BMJ Public Health

Factors associated with early childhood development: results from the Brazilian National Survey on Child Nutrition (ENANI-2019)

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To cite: Freitas-Costa NC, Farias DR, Alves-Santos NH, *et al*. Factors associated with early childhood development: results from the Brazilian National Survey on Child Nutrition (ENANI-2019). *BMJ Public Health* 2025;**3**:e001516. doi:10.1136/bmjph-2024-001516

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/bmjph-2024-001516).

Received 27 May 2024
Accepted 17 January 2025

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ABSTRACT

Introduction The full achievement of early childhood development (ECD) is a human right and adhering to the nurturing care framework may facilitate it.

Objective To evaluate the association between distal and proximal variables and developmental quotient (DQ).

Methods Data from 14 159 children <5 years were evaluated in the Brazilian National Survey on Child Nutrition. The Survey of Well-being of Young Children—Brazilian version milestones questionnaire was used to evaluate ECD. The developmental age was estimated using the graded response models. DQ was calculated by dividing developmental age by chronological age. The expected age milestones are attained when DQ=1. DQ predictors were defined considering distal and proximal levels/variables using a multiple linear regression model and a hierarchical approach.

Results The DQ mean was significantly lower among children aged 36–59 months (0.91 (0.88 to 0.93)), boys (1.03 (1.01 to 1.06)) and those from the North region (0.98 (0.93 to 1.04)) compared with children aged 1–35 months (1.18 (1.15 to 1.22)), girls (1.11 (1.08 to 1.13)) and from the Southeast region (1.11 (1.07 to 1.16)). For children aged 1–35 months, DQ was inversely associated with emergency C-section (β=−0.08; p<0.01), consumption of ultra-processed food (β=−0.33; p<0.01), and positively associated with attendance at daycare/school (private: β=0.09; p=0.02 and No: β=0.12; p<0.01). For children aged 36–59 months, attendance to private daycare/school (β=0.08; p<0.01) was positively associated with DQ, and small for gestational age at birth (β=−0.05; p=0.01) and access to public health services (no-primary care) (β=−0.07; p<0.01) were inversely associated with DQ.

Conclusions Adverse health, nutrition and learning factors predicted the ECD, demonstrating an inequitable environment for Brazilian children. These findings indicate a need for public policies to ensure social and health equity in early childhood.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ According to the WHO, the achievement of full early childhood development (ECD) requires an environment that is sensitive to the child's needs, provides emotional support, stimulation and responsiveness, and is developmentally appropriate. This set of conditions is defined as the Nurturing Care Framework.

⇒ There are limited data on ECD in low- and middle-income countries. In Brazil, the ECD status among children under 5 years is overlooked, and previous nationally representative studies did not assess ECD.

WHAT THIS STUDY ADDS

⇒ This is the first study on ECD with representative data of the Brazilian population under 5 years.

⇒ This study demonstrated a lower mean development quotient for the 36–59 months age group and children living in the Northern region, a more vulnerable Brazilian region.

⇒ Social inequalities variables are significant ECD predictors for Brazilian children under 5 years. Access to adequate health services and nutrition (no consumption of ultra-processed foods), attendance at private daycare/schools, higher maternal/caregiver education and family income were predictors of better ECD.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Public policies targeting ECD are essential, particularly in establishing a stable environment and reducing inequalities. This involves implementing policies that secure consistent socioeconomic status and provide adequate learning opportunities.

BACKGROUND

Early childhood development (ECD) is a complex process that comprises the physical, cognitive, motor and socioemotional growth of children up to 8 years of age. It is considered the critical basis for lifelong development, impacting educational performance, productivity at work, physical and mental health, and social well-being into adulthood.[1–5] Children should be exposed to an environment sensitive to their needs, with emotional support, stimulus and responsiveness, and be developmentally appropriate.[5] This set of conditions is defined as the Nurturing Care Framework (NCF) by the WHO and is recommended as the focus for planning government actions and improving the development of children under 5 years as a society.[6] Moreover, the WHO recognises that achieving full ECD potential is a human right and a requirement for global sustainable development.[6]

Children exposed to adversities in early childhood—such as poverty, inadequate nutrition, recurring illnesses, stunting, abuse, violence and lack of learning opportunities (eg, no access to books, toys and child daycare centres/preschools)—along with no or insufficient access to health services may not reach their full ECD potential.[7] In low- and middle-income countries (LMICs), children are at greater risk of not reaching their developmental potential. McCoy *et al* estimated that 80.8 million children aged 36–59 months from 35 LMICs as part of the Multiple Indicator Cluster Survey (MICS) and Demographic and Health Surveys programmes had low cognitive and socioemotional development between 2005 and 2015.[8] A meta-analysis with data from 20 000 children living in LMICs revealed that maternal education, preterm birth, anaemia and lack of access to clean water and sanitation had negative associations with cognitive and motor development.[9] In addition, worst early childhood care and development have been found in the lowest wealth quintiles compared with the highest ones in these LMICs, revealing important disparities.[10] Therefore, there is a strong need to identify factors that support early childhood interventions to guarantee full ECD.

It is estimated that up to 20% of Brazilian children under the age of 5 are at risk of poor ECD due to stunting or extreme poverty.[7] Other countries, such as Argentina, Mexico and Iran, suffer similar burdens.[7] Brazil is a highly unequal society, reflected in significant socioeconomic disparities across its regions and 5570 municipalities.[11] These Brazilian features are also quite common in other LMICs. These inequalities are also starkly evident concerning skin colour, with black and brown individuals being far more likely to live in poverty. Black and brown individuals constitute 55% of the Brazilian population and account for 75% of the least wealthy population in the country.[12]

The Brazilian children's developmental status and regional differences for the Brazilian population remain unknown. Local or non-representative studies of the Brazilian population with different approaches to assessing child development have revealed a prevalence of development below expectations between 20% and 50%, varying with the location and age group evaluated. Therefore, this manuscript aims to describe the developmental quotient (DQ) in a nationally representative sample of Brazilian children under 5 years and examine the association between distal and proximal variables and the DQ, considering the NCF dimensions.

MATERIALS AND METHODS

Study design and participants

This is a cross-sectional study developed with data from the Brazilian National Survey on Child Nutrition (ENANI-2019), the first Brazilian household-based survey with national representation carried out to generate evidence on ECD, diet and nutritional status of children under the age of 5 years.[13] Details and the steps for the sample calculation can be found in Vasconcellos *et al*.

