Nutritional causes of anemia in Mexican children under 5 years. Results from the 2006 National Health and Nutrition Survey

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Abstract

Objective. To describe the frequency and severity of anemia and the nutritional variables associated to hemoglobin levels (Hb) in children <5 years of age. **Materials and methods.** We studied 981 children measuring hemoglobin and serum concentrations of ferritin, soluble transferrin receptors (sTfR), C-reactive protein (CRP), zinc, iron, copper, magnesium, folate and vitamin B12. Ordinal logit or multiple regression models were constructed to assess the risk for anemia and the associations among nutritional variables. **Results.** The overall prevalence of anemia was 20.6%, of which 14% were mild cases and 6.38% moderate. Anemia was associated with iron deficiency (ID) in 42.17% of the cases, whereas ID coexisted with either folate or vitamin B12 deficiency in 9%. Only 2% of cases of anemia were associated with either folate or vitamin B12 deficiencies. CRP (coef: 0.17 g/dl) and third tertile of s-copper (coef: -0.85 g/dl) were associated to unexplained anemia (*p*<0.05). **Conclusions.** ID is the main cause of anemia in children <5 y. Folate and vitamin B12 concentrations were associated with anemia. CRP was associated to unexplained anemia. However, vitamin A deficiency, which is associated with anemia, was not studied.

Key words: anemia; child, preschool; iron deficiency; copper; Mexico

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Resumen

Objetivo. Describir las causas y severidad de la anemia y los factores nutricionales asociados con hemoglobina en niños anémicos <5 años. **Material y métodos.** Estudiamos los niveles de hemoglobina y las concentraciones séricas de ferritina, receptores solubles de transferrina, proteína C reactiva (CRP), zinc, hierro, cobre, magnesio, vitamina B12 y folato en 981 niños. Se utilizaron modelos de regresión ordinal y regresiones lineales múltiples para evaluar el riesgo de severidad de anemia y la variabilidad en hemoglobina. **Resultados.** La prevalencia de anemia fue de 20.6%; el 14 y 6.38% tenían anemia leve y moderada. La anemia se asoció con deficiencia de hierro (DH) en 42.17%; la DH coexistió con deficiencia de folatos y vitamina B12 en 9%. Sólo 2% de la anemia se asoció con deficiencia de folatos o vitamina B12. CRP (coef: 0.17 g/dl) y el tercer tercil de cobre (coef: -0.85 g/dl) se asociaron con anemia sin explicar (*p*<0.05). **Conclusiones.** DH es la principal causa de anemia en niños <5 años. Las concentraciones de folato y vitamina B12 se asociaron con anemia. La CRP se asoció con anemia sin explicar. Sin embargo, la deficiencia de vitamina A, que se asocia con anemia, no fue estudiada.

Palabras clave: anemia; infantes; deficiencia de hierro; cobre; México

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Anemia is still highly prevalent in small Mexican children,[1] despite serious public efforts to reduce it, which focus the distribution of food and micronutrient fortified supplements to children, as well as pregnant and lactating women.[2,3] Preschoolers are prone to suffer anemia and other micronutrient deficiencies for several reasons, such as inadequate body stores at birth and increased nutritional requirements due to their fast growth.[4] Anemia and iron deficiency anemia (IDA) have negative consequences on their neurological and mental development.[5,6] Because nutritional anemia may be produced by iron, folate, and vitamins A and B12 deficiencies,[7] it is important to have a good measure of its association with these potentially causing deficiencies. This information is crucial for evaluating and reformulating strategies aiming to control and reduce anemia. The Mexican National Nutrition Survey of 1999 (Encuesta Nacional de Nutrición 1999, ENN 99) showed that 65% of cases of anemia were associated with iron deficiency (ID)[8] and in variable proportions with folate (27.7%) and vitamin A deficiency (40.6%) in children under 5 years of age with ID.[9]

The objective of this study is to analyze some nutritional causes of anemia in a subsample of children under 5 years from Mexican National Health and Nutrition Survey 2006 (Encuesta Nacional de Salud y Nutrición 2006, ENSANUT 2006), stratified by degree of anemia, and to describe the characteristics of children that explain the variability in hemoglobin concentrations in those with known nutritional deficiencies and those with unexplained anemia.

