Research article

Assessment of nutrition and learning skills in children aged 5–11 years old from two elementary schools in Chocó, Colombia

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ABSTRACT

Background: Malnutrition has been identified as a factor in growth and learning. The current study aimed to determine the nutritional status and basic learning skills of children from Chocó, Colombia.
Methods: We conducted a cross-sectional study of 631 children aged 5–11 years from two schools, collecting anthropometric measurements, nutritional quality surveys and sociodemographic data. Neuropsychological batteries were applied.
Results: A total of 523 children were evaluated, with an average age of 8.49 $\pm$ 2.1 years. The results revealed that 2.9% of children were underweight, 0.4% were severely underweight, and 4.8% were diagnosed as having stunted growth. In addition, 71.8% of children were unable to draw a human figure. Beery-Buktenica Visual-Motor Integration test (VMI) performance was below the scores expected for these age groups in 73.9% of children. Battery of Differential and General Abilities (BADYG) performance revealed limited verbal skills. In a subsample of 117 children, anemia was detected in 12.8% of cases, and iron deficiency was present in 44.4% of cases. Global malnutrition was associated with impairments in BADYG performance (OR: 1.98; 95% CI: 1.07–3.86).
Conclusions: The current results revealed that learning performance was below the expected level for children in these age groups across all of the applied tests. Although malnutrition could partially explain the poor performance of children in tests of learning abilities, additional factors are likely to be involved.

1. Introduction

According to World Health Organization (WHO) data, 2 billion people suffer from some degree of malnourishment, and 155 million children under 5 years old suffer from chronic malnutrition and consequent neurodevelopmental delay [1]. Although three quarters of the children with malnutrition are located in sub-Saharan Africa and South-Asia, malnourishment in Latin America constitutes a significant public health issue, posing substantial challenges for governments in the coming years.

In addition to negatively impacting multiple organ systems and bodily functions, including the cardiovascular and gastrointestinal systems, malnourishment significantly affects immune function, increasing susceptibility to prevalent infections, such as diarrhea and pneumonia. Furthermore, nutritional imbalances during the learning period are closely linked to impaired physical and functional development of the brain. Previous studies have reported that children who had experienced malnourishment tend to have fewer years of study and more academic performance issues, as well as reduced income and significantly lower economic productivity in adult life [2].

According to data from the Colombian National Nutritional Status Survey, the five departments of Colombia with the highest prevalence of global malnutrition in children under 5 years of age are Guajira, Magdalena, Chocó, Guainía, and Amazonas [3]. These same departments have the highest indices of poverty and inequality, and contain the largest numbers of groups at greatest risk (indigenous tribes, Afro-Colombians, low-income families, and displaced populations) [4].

Despite being one of the departments with the most extensive governmental and non-governmental involvement in matters of

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nutrition, Chocó's cultural and political characteristics have historically impeded the achievement of public health objectives, including child health and nutrition. Thus, child mortality in Chocó (82 per 1000 newborns) resembles that of countries in sub-Saharan Africa, and the global malnutrition rate in children under 5 years old is of 6.7%, almost double the national rate of 3% [5].

There is a lack of studies examining the current nutritional status, developmental status, and learning performance of children in Chocó, making the allocation of resources and the determination of optimal strategies challenging for both local and national authorities. The objective of the current study was to assess the nutritional status, learning skills, and cognitive development of children between the ages of 5 and 11 years enrolled in two public schools in a municipality of the department of Chocó, Colombia.

2. Methods

2.1. Study design and population

This cross-sectional study was carried out in a commune of the municipality of Quibdo, Chocó. Since the late 1990s, the neighborhoods that make up this commune have developed from the irregular occupation of the land by families forcibly displaced by internal conflict [6]. The living conditions of this population are precarious, with low family incomes, low literacy rates, and insufficient access to basic utilities. Participants were sampled from two schools located in this commune and underwent nutritional and cognitive assessment between October and November 2015. A total sample of 631 children between the ages of 5 and 11 years were included in the study. Children's assent and informed consent from parents or guardians was obtained for all subjects. This research protocol was approved by Universidad del Rosario Research Ethics Committee, Research Ethics Number CEI-ABN-026-000125.