Households with at least one child under 5 years of age were eligible to be included in the ENANI-2019 study population. The following was not eligible: (1) households with indigenous people who lived in villages; (2) households where foreigners reside, and Portuguese was not spoken; (3) children with conditions that disable them for anthropometric measurement and (4) children residing in collective households such as hotels, pensions, orphanages and hospitals.

The ENANI-2019 was conducted in a probabilistic sample of 12 524 households between February 2019 and March 2020. A total of 14 558 children under 5 years of age were evaluated. For the present study, data from 14 159 children were used, considering the ECD assessment does not apply to children <1 month (n=249) and that 150 subjects missed anthropometric data (n=5 for height/length and 145 for weight) (online supplemental figure S1).

ECD assessment

The Survey of Well-being of Young Children Brazilian version (SWYC-BR) developmental milestones questionnaire was used to evaluate the ECD.[14 15] The Brazilian version has been translated, adapted and validated for Brazilian children.[15 16] This questionnaire encompasses the assessment of motor, language and cognitive milestones relevant to the age range specified, providing a single score and not a score per domain.

The 1.01 version of the SWYC-BR used in the present study showed satisfactory internal consistency (Cronbach's alpha=0.97) for the developmental milestones questionnaire. The exploratory factor analysis indicated the unidimensionality of the developmental items and showed satisfactory adjustment of the exploratory model (Kaiser-Meyer-Olkin (KMO=0.97), average variance extracted (AVE=0.73)). The factor loadings varied from 0.78 to 0.97 across the 54 items tested. We also assessed the internal consistency of the SWYC-BR milestones questionnaire using data from ENANI-2019 and Cronbach's alpha. The results demonstrated adequate performance (0.965, 95% CI: 0.963 to 0.968). In the confirmatory factor analysis, the two-factor model provided a better fit than the one-factor and three-factor models. So, both assessments demonstrated that the Brazilian version is similar to the original version.[14]

SWYC-BR is a questionnaire designed to screen for child developmental delays and behavioural problems based on reports from parents/caregivers. The SWYC-BR questionnaire has 10 short questions by age range with three answer options: not yet, somewhat or very much. Overall, 54 milestones were evaluated through 12 sets of 10 age-specific items. Some of these items are repeated among the nearby age groups. Age range milestones set was applied to each age group, and data interpretation was defined by Sheldrick and Perrin.[14]

The ENANI-2019 data collection system automatically selected the appropriate developmental milestones set according to the child's age obtained previously using the date of birth. For children under 2 years born prematurely (<37 weeks of gestation), the corrected age was considered in selecting the appropriate questionnaire. The corrected age was calculated by subtracting the child's gestational age at birth from 40 weeks (full-term) and then subtracting the result from the child's chronological age at the moment of assessment. More details can be found in Freitas-Costa *et al*.[17]

Developmental quotient

The developmental age was estimated using the item response theory and graded response models,[18] using the Mplus software V.7 (Los Angeles, EUA), with the full information method and incorporating the complex sample design.[19] The estimated model allowed the construction of an item characteristic curve (ICC) for each milestone, representing the change in the probability of a given response (sometimes or always) from birth to 62 months of age and estimating the developmental age. The analysis was extended to the chronological age of 62 months because the dataset has five children aged 59–62 months. This was due to the difference between the general interview and child development assessment dates. The graded response model generated an ICC and two parameters (α and β). The $\alpha1$ and $\alpha2$ parameters refer to the probable age at which children reach each developmental milestone, performing them sometimes ($\alpha1$) or always ($\alpha2$), respectively. The β relates to the discrimination power of each milestone. It describes the curve slope, indicating the probability of reaching the developmental milestone, which increases with the child's chronological age. ICC, $\alpha1$, $\alpha2$ and β made it possible to estimate developmental age according to the milestones reached by each child. This methodology has been previously used to assess ECD with the SWYC[14 17 20] and the Denver Test.[21]

The DQ was calculated by dividing the developmental age by the chronological age.[20] DQ=1, which suggests that the milestones expected for age were attained. Values <1 and >1 suggest that attaining milestones were below and above expectations for age, respectively.

Predictors of ECD

The predictors of ECD were defined according to the conceptual model proposed by Black *et al*. The authors proposed a conceptual framework comprised of three levels—nurturing care, environmental and context factors—that directly and indirectly impact full ECD potential and may influence development into adulthood.[3] The ENANI-2019 variables were allocated as distal and proximal levels. The variables referring to NCF (good health, adequate nutrition, opportunities for early learning, security and safety and responsive caregiving) were considered at the proximal level.

Proximal level variables

Mode of delivery (vaginal, planned or elective C-section and emergency C-section), access to health services (public–primary care unit, public–no-primary care and private practice or clinic) and attendance at child daycare centres or schools (public, private or no daycare/school) were assessed through a structured questionnaire.

The gestational age and weight at birth were reported by the mother/caregiver, and the International Fetal and Newborn Growth Consortium for the 21st Century (Intergrowth-21st) recommendations were used to define birth weight percentile. These percentiles were classified as small for gestational age (SGA <10th percentile), adequate for gestational age (AGA 10–90 percentile) and large for gestational age (AGA >90th percentile).[22]

The anthropometric assessment was carried out by measuring the child's length/height and weight. Details for the anthropometric evaluation were described previously.[23] BMI-for-age and length/height-for-age z-scores were calculated and classified considering the child's age (in days) and sex according to WHO standards.[24]

Food markers consumed the day before the interview were assessed using a structured questionnaire with 40 items.[25] The structure of the questions was: 'Did (child name) eat (type of food) yesterday?' The answer options were: 'yes,' 'no' and 'does not know/did not want to answer'. More details about this questionnaire can be found in Lacerda *et al*. Consumption of ultra-processed food (UPF) was considered when the child received one or more UPF the day before the interview,[26] such as soda, other sweetened beverages (industrialised juices and coconut water in cartons, natural guarana or guarana syrup, currant drink, powdered fruit juice, natural fruit, juice with added sugar); packaged snacks (including crisps); cookies, crackers; candy, lollipops and other sweets; industrialised bread; instant flours (rice, corn, wheat or oat); processed meats (hamburger, ham, baloney, salami, nuggets, sausage, hotdogs); industrialised seasonings and instant noodles.

