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ORIGINAL ARTICLE

Anemia and effective verbal communication in children aged 9 to 36 months

Anemia y comunicación verbal efectiva en niños y niñas de 9 a 36 meses

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What do we know about the subject matter of this study?

Iron deficiency anemia adversely affects the physical growth and neurobehavioral development of children. The impact of anemia on language development or communication skills has not been clearly established.

What does this study contribute to what is already known?

This is the study that. to date. has the largest sample size evaluating the possible association between anemia and EVC in children aged 9 to 36 months. considering the characteristics of the child. their caregivers. and the home. finding no association between anemia and EVC in any age range.

Abstract

Effective Verbal Communication (EVC) is the ability to understand and say what children feel and think, which could be affected by anemia. **Objective:** to determine the association between anemia and EVC at a comprehensive and expressive level according to age in children from 9 to 36 months. **Subjects and Method:** study based on the 2020 Demographic and Family Health Survey of Peru, using a cross-sectional design. Women with no-disabled children aged 9 to 36 months with hemoglobinometry, participants of the Early Childhood Development Module were selected. The degree of anemia was classified according to hemoglobin levels as: normal 11.0 to 14.0; mild 10.0 to 10.9; moderate 7.0 to 9.9, and severe < 7.0 g/dL. These categorizations considered the hemoglobin level adjusted for altitude. For bivariate and multivariate analysis, anemia was defined as present (hemoglobin < 11.0 g/dL) or absent (≥ 11.0 g/dL). EVC was measured with the "Battelle Developmental Inventory", modified and validated for Peruvian children. Binary logistic regression was used, where EVC was the dependent variable and anemia together with other covariates was the independent variable. **Results:** 26.2% and 10.9% of children had mild and moderate-severe anemia, respectively. The proportion of children with EVC without risk according to age was: 9 to 12 months (76.6%), 13 to 18 months (35.4%), 19 to 23 months (25.6%), and 24 to 36 months (55.3%). The association between anemia and EVC was not significant in any age range. The covariates associated with EVC without risk were: sex (13-36 months), maternal literacy (9-12 and 24-36 months), place of residence (24-36 months), and iron administration in the last 12 months (13-18 months). **Conclusions:** anemia is not a factor associated with EVC according to age; there would be other causal pathways that would put the development of EVC at risk.

Keywords:
Anemia;
Child Development;
Verbal Learning;
Preschool;
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Introduction

In 2020, anemia in Peru affected 4 out of 10 children aged 6 to 35 months, with 48.4% prevalence in rural areas and 50.5% in the poorest ones[1]. A quarter of anemia cases among preschoolers are secondary to iron deficiency[2]. In Peru, the risk for anemia starts early; in 2015, the prevalence of anemia in children under 6 months was 23.4%, and in children aged 3 to 5 months was 30.6%[3] which reached 55% in 80 infants hospitalized in a specialized institute[4].

Anemia negatively affects the physical growth and neurobehavioral development of children[5]. This association has been reported mainly for iron deficiency anemia as a risk factor[6-8]. Some cross-sectional[6-9] and longitudinal studies have explored the effect of iron deficiency anemia on cognitive behavioral development at early and later stages[10-12]. Most studies have reported outcomes as psychomotor development or cognitive skills; however, few investigations have evaluated the association between anemia and verbal communication in preschoolers[6,13].

Effective verbal communication (EVC) is the ability of children to understand and communicate what they feel and think. It is a skill acquired progressively, starting with gestures and intentional sounds emitted by the child, followed by the voice discrimination of a recognized adult, until the emission of the first words and phrases. This process should be achieved up to 36 months of age and is measured by the demonstration of certain achievements according to age[14].

The negative impact of anemia on language development or communication skills has not been clearly established. Studies developed in Egyptian[13], Mexican[8], and Chinese[6] children have applied different instruments to assess verbal skills; two of them have had a small sample[8,13] and all have found no association.

The National Institute of Statistics and Informatics (INEI) of Peru conducts the Demographic and Family Health Survey (ENDES), which includes the Early Childhood Development (ECD) Module that assesses five areas of development between the ages 9 and 71 months, including EVC[14]. The ENDES measures hemoglobin in children aged 6 to 35 months and collects information on childcare and sociodemographic characteristics that may be covariates in the association between anemia and EVC[6,15,16]. In Peru, these data have allowed estimating the effect of chronic malnutrition on EVC[17]; however, the effect of anemia on EVC has not been studied.

Given the small sample of previous studies, which may have affected their ability to identify associations and, according to the principle of analogy supported by the existence of negative effects of anemia on other dimensions of psychomotor development in children, we conducted this research to determine whether there is an association between anemia and the EVC development at the comprehensive and expressive level according to age in children aged 9 to 36 months who participated in the 2020 ENDES in Peru.

