23(44.2)	29(55.8)	52(12.8)		
8	28(51.9)	26(48.1)	54(13.3)		
9	38(54.3)	32(45.7)	70(17.2)	3.266	0.775
10	39(41.9)	54(58.1)	93(22.9)		
11	23(45.1)	28(54.9)	51(12.5)		
12	28(49.1)	29(50.9)	57(14.0)		
Mean ages±SD (years)	9.3±1.8	9.3±1.8	9.3±1.8		

Table 2. Socio-economic and educational characteristic of parents according to school type

Characteristics	School type			x^2	*p*-value
	Public n =178 (%)	Private n =229 (%)	Total n=407 (%)		
Fathers' education					
No formal education	58(52.7)	52(47.3)	110(27.0)		
Primary school	41(70.7)	17(29.3)	58(14.3)		
Secondary school	53(60.9)	34(39.1)	87(21.4)	80.356	<0.001
College of education/ diploma certificate	17(28.8)	42(71.2)	59(14.5)		
University degree/ Higher National Diploma	9(9.7)	84(90.3)	93(22.9)		
Mothers' education					
No formal education	62(41.3)	88(58.7)	150(36.6)		
Primary school	38(86.4)	6(13.6)	44(10.8)		
Secondary school	63(65.6)	33(34.4)	96(23.6)		<0.001*
College of education/ diploma certificate	12(17.6)	56(82.4)	68(16.7)		
University degree/ Higher National Diploma	3(6.1)	46(93.9)	49(12.0)		
Social class					
Upper	6(8.8)	62(91.2)	68(16.7)		
Middle	41(32.0)	87(68.0)	128(31.4)	69.679	<0.001
Lower	131(62.1)	80(37.9)	211(51.8)		

** = Fisher's exact derived p-value*

Table 3. Mean WAZ, HAZ, and BMIZ according to sex and school type

Nutritional status	Sex		t-test	*p*-value	School type		t-test	*p*-value
	Male	Female			Public	Private		
WAZ	-0.42±1.33	-0.22±1.41	1.441	0.150	-0.79±1.35	0.06±1.27	6.530	<0.001
HAZ	-0.38±1.29	-0.48±1.35	0.792	0.429	-0.87±1.22	-0.09±1.30	6.228	<0.001
BMIZ	-0.48±1.75	-0.52±1.63	0.236	0.814	-0.57±1.67	-0.45±1.70	0.739	0.460

WAZ-weight-for-age z-score, HAZ- height-for-age z score, BMIZ-body mass index z -score

stunting (10.9% vs 9.3%) and thinness (12.9% vs 9.3%), while females had a higher prevalence of underweight malnutrition (9.9 vs 11.6%), these differences were however not significant (See Table 5). Also, a significantly higher proportion of the stunted (71%) and underweight pupils (70%) attended public schools (p<0.001) (See Table 6).

There is apparent rise in the prevalence of stunting and underweight malnutrition with increasing age. The association between these two variants of under-nutrition and age was found to be highly significant (p<0.001) (See Table 7).

3.5 IQ Test Grades

The IQ tests results as seen in Table 8 revealed that 37.3% of the pupils had optimal intelligence while 62.7% had sub-optimal IQ based on RSPM.

Table 4. Prevalence of malnutrition among subjects

Nutritional status	Percent
Overall prevalence of malnutrition	35.4
Obese	0.5
Overweight	2.9
Total underweight	10.8
Moderately underweight	9.5
Severely underweight	1.2
Total stunting	10.1
Moderately stunted	7.9
Severely stunted	2.2
Total thinness	11.1
Thin	4.7
Very thin	6.4

3.6 Intelligence and Nutritional Status

As shown in Table 9, 79.5% and 82.9% of underweight and stunted pupils had suboptimal

IQ based on RSPM respectively. This relationship between nutritional status and IQ results was significant for underweight and stunting forms of malnutrition (p=0.014, p=0.005 respectively). Majority of the thin pupils (68.9%) had suboptimal IQ, however, this finding was not significant.

3.7 Intelligence and Socio-economic Class

Most (75%) of the subjects of the parents in the high socio-economic class had optimal IQ test scores using the RSPM tool. Conversely, most (80%) of the subjects of parents in the low socio-economic class had suboptimal IQ on RSPM. This observation was significant (p<0.001) (See Fig. 1).

3.8 Effects of Socio-demographic Factors on Both Nutrition and Intelligence

Table 10 describes the influence of selected socio-demographic variables on the association between nutritional status and intelligence. The table shows that a significantly higher percentage of the malnourished pupils with sub-optimal intelligence, were found in public schools (59%, p < 0.001), belonged to the lower socio-economic strata (63.5%, p < 0.001) and were below ten years old (60.2%, p< 0.001).