Distal level variables

The following variables were considered at the distal level: sex, skin colour (white, brown, black), Brazilian macroregion (Southeast, North, Northeast, South, Midwest), maternal/caregiver occupation (working, unemployed, housewife, student), habitation condition (home ownership, rented, borrowed), maternal/caregiver marital status (lives with a partner, lives without a partner), maternal/caregiver education (0–7, 8–10, ≥11 years), water supply (distribution network and well or spring, other), sanitation (sewage system, septic tank and ditch, discarded in rivers, lake, sea or other), the families' access to income transfer programmes ('Bolsa Familia' cash transfer programme, another benefit, does not receive any benefit) and per-capita family income categories in US$ (0–62.2, 62.2–124.4, 124.5–248.7, >248.7–8281.4). The family income was estimated from the Brazilian minimum monthly wage (R$ 998.00) and converted to the US$ exchange rate (R$ 4.013=US$1) on 30 December 2019. The Brazilian education system is structured into elementary education (up to 8 years), secondary education (between 8 and 10 years) and higher education and above (≥11 years). We opted to classify maternal/caregiver education into three categories: incomplete elementary education (0–7 years), incomplete secondary education (8–10 years) and complete secondary, higher and above (≥11 years).

Statistical analyses

The statistical analyses were performed in the R language using 'srvyr' an 'survey' packages, considering the complex sample design of the study, so the sample weights were incorporated into the design object R. Descriptive analysis was performed using mean DQ and 95% CI. The coefficient of variation (CV) was used to assess the level of precision for variables evaluated in ENANI-2019. CV is a dispersion measure obtained from the ratio between the SE and the estimated value for each indicator. CV <30% was established as an adequate level. This threshold has been based on the recommendations of the Brazilian Institute of Geography and Statistics.[27] All estimates presented in this paper show a CV <30%. Statistical significance was determined by the absence of overlap in the 95% CIs and a p value of <0.05.

ECD predictors were classified into distal and proximal, considering the conceptual framework proposed by Black *et al*. Then, the hierarchical approach procedure was applied to prevent underestimating the effects of distal level factors in a theoretical model.[28] The first step consisted of running two distinct multiple linear regression models, one for each level (distal and proximal). Variables that showed statistical significance considering p value <0.20 were kept in each model.[29] Then, in the second step, a new multiple linear regression model was run only with the variables from the distal level. Those with p value <0.05 were interpreted as the distal level variables associated with DQ. These variables were taken to the next step. In the third step, the distal predictors associated with the DQ that showed statistical significance (p value <0.05) were retained in the model with all variables from the proximal level that presented p value <0.20 in the first step. The final step comprised running a new model with distal variables from step 3, and the variables from proximal level with p value <0.05 were considered predictors associated with the DQ. Additionally, different models by age group (1–35 and 36–59 months) were implemented, and forest plots were used to present the regression model coefficients.

RESULTS

The mean (95% CI) DQ for Brazilian children was 1.07 (1.04 to 1.09) (figure 1), and 53.7% of children assessed had a DQ <1, suggesting that attaining milestones was below expectations for age. Lower mean DQ was observed among children aged 36–59 months (0.91 (0.88 to 0.93)) than 1–35 months (1.18 (1.15 to 1.22)), and for boys (1.03 (1.01 to 1.06)) compared with girls (1.11 (1.08 to 1.13)) independently of the age group (figure 1 and table 1). The mean DQ for children from the Northern region (0.98 (0.93 to 1.04)) was statistically lower than those from the Southeast region (1.11 (1.07 to 1.16)) between 1 and 59 months. The same was observed for children aged 1–35 months, but no regional differences were observed for mean DQ in the 36–59 months age group (figure 1). The prevalence of DQ <1 differed according to age group (1–35 months: 44.4 (95% CI: 41.4 to 47.4); than 36–59 months: 67.1 (95% CI: 63.8 to 70.4)) and Brazilian macro-region (North: 63.1 (95% CI: 57.8 to 68.3) compared with Southeast: 49.6 (95% CI: 44.3 to 54.9)) (results not showed).

Lower DQ means were observed for children whose mother/caregiver had 0–7 years of education, residing in households with inadequate sanitation, with waste discarded in ditches, rivers, lakes, seas and other unsanitary conditions, living in households with a ditch, discarded in rivers, lakes, sea or other sanitation, with lower per-capita family income categories, and who participated in the 'Bolsa Familia' programme (table 1). In the proximal level, children who did not consume UPF on the previous day had higher mean DQ than those who did consume. Higher mean DQ was observed among children who did not attend any daycare/school or attended private daycare/school between the ages of 1–59 months and 1–35 months. On the other hand, among children aged 36–59 months, the mean DQ was higher for those who attended private daycare/school compared with other categories (public or did not attend daycare/school) (table 2).

The multiple regression model result shows several proximal variables are associated with DQ. Attendance at child daycare/schools was positively associated with DQ for all age groups (private: 1–59 months: β=0.081; p=0.001; 1–35 months: β=0.090; p=0.025; 36–59 months: β=0.084; p<0.001; No attendance: 1–59 months: β=0.160; p=0.001; 1–35 months: β=0.117; p<0.001). In contrast, consumption of UPF (yes: 1–59 months: β=−0.317; p<0.001; 1–35 months: β=−0.333; p<0.001), mode of delivery (emergency C-section: 1–59 months: β=−0.044; p=0.007; 1–35 months: β=−0.079; p=0.002), birth weight for gestational age (SGA: 36–59 months: β=−0.046; p=0.009) and access