Subjects and Method

Scope and study design

This is a secondary source study based on the Peruvian 2020 ENDES, which is a cross-sectional population-based survey with a two-stage, probabilistic sample design that provides representative estimates for the national and regional levels, as well as for urban and rural areas. In 2020, of 37,895 eligible women, 35,430 were interviewed (6.5% nonresponse) and, out of 13,529 eligible children, 13,197 were studied (2.5% nonresponse). In that year, because of the mandatory social isolation due to the COVID-19 pandemic, much of the survey was conducted by telephone calls. Once the restrictions of mobility and social isolation were lifted, the face-to-face interviews were resumed, and hemoglobin measurement was performed according to the original design of the survey.

Study population

The target populations of the ENDES are women aged between 12 and 49 years and their children under 5 years of age who are regular residents of the selected house and those who, not being residents, stayed overnight in the house the night before the day of the interview. In this study, a subsample was selected, with inclusion criteria as follows: [a] woman living with a child aged 9 to 36 months without disability and who had participated in the Early Childhood Development (ECD) Module and [b] a child with blood hemoglobin measurement.

Effective verbal communication

The EVC is one of the five areas assessed in the ECD Module which is a tool built to measure the results considered in the National Policy called "Childhood First" approved in 2016[18]. The 2020 ENDES evaluated the EVC with 4 questions for each age bracket: children aged 9 to 12 months (bracket 1), 13 to 18 months (bracket 2), 19 to 23 months (bracket 3), and 24 to 36 months (bracket 4). The first 3 questions evaluate the children's verbal communication and the last one measures the child's participation in adult conversations.

The technique used to collect information was a semi-structured interview of 8 minutes per section answered by the mother. The interaction with the interviewer was a conversation to generate a comfortable environment for the mother according to the technique

described[14]. The interviewers were health professionals trained to apply the ECD Module according to the manual[19]. The INEI, in collaboration with the Peruvian Ministry of Social Inclusion, designed the questions to evaluate the EVC, using the Battelle Developmental Inventory (BDI) as a base instrument for the communication domain. They then validated the resulting instrument in 321 Peruvian children aged 9 to 36 months, obtaining an internal consistency score of 0.786 and 0.851 for the receptive and expressive components, respectively[20].

In the ECD Module questions, the responses were "yes", "no", and "no answer/don't know" and then we evaluated the responses to the first three questions[14,17]. For bracket 1, we considered the following questions: 1. "Does the child try to imitate the words she/he hears?", 2. "Does the child understand when you tell her/him "no" even if she/he ignores you?", and 3. "Does the child understand a simple command such as "give me" or "take it?".

In bracket 2, the following questions were considered: 1. "When the child wants something, does she/he ask with words?"; 2. "When the child is asked to carry from one place to another an object she/he knows as one of her/his toys, does she/he do it?", and 3. "When the child is asked to do something without showing her/him how to do it, does she/he do it?".

In bracket 3, we considered the following questions: 1. "Does she/he name the parts of her/his body?", 2. "When the child talks, does she/he use words?", "When the child talks, does she/he use words that everyone understands?", and "When the child speaks, does she/he use sentences of 2 to 4 words that everyone understands?"; and 3. "When the child is asked to pick up an object that is not in sight and then place it where you indicate without showing her/him how to do it, does she/he do it?". For the questions in item 2, we created a new variable and considered "yes" when all three sub-questions were answered affirmatively.

Finally, in bracket 4, we considered the following questions: 1. "When the child speaks, does she/he use sentences with a subject and an action such as "baby cries"?; 2. "When the child speaks, does she/he use sentences such as "let's go home", "Where is grandma?", and "my mommy is pretty"; and 3. "Does the child understand words that indicate the position of things such as inside and outside or above and below?". In all sections, we defined risk-free EVC when there was an affirmative response ("yes") to all questions.

Anemia

The ENDES determined the hemoglobin concentration in capillary blood using a portable hemoglobinometer (HemoCue® Hb 201+ System). The procedures and supplies for the measurement can be found in the anthropometry procedures manual[21]. The anthropometrists were trained to measure hemoglobin levels which included a workshop on variability in the hemoglobinometer reading and capillary puncture quality, and finally, they were evaluated practically in the work field. Intra- and interobserver measurement reliability was evaluated and was considered acceptable when the difference between measurements did not exceed 0.5 g/dL[22].

The classification of children according to hemoglobin values was: 11.0 to 14.0 g/dL as normal; 10.0 to 10.9 g/dL as mild anemia; 7.0 to 9.9 g/dL as moderate anemia; and < 7.0 g/dL as severe anemia. These categorizations considered the "altitude-adjusted hemoglobin level". For bivariate and multivariate analysis, anemia was defined as present (hemoglobin < 11.0 g/dL) or absent (≥ 11.0 g/dL).