Children with a prior diagnosis of an endocrine, cardiopulmonary, or renal alteration that could affect their growth or the results of a complete blood count, were excluded. Children were also excluded if they were undergoing growth hormone therapy.

2.2. Measurements

Children underwent general physical examinations, including measurement of weight and height and testing of verbal and visuomotor skills. We measured the children in a private room, in their underwear, using a Tanita BF 689 scale for weight and a portable height measuring board. All measurements were taken twice. Parents completed a survey on general demographic information, the family's nutritional habits and the child's nutrition at school. This survey was based on the instrument used in the National Survey on Nutritional Status 2010 [3].

Anthropometric measurements followed the WHO standardization guidelines [7]. For children aged between 5 and 10 years, we used the WHO growth scales for weight for age, height for age, body mass index (BMI) for age, and weight for age. For children aged 10–11 years, we used the aforementioned scales, with the exception of the weight for age scale, which is not appropriate for children in this age range [7]. Nursing students from a local university and teachers at each school received training to take anthropometric measurements and assess nutritional status. The nutritional status assessment enabled diagnoses of global malnutrition, chronic malnutrition, overweight, and obesity. Global malnutrition or low weight for age and chronic malnutrition or low height for age were considered when the child had a z-score below 2 standard deviations of the mean on the respective measure, overweight status was considered when the BMI z-score was above the mean by 1 standard deviation and obesity when it was 2 standard deviations above the mean. The definitions were stablished following the recommendations of the WHO [8] and the z-scores were calculated using WHO AnthroPlus software [9].

Blood samples were taken from a random subgroup of 117 children by certified laboratory personnel to determine hemoglobin and ferritin levels. The number of children selected to undergo these tests was calculated by considering the prevalence of anemia in Colombia of 8% [6], a confidence level of 95% and a power of 80%. The blood samples were processed in the same laboratory and compared with reference values. The reference values of hemoglobin levels for anemia were as follows: mild anemia 11–11.49 mg/dL, moderate anemia 8–10.99 mg/dL and severe anemia under 8 mg/dL. The reference value for iron deficiency in school age children was a ferritin level under 15 ng/dL.

Performance in language skills was evaluated using the *Batería de Aptitudes Diferenciales Y Generales* (battery of differential and general abilities) (BADYG) [10, 11, 12]. This widely used instrument contains different questionnaires and scoring schemes for each age group. The BADYG has been validated for the Spanish-speaking population [13], and can be applied in a group setting. Each module in this test is composed of subtests measuring verbal skills, calculation skills, perceptual skills, fine motor skills and attention. The subtests that corresponded to the assessment of "language" and "basic concepts" were used in this study according to age. From the BADYG A1 test for children aged 5–7 years, the subtests of "general information" and "visual vocabulary" subtests were used; from the BADYG E1 for children aged 8–9 years, the "analogic associations" and "complex verbal orders" subtests were used; finally, from the BADYG E2 for children aged 10–11 years, the "analogy resolution" and "sentence completion" subtests were used. All children underwent the Beery-Buktenica Visual Motor Inventory test (VMI), which consists of 24 geometrical figures of increasing complexity, which the child is instructed to reproduce on a blank sheet. This test measures the degree of integration of visual perception and motor coordination and is highly correlated with cognitive development [14]. The Human Figure Drawing test (HFD) was also used to evaluate maturity and was graded according to the thresholds set in the *Evaluación Neuropsicológica Infantil* (child neuropsychological evaluation) (ENI), which has been validated for the Colombian population [15]. HFD and BADYG performance was categorized as normal or altered, using the 15th percentile as a cutoff value. VMI performance was categorized according to developmental age.

2.3. Statistical analysis

Data were entered into Microsoft Excel spreadsheets and imported into SPSS (v.22) statistical software. The information was checked and validated by filters and variables, and data were recoded for analysis. Descriptive statistics were calculated for each variable. Bivariate analyses were performed with the results of the neurocognitive testing as dependent variables and the sociodemographic and nutritional characteristics as independent variables.

