Influence of domestic violence on the association between malnutrition and low cognitive development

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Abstract

Objective: To investigate the size and direction of the association between malnutrition and low cognitive performance and to evaluate the effect of domestic violence on this association.

Methods: This cross-sectional study enrolled students of both sexes, aged 7 to 14 years old, attending public elementary schools. The Raven's Progressive Matrices Test was used to measure cognitive development, the Revised Conflict Tactics Scales (CTS2), to measure domestic violence, and the body mass index (BMI) for age and sex, to define anthropometric indices. Socioeconomic data and information about food intake were also collected. Malnutrition was defined as BMI < 3rd percentile. Cognitive deficit was defined when the results of Raven's test were ≤ 25th percentile. Family violence was defined as a positive answer in at least one item about severe physical violence in the last 12 months. The size of the associations of interest was expressed as prevalence ratio (PR) and 95% confidence interval (95%CI).

Results: Below-average intellectual development was found for 63.3% of the participants. Malnutrition was identified in 9.5%. Malnutrition had a negative effect on cognitive performance (adjusted prevalence ratio [aPR] = 1.60, 95%CI = 1.01 - 2.52; p = 0.042) when adjusted for the association between exposure to domestic violence and age.

Conclusion: The association between malnutrition and below-average intellectual development found in this study was affected by domestic violence, which must be taken into account when addressing the problem.

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Introduction

The prevalence of malnutrition in childhood has declined worldwide along the last decades, but such reduction has been unequal, and in some countries the problem has even become more serious.[1] Protein energy malnutrition is estimated to affect 186 million children younger than 5 years all over the world.[1] In Brazil, malnutrition affects 6% of all children younger than 5 years. Among schoolchildren, the prevalence of malnutrition, estimated using height-for-age indices, is about 6.8%; among adolescents evaluated using the body mass index (BMI) for age, about 3.4%, but varying according to income.[2] Social and economic inequality between nations remains a predictive factor of malnutrition.[3]

Studies show that malnutrition is associated with impaired cognition,[4,5] but few studies have attempted to investigate the different aspects of this problem. For some

authors, the deleterious effects of childhood malnutrition on intellectual development seem to be irreversible and remain visible during school years and adolescence.[6]

The evidence that malnutrition leads to delays in cognitive development is strong, but not unequivocal. Some results are inconsistent and limited due to the methods used in experimental trials with human beings and because studies do not include important epidemiological variables that may affect the highly complex networks that determine this association. Malnutrition usually occurs in contexts of multiple psychosocial and economic disadvantages, factors that may independently affect the development of children or change the effects of malnutrition. Therefore, it is extremely difficult to infer a causal relationship between malnutrition and cognitive development. Investments should be made in methodologically sound studies in this field.

This study evaluated the size and the direction of the association between malnutrition and low cognitive performance. It also evaluated the effect of confounding or moderator variables, particularly of exposure to domestic violence, which have not been analyzed in other studies in this area.

Material and methods
Design and study population

This cross-sectional study included boys and girls aged 7 to 14 years old who were attending public elementary schools. Participants were selected as part of a broader study whose objective was to identify factors associated with anemia in children and adolescents enrolled in public schools in Salvador, Brazil.[7] Using simple random sampling, 264 students were selected, which corresponded to 25% of the original sample. For that purpose, a list of students was made and names were drawn to select participants for the study. The original sample size was not estimated for the investigation planned in this study; therefore, power was calculated after the original selection. For a 2-point difference of cognitive score means[8] (alpha = 5%), power to measure the association of interest was 80%.

Measurements and data collection
Nutritional status

Anthropometric data were collected in schools by anthropometrists and qualified interviewers previously trained to collect data. The evaluation of nutritional status used the World Health Organization (WHO)[9] reference standards based on BMI percentiles (weight[kg]/height squared[m^2]) for sex and age. Weight was recorded using a microelectronic scale (PP 200-50, Marte Balanças e Aparelhos de Precisão Ltda., São Paulo, Brazil) measuring up to 100.95 kg to the nearest 50 grams. Height was recorded using a

stadiometer (Leicester Height Measure, London, England) reading to the nearest millimeter. Malnutrition was defined as BMI below the 3rd percentile.[10]

To evaluate fat reserves, the sum of tricipital and subscapular skinfold thicknesses was used.[11] Protein reserves were assessed using the arm muscle area index.[11] Measurements were made according to the procedures defined by the Anthropometric Standardization Reference Manual.[12] For the analyses, both indices were used as continuous variables.