Table 5. Prevalence of malnutrition among subjects according to sex

Variable	Sex			x^2	*p*-value
	Male n=193 (%)	Female n=214 (%)	Total n=407 (%)		
Obese	1(0.5)	1(0.5)	2(0.5)		0.999*
Overweight	7(3.6)	5(2.4)	12(2.9)	0.312	0.576
Underweight	19(9.9)	25(11.6)	44(10.8)	0.355	0.551
Stunted	21(10.9)	20(9.3)	41(10.1)	0.264	0.607
Thin	25(12.9)	20(9.3)	45(11.1)	1.343	0.247

** = Fishers exact derived p-value*

Table 6. Prevalence of malnutrition among subjects according to school type

Variable	School type			x^2	*p*-value
	Public n=178 (%)	Private n=229 (%)	Total n=407 (%)		
Obese	0(0.0)	2(100)	2(0.5)		0.506*
Overweight	2(17)	10(83)	12(2.9)		0.075*
Underweight	31(70.4)	13(29.6)	44(10.8)	14.313	<0.001
Stunted	29(70.7)	12(29.3)	41(10.1)	13.504	<0.001
Thin	21(46.7)	24(53.3)	45(11.1)	0.177	0.6741

** = Fishers exact derived p-value*

Table 7. Prevalence of malnutrition according to age

Age (years)	Stunting	Thinness	Underweight	Overweight	Obese
6	0(0)	4(1.0)	0(0)	0(0)	0(0)
7	0(0)	10(2.5)	0(0)	2(0.5)	0(0)
8	2(0.5)	8 (2.0)	3(0.7)	1(0.3)	0(0)
9	7(1.7)	4 (1.0)	7(1.7)	1(0.3)	0(0)
10	8(1.9)	6(1.5)	9(2.2)	7(1.7)	0(0)
11	6(1.5)	5(1.2)	7(1.7)	1(0.3)	0(0)
12	18(4.4)	8(2.0)	18(4.4)	0(0)	2(0.5)
Total	41(10.1)	45(11.1)	44(10.7)	12(2.9)	2(0.5)
p-value	<0.001	0.124*	<0.001	0.421*	-

** = Fishers exact derived p-value*

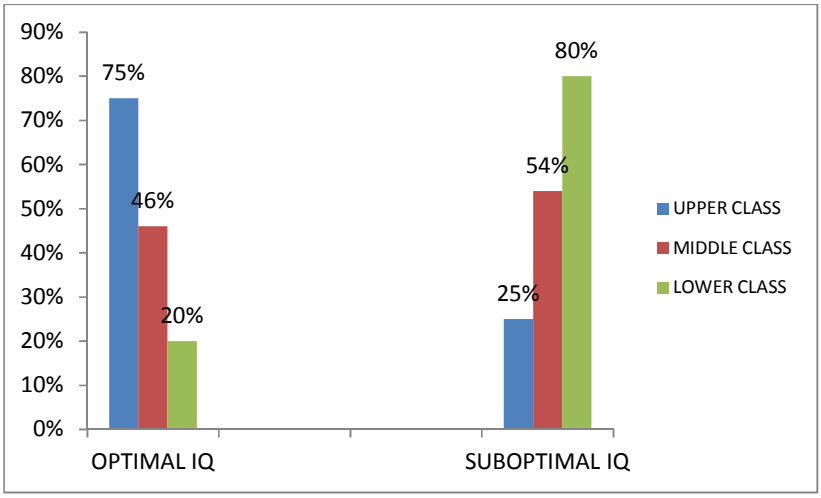

Fig. 1. Intelligence categories according to parental social-economic class

Table 8. IQ grades

Grade	Percentage
Superior	4.2
Above average	5.9
Average	27.3
Below average	45.7
Deficient	17.0
Total	100.0
Categories	
Optimal	37.3
Suboptimal	62.7
Total	100.0

3.9 Logistic Regression of Factors Associated with Optimal Intelligence

Upper socio-economic class, attending a private school, parental literacy, not being stunted and not being underweight were all associated with increased odds of having optimal intelligence, however, following adjustment for confounders; none of these factors independently increase the odds of having optimal intelligence (See Table 11).