Materials and methods

Information for the present analysis was extracted from ENSANUT 2006. This is a probabilistic survey, representative at the national, regional, urban and rural levels. A systematic subsample of children from ENSANUT 2006 was selected, choosing one out of three children 1-11 y. This subsample corresponded to 30% of the overall sample. For the present analysis 981 children aged 1-4.9 years with a complete set of hemoglobin (Hb), serum, ferritin, soluble transferrin receptors (sTfR), iron, zinc, copper, folate and vitamin B12 determinations, were included. The design of this probabilistic population sample has been described elsewhere.[10] Collected information includes demographic and socioeconomic aspects.

Measuring hemoglobin, minerals status and concentrations of C-reactive protein

Venous blood samples were drawn and centrifuged at 268 g, *in situ*. Serum was separated and stored in coded cryovials, preserved in liquid nitrogen until delivery to the central laboratory in Cuernavaca, Mexico.

The serum concentrations of ferritin and sTfR were measured by immunoassay method using commercial kits (Dade Behring Inc). C-reactive protein (CRP) was measured by nephelometry, using ultrasensitive monoclonal antibodies (Behring Nephelometer BN-100 Analyzer).

The serum concentrations of iron, zinc, copper and magnesium were measured by inductively coupled plasma atomic emission spectroscopy using a Varian Vista Pro CCD spectrometer. Capillary hemoglobin was measured using a portable photometer HemoCue.

Measuring vitamin concentration

Vitamin B12 and folates were measured by competitive immunoassay, using comercial kits (TOSOH Co, Tokio, Japan).

Definitions of variables

Anemia was defined when Hb concentration adjusted by altitude[11] was <11 g/dl.[12] Anemia was classified according to the degree of severity as follows: mild anemia, 10.0≥ Hb <11 g/dl; moderate anemia ≥7.0 Hb <10 g/dl, and severe anemia Hb <7 g/dl.[13]

It was considered that ID existed when either of the following iron status indicators were present: serum ferritin <12 μg/L, sTfR>6 mg/L or serum iron <45 ug/dL.[14] Deficiencies were defined if serum folate <4 ng/mL,[15] vitamin B12 <203 pg/mL,[15] zinc <65 ug/dL[16] or copper <90 ug/dL.[17]

The category of explained anemia by known nutritional deficiencies was defined if Hb<11 g/dL in addition to the presence of at least one of the following conditions: iron, folate or vitamin B12 deficiencies. Unexplained anemia (anemia with unidentified causes) was categorized when the cases of anemia did not meet the above criteria.

Indian ethnicity was defined when an indigenous language was spoken by parents. Localities with less than 2 500 habitants were considered as rural dwelling. A socioeconomic index was constructed based on the household characteristics and family assets by a principal component analysis. The country was divided in four geographic regions: Northern, Center, Mexico City and Southern. Children who participated in social programs were classified as beneficiaries of *Oportunidades* and Liconsa programs. *Oportunidades* program targets families suffering from extreme poverty by increasing the capacities, education, health care and food options of their members. Children <2 y and pregnant women receive a micronutrients food supplement to improve their nutritional status.[2,18] Liconsa program distributes low-cost milk fortified with iron, zinc, and other vitamins to low-income children aged 1-11 years.[3]

Statistical analysis

Initial analysis includes prevalences and 95% confidence intervals. Unadjusted bivariate comparisons were made to assess the associations among micronutrient deficiencies in mild, moderate anemic vs non-anemic children. Ordinal logistic regression models were used to estimate the risk for mild and moderate anemia related to specific micronutrient deficiencies. The models were adjusted by sex, age, dwelling, being *Oportunidades* and Liconsa beneficiaries, socioeconomic status (SES), CRP, geographic region, and serum copper tertiles. To explore the characteristics of children that explain the variability of Hb concentration, we performed a multiple linear regression analysis: all children, children without anemia, and children with explained anemia by known nutritional deficiencies and unexplained anemia were included. Since there is no information regarding the distribution of serum copper and its association with hemoglobin concentration in Mexican population, we explored it in tertiles, to see if there was any association with anemia.

Variables with not normal distributions were transformed logarithmically, data are presented as antilogarithms. Spearman correlations were performed between CRP, ferritin and minerals concentrations.

Due to a possible selection bias in ENSANUT 2006 subsamples (because of oversampling of the poorest population from the Southern region), a procedure based on regression model estimates was used to reduce it. Population means for height, weight and the estimated SES index for region, age, sex, area, and strata were used to correct estimators. Sampling weights were readjusted according to the Total Counting of 2005, INEGI (Instituto Nacional de Estadística y Geografía).[19] This correction allowed us to estimate the corrected total population, so that the weighted estimations are population projections based on the sample.