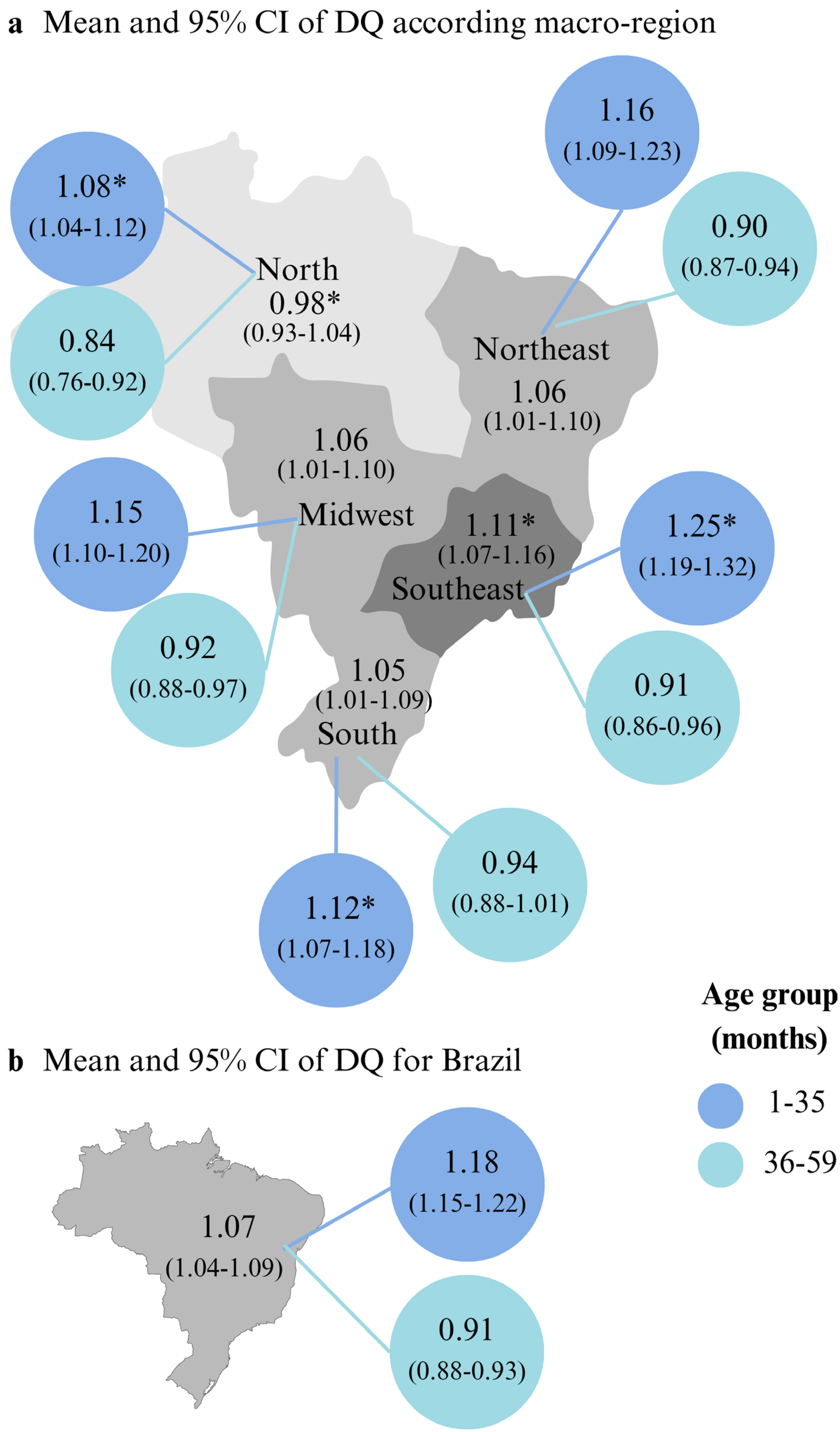

Figure 1 Developmental quotient (DQ) mean and 95% CI according to Brazilian macro-region (a) and for Brazil (b) according to age group: 1–59, 1–35 and 36–59 months children evaluated in ENANI-2019 (n=14 159). Note: *differences between mean DQ according to the Brazilian macro-region in the same age group consider the lack 95% CI overlap. DQ was calculated using the Survey of Well-being of Young Children's—Brazilian version (SWYC-BR) milestones questionnaire. The developmental age was estimated considering the child's age at which the developmental milestones were achieved. DQ=developmental age÷chronological age.[20] DQ=1 indicates that expected age milestones have been attained; DQ<1 and >1 suggest the attainment of specific age milestones happened below or above expectations, respectively.

Table 1 Mean developmental quotient according to distal level variables by age groups for children 1–59 months evaluated in ENANI-2019 (n=14 159)

				Age groups (months)			
	All children			1–35		36–59	
Variables	**%**	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**
Zone							
Urban	96.2	1.07	1.05 to 1.10	1.19	1.15 to 1.22	0.91	0.88 to 0.93
Rural	3.8	1.04	0.98 to 1.10	1.11	1.03 to 1.19	0.86	0.77 to 0.95
Sex							
Male	51.2	1.03*	1.01 to 1.06	1.15*	1.11 to 1.19	0.87*	0.84 to 0.90
Female	48.8	1.11*	1.08 to 1.13	1.22*	1.18 to 1.26	0.94*	0.91 to 0.97
Skin colour†							
White	41.2	1.10	1.07 to 1.12	1.21	1.17 to 1.24	0.93	0.89 to 0.96
Brown	51.7	1.05	1.02 to 1.08	1.16	1.12 to 1.20	0.89	0.86 to 0.91
Black	6.5	1.09	1.02 to 1.15	1.21	1.12 to 1.30	0.93	0.87 to 1.00
Caregiver/maternal occupation							
Working	42.1	1.08	1.05 to 1.10	1.20	1.16 to 1.23	0.93	0.90 to 0.97
Unemployed	24.9	1.05	1.02 to 1.09	1.16	1.12 to 1.21	0.88	0.84 to 0.91
Housewife	30.6	1.06	1.03 to 1.09	1.16	1.12 to 1.21	0.89	0.85 to 0.92
Student or other	2.4	1.17	1.02 to 1.32	1.34	1.09 to 1.58	0.88	0.82 to 0.94
Habitation†							
Home ownership	62.6	1.07	1.04 to 1.11	1.19	1.14 to 1.23	0.92	0.89 to 0.94
Rented	27.1	1.07	1.03 to 1.10	1.19	1.14 to 1.23	0.87	0.83 to 0.91
Borrowed	9.8	1.04	1.00 to 1.09	1.14	1.08 to 1.20	0.91	0.85 to 0.97
Caregiver marital status							
Lives with partner	72.7	1.06	1.04 to 1.09	1.17	1.13 to 1.21	0.90	0.88 to 0.93
Lives without partner	27.3	1.08	1.05 to 1.12	1.22	1.17 to 1.27	0.91	0.87 to 0.95
Maternal/caregiver education (years)							
0–7	22.4	0.98*	0.95 to 1.01	1.09*	1.06 to 1.13	0.84*	0.80 to 0.88
8–10	21.2	1.06	1.01 to 1.10	1.15	1.09 to 1.21	0.89	0.85 to 0.93
≥11	56.4	1.11*	1.08 to 1.14	1.23*	1.18 to 1.27	0.94*	0.91 to 0.97
Water supply							
Network distribution	93.3	1.07	1.05 to 1.10	1.19	1.15 to 1.23	0.91	0.88 to 0.93
Well, spring or other	6.7	1.00	0.94 to 1.06	1.08	1.02 to 1.14	0.85	0.76 to 0.94
Sanitation							
Sewage system	74.5	1.09*	1.06 to 1.12	1.20*	1.16 to 1.25	0.92	0.89 to 0.95
Septic tank	23.0	1.02	0.99 to 1.06	1.12	1.08 to 1.16	0.87	0.83 to 0.91
Ditch, discarded in rivers, lakes, sea or other	2.5	0.96*	0.90 to 1.03	1.08*	0.99 to 1.17	0.83	0.73 to 0.93
Per-capita family income (USD)‡							
<62.2	28.1	1.05	1.00 to 1.09	1.16	1.11 to 1.22	0.88*	0.84 to 0.91
62.2–124.4	32.9	1.03	1.00 to 1.05	1.14*	1.10 to 1.18	0.86*	0.82 to 0.89
124.5–248.7	25.8	1.12	1.08 to 1.15	1.24*	1.19 to 1.29	0.94	0.91 to 0.98
>248.7	13.2	1.14	1.09 to 1.18	1.22	1.16 to 1.28	1.01*	0.96 to 1.05
'Bolsa Família' cash transfer programme							
Yes	37.3	1.01*	0.98 to 1.04	1.11*	1.08 to 1.15	0.86*	0.83 to 0.89
Receive other benefit	5.7	1.03	0.97 to 1.09	1.19	1.11 to 1.28	0.87	0.80 to 0.94
Does not receive any benefit	57.0	1.11*	1.07 to 1.15	1.23*	1.17 to 1.28	0.94*	0.91 to 0.97