To study the association between malnutrition and low cognitive performance, only BMI was used; the other indices were used only for complementary descriptive analyses.

Student age was confirmed by checking date of birth in birth certificates or ID cards.

Cognitive development and instrument to measure cognitive competence (intelligence or non-verbal reasoning): Raven's Progressive Matrices

Raven's Progressive Matrices, a test used to measure cognitive competence (intelligence and non-verbal reasoning), was applied to each student in the sample during 4 months. Tests were applied by a trained team, made up of psychologists that were responsible for their administration and scoring. Evaluations were made collectively in an adequate environment in the schools. This test is based on the Spearman's theory of multifactorial intelligence[13] and has five series, organized according to increasing difficulty, with 12 problems in each series, which provide a general score after all partial scores are added. Series A and B evaluate the capacity to perceive similarities, differences, symmetry and continuity of parts in relation to the whole. Series C, D and E demand analytical operations to make deductions about relationships. Children aged 7 to 12 years took the Raven's progressive matrices test for children, called colored progressive matrices (CPM), which form a subset of 36 figures taken from the set of 60 progressive matrices of the general Raven's test. Therefore, the theory that underlies CPM is the same that served as the basis to construct the general test. The accuracy and validity of this test has been confirmed.[14] The score is calculated as the total sum of right answers according to age, and performance is classified according to percentiles. Low cognitive performance was any result in the Raven's test below the 25th percentile.[13] Therefore, students whose results were in the percentile equal to or below 25th were identified as having below-average intellectual development.[13,14]

Revised Conflict Tactic Scales

Violence between couples was evaluated using the Portuguese version of the revised Conflict Tactics Scales (CTS2), previously adapted[15] and validated[16] for use in Brazil. The instrument has five scales: negotiation (six items),

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psychological aggression (eight items), physical violence (12 items), injury (six items) and sexual coercion (seven items). The items in each scale are classified as more or less severe. In this study, only the scale for severe physical violence was used. It was positive if the main caregiver, the mother in 94% of the cases, reported having experienced at least one of the behaviors that are part of the subscale, either as a victim or perpetrator, during the last 12 months of spousal relationship. Data were collected in the school by a team of psychologists.

Dietary intake

The 24-hour recall method was used to evaluate dietary intake. The composition of dietary macronutrients (carbohydrates, proteins and lipids) and micronutrients of diet was calculated in percentage points using the Virtual Nutri software (Department of Nutrition, School of Public Health, Universidade de São Paulo, São Paulo, Brazil).[17] The availability of dietary calories was considered a continuous variable.

Socioeconomic and demographic variables

For multivariate analyses, income was expressed in minimum wages at the time of the study (R$ 380.00) and was classified into two brackets: < one minimum wage, and ≥ minimum wage (reference category). Data about maternal education were also collected and classified into one of two levels according to the most advanced school grade attended: I = < 5th grade, II = ≥ 5th grade (reference category). The demographic variables were: sex = male (reference category), female; and age (< 10 years and ≥ 10 years [reference category]).

Ethical issues

This study was approved by the Ethics Committee of the Instituto de Saúde Coletiva of Universidade Federal da Bahia, under registration 006-06/CEP-ISC.

Statistical analysis

Descriptive analysis was used to analyze population characteristics calculating prevalence ratios for categorical data and means and standard deviations for continuous variables.

The Poisson regression model with robust variance was used to calculate prevalence ratios (PR) and their 95% confidence intervals (CI) to evaluate the association between malnutrition and below-average intellectual development. Two-tailed tests were used for statistical analyses, and the level of significance was set at 5%. Confounding and data base interactions were analyzed using backward regression models. Analyses started with a saturated model with all potential moderator variables and their product terms,

in addition to possible confounding variables. Moderator variables were those that had statistically significant results ($p < 0.05$) according to the maximum likelihood test. The confounding variables were those that, when removed from the model, affected the size of the association between malnutrition and below-average intellectual development.[18] The choice of variables for the model was based on current understandings apprehended from the literature.