Covariates

Covariates were recategorized into nominal or ordinal scales and were divided into 3 groups. Within child characteristics, we included sex (male, female), age in months (9 to 12, 13 to 18, 19 to 23, and 24 to 36); number of prenatal check-up visits (no visits, 1 to 7 visits, and ≥ 8 visits), cesarean delivery (yes or no), birth weight (< 2,500 g, 2,500 to < 4,000 g, and ≥ 4,000 g); duration of breastfeeding in months (≤ 2 and > 12), immediate breastfeeding (yes or no), exclusive breastfeeding (yes or no); and having received iron supplementation to prevent anemia in the past 12 months, recategorized as "yes" for those who received some form of iron and "no" for those who did not.

The second group of covariates were characteristics of the mother and husband/partner, including maternal educational level (no education, elementary, secondary, and higher); mother's marital status ("never been in a relationship, married, or living with her partner", and "widowed, divorced, or separated"); ethnicity recategorized as "non-indigenous" for those who spoke Spanish, Portuguese, or another foreign language; literacy recategorized as "yes" for those who can read a full sentence and "no" for those who cannot read or read only part of the sentence; number of live births (one, two, three, or more); and health system insurance coverage (yes or no).

The third group of household characteristics included type of area of residence (urban and rural); type of natural region of residence (coast, highlands, and jungle); and wealth index in quintiles. The covariates identified were selected according to the literature review[5,9,15,16,23-26] (Supplementary material, available in the online version).

Statistical analysis

Considering the complex sample design of the

ENDES, we applied the variables V001 (cluster), V022 (stratum), and V005 corresponding to the woman weighting factor. The weight of this last variable (V005) was calculated by dividing it by 1,00,000. This analysis was performed with the complex sample module of SPSS version 25. Estimates were made for the subpopulation defined by women with children aged 9 to 36 months with complete data for the ECD Module and hemoglobin measurement.

We performed a descriptive analysis of anemia, EVC, and covariates of interest using absolute frequencies and weighted proportions with 95% confidence intervals (95%CI). In the bivariate analysis, we considered EVC as the dependent variable and used the Chi-square test (uncorrected) for comparing proportions.

Multivariate analysis was performed by binary logistic regression, where four models were formulated, one per age group. Each model had anemia as the exposure and EVC as the dependent variable. The covariates that entered the model were those that obtained a value of $p < 0.05$ (two-tailed) in the bivariate analysis. All covariates were entered simultaneously into each of the models. We evaluated the absence of multicollinearity among the independent variables in the four models by assessing the standard error of the regression coefficient of each variable. A standard error higher than 2.0 indicated multicollinearity problems between independent variables[27]. In all models, the variables had standard errors of the regression coefficients less than 1.0.

The strength of association between exposure and the dependent variable was estimated with the adjusted Odd Ratio (OR); we present the estimates specifically and with their 95%CI. We considered as statistically significant when the confidence interval did not include unity.

Ethical considerations

The study protocol was approved by the Institutional Research Ethics Committee (CIEI) of the *Universidad de Piura* before its execution. The ENDES database is anonymized and freely accessible on the INEI website[a].

Results

Participant selection flow

There were 10,966 records in the ECD database; after applying the selection criteria, we included data from 4,562 subjects (figure 1). When comparing some characteristics of children included in the analysis with respect to those not included (n = 149), we found no differences regarding the proportion of female children ($p = 0.747$), composition by child age ($p = 0.155$), and proportion of EVC ($p = 0.625$).

Characteristics of the sample

Among the characteristics of the children, the 24 to 36 months age bracket had the highest proportion of participants with 49.6%; 85.7% were born with normal weight; and 62.9% of the children did not have anemia. Regarding the main characteristics of the mother, 83.8% were married or living with her partner, 94.3% were non-indigenous, and 95.1% could read and write. 81.8% had health insurance and 77.9% of the households were from urban areas (table 1). Among the children with anemia, 72.7% received iron in the last 12 months as a preventive measure, and, among those without anemia, 62.7% received iron ($p < 0.001$).

Frequency of effective verbal communication

The proportion of risk-free EVC varied according to age bracket (table 2). In children, according to the degree of anemia, the frequency of risk-free EVC was 49.4% in those without anemia (95%CI: 46.8 to 51.9); 48.3% in those with mild anemia (95%CI: 44.7 to 52.0), and 45.6% in those with moderate or severe anemia (95%CI: 40.0 to 52.4). A higher proportion of risk-free EVC was also observed in females, in children not delivered by cesarean section, those with breastfeeding ≤ 12, and those who had immediate breastfeeding (table 3).

In the bivariate analysis by bracket, in bracket 1, there was an association between risk-free EVC and maternal literacy (78.3% literate v/s 47.1% illiterate; $p = 0.003$). In bracket 2, risk-free EVC was associated with the sex of the child (40.0% females v/s 31.2% males; $p = 0.038$), cesarean delivery (39.1% no v/s 30.4% yes; $p = 0.047$), and having received iron in the last 12 months (38.4% yes v/s 21.7% no; $p = 0.002$). In bracket 3, we found an association between risk-free EVC and the sex of the child (31.3% females v/s 20.4% males; $p = 0.009$). Finally, in bracket 4, we found association of risk-free EVC with the sex of the child (61.5% females v/s 49.2% males; $p < 0.001$), cesarean delivery (58.4% no v/s 50.2% yes; $p = 0.005$), maternal literacy (56.0% literate v/s 42.6% illiterate; $p = 0.041$), type of natural region (60.9% jungle, 58.7% highlands, and 52.6% coast; $p = 0.048$), and rurality (60.8% rural v/s 53.9% urban; $p = 0.044$).