Developmental quotient (DQ) was calculated using the Survey of Well-being of Young Children's - Brazilian version (SWYC-BR) milestones questionnaire. The developmental age was estimated considering the child's age at the developmental milestones were achieved. DQ = developmental age ÷ chronological age.[20] DQ = 1 indicates that expected age milestones have been attained; DQ < 1 and > 1 suggest that the attainment of specific age milestones happened below or above expectations, respectively.
*Indicate the presence of statistical differences in mean DQ according to the variable categories. Statistical differences are based on the lack of overlap in the 95% confidence intervals within the age range.
†A category of "other" represents < 1% of the population and was not shown in the results.
‡Estimated from the Brazilian minimum wage (R$ 998.00) and converted to the dollar exchange rate (R$ 4.013 = $ 1) in December 30th, 2019
95% CI, 95% confidence interval; USD, United States Dollar.

Table 2 Mean developmental quotient according to proximal levels variables and age groups for children 1–59 months evaluated in ENANI-2019 (n=14 159)

Variables	All children			Age groups (months) 1–35		36–59	
	%	Mean	95% CI	Mean	95% CI	Mean	95% CI
Birth weight for gestational age*							
SGA (<P10)	11.8	1.03	0.98 to 1.08	1.17	1.09 to 1.24	0.86	0.82 to 0.91
AGA (P10–P90)	71.5	1.09	1.06 to 1.11	1.19	1.16 to 1.23	0.92	0.90 to 0.94
LGA (>P90)	16.4	1.02	0.98 to 1.06	1.14	1.09 to 1.18	0.88	0.83 to 0.93
Mode of delivery							
Vaginal	51.7	1.07	1.04 to 1.10	1.19	1.15 to 1.23	0.89	0.87 to 0.92
Planned or elective C-section	21.7	1.10	1.06 to 1.14	1.23	1.18 to 1.28	0.94	0.90 to 0.99
Emergency C-section	26.6	1.04	1.00 to 1.07	1.13	1.08 to 1.17	0.89	0.86 to 0.92
Access to health services†							
Public (primary care unit)	73.2	1.06	1.03 to 1.09	1.18	1.14 to 1.22	0.90	0.87 to 0.92
Public (no-primary care)	6.7	1.01	0.94 to 1.07	1.13	1.04 to 1.22	0.84	0.80 to 0.88
Private practice or clinic	19.1	1.12	1.08 to 1.15	1.22	1.17 to 1.27	0.96	0.92 to 1.00
Length/height-for-age (Z-score <−2)							
Yes	6.8	1.08	1.00 to 1.16	1.16	1.06 to 1.25	0.87	0.81 to 0.93
No	93.2	1.07	1.04 to 1.09	1.18	1.15 to 1.22	0.91	0.88 to 0.93
Body mass index for-age (Z-score)							
Underweight (Z<−2)	2.9	1.12	1.03 to 1.21	1.25	1.14 to 1.36	0.89	0.80 to 0.98
Eutrophic (−2≤Z≤1)	68.6	1.07	1.04 to 1.10	1.20	1.16 to 1.24	0.90	0.88 to 0.93
Overweight risk (1<Z≤2)	18.3	1.07	1.03 to 1.11	1.15	1.10 to 1.20	0.92	0.87 to 0.96
Overweight (Z>2)	10.2	1.06	1.00 to 1.12	1.13	1.05 to 1.21	0.92	0.85 to 1.00
Consumption of ultra-processed foods‡							
No	17.4	1.37§	1.29 to 1.45	1.45§	1.36 to 1.54	0.92	0.85 to 0.99
Yes	82.6	1.01§	0.98 to 1.03	1.09§	1.07 to 1.12	0.90	0.88 to 0.93
Daycare or school							
Public daycare or school	31.2	0.95§¶	0.92 to 0.97	1.06§	1.03 to 1.10	0.90§	0.87 to 0.93
Private daycare or school	9.8	1.05¶**	1.01 to 1.09	1.17	1.10 to 1.24	1.00§¶	0.96 to 1.04
No	59.0	1.14§**	1.10 to 1.17	1.21§	1.17 to 1.25	0.86¶	0.83 to 0.90

The information is missing for 0.91% of the sample, referring to children born at 43 weeks of gestation, and cannot be classified by the intergrowth-21st curves. The following foods were considered ultra-processed: soda, other sweetened beverages (industrialized juices in cartons, coconut water in cartons, natural guarana or guarana syrup, currant drink, powdered fruit juice, natural fruit, juice with added sugar); packaged snacks (including crisps); cookies, crackers; candy, lollipops, and other sweets; industrialized bread; instant flours (rice, corn, wheat, or oat); processed meats (hamburger, ham, baloney, salami, nuggets, sausage, hotdogs); industrialized seasonings; and instant noodles. Developmental quotient (DQ) was calculated using the Survey of Well-being of Young Children's - Brazilian version (SWYC-BR) milestones questionnaire. The developmental age was estimated considering the child's age at the developmental milestones were achieved. DQ = developmental age ÷ chronological age [20]. DQ = 1 indicates that expected age milestones have been attained; DQ < 1 and > 1 suggest the attainment of specific age milestones happened below or above expectations, respectively.