3. Results

Of the 631 children enrolled in the 2015 academic year who were potentially eligible, 564 attended class when data were collected, comprising a sample from preschool to the 5th grade. Thirty-nine of these children were excluded due to age, leading to a final sample of 523 children. The children had an average age of 8.47 ± 1.8 years, with a slightly greater number of girls in the sample (53.5%). In addition, 87.8% of the children were of Afro-Colombian descent. The mothers' average age was 32.7 ± 9.76 years, and 32.3% of the sample had between no secondary education and incomplete secondary education. Two-thirds of the sample (66.2%) were forcibly displaced and had limited economic resources (65%). These results indicate the characteristics of a vulnerable population. Data collection for the sociodemographic survey was scarce; parents answered a total of 348 surveys, with a response rate of 66.5% (Table 1). Item-wise responses varied extensively, with a non-response rate of over 90% for some items. Data were not missing at random, and there were associations between the presence of malnutrition or

Table 1. Socio-demographic characteristics.

Child	
Sex-female	53%
Age	8.49 ± 2.1
Afro-Colombian ethnicity	87.80%
Received antiparasitic medication in the past 6 months	42.20%
Mother	
Age	32.7 ± 9.76
Marital status	
Married/common law marriage	61.0%
Single/separated/widowed	39.0%
Currently employed	37.9%
Literate	71.2%
Schooling	
No secondary education to incomplete secondary education	32.3%
Complete secondary education	44.7%
Trade school/university	22.9%
Number of children	
1–2	35.7%
3–5	50.9%
>5	13.4%
Living conditions	
Home ownership	59.3%
Lived in the municipality for >5 years	86.5%
Forcibly displaced	66.2%
*Monthly household income**	
Under minimum wage	65.0%
Minimum wage	26.1%
Over minimum wage	8.8%

SD: Standard deviation.
*: Minimum wage of 644.350 COP ≈222 USD.

Table 2. Nutritional status.

General (n = 523)	
At risk for malnutrition (weight/age)	13.4%
Global malnutrition (weight/age)	2.9%
Severe global malnutrition (weight/age)	0.4%
Chronic malnutrition (height/age)	4.8%
Overweight (BMI/age)	9.4%
Obesity (BMI/age)	3.8%
Subsample (n = 117)	
Mild anemia	12.8%
Moderate anemia	17.9%
Iron deficiency	44.4%

BMI: body mass index.

alteration in tests and nonresponse, making imputation inappropriate. Confronted with these results, the authors called 10 respondents at random and learned that the information given in the surveys was not reliable. Although the respondents had agreed to participate in the study, they did not answer the survey with valid information, and thus we did not consider these data in the results.

Learning skills were evaluated to identify children with difficulties in language, visual perception, motor coordination, and maturation. All children that were identified with anemia, iron deficiency or intestinal parasites received a printed copy of their tests and were referred for treatment to their local health provider.

3.1. Nutritional status

The prevalence of global malnutrition was 2.9%, with 13.4% of children at risk of malnutrition, and 0.4% exhibiting severe malnutrition. Chronic malnutrition was found in 4.8% of the children assessed. In addition, the prevalence of overweight status and obesity was 13.2% (Table 2).

The prevalence of anemia in the subgroup of 117 children was 12.8% for mild anemia and 17.9% for moderate anemia. No children met the criteria for severe anemia. The prevalence of iron deficiency in this group of children was 44.4%.

3.2. Results of verbal and visual skills tests

Overall, the performance of the children in the two participating schools was below expected for both age and schooling. VMI performance was below the expected developmental age in 75.9% of the sample (Figure 1a). BADYG performance showed overall changes, and performance below that expected for children of this age. The results were less disparate among children aged 8–9 years, with 58.5% of children showing impaired performance (Figure 1b). Finally, the HFD results indicated that 71.8% of children scored below the 15th percentile (Figure 1c).

Unadjusted odds ratios between the presence of impaired performance in any of the tests and the presence of global malnutrition are shown in Table 3. Only global malnutrition was significantly associated with alterations in the results of the BADYG (OR: 1.98; 95% CI: 1.06–3.85). The scarcity of sociodemographic data made it difficult to adjust for known confounders like parents' education or family income. Adjustment by age and sex, which could be ascertained for the entire population, did not reveal any confounding effects.

4. Discussion

This study assessed the nutritional status and learning skills of a disadvantaged population of children in elementary education in a municipality of Chocó, Colombia. From a nutritional perspective, the study reported that the prevalence of chronic malnutrition was 4.8%. This percentage is twice the national average of 2.1% for children between 5 and 17 years of age, which could potentially be explained by the socio-economic conditions of the study population [3]. Importantly, the results revealed that impairments in learning skills were highly prevalent.