Association between anemia and effective verbal communication

No significant association between anemia and EVC was found in all brackets. However, an increase in the possibility of having risk-free EVC was observed

[a] Available at http://iinei.inei.gob.pe/microdatos/Consulta_por_Encuesta.asp

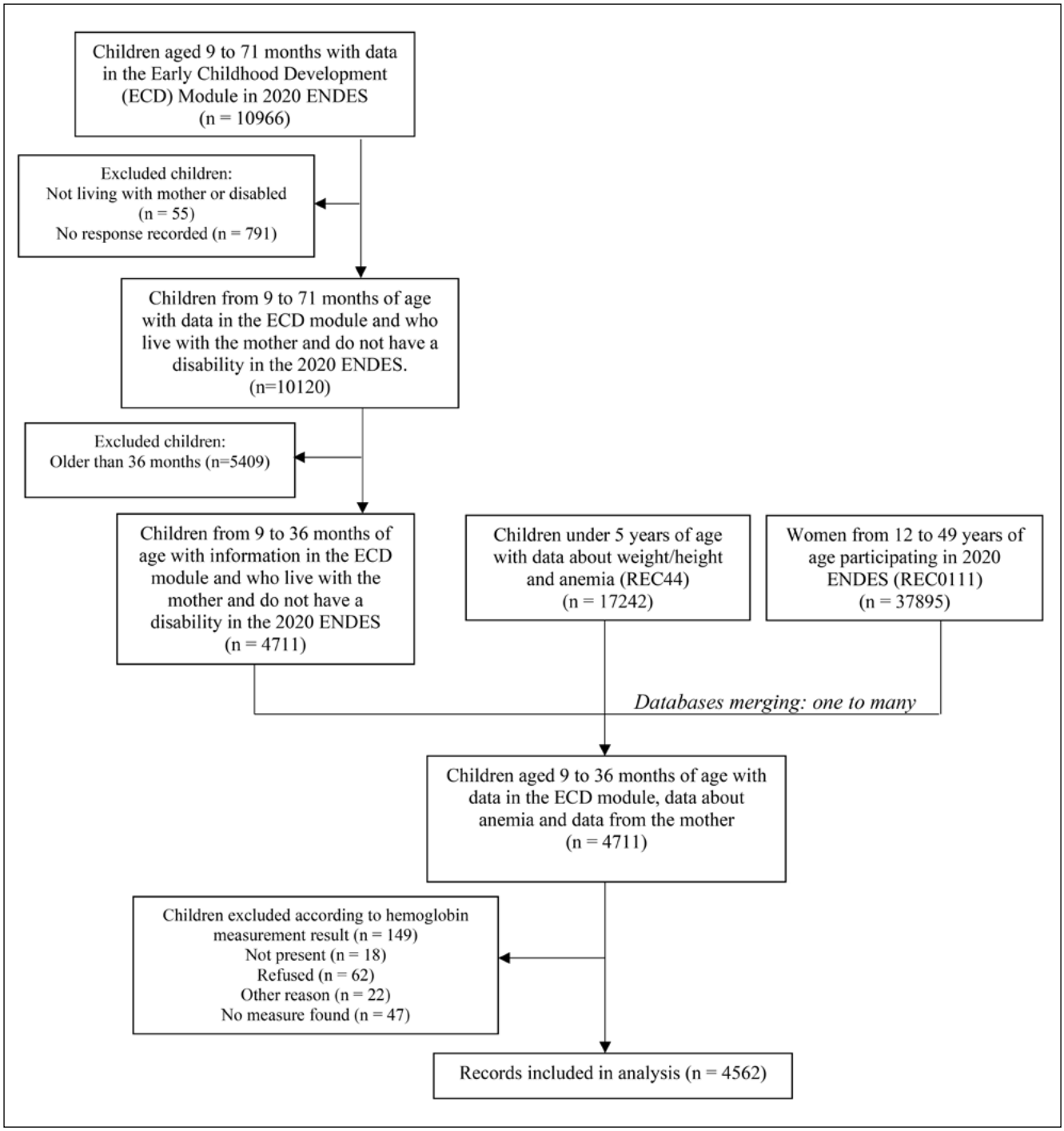

Figure 1. Flowchart for the selection of participants in the analysis. ENDES: Demographic and Family Health Survey. ECD: Early Childhood Development.

in children without anemia (14%-27%), but the 95%CI for all ORs included the unit. On the other hand, the covariates associated with risk-free EVC were sex in brackets 2 to 4, maternal literacy in brackets 1 and 4, place of residence in bracket 4, and iron administration in the last 12 months in bracket 2 (table 4).