4. DISCUSSION

Our study demonstrates a significant prevalence of malnutrition among the school-age population. Prevalence of 11.1%, 10.8%, 10.1%, 2.9% and 0.5% was recorded for thinness, underweight, stunting, overweight and obesity respectively (Table 4). Overall, 35.4% of the pupils had at least one form of malnutrition (Table 4). This finding is consistent with some earlier studies on the prevalence of under-nutrition among school-age children in Nigeria [20-22]. These include studies by Akor et al. [20] in Jos, who reported a prevalence of 11.1% and 10.3% for stunting and underweight respectively, Abidoye and Akande in Lagos [21], who observed a prevalence of 14.2% for underweight malnutrition, as well as Fetuga et al. in Sagamu [22], who reported an overall prevalence of 39% for malnutrition among school-age children. Our findings are however at variance with studies by Goon et al. [5] and Eze et al. [6]. Goon et al. [5] observed a much higher prevalence of 52.7% and 43.4% for underweight malnutrition and stunting respectively. Unlike our study, where the age group studied was 6-12 years, the age range of the pupils evaluated in their study was 9-12 years [5]. The possibly higher mean age in the study by Goon et al. [5] may perhaps explain the higher prevalence they recorded. Eze et al. [6] who similar to our study evaluated pupils between the ages of 6-12 years, recorded a much lower prevalence of under-nutrition (stunting; 0.4%, underweight malnutrition; 0.9%) and a higher prevalence of over-nutrition (obesity 4.4%, overweight; 6.3%). The explanation for their findings may be the better socio-economic indices in Enugu, Nigeria, where their study was done, as compared with our study site [4]. Low socio-economic status is a well recognized risk for under-nutrition among children. Appiah and Amosin Volta region, Ghana [23], documented a prevalence of 50% for stunting among primary school pupils. The higher prevalence of stunting in their study [23] may be as a result of the higher mean age of the children they evaluated (13 years), as compared with our study (9 years). A relationship between advancing age and a rising prevalence of

malnutrition among school-age children in Africa had earlier been documented [20]. Furthermore, our work also revealed an increasing prevalence of stunting and underweight malnutrition among the children in the higher spectrum of the age range we evaluated.

Our study found a significant association between school type and malnutrition. Most of the underweight and stunted pupils were in public schools. The explanation for the greater prevalence of under-nutrition among pupils in public schools may simply be the low parental socio-economic class, which we observed occurred more frequently among the parents of the pupils in public schools. The reverse was the case with the private school pupils, amongst whom 73% of the parents were educated and categorised into the middle and upper social strata. Earlier studies by Owoaje et al. [15] in Ibadan, Nigeria, as well as that by Milan et al. [24] in Islamabad, Pakistan, have both found poverty and lower socio-economic class of parents to be predictors of under-nutrition.

Using the RSPM, 62.7% of the pupils in our study had suboptimal intelligence, among whom 45.7% had below-average intelligence and 17% were adjudged intellectually deficient. A similar observation was made by Ejekwu and co-workers in Enugu [11], who reported that 45% and 24.7% of the pupils they evaluated had below-average intelligence and were intellectually deficient respectively. These findings are at variance with that of Ijarotimi and Ijadunola in Akure [12]. The latter authors had reported a much worse performance of primary school pupils on RSPM, following a study that identified 64.2% of the pupils as intellectually deficient [12]. Unlike our study and the study by Ejekwu et al. [11], where the IQ test was conducted in the morning, the IQ test in the study by Ijarotimi and Ijadunola was carried out in the afternoon, after the pupils had been subjected to an initial clinical evaluation. Thus, fatigue and perhaps hunger could have contributed to the poorer outcome observed by Ijarotimi and Ijadunola [12]. In a study by van der Heijden et al. [25], which examined the effect of the time of the day on intellectual test performance, individuals tested in the morning performed significantly better than the ones tested at other times of the day.

Table 9. Relationship between RSPM IQ test and nutritional status

Malnutrition	RSPM IQ Test			x^2	*p*-value
	Optimal n=152 (%)	Sub-optimal n=225 (%)	Total n =407 (%)		
Obese	0 (0.0)	2(100)	2(0.5)		0.531*
Overweight	5(41.7)	7(58.3)	12(2.9)	0.099	0.753
Underweight	9(20.5)	35(79.5)	44(10.8)	6.016	0.014**
Stunted	7(17.1)	34(82.9)	41(11.2)	7.969	0.005**
Thinness	14(31.1)	31 (68.9)	45(11.1)	0.742	0.389

** = Fishers exact derived p-value*

Table 10. Effects socio-demographic factors on both intelligence and nutritional status