To the best of our knowledge, the current study is the largest study of this type carried out in this disadvantaged population. The testing procedure we used has previously been applied in other disadvantaged populations in Colombia, allowing some comparisons to be made between groups of children of the same age in different sociocultural environments.

A significant proportion of the study population scored below the expected performance for developmental age across all the neuropsychological tests (VMI 75.9%, BADYG 58.5%, HFD 71.8). These tests evaluated visuomotor skills and language skills, which are two separate domains of cognition that are prerequisites for reading and writing, and are the basic skills acquired in formal elementary school education. The VMI and HFD tests are relatively insensitive to cultural variations [16]. Development and acquisition of visuomotor skills typically occur spontaneously in childhood, depending on environmental stimuli. However, the BADYG test, which evaluates verbal skills, is more susceptible to variations in context, culture, and upbringing.

The neuropsychological tests used in the current study are widely used in the pediatric population and have been validated for the setting of the current study. Our research group has previously used these tests to assess the status of similar populations in other cities [12]. All of these tests provide a general overview of the learning abilities of children, and provide a baseline for tailored intervention programs in education. Children were evaluated while they performed their usual school activities, providing a familiar setting and avoiding bias.
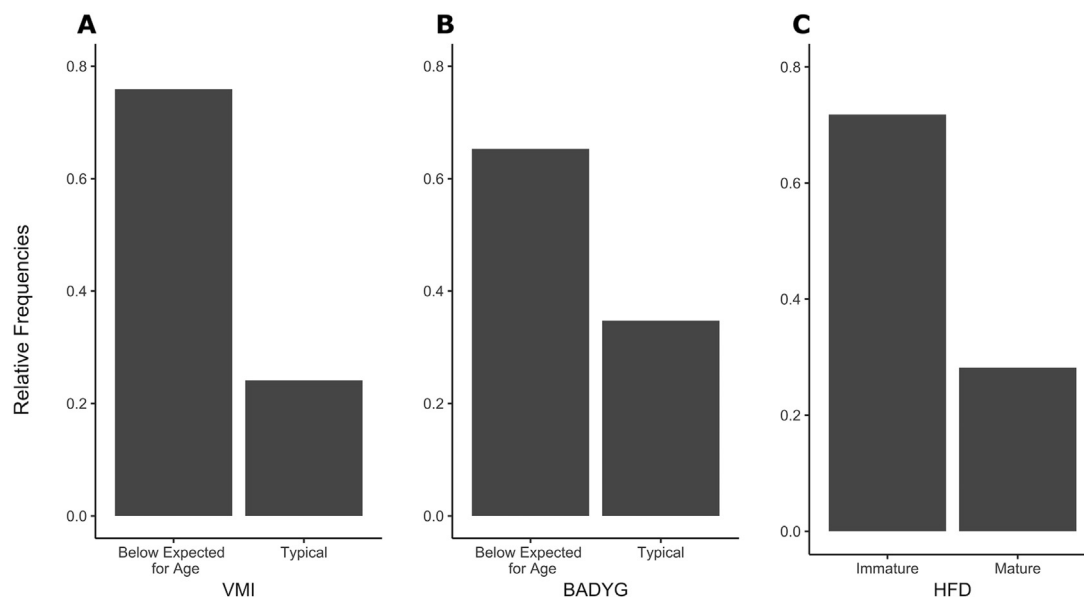
Figure 1. (A) Results of the Beery-Buktenica Visual Motor Inventory (VMI), (B) Batería de Aptitudes Diferenciales y Generales del Aprendizaje (BADYG), (C) Human figure drawing (HFD).

It is noteworthy that children in our previous study also scored below average in visuomotor skills. Children's verbal communication performance, however, was less affected [17]. The discrepancy between these two results may be due to a variety of factors. Although both groups of children came from families earning no more than two minimum wages, children in the current study are more deeply affected by poverty. Although the current study did not comprehensively examine the children's living conditions, home visits were conducted by two of the authors, observing houses without flooring, single-bedroom homes that housed large families, and generally substandard housing conditions. Furthermore, the children in our previous study, although not significantly different in terms of income, have substantially better habitation.