Discussion

Our results showed no association between anemia and EVC in any of the age brackets among children aged 9 to 36 months participating in a population-based survey in Peru. Some studies show results

Table 1. Characteristics of children aged 9-36 months and their mothers participating in the Peru Demographic and Family Health Survey. 2020 (n = 4562)

Variables	Number of participants included in the study	Unweighted proportion (%)	Weighted proportion (%)	95%CI		Standard error (%)
Anemia						
Without anemia	2728	59.8	62.9	60.7	65.1	1.1
Mild anemia	1255	27.5	26.2	24.4	28.0	0.9
Moderate or severe anemia	579	12.7	10.9	9.7	12.1	0.6
Characteristics of the child						
Sex						
Male	2327	51.0	50.9	48.9	52.9	1.0
Female	2235	49.0	49.1	47.1	51.1	1.0
Age in months						
9 to 12	570	12.5	12.5	11.3	13.7	0.6
13 to 18	934	20.5	20.1	18.3	21.9	0.9
19 to 23	834	18.3	17.8	16.2	19.4	0.8
24 to 36	2224	48.8	49.6	47.6	51.6	1.0
Cesarean delivery						
No	2986	65.5	61.3	59.1	63.5	1.1
Yes	1576	34.5	38.7	36.5	40.9	1.1
Antenatal care a						
No visits	40	0.9	0.8	0.4	1.2	0.2
1 to 7	1048	24.6	24.5	22.7	26.3	0.9
≥ 8	3171	74.5	74.6	72.8	76.4	0.9
Birth weight (grams) b						
< 2500	340	7.7	7.4	6.4	8.4	0.5
2500 to < 4000	3783	85.7	85.7	84.3	87.1	0.7
≥ 4000	292	6.6	6.9	5.9	7.9	0.5
Duration of breastfeeding (months) c						
≤ 12	1409	31.0	31.2	29.2	33.2	1.0
> 12	3129	69.0	68.8	66.8	70.8	1.0
Immediate breastfeeding d						
No	2127	46.9	51.8	49.6	54.0	1.1
Yes	2411	53.1	48.2	46.0	50.4	1.1
Exclusive breastfeeding e						
No	697	25.9	29.5	27.0	32.0	1.3
Yes	1990	74.1	70.5	68.0	73.0	1.3
In the last 12 months received iron to prevent anemia						
No	1383	30.3	33.5	31.5	35.6	1.0
Yes	3179	69.7	66.5	64.4	68.5	1.0
Characteristics of the mother						
Mother's educational level						
No education-Primary	842	18.4	15.4	14.0	16.8	0.7
Secondary	2224	48.8	48.5	46.3	50.7	1.1
Superior	1496	32.8	36.1	33.7	38.5	1.2
Type of mother's union with the child's father						
Never united	221	4.8	4.8	4.0	5.6	0.4
Married or cohabiting	3827	83.9	83.8	82.2	85.4	0.8
Widowed. divorced. or separated	514	11.3	11.4	10.0	12.8	0.7
Ethnicity						
Non-native	4146	90.9	94.3	93.3	95.3	0.5
Native	416	9.1	5.7	4.7	6.7	0.5
Literacy[f]						
No	266	5.8	4.9	4.1	5.7	0.4
Yes	4287	94.2	95.1	94.3	95.9	0.4

Number of live births						
One	1368	30.0	25.7	23.9	27.5	0.9
Two	1421	31.1	35.1	33.1	37.1	1.0
Three or more	1773	38.9	39.2	37.2	41.2	1.0
Health insurance						
No	724	15.9	18.2	16.4	20.0	0.9
Yes	3838	84.1	81.8	80.0	83.6	0.9
Household characteristics						
Place of residence						
Urban	3244	71.1	77.9	76.3	79.5	0.8
Rural	1318	28.9	22.1	20.5	23.7	0.8
Wealth index						
Very poor	1223	26.8	20.0	18.4	21.6	0.8
Poor	1225	26.9	23.8	22.0	25.6	0.9
Middle	935	20.5	20.7	18.9	22.5	0.9
Wealthy	687	15.1	18.2	16.4	20.0	0.9
Very wealthy	492	10.8	17.3	15.1	19.5	1.1
Natural region						
Coast	2020	44.3	60.6	58.4	62.8	1.1
Highland	1349	29.6	22.7	20.9	24.5	0.9
Jungle	1193	26.2	16.6	15.0	18.2	0.8

[a]303 missing data. [b]147 missing data. [c]24 never breastfed. [d]24 missing data.[e]2 reported not knowing and 1873 missing data. [f]9 missing data. N: number. 95% CI: 95% confidence interval.

consistent with ours. Three of these had a cross-sectional design[6,8,13] and one was a prospective cohort[15]. These studies used different tools to measure language development, which makes comparison difficult.