*Birth weight according to sex and gestational age-specific percentiles using the INTERGROWTH-21st charts.

†A category of "other" represents < 1% of the population and was not shown in the results.

‡If the child received one or more ultra-processed foods the day before the interview. The following foods were considered ultra-processed: soda, other sweetened beverages (industrialized juices in cartons, coconut water in cartons, natural guarana or guarana syrup, currant drink, powdered fruit juice, natural fruit, juice with added sugar); packaged snacks (including crisps); cookies, crackers; candy, lollipops, and other sweets; industrialized bread; instant flours (rice, corn, wheat, or oat); processed meats (hamburger, ham, baloney, salami, nuggets, sausage, hotdogs); industrialized seasonings; and instant noodles.

§Indicate the presence of statistical differences in mean DQ according to the variable categories. Statistical differences are based on the lack of overlap in the 95% confidence intervals within the age range. The means were different between age groups for all variables.

¶Indicates the presence of statistical differences in mean DQ according to the variable categories. Statistical differences are based on the lack of overlap in the 95% confidence intervals within the age range. The means were different between age groups for all variables.

**Upper script letters indicate the presence of statistical differences in mean DQ according to the variable categories. Statistical differences are based on the lack of overlap in the 95% confidence intervals within the age range. The means were different between age groups for all variables.

AGA, adequate for gestational age (P10–P90); 95% CI, 95% confidence interval; LGA, large for gestational age (>P90); SGA, small for gestational age (<P90).