The population in this region is comprised primarily of people belonging to minority groups and forcibly displaced groups who may have unmet basic needs and are thus reluctant to share information related to their living conditions. Hence, the response rate of our survey was both low and inconsistent. The lack of resources that these populations have historically experienced cannot be ignored. The low response rate to our survey may have been at least partially due to the resemblance of our approach to that of a variety of organizations which people in our study population have come to mistrust.

From a cultural standpoint, differences in family dynamics and social behavior are also relevant. The local use of language combines a very particular Spanish vernacular with indigenous languages, which are mixed together in everyday communication. Hence, scores from verbal tasks may be misleading due to differences in the use of language and comprehension of everyday concepts. Interestingly, VMI scores, which should not be influenced by culture or context, were similarly affected.

In the current study, the results did not establish a correlation between nutritional status and learning difficulties, except for the BADYG assessment, in which children with global malnutrition exhibited poorer performance. This could mean that additional factors hindered the acquisition of learning skills in this population, including but not limited to lack of early stimulation, poor access to healthcare services, lower socioeconomic status, and current education quality standards. In addition, this finding could be attributed to the low number of children suffering from malnutrition in the study sample.

This was a cross-sectional study in which causality could not be determined. The current study only considered children from two elementary schools in a municipality of Chocó, both of which provided nutritional interventions to children. In addition, a possible reporting bias must be considered, particularly for the sociodemographic survey, which included sensitive items. In the current study, we did not consider this information, because the authors concluded that it was not valid. Although all of the participants came from a low socioeconomic background, the lack of socioeconomic data limited the analysis.

It is important to clarify that since the study design provides only a cross-sectional view, acute episodes of wasting may not be accurately diagnosed. Although we measured nutrition comprehensively, some of these measurements are very time-sensitive and thus a different approach will be needed in the future to establish a more precise relationship between learning skills and malnutrition.

The skills we assessed provide the basis on which learning and formal schooling are built. Without them, academic success becomes further out

Table 3. Unadjusted and adjusted odds ratios for alterations in tests and global malnutrition.

	Unadjusted OR	95% CI
VMI	0.856	0.483–1.551
HFD	1.27	0.706–2.255
BADYG	**1.982**	**1.066–3.855**
	Adjusted OR	95% CI
BADYG		
Age	0.88	1.10–0.71
Sex	1.63	2.79–0.95
Global malnutrition	**2.05**	**3.90–1.08**
HFD		
Age	0.93	1.13–0.76
Sex	1.61	2.71–0.96
Global malnutrition	1.27	2.27–0.71
VMI		
Age	1.39	1.70–1.13
Sex	1.09	1.85–0.64
Global malnutrition	0.88	1.58–0.49

VMI: Beery-Buktenica Visual Motor Inventory; HFD: Human Figure Drawing; BADYG: Batería de Aptitudes Diferenciales y Generales de Aprendizaje; OR: odds ratio; CI: confidence interval.

The significance of the values presented in bold shows where statistic difference was found.

of reach, which in turn impacts future outcomes in professional and economic performance.

Across the study population, we observed low scores in objective neuropsychological tests. However, a substantial amount of missing data from the nutritional survey and its inherent subjectivity could have led to misrepresentation of the actual nutritional status of children.

5. Conclusions

The results of the current study revealed that learning skill performance was below the level expected for the age groups of interest, across all of the applied tests. Although we hypothesized that malnutrition could account for this poor performance, we only found an association between global malnutrition and BADYG performance. It is possible that a confluence of nutritional deficiencies with socioeconomic factors and schooling characteristics, among others, could provide a better explanation of the development of learning impairments. Further studies will be needed to address this hypothesis.

These results should be used to create and evaluate targeted intervention programs aimed at addressing learning skills delays for populations such as children from Chocó. The implementation of early strategies may help prevent the occurrence of learning disabilities and academic failure in this population.

Declarations

Author contribution statement

Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

J. Botero-Meneses and P. Aguilera-Otalvaro: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

I. Pradilla: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

C. Talero-Gutiérrez, Á. Ruíz-Sternberg and Á. Pinzón-Rondó: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

A. Vélez-van-Meerbeke: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

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