In Egyptian children aged 4 to 6 years, it was found that, among 90 children without anemia, 14.4% had delayed language development and, among 122 children with anemia, 17.2% presented the same problem ($p = 0.719$)[13]. In 875 Chilean children, iron deficiency was not found to be associated with verbal skills at 5 years of age[15]. In 58 Mexican children aged 14 to 18 months, there were no differences in scores for expressive and receptive language between three groups: 30 children with normal iron levels, 17 with iron deficiency but without anemia, and 9 with iron deficiency anemia[8]. In 2,601 Chinese children aged 6 to 24 months, no differences were found in the score of a tool that assessed language between children with and without anemia; this finding was obtained after adjustment for age, sex, type of delivery, feeding pattern in the first 6 months, age of initiation of supplementary feeding, maternal educational level, and annual family income[6]. Finally, in Chinese children aged 4 years, there was no association between hemoglobin levels and the development of verbal skills[10].

In our analysis, as in two other studies[6,15], we performed the analysis adjusted for covariates identified in the scientific literature. A study in 66 Brazilian children aged 2 to 6 years did find differences in the median of a score that assessed receptive and expres-

Table 2. Frequency of children aged 9 to 36 months with effective verbal communication without risk at comprehension and expression levels (n = 4562).

Age range (months)	n	Unweighted absolute frequency	Weighted proportion[a]	95%CI
Range 1: 9 to 12	570	435	76.6	71.8 - 80.7
Range 2: 13 to 18	934	320	35.4	30.9 - 40.3
Range 3: 19 to 23	834	213	25.6	22.0 - 29.6
Range 4: 24 to 36	2.224	1266	55.3	52.5 - 58.1

[a]Comparison of proportions: Chi-square test (p-value < 0.001), linear trend chi-square test (p-value = 0.360). N: number of participants, 95% confidence interval, 95% CI: 95% confidence interval.

Table 3. Frequency of effective verbal communication without risk in children aged 9 to 36 months according to categories of anemia status and other covariates in the study, Peru (2020)

Variables		Effective verbal communication			
	Number of participants	Unweighted frequency	Weighted proportion (%)	95%CI	p-value
Anemia					
No	2.728	1.381	49.4	46.8 - 51.9	0.366
Yes	1.834	853	47.5	44.5 - 50.5	
Characteristics of the child					
Sex					
Male	2.327	1.013	43.6	41.0 - 46.3	< 0.001
Female	2.235	1.221	48.7	46.7 - 50.7	
Cesarean delivery					
No	2.986	1.490	50.9	48.4 - 53.4	0.005
Yes	1.576	744	45.2	41.9 - 48.5	
Antenatal care[a]					
No visits	40	12	38.5	21.7 - 58.6	0.753
1 to 7	1.048	497	48.2	44.2 - 52.2	
≥8	3.171	1.561	48.5	46.0 - 50.9	
Birth weight (grams)[b]					
< 2500	340	160	46.9	40.0 - 53.8	0.790
2500 to < 4000	3.783	1.877	48.9	46.7 - 51.1	
≥ 4000	292	140	50.5	42.5 - 58.4	
Duration of breastfeeding (months)[c]					
≤ 12	1.409	841	58.6	55.0 - 62.1	< 0.001
> 12	3.129	1.381	44.3	41.9 - 46.7	
Immediate breastfeeding[d]					
No	2.127	1.019	45.8	43.1 - 48.6	0.003
Yes	2.411	1.203	51.9	49.1 - 54.7	
Exclusive breastfeeding[e]					
No	697	338	49.2	43.8 - 54.6	0.436
Yes	1.990	994	51.4	48.5 - 54.4	
In the last 12 months received iron to prevent anemia					
No	1.383	724	51.1	47.3 - 54.8	0.092
Yes	3.179	1.510	47.5	45.1 - 49.7	
Characteristics of the mother					
Mother's educational level					
No education-Primary	842	383	45.1	40.7 - 49.6	0.287
Secondary	2.224	1.085	49.7	46.9 - 52.4	
Superior	1.496	766	48.9	45.2 - 52.6	
Type of mother's union with the child's father					
Never united	221	97	45.8	37.4 - 54.4	0.812
Married or cohabiting	3.827	1.888	48.9	46.7 - 51.0	
Widowed, divorced, or separated	514	249	48.7	43.5 - 53.9	
Ethnicity					
Non-native	4.146	2.057	49.1	47.0 - 51.2	0.115
Native	416	177	42.2	36.1 - 48.5	
Literacy[f]					
No	266	106	39.9	33.0 - 47.3	0.053
Yes	4.287	2.125	49.1	47.1 - 51.2	
Number of live births					
One	1.368	677	50.3	47.0 - 53.6	0.202
Two	1.421	705	49.8	46.3 - 53.3	
Three or more	1.773	852	46.4	43.1 - 49.7	