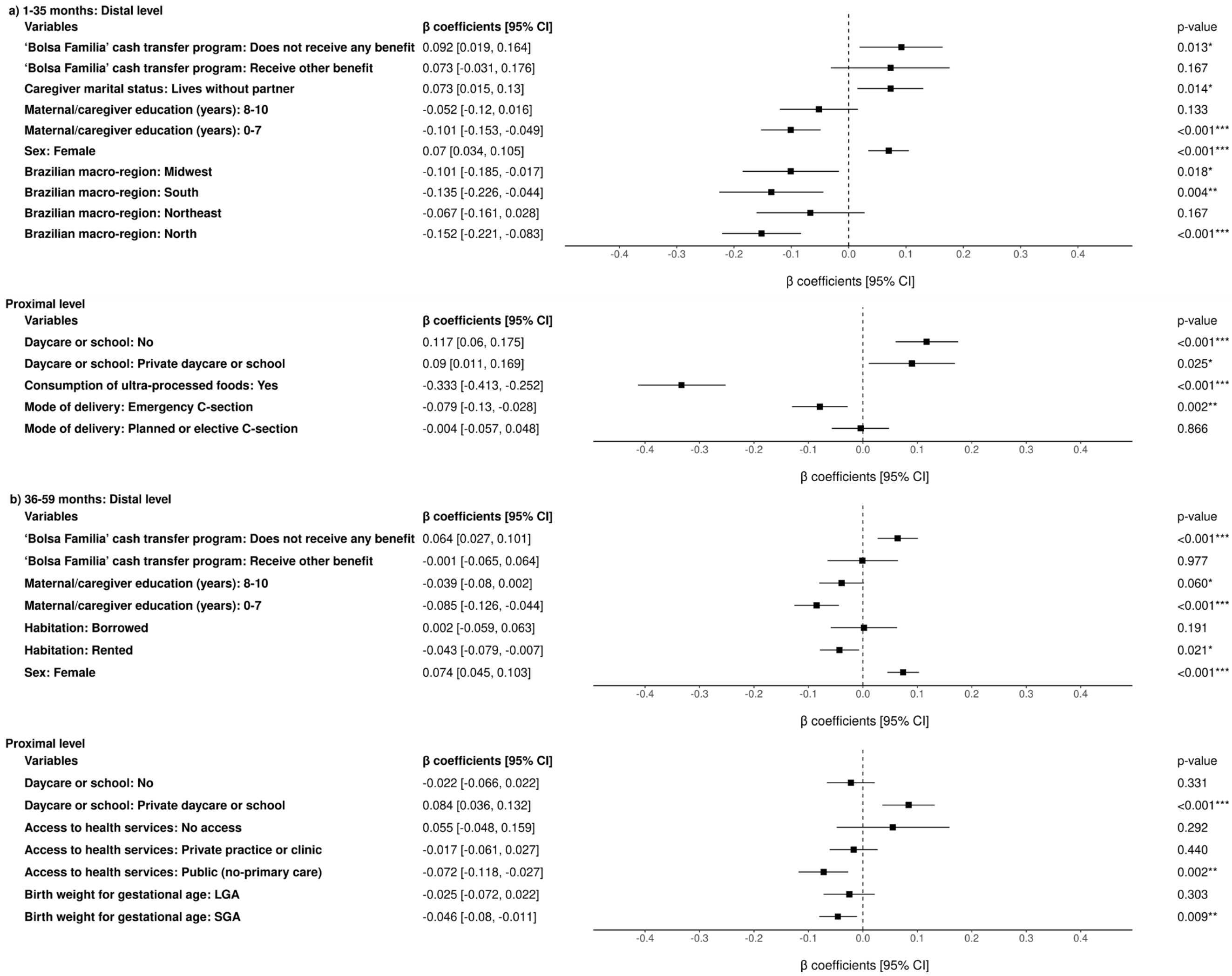

Figure 2 Association between developmental quotient (DQ) and distal and proximal variables according to age groups for children (a) 1–35 and (b) 36–59 months evaluated in ENANI-2019 (n=14 159). Note: multiple linear regression adjusted according to the hierarchical model. Individual models were developed for each group (1–35 and 36–59 months). Therefore, the variables included in the multiple models varied between age groups. The following steps were implemented for all age groups: (1) An individual model for each hierarchical category (distal and proximal levels) was performed. The variables with statistical significance of p<0.20 were kept for the subsequent level of the hierarchical model. (2) The variables of the previous level were added in the hierarchical order. First, the distal level variables with statistical significance of p<0.05 were kept in the model. Then, the proximal level variables were added to the model, and those with statistical significance (p<0.05) were kept for the final model. (3) The multiple models were performed. Family income: estimated from the Brazilian minimum wage (R$ 998.00) and converted to the dollar exchange rate (R$ 4.013=$1) in 30 December 2019. Birth weight according to sex and gestational age-specific percentiles using the INTERGROWTH-21st charts. SGA, small for gestational age (<P10); AGA, adequate for gestational age (P10–P90) and LGA, large for gestational age (>P90). Consumption of ultra-processed foods: The following foods were considered ultra-processed: soda, other sweetened beverages (industrialised juices in cartons, coconut water in cartons, natural guarana or guarana syrup, currant drink, powdered fruit juice, natural fruit, juice with added sugar); packaged snacks (including crisps); cookies, crackers; candy, lollipops and other sweets; industrialised bread; instant flours (rice, corn, wheat or oat); processed meats (hamburger, ham, baloney, salami, nuggets, sausage, hotdogs); industrialised seasonings and instant noodles. DQ was calculated using the Survey of Well-being of Young Children's—Brazilian version (SWYC-BR) milestones questionnaire. The developmental age was estimated considering the child's age at which the developmental milestones were achieved. DQ=developmental age÷chronological age.[20] DQ=1 indicates that expected age milestones have been attained; DQ<1 and >1 suggest the attainment of specific age milestones happened below or above expectations, respectively.

to health services (36–59 months: Public (no-primary care): β=–0.072; p=0.002) were inversely associated with DQ (figure 2 and online supplemental table S1).

In the distal level, the habitation condition (rented: 36–59 months: β=–0.043; p=0.021), family income (1–59 months: 62.2–124.4 US$: β=–0.069; p=0.008) and caregiver/maternal education (1–59 months: 0–7 years: β=–0.100; p<0.001; 1–35 months: 0–7 years: β=–0.101; p<0.001; 36–59 months: 0–7 years: β=–0.085; p<0.001) were inversely associated with DQ. The mother/caregiver marital status (lives without a partner: 1–59 months: β=0.041; p=0.045; 1–35 months: β=0.073; p=0.014), non-participation in 'Bolsa Família' cash transfer programme (1–59 months: β=0.067; p=0.031; 1–35 months: β=−0.092; p=0.013; 36–59 months: β=0.064; p<0.001) and sex (female: 1–59 months: β=0.072; p<0.001; 1–35 months: β=−0.070; p<0.001; 36–59 months: β=0.074; p<0.001) were positively associated with DQ. Additionally, the Brazilian macro-region of the household was inversely associated with DQ in the age groups of 1–59 (North: β=−0.118; p<0.001; South: β=−0.067; p=0.032) and 1–35 (North: β=−0.162; p<0.001; Midwest: β=−0.097; p=0.020; South: β=−0.120; p=0.005), but not for the 36–59 months (figure 2 and online supplemental table S1).

DISCUSSION

The ENANI-2019 results revealed that girls, children aged between 1–35 months and those living in the Southeast region of Brazil had higher mean DQ than boys, children aged between 36–59 months and the other Brazilian regions, especially the North. We also observed that distal variables, such as living in the North, Midwest or South region, a rented household, a less educated mother or caregiver and having lower family income were inversely associated with ECD while being a girl, mothers or caregivers living without a partner, and no participation in cash transfer programmes were positively associated. At the proximal level, for children between 1–35 months, emergency C-section birth and consumption of UPF were inversely associated, and no attendance or attendance at private child daycare/schools was positively associated with ECD. Among children 36–59 months, being born SGA and access to public health services different from primary care were inversely associated. Attendance at private child daycare/schools was positively associated with ECD.

Several studies have reported that girls tend to have better ECD compared with boys, which is consistent with the current study findings for both age groups.[30–32] Some theories have attempted to explain this sex difference, involving biological and social factors. According to biological theory, sexual hormones such as oestrogen and testosterone and genetic factors, mainly the holding of an XX versus an XY genotype, play a role in the brain structure and function.[33 34] In addition, societal factors and gender norms impact how girls and boys are raised, influencing their language, cognitive, and behavioural development, contributing to gender differences.[35–37] It has been observed that girls tend to acquire various language skills earlier than boys.[38–40] One possible explanation is how parents speak and play with sons and daughters. Parents tend to talk more with daughters and use their sounds in a supportive conversation, which offers daughters greater exposure to the language.[39] For games, a study showed that parents prefer symbolic play with daughters while with sons, it is action-oriented, which tends to affect different abilities between boys and girls.[41]

The 36–59 months age group has been reported to be at higher risk of ECD delay.[30 42] Our previous work revealed an inverse association between chronological age and ECD, that is, a significant drop in the mean DQ occurred after 36 months.[17] ECD is a continuous and cumulative process; therefore, noticeable delays in the first years of life may take some time to achieve a detrimental level. Besides, it is known that these delays tend to prevent the full achievement of the following milestones, mainly if the harmful exposure to developmental determinants persists for long periods.[43 44] The first 1000 days of life, from conception to 23 months, are critical for child growth and development. Furthermore, adversity and toxic stress during the first years of life may not produce immediately apparent effects but can manifest later in life.[3 45]

This is the first study that evaluates ECD considering regional differences in a representative Brazilian sample. Brazil has continental dimensions and regions with unique cultural and socioeconomic characteristics. The Human Development Index (HDI) is higher in the regions characterised by higher socioeconomic development and access to health services, such as South (0.754), Southeast (0.766) and MidWest (0.757). In contrast, the North and Northeast have lower HDI values of 0.667 and 0.663, respectively, and are regions with lower socioeconomic development and lower access to health services.[46 47] Thus, social and health inequalities and cultural behaviours may explain differences in ECD according to Brazilian regions.