Statistical analyses were adjusted for the complex design of the sample using the set of SVY tools of the STATA 9.0 software.

Results

This study included 264 students aged 7 to 14 years; there was a slightly greater percentage of girls (50.8%) and students aged 7 to 10 years (75.4%). The other sample characteristics are described in Table 1. Although the study population was selected in another study, there were no statistically significant differences between sociodemographic characteristics of the original sample and the subsample used in this study (data not shown). The distribution of frequencies of the general score of the Raven's test had some asymmetry, as the deviation was more marked to the left, which suggested a high percentage of low cognitive performances (mean = 26.48±9.70 points). There was a statistically significant trend toward an increase of scores with older age ($p < 0.01$). In addition, lower scores were found among students exposed to domestic violence ($p = 0.003$). For the other variables, there were no significant differences in mean scores according to caregiver's or student's characteristics (Table 1). The percentage of students with below-average intellectual development was 63.3% (95%CI = 57.4 – 69.0). Malnutrition according to BMI was identified in 9.5% (95%CI = 5.0 - 13.0) of the students.

Most mean anthropometric indices were statistically lower among those exposed to domestic violence (Table 2).

According to the results of unconditional logistic regression analysis, there were no changes in the size of the main association under study (maximum likelihood ratio) (Table 3). However, findings confirmed that exposure to domestic violence was a potential confounding factor. Adjustment for that variable, in addition to age, changed the association between malnutrition and below-average intellectual development, and the value went from crude PR = 1.34, 95% CI = 0.99 - 1.82 ($p = 0.055$) to aPR = 1.60, IC95% = 1.01 – 2.52 ($p = 0.042$).

Discussion

This study findings confirmed that control of logical reasoning tends to improve with age so that the cognitive

Table 1 - Cognitive score (Raven's Progressive Matrices) according to the characteristics of the caregiver, children and adolescents, Salvador, Brazil, 2008

Variable	n	%	Raven's Progressive Matrices - scores	
			Mean ± SD	p
Sex				
Male	130	49.2	26.34±8.87	0.824
Female	134	50.8	26.61±10.47	
Age*				
< 10 years	199	75.4	19.81±5.55	< 0.001
≥ 10 years	65	24.6	28.81±9.64	
Maternal education				
Illiterate	8	3.1	21.75±7.72	0.394
1st - 4th grade	72	27.8	26.47±10.24	
5th - 8th grade	101	39.0	26.63±9.21	
Secondary school or higher education	78	30.1	26.93±10.15	
Household income				
< 1 MW	71	27.3	26.38±10.93	0.873
≥ 1 MW	189	72.7	26.59±9.59	
Exposure to domestic violence				
Yes	49	29.5	22.83±8.37	0.003
No	117	70.5	27.77±10.03	
Calorie intake (mean calories)	2,086.22	SD = ±748.78		0.893[†]

* Correlation test for continuous variable p < 0.001
† Correlation test p = 0.893
MW = minimum wage; n = number of individuals; SD = standard deviation.

performance measured by means of tests of intellectual capacity is superior when tests are administered to children older than 11 years.[19] The scores of cognitive competence evaluations using the Raven's test (mean = 26.48±9.70 points) were higher than the variation of the results found by Santos et al.[20] (mean = 20.0±10.1 points) in Jequié, Brazil, in a study that included participants of a similar age group and a sample of Brazilian students attending public elementary schools. No data are available to support a more profound discussion about the reasons why a high prevalence of students with low levels of cognitive development was found in this study (63.3%). According to several authors, factors associated with the children themselves, their families and their schools contribute to the poor school performance and low performance in cognitive development tets.[20] The nature of the sample included may partly explain the low cognitive levels found in this study, as the participants were poor children enrolled in public schools, which usually have meager pedagogical resources.