Health insurance					
No	724	340	47.3	42.7 - 51.9	0.500
Yes	3.838	1.894	49.0	46.8 - 51.2	
Household characteristics					
Place of residence					
Urban	3.244	1.572	48.0	45.6 - 50.4	0.187
Rural	1.318	662	51.1	47.8 - 54.5	
Wealth index					
Very poor	1.223	594	49.5	46.0 - 53.1	0.819
Poor	1.225	594	49.4	45.6 - 53.1	
Middle	935	468	49.7	45.5 - 53.9	
Wealthy	687	342	48.0	43.2 - 52.9	
Very wealthy	492	236	46.2	40.6 - 52.0	
Natural region					
Coast	2.020	954	47.1	44.1 - 50.0	0.133
Highland	1.349	691	51.0	47.8 - 54.2	
Jungle	1.193	589	51.4	48.0 - 54.9	

[a]303 missing data, [b]147 missing data, [c]24 never breastfed, [d]24 missing data, [e]2 reported not knowing and 1873 missing data, [f]9 missing data.
N: number, 95% CI: 95% confidence interval.

sive language development in anemic and non-anemic children; however, that study did not control for the adjustment variables identified in our study[28].

Given the evidence regarding the effect of iron deficiency, even with overt anemia, on neurocognitive development in general[10,11,29,30] and psychomotor development[6,7], our findings should be evaluated with caution. Indeed, other manifestations of nutritional deficits may affect language development in early life. An analysis of the 2019 ENDES in Peru found that children with growth retardation were 8% less likely to show EVC compared with the group that presented a normal weight[17]. This finding is consistent with studies in Bangladesh[31], Vietnam[32], and Peru[33], therefore, we can observe strong evidence that stunted children have poorer communication skills than those non-stunted[34].

Our results suggest that EVC may be more influenced by socioeconomic factors such as rurality or maternal literacy. These characteristics could facilitate a favorable psychosocial environment for the acquisition of communication skills, including verbal skills in children. In the rural Peruvian environment, mothers usually take care of the children[35], which, combined with the mother's literacy, may be a permanent stimulating factor during the first 36 months for the development of expressive and receptive EVC[15].

An interesting finding was that in children who received iron during the last year to prevent anemia, there was twice the chance of having risk-free EVC, however, this finding was only in children aged between 13 and 18 months while those aged from 18 to 36 months, it had the opposite effect. Similar behavior was observed in a controlled clinical trial (CCT) in China in children aged 6 to 11 months, which evaluated the effect of iron-containing micronutrient powders on infant mental development, finding significant differences between the study group and the control group at 6 months of treatment (children aged 12 to 17 months), but the effect disappeared after 12 to 18 months of supplementation (children aged 18 months and older)[36]. A systematic review of 8 CCTs conducted between 1978 and 1993 found no evidence that iron administration in children with iron deficiency anemia improves psychomotor development[37]. These findings suggest that prevention of the neurodevelopmental consequences of iron deficiency anemia, including the development of verbal skills, requires sustained preventive strategies rather than treatment of iron depletion.

We found different proportions of risk-free EVC according to age, with the highest proportion between 9 to 12 months (76.6%) and a progressive reduction between 13 to 18 months (35.4%) and 19 to 23 months (25.6%), finally rising to 55.5% between 24 to 36 months. Among the explanations are first, the complex interactions between the bonding, stimulation, and nutritional intake of the first months of life generated by breastfeeding[24] and the increasingly stimulating environment and participation in play activities at home that can attenuate or recover the development of EVC[32]. While we found no association with breastfeeding, a study in Greece found that each additional month of breastfeeding increased the score on a receptive and expressive communication scale[38], with a similar positive effect on cognitive development[24]. In addition, a risk-free EVC requires affirmative responses to three questions, which may introduce potential

Table 4. Binary logistic regression analysis to evaluate the association between anemia and effective verbal communication without risk in different age range in children aged 9 to 36 months, Peru (2020).