Social inequalities have been reported with significant imprints in the short and long-term ECD.[48] Barros and Ewerling analysed data from 44 MICS studies (2010–2014) and found a 20% difference in ECD adequacy indicator when comparisons were made between the highest and the lowest wealth quintile in the Latin American and Caribbean for children aged 36–59 months.[49] Access to educational programmes such as child daycare centres and preschools, and early learning activities delivered at home in LMICs are also prone to disparities. According to Lu *et al*, the difference in the availability of such programmes was 33.7% for early care programmes and 26.5% for home stimulation when the highest and lowest quintiles were compared.[10] Johnson *et al* found that 28 761 American children from low socioeconomic backgrounds showed significant cognitive development improvement by age seven, but only when family income increased.[48] Several studies have associated family income or socioeconomic status with ECD.[48 49] Our findings corroborate this literature. We found that the lowest family income categories and habitation conditions (rented compared with home ownership) were inversely associated with DQ. We also found a direct association between non-participation in any cash transfer programme, that is, a proxy of better socioeconomic status, and ECD.

In our study, caregiver/mother education was inversely associated with DQ, that is, children from mothers/caregivers with lower schooling presented lower DQ. In a meta-analysis conducted by Ayesha *et al* with 21 studies representing 20 882 children, maternal and paternal education was associated with children's motor, cognitive and language development. The authors observed a dose-response to the parental education level; stronger and direct associations were observed with increasing education.[9] Children of mothers with more education tend to benefit from greater ECD stimulation at home, better feeding and hygiene practices, and access to health services and immunisation, which will also positively impact ECD.[50 51] Furthermore, parents' education correlates with higher family income and better housing conditions, health, and education services.

Achieving health and nutrition indicators is essential for reaching the ECD potential. We revealed that emergency C-section and being born SGA were inversely associated with DQ in children aged 1–35 months and 36–59 months, respectively. Both indicators may reflect the health conditions during the prenatal period and appear to have long-term consequences.[52 53] Birth weight/gestational age is a fetal growth indicator that could affect ECD. In developing countries like Brazil, it has been reported to be a good ECD predictor.[30 54] In contrast, in the meta-analysis of Ayesha *et al*, SGA was not associated with ECD.[9] The lack of association of SGA on ECD in this meta-analysis may be due to the extensive age variation (1–8 years), assuming that ECD predictors differ by age group. The emergency C-section indicates an unhealthy condition that limits the continuation of the pregnancy, requiring surgical intervention. Other Brazilian studies have revealed the relationship between the mode of delivery and ECD, which agrees with our findings.[55 56]

We observed that consumption of UPF was inversely associated with ECD among children aged 1–35 months. UPF are industrial formulations rich in sodium, refined sugars and saturated fats, including hydrogenated and trans fatty acids.[26] In children, data associating UPF intake and its negative consequences in ECD are still scarce in the literature. A birth cohort in Spain with 2377 mother-child dyads revealed that maternal UPF consumption in the third trimester of pregnancy was inversely associated with children's verbal function at 4–5 years of age.[57] The consumption of UPF appears to affect the brain through two mechanisms: neuroinflammation and/or via the gut-brain axis. The excessive intake of trans and saturated fat produces oxidative stress and dysbiosis, consequently neuroinflammation, impairing adequate neurodevelopment.[58 59] Furthermore, UPF consumption may also be associated with nutritional deficiencies contributing to lower ECD levels.[60]

Notably, attendance at child daycare/schools was associated with ECD. For all age groups, no attendance or attendance at private daycare/schools was positively associated with ECD compared with public daycare/schools. Child daycare/schools are essential settings for providing early learning opportunities, maintaining/improving nutritional status and ensuring food security once some meals are eaten at these places.[61–63] In Brazil, enrolment in child daycare centres is optional for ages 0–3 and mandatory in preschools for children aged >3 since 2013.[64] The quality of the activities, the class size, the number of children per educator and teacher qualifications are essential for the success of the learning process.[65 66] Recent meta-analyses revealed positive correlations between the quality of the daycare centres and staff education with social skills, vocabulary and word recognition among children aged 30–72 months.[67 68] On the other hand, children who do not attend daycare centres are usually cared for by parents or other family members, which allows a more intimate relationship with the caregiver and greater interaction and stimulation.[69] Barros *et al* demonstrated that child stimulation at home (eg, someone reads or tells a story, uses the playground, goes to someone else's house, watches TV or has a storybook) is associated with ECD at 24 months.[70]

Some strengths of the ENANI-2019 survey are related to the evidence produced for the ECD discussion on the national and global scene. The ECD of Brazilian children under 5 has been evaluated in a nationally representative sample for the first time. We also used the NCF to assess the factors associated with ECD, a model recommended by the WHO since 2018. These findings will potentially contribute to developing and reviewing early childhood public policies. This includes ensuring a suitable and equitable environment, promoting quality nurturing care and access to quality healthcare throughout life and providing early learning opportunities through high-quality child daycare centres/schools. There are also limitations to consider. The data are from a Brazilian National Survey on Child Nutrition. Since it is a cross-sectional study, we can only make limited inferences about the direction of the associations. Despite the lack of data on responsive caregiving, we were able to analyse variables related to the other domains of the NCF as proximal variables.

In conclusion, distal variables, such as Brazilian macro-region, sex, lower mother/caregiver education and family income, were inversely associated with ECD. Non-participation in the cash transfer programme was positively associated with ECD. Proximal variables, such as birth through emergency caesarean section for children aged 1–35 months and being born SGA among children aged 36–59 months, were associated with lower ECD. Non-attendance and attendance at private daycare/schools were directly associated with ECD for all age groups. Public policies for early childhood should include actions to promote and assure access to quality health assistance from the gestation, address social and economic inequalities and offer opportunities for early learning at home, in the community and educational settings.

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Funding This work was supported by The Brazilian Ministry of Health [Grant/Award Number: Not Applicable] and the Brazilian National Research Council (CPNq) grant number 440890/2017-9. We also thank the Rio de Janeiro State Research Support Foundation—FAPERJ, and the Coordination of Improvement of Higher Education Personnel (CAPES, PhD's fellowship for Freitas-Costa) for funding this study.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved. The ENANI-2019 was approved by the research ethics committee of the Clementino Fraga Filho University Hospital of the Federal University of Rio de Janeiro (CAAE: 89798718.7.0000.5257). Research participation occurred after signing the free and informed consent form by the child's parents or caregivers and after hearing an explanation of all the ethical issues of the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data described and the code book in the manuscript will be made publicly and freely available without restriction at https://enani.nutricao.ufrj.br. Upon request, an analytical code will be made available via the corresponding author's email.

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