Variable	Optimal IQ and well-nnourished	Optimal IQ and malnourished	Suboptimal IQ and well-nourished	Suboptimal IQ and malnourished	x^2	*p-value*
School type						
Private	91(39.7)	6(2.6)	11(4.8)	121(52.8)		
Public	25(14.0)	2(1.1)	46(25.8)	105(59.0)	56.675	<0.001**
Social class						
Upper	39(57.4)	2(2.9)	3(4.4)	24(10.6)		
Middle	45(38.8)	4(3.1)	11(19.3)	68(53.1)	58.163	<0.001**
Lower	32(15.2)	2(0.9)	43(20.4)	134(63.5)		
Family type						
Monogamous	85(29.9)	34(12.4)	23(8.4)	132(48.2)		
Polygamous	21(15.8)	28(21.1)	22(16.5)	62(46.6)	13.122	0.004**
Age (years)						
6-9	65(33.1)	2(1.0)	11(5.6)	118(60.2)		
10-12	61(25.4)	6(3.0)	46(22.9)	98(48.8)	29.106	<0.001**

Table 11. Logistic regression of factors associated with optimal intelligence quotient

Variable	Unadjusted			Adjusted		
	Odds ratio	95% CI	*p*-value	Odds Ratio	95% CI	*p*-value
Socio-economic class						
Lower	1	-	-	1	-	-
Middle	3.4	2.1-5.6	<.001	0.670	0.3-1.6	0.367
Upper	12.07	6.3-23.0	<.001	0.340	0.1-1.0	0.054
School-type						
Public	1	-	-	1	-	-
Private	5.023	3.2-8.0	<0.001	1.722	0.9-3.3	0.101
Fathers' level of education						
No formal education	1	-	-	1	-	-
Primary school	0.546	0.3-1.2	0.125	0.787	0.3-2.0	0.615
Secondary school	0.995	0.5-1.8	0.986	1.242	0.6-2.8	0.592
College of education/ diploma certificate	1.289	0.7-2.5	0.458	0.875	0.4-2.0	0.745
University degree/ Higher National Diploma	4.448	2.5-8.0	<0.001	1.559	0.7-3.4	0.263
Mothers' level of education						
No formal education	1	-	-	1	-	-
Primary school	0.456	0.2-11	0.080	0.873	0.3-2.6	0.806
Secondary school	0.803	0.4-1.4	0.459	0.605	0.3-1.4	0.241
College of education/ diploma certificate	2.710	1.5-4.9	0.001	1.168	0.5-2.7	0.711
University degree/ Higher National Diploma	12.34	5.4-28.5	<0.001	2.436	0.7-8.1	0.148
Family type						
Polygamous	1	-	-	1	-	-
Monogamous	2.156	1.3-3.5	0.002	1.316	0.6-2.1	0.7
Stunting						
Present	1	-	-	1	-	-
Absent	3.165	1.4-7.3	0.007	1.458	0.5-4.0	0.469
Underweight						
Present	1	-	-	1	-	-
Absent	2.528	1.2-5.4	0.017	1.264	0.5-3.3	0.638

The likelihood of having optimal IQ in the present study was significantly higher among children in the upper socio-economic class and children whose mothers had tertiary education. Their odds of performing optimally on RSPM was twelve times more than those of the lower socio-economic class and those whose mothers had no formal education respectively. These two factors are however inter-related, as the social status of the parents is to a large extent dependent on the mother's educational status [17]. Similar observations were made by Ijarotimiand Ijadunola [12], as well as Ebigbo and Izuora in Nigeria [26]. Motlagh et al. [27] in Iran also reported that University education in mothers tripled the chances of a child having optimal intelligence. The lower IQ among children in the lower socio-economic class is

largely attributable to unfavorable environmental factors that usually accompany poverty. Such children are at a higher risk of diseases that may impair cognitive function, and many are also likely to be deprived of surroundings that enable adequate stimulation of proper cognitive development. Offsprings of literate mothers are less frequently exposed to environments and diseases that may adversely affect their cognitive development; literate mothers are generally more assertive in making decisions that favour the adequate development of their children. They have been shown to partake more actively in health intervention methods such as immunization among others [4].

The results of our study suggested that private school attendance increased the chances of having optimal IQ by 6-folds, compared to the expectation from attending public school. A similar observation was made by Millones and Leeuwen in Peru [28] who also documented higher scores on RSPM among private school pupils. The explanation for this observation may be due to the more conducive learning atmosphere in privately-owned schools, which encourages intellectual stimulation and development. On the other hand, many of the public schools visited in this study lacked an enabling environment for adequate intellectual development. They were overpopulated and most lacked basic amenities such as tables and chairs. Indeed, in many of the visited public schools, several of the pupils had to sit on the bare floor during classes. These challenges could have contributed to the much poorer outcome on IQ tests by public school pupils in this study.