Variables	Range 1: 9 to 12 months (n = 570)				Range 2: 13 to 18 months (n = 934)				Range 3: 19 to 23 months (n = 834)				Range 4: 24 to 36 months (n = 2.224)			
	N	n	OR (IC95%)	aOR (IC95%)	N	n	OR (IC95%)	aOR (IC95%)	N	n	OR (IC95%)	aOR (IC95%)	N	n	OR (IC95%)	OR (IC95%)
Exposure																
Anemia																
Yes	356	265	1	1	486	158	1	1	328	83	1	1	664	347	1	1
No	214	170	1.34 (0.80; 2.22)	1.27 (0.76; 2.13)	448	162	1.12 (0.79; 1.59)	1.22 (0.85; 1.74)	506	130	1.12 (0.72; 1.73)	1.14 (0.75; 1.73)	1.560	919	1.19 (0.93; 1.53)	1.21 (0.94; 1.57)
Covariates																
Sex of child																
Male	285	216	1	1	483	138	1	1	429	87	1	1	1.130	572	1	1
Female	285	219	1.08 (0.66; 1.77)	1.03 (0.62; 1.70)	451	182	1.47 (1.05; 2.07)	1.46 (1.04; 2.06)	405	126	1.79 (1.20; 2.68)	1.83 (1.24; 2.70)	1.094	694	1.65 (1.31; 2.07)	1.59 (1.26; 1.99)
Cesarean delivery																
No	362	278	1	1	607	220	1	1	553	140	1	1	1.464	852	1	1
Yes	208	157	1.10 (0.65; 1.86)	1.39 (0.73; 2.65)	327	100	0.68 (0.45; 1.02)	0.80 (0.50; 1.27)	281	73	0.98 (0.63; 1.53)	1.14 (0.68; 1.93)	760	414	0.72 (0.56; 0.92)	0.70 (0.53; 0.93)
Duration of breastfeeding (months)																
≤ 12	-	-	-	-	128	44	1	1	166	43	1	1	321	547	1	1
> 12	-	-	-	-	805	276	0.87 (0.51; 1.48)	0.84 (0.49; 1.46)	664	169	0.92 (0.53; 1.60)	0.88 (0.51; 1.51)	1.660	936	1.05 (0.80; 1.38)	1.04 (0.78; 1.38)
Immediate breastfeeding																
No	267	199	1	1	403	134	1	1	398	102	1	1	1.059	584	1	1
Yes	301	234	1.26 (0.80; 2.00)	1.67 (0.96; 2.91)	530	186	1.41 (0.95; 2.08)	1.20 (0.75; 1.90)	432	110	1.15 (0.75; 1.74)	1.28 (0.76; 2.16)	1.148	673	1.25 (0.99; 1.58)	1.02 (0.78; 1.33)
Mother's literacy																
No	35	17	1	1	56	19	1	1	42	10	1	1	133	60	1	1
Yes	534	418	4.24 (1.75; 10.24)	5.02 (1.98; 12.70)	876	300	0.86 (0.44; 1.71)	0.96 (0.46; 2.01)	791	203	0.90 (0.46; 1.78)	0.81 (0.39; 1.68)	2.086	1.204	1.71 (1.14; 2.57)	2.24 (1.47; 3.44)
Place of residence																
Urban	405	310	1	1	643	210	1	1	592	154	1	1	1.604	898	1	1
Rural	165	125	0.92 (0.55; 1.53)	1.28 (0.69; 2.37)	291	110	1.27 (0.86; 1.89)	1.11 (0.72: 1.71)	242	59	0.86 (0.58; 1.27)	0.86 (0.57; 1.30)	620	368	1.33 (1.04; 1.68)	1.51 (1.18; 1.94)
In the last 12 months received iron to prevent anemia																
No	93	63	1	1	145	39	1	1	194	51	1	1	951	571	1	1
Yes	477	372	1.58 (0.82; 3.06)	1.54 (0.86; 2.75)	789	281	2.25 (1.32; 3.83)	2.03 (1.14; 3.61)	640	162	0.78 (0.48; 1.26)	0.81 (0.49; 1.32)	1.273	695	0.80 (0.64; 1.00)	0.76 (0.58; 0.98)

All models include as covariates for child sex, cesarean delivery, duration of breastfeeding, immediate breastfeeding, having received iron in the last 12 months, mother's literacy and place of residence. An exception was made for the model of range 1 which does not include duration of breastfeeding. N = absolute frequency of participants in the stratum, n = absolute frequency of children with EVC within the stratum, OR = odds ratio, aOR = adjusted odds ratio, 95%CI = 95% confidence interval,

instrumental bias. In the 13- to 18-month age bracket, it is necessary for the child to utter words to ask for something and, in the 19- to 23-month age bracket, it is required to use words and phrases to communicate and to mention parts of the body. These skills may have been affected by the deficient socialization that Peruvian children experienced since March 2020, due to the restrictions of the national state of emergency due to COVID-19. This phenomenon has been documented in recent publications in different populations[39,40].

Our analysis has limitations. First, the measurement of EVC was by the mother's report; although the instrument was validated and the interviewers were trained, the responses could be affected by social desirability bias. Second, the cross-sectional design opens the possibility of reverse causality, however, a causal pathway in which EVC in the child generates anemia is unlikely. In addition, our analysis has an important assumption that the risk of anemia in Peruvian children begins before the age of 6 months[3]. Finally, since this is a secondary source study, some covariates may confound or mediate the association between anemia and EVC that we were unable to analyze.

Despite the limitations, our study is the one that has used the largest sample size to evaluate the specific association between anemia and EVC in children aged 9 to 36 months; in addition, the data come from a representative sample for Peru and we have estimated the strength of association adjusted for relevant covariates identified in the scientific literature.

Conclusion

Anemia is not associated with EVC in children aged 9 to 36 months participating in a population-based survey in Peru. This finding was observed in all age brackets analyzed and considered the control of variables such as sex of the child, type of delivery, duration of breastfeeding, exposure to immediate breastfeeding, mother's literacy, place of residence, and iron intake as a prevention for anemia in the last 12 months.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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