In some geographic regions, error estimations are higher due to smaller sample size. Analyses were performed in children with a complete dataset of ferritin, sTfR, folic acid, vitamin B12, zinc, copper and magnesium determinations. About 54% of the data had incomplete sets of biomarkers, and thus, excluded. Since this procedure could mean a higher risk of selection bias, weighted and expansion factors were readjusted to improve population representativeness for estimators at the national level.

Associations were considered significant with an alpha=0.05. All analyses were adjusted for the sampling design of the survey, using STATA SE v10.1 SVY module for complex samples.

The protocol for ENSANUT 2006 was approved by the Research, Ethics, and Biosecurity Committees of Mexican National Institute of Public Health (Instituto Nacional de Salud Pública, INSP). Informed consent letters were obtained from the parents of all participants.

Results

Descriptive characteristics are shown in table I. The global prevalence of anemia was 20.4%, children <2 years old had the highest prevalence (28.96 vs children 3-4 y: 14%); no differences by sex were found (table I). The prevalence for mild anemia was 14% (CI95% 10.91, 17.75%) and moderate anemia 6.38% (CI95% 4.31, 9.34%).

The prevalence of ID was higher in mild and moderate anemic than in non-anemic children. The prevalence of copper, folate, zinc and magnesium deficiencies was not different between mild or moderate anemic vs non-anemic children (table II). The mean serum concentrations of iron, sTfR, s-ferritin, folate, zinc and magnesium were not different between moderate anemic vs non anemic children. The serum concentration of vitamin B12 was lower and s-copper was higher, in moderate anemic than in non-anemic children. There were no differences in serum micronutrients status in mild anemic vs non-anemic children (table II).

Anemia was associated with ID in 42.17% (CI95% 32.3, 52.6) of the cases; ID coexisted with either folate or vitamin B12 deficiency in 9% (CI95% 5.28, 17.96). Only 2% (CI95% 1.09, 6.28) of the cases of anemia were associated with either folate or vitamin B12 deficiencies. Thus, anemia with potentially explainable causes was present in 54.76% (CI95% 44.07, 65.03) and unexplained anemia in 45.24% (CI95% 34.97, 55.93) of the cases.

In a bivariate analysis, children with unexplained anemia had "better" iron status indicators than non-anemic children. No significant differences were observed between the rest of serum vitamins and minerals concentrations in non-anemic children vs children with unexplained anemia (table II).

In an ordered logistic model, progression of age represented a lower risk for mild and moderate anemia (OR=0.72 and OR=0.62, respectively, $p<0.05$). The second tertile of SES compared with the first tertile was associated with lower risk for mild anemia (OR=0.44, $p=0.006$); ID was marginally associated to mild anemia (OR: 1.56, $p=0.06$). The third tertile of serum copper concentrations compared with the second tertile (OR=3.64, $p=0.02$) represented a higher risk for moderate anemia (table III).

Table I
Descriptive characteristics of the sub-sample of children <5 years old with complete micronutrients datasets. ENSANUT 2006.

	%	CI	n	thousands
Sex				
Male			503	4 924.93
Female			478	4 756.28
Dwelling				
Rural			449	2 533.22
Urban			532	7 147.99
Region				
North			195	1 905.04
Center			268	3 059.87
Mexico City			16	1 495.75
Southern			502	3 220.55
Socioeconomic status				
Tertile 1			606	3 922.64
Tertile 2			269	3 292.83
Tertile 3			101	2 436.62
Global Anemia	20.37	(16.2, 24.53)	211	1 972.06
1 – 2 y	28.96	(21.35, 36.58)	102	2 803.68
3 – 4 y	14.6	(10.35, 18.82)	109	1 413.46
BMI				
Normal	77.28	(71.34, 83.22)	683	7 481.64
Overweigth/Obesity	22.71	(16.77, 28.65)	151	2 198.60
Beneficiary of social programs				
Liconsa	9	(5.53, 12.44)	85	871.31
Oportunidades	13.85	(10.74, 16.94)	157	1 340.85
C reactive protein >5 mg/dl	9.85	(6.4, 13.32)	90	953.60
C reactive protein* (geometric mean)	0.59 ± 1.07	(0.51, 0.68)	981	9 681.21

In a multiple linear regression model, ID (coef: -0.34 g/dL, p=0.004) and marginally folate deficiency (coef: -0.50 g/dL, *p* =0.08) were negatively associated with Hb concentrations in all children (table IV).