Polygamy had a negative association with intelligence in this study, as it was observed that children from polygamous homes had twice the odds of having suboptimal intelligence when compared with children from monogamous homes. Adeshinwa in Ibadan had reported polygamy to be associated with poor academic performance among primary school pupils [29]. Polygamy is commonly associated with a large family size that may limit adequate nurturing, which may subsequently result in impaired cognitive gains. Also, frequent rancour, jealousy and unhealthy rivalry that characterise many polygamous homes are conceivably un-supportive of a healthy psychological well-being and cognitive developments of children from such homes. Moreover, this study observed a higher rate of public school attendance among pupils from polygamous homes. Public school attendance has been shown earlier in this study to have a negative correlation with IQ.

This current study revealed a negative relationship between intelligence and under-nutrition (stunting and underweight malnutrition). Suboptimal intelligence was observed in 80% of underweight malnourished children, and in 82% of stunted children. Although this did not reach a level of statistical significance, most of the thin children performed suboptimally on the RSPM IQ test (66%). This study also showed that stunting and underweight malnutrition increased the odds of performing suboptimally on RSPM by about three times. These findings are in agreement with those of other local studies [10,11] that have established a link between malnutrition and impaired cognitive capabilities. Ikefuna and Iloeje [10], while evaluating for the readiness of children for primary school observed that 38% of the pupils that performed poorly on Draw-a-person (DAP) and neurodevelopmental tests were undernourished. Similarly, Ejekwu et al. [11] found a significant relationship between stunting and cognitive performance of rural primary school children in Enugu. In addition, Survana and Itagi in India [30] and a meta-analysis by Grantham-McGreggor [31] have reported inferior intelligence in malnourished children.

In the present study, as well as in previous reports [9-11], stunting, which is often an indication of nutrient depletion in early life, was associated with suboptimal intelligence. This observation can be explained by the chronic nutritional deficiency that often results in neuropathological changes in the brain. These changes may subsequently manifest later in life as cognitive impairment [9,11]. Wasting/thinness, which reflects an acute or current nutrient depletion occurring at, or just before the nutritional evaluation may not have as much effect on cognitive function [32]. This may perhaps explain why the present study did not find a significant association between thinness and the IQ tests outcome.

Contrary to the findings from our study and some earlier studies [10,11,31,33], Ijarotimi and Ijadunola in Akure [12], reported the absence of a significant association between nutritional status and IQ. Although in the same study [12], more of the stunted pupils performed worse in the IQ tests, compared to their well-nourished counterparts. The apparent disparity in the

observations in our study, compared with the Akure study [12], may be ascribed to the younger mean age in our study (nine years) as against 12 years in the earlier study [10]. Indeed, the mean age in most other studies [9-11,33,34] that have found an association between intelligence and malnutrition was less than 10 years. Moreover, the current study also observed that most of the undernourished pupils with impaired intelligence were under the age of 9 years, which may imply that the ill-effects of under-nutrition on cognition declines with advancing age. This observation agrees with an earlier study, which revealed that as a child grows older, the influence of nutrition on cognition diminishes [35].

In spite of the significant relationship observed between under-nutrition and intelligence in our study (on bivariate analysis), under-nutrition was not an independent predictor of intelligence (on multivariate logistic regression). The explanation for this may be because in this study, under-nutrition was strongly associated with some adverse socio-demographic factors, many of which also affected intelligence. These factors include low socio-economic class, low level of education among parents, public school attendance and polygamous family setting.

Our study also found that among the undernourished children, those with these unfavorable socio-demographic variables had a greater prevalence of suboptimal intelligence. This was observed when the IQ of undernourished children with unfavorable socio-demographic background was compared with those of their undernourished counterparts, who had a more favorable socio-demographic background. This observation is in keeping with those of Strupp and Levitsky [9], as well as Grantham McGreggor [31], who had earlier concluded that unfavorable environments appeared to exacerbate the effects of under-nutrition on intelligence.

5. CONCLUSIONS

There is a strong relationship between under-nutrition and IQ. However, the negative relationship, which undoubtedly exists between under-nutrition and the intellectual function of children, may not always be attributable to nutritional factors alone. Socio-demographic variables such as lower socio-economic class, attending public schools and age less than 10 years are factors associated with a greater occurrence of sub-optimal intelligence among the undernourished children.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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