In this study, data revealed the effect of malnutrition on below-average intellectual development, an association observed when adjusted for domestic violence (aPR = 1.60; 95%CI = 1.01 – 2.52; p = 0.042). Of the few studies found in Brazilian literature, the one conducted by Miranda et al.[8] stands out, as they used the same psychometric tests (Raven's Progressive Matrices) to evaluate cognitive development. Their results confirmed the negative effect of malnutrition on cognitive levels in the same stage of life. Studies conducted in other parts of the world reported similar findings.[21] However, no study has discussed the role of the family microsystem in which there is violence, directly approached in our study. In the literature, Grantham-McGregor and Baker-Henningham provided a detailed description of the main mechanisms by which malnutrition may affect cognitive functioning.[5] According to their arguments, children that undergo nutritional deprivation have low vitality, which reduces their interaction with the environment, a factor that limits cognitive development.[22,23]

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Our study confirmed that exposure to domestic violence was a potential confounding factor of the association between malnutrition and below-average intellectual development. The negative effects of direct or indirect exposure to domestic violence on morbidity among children and adolescents have been discussed by several authors.[24,25] Children exposed to domestic violence may present with depression or behaviors characterized by progressive social isolation, as well as sleep or appetite disorders. Anorexia in children and adolescents may be an example of the dysfunction between nutrition and psyche.[21] At the same time, the negative effects of domestic violence may be reflected in their cognitive and emotional functioning, as well as in their school performance and social life.[26,27] Several hypotheses to explain this association have been discussed in the literature.[26-28] It is a consensus among authors that the stress associated with witnessing domestic violence may contribute to emotional and behavioral problems, such as anxiety, depression and behavior disorders, which negatively affect cognitive development.[29] Studies in the literature have also suggested that families with a poor emotional state are less available for the care and interaction with the child, which raises the risk of diseases and delays in growth and development.[28]

This study has limitations that are inherent to cross-sectional investigations, particularly because it estimated the associations between the variables (response and exposure) at the same time, and especially because it does not approach

Table 2 - Mean and standard deviation of anthropometric measures and indices according to exposure to domestic violence among children and adolescents in public elementary schools. Salvador, Brazil, 2008

	Exposure to domestic violence		
	Yes (n = 49)	No (n = 117)	
Variable	Mean (SD)	Mean (SD)	p
Body mass index	16.68 (3.07)	17.48 (3.06)	0.097
Percentage of fat (%)	15.83 (6.71)	17.93 (6.82)	0.051
Arm circumference	20.08 (3.27)	21.26 (3.39)	0.027
Tricipital skinfold	9.94 (4.96)	11.30 (4.76)	0.076
Subscapular skinfold	7.71 (4.20)	9.17 (4.20)	0.025
Sum of skinfold thicknesses	17.79 (8.64)	21.05 (8.54)	0.027
Arm muscle area	23.45 (7.11)	25.64 (6.93)	0.068
Weight	34.62 (12.18)	39.43 (12.52)	0.015
Height	1.42 (0.14)	1.48 (0.14)	0.005

n = number of individuals; SD = standard deviation.

Table 3 - Association between malnutrition and cognitive deficit in children and adolescents in public elementary schools. Salvador, Brazil, 2008

	Univariate analysis		Complete model		Adjusted model*	
Variable	PR	95%CI	PR	95%CI	PR	95%CI
Malnutrition	1.34	0.99-1.82	1.65	1.04-2.60	1.60	1.01-2.52
Sex			0.87	0.56-1.34		
Age			1.16	1.05-1.29	1.18	1.07-1.31
Household income			1.00	0.99-1.00		
Maternal education			1.12	0.71-1.76		
Calories			1.00	0.99-1.00		
Exposure to domestic violence			1.34	0.87-2.06	1.07	0.66-1.71

* p < 0.042.
95%CI = 95% confidence interval; PR = prevalence ratio.

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the time differences between events, which precludes the definition of cause and effect relationships. Future studies should have longitudinal designs to further investigate the causality in the events studied here. Moreover, hierarchical models should be used to include a larger number of both distal and proximal predicting variables in an attempt to clarify the effects of the family microsystem on cognitive development. The use of a single 24-hour dietary recall seems to be one more limitation of this study. However, this method provides reliable information about the mean dietary intake of populations, even when applied only one time, as long as the methodological assumptions are met and the analytical resources are adequate.[30]

Despite the limitations discussed above, the results of this study have scientific merit. In addition to drawing attention to the high prevalence of low cognitive performance among the schoolchildren under evaluation, this study demonstrated the association between malnutrition and below-average intellectual development, in which exposure to domestic violence was a variable that should be included in similar investigations, maybe as the focus of future studies.

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