The 10% of variability of hemoglobin concentrations in non-anemic children was positively associated with age (coef: 0.24 g/dL, *p*=0.01) and the highest tertile of SES (coef: 0.59 g/dL, *p*=0.03); and being beneficiary of Liconsa (coef: 0.37 g/dl, *p*=0.07) and negatively with ID (coef: -0.33 g/dL, *p*=0.07). Both were marginal. Children with folate deficiency (FD) had Hb 0.96 g/dL (*p*=0.01), lower than their non-folate deficient counterparts (table IV).

In children with anemia by known nutritional deficiencies, those in the first and third tertile of copper concentration had 0.67 and 0.45 g/dL of Hb less than children in the second tertile (*p*=0.02 and p=0.05). Age and the highest tertile of SES were positively associated with Hb concentration (coef: 0.23 and 0.59 g/dL, respectively, *p*<0.05) (table IV).

The model for children with unexplained anemia responded for 50% of the variability of Hb concentration. The third tertile of copper concentration had an Hb concentration 0.85 g/dL lower than the second tertile (*p*= 0.001). Zinc deficiency was associated with a lower Hb concentration (coef: -0.4 g/dL, *p*= 0.03) compared to non zinc deficient children. Living in the Northern region was negatively associated with Hb concentration (coef: -0.50 g/dL, *p* = 0.03), while CRP was associated positively with Hb concentration (coef: 1.18 g/dL, *p*<0.001) (table IV).

Spearman correlations between CRP and copper were Rho=0.2440, *p*<0.001; ferritin: Rho=0.3012, *p*<0.001; serum iron: Rho=-0.2044, *p*<0.001; serum zinc: Rho=-0.0097, p= 0.76.

Discussion

Anemia is still a serious public health problem in children <5 years old in Mexico. ID is the cause of anemia in 42% of cases. Despite the public efforts for controlling and reducing its prevalence, only a modest decrease was observed in 2006 compared with NNS-99 (20.1% vs 27.2%, respectively).[1,8] *Oportunidades*[2] and Liconsa[3] programs had a significant contribution in reducing anemia in vulnerable population. Folate and vitamin B12 deficiencies had a small contribution, independently of ID, in causing anemia. These results contrast with Duque *et al.*,[20] who found that the cause of anemia in Mexican children was folate deficiency.[20] Data are not comparable due to the differences in methodologies to assess folate status and differences in age groups. Duque and colleagues measured folate in erythrocytes, an indicator of folate stores, while we measured serum folate, indicative of recent intake. In their article they studied children <2 years of age, while we studied children 1-5 years old.

There was a tendency for higher risk of mild anemia but not for moderate anemia in children with ID. Children in the highest tertile of copper concentration were strongly associated to moderate anemia and to lower Hb concentrations in case of anemia. It is possible that higher values of copper concentration could have "hindered" the association of ID for moderate anemia, since in bivari-

Table II
Adjusted means of micronutrient status* and proportion of micronutrient deficiency in children <5 years old stratified by category of severity of anemia and explained and unexplained causes of anemia by known nutritional deficiencies. ENSANUT 2006.

	Non anemic	Category of severity: Mild anemia	Category of severity: Moderate anemia	Explained and unexplained anemia by known nutritional deficiencies: Explained anemia	Explained and unexplained anemia by known nutritional deficiencies: Unexplained anemia
n sample	770	148	62	117	94
Population size	7,709,025	1,079,978	892,206	68,116.479	56,273.318
Serum concentration	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Ferritin ug/L	17.5 ± 1.05	15.26 ± 1.12	13.5 ± 1.18	8.41 ± 1.13‡	28.51 ± 1.07‡
Serum Iron ug/dL	107.33 ± 1.02	98.29 ± 1.05	96.56 ± 1.01	88.38 ± 1.07‡	110.14± 1.05
S-Transferrin Receptors mg/L	4.39 ± 1.01	4.55 ± 1.02	4.82 ± 1.04	5.11 ± 0.2‡	4.12 ± 1.02‡
Folate(ng/dL	11.95 ± 1.02	10.9 ± 1.06	10.9 ± 1.07	10.02 ± 1.07‡	12.05 ± 1.06
Vitamin B12 (pg/dL)	485.46 ± 1.03	419.68 ± 1.08	395.8 ± 1.1‡	368.16 ± 1.09‡	470.5 ± 1.07
Zinc (ug/dL)	88.46 ± 1.04	98.84 ± 1.08	99.66 ± 1.17	97.27 ± 1.11	101.3 ± 1.10
Magnesium (ug/dL)	2140.9 ± 1	2154.08 ± 1.01	2158.74 ± 1.02	2131 ± 1.01	2184.6 ± 1.02
Copper (ug/dL)	99.42 ± 1.15	99.14 ± 2.64	111.85 ± 4.88‡	107.88 ± 3.28	97.31 ± 3.65

Micronutrient deficiencies	%	*IC 95%*	%	*IC 95%*	%	*IC 95%*	%	*IC 95%*	%	*IC 95%*
Iron	35.93	(30.0, 41.85)	51.2‡	(38.77, 63.64)	54.06‡	(33.72, 74.39)	95.17	(90.9, 99.4)	-	-
Folate	2.64	(0.4, 4.9)	1.21	(-0.20, 2.63)	7.7	(-0.08, 15.47)	5.92	(1.11, 10.72)	-	-
Vitamin B12	5.9	(3.63, 8.14)	10.78	(2.84, 18.73)	7.28	(-0.04, 14.62)	17.74	(7.52, 27.96)	-	-
Copper	31.84	(26.36, 37.32)	32.61	(19.86, 45.36)	21.03	(8.24, 33.80)	21.62	(11.38, 31.85)	37.88	(20.94, 54.82)
Zinc	31.65	(25.68, 37.62)	26.28	(14.25, 38.31)	36.68	(18.63, 54.73)	33.42	(19.43, 47.41)	24.88	(12.2, 37.5)
Magnesium	5.51	(3.17, 7.86)	4.96	(0.91, 9.02)	7.22	(0.38, 14.06)	7.67	(1.92, 13.42)	3.25	(0.01, 6.41)
C-reactive protein >5mg/L	9.76	(5.59, 13.92)	8.04	(3.18, 12.90)	15.01	(4.27, 25.74)	11.06	(4.7, 17.42)	9.2	(2.39, 16)

* Mean ± SE, adjusted by age and sex
‡ Statically different from non-anemic children, p value<0.05

ate analysis, children with moderate anemia had lower ferritin levels, higher proportion of ID and higher serum concentration of copper than non-anemic children.

Knovich *et al*.[21] reported an U-shaped dose-response of serum copper and unexplained anemia in American population. Copper deficiency has been associated as a rare cause of anemia and neutropenia.[22] In Mexico, copper deficiency in children is higher than that reported in other countries.[23] High prevalence of copper deficiency in children in this study could explain part of the variability in Hb in children with "explained anemia", due to the role of copper as a cofactor for the expression iron-export proteins such as hephaestin and ceruloplasmin.[24] We do not know the possible mechanisms of anemia in children with higher copper concentrations.

Half of the cases of anemia in the present study remain unexplained; other causes, like parasite infections (malaria and uncinariasis)[25] and chronic renal disease[26] were not explored in this study. However, the frequency of malaria and uncinariasis in Mexico is relatively low.[27,28] Other causes of anemia, such as vitamin A, were not evaluated.[9] However, if we consider the level of vitamin A deficiency seen in 1999, about 40% of ID cases could be associated to such a deficiency. Low serum zinc has been associated to be a risk factor for low serum retinol in children[29] and a risk factor for anemia and lower Hb concentrations in pregnant women.[30,31] We speculate that since vitamin A deficiency has been associated with ID[9] and with low Hb concentrations in preschoolers[9,32] it could result a relevant cause of anemia. Zinc influences absorption, transport, and utilization of vitamin A, through protein synthesis and as cofactor in zinc-dependent enzymes;[33] thus, it is possible that zinc deficiency could be correlated to vitamin A deficiency in non ID anemic children (unexplained anemia).

Another unexplored cause of anemia is inflammation.[34] In children, inflammation is mostly related to acute infections. Prevalence of overweight and obesity

Table III
ORDINAL REGRESSION MODEL TO ASSESS THE RISK FOR MILD AND MODERATE ANEMIA IN CHILDREN <5 YEARS OLD. ENSANUT 2006

	Mild anemia			*Moderate anemia*		
	OR	*P value*	*CI 95%*	*OR*	*P value*	*CI 95%*
Micronutrient deficiency						
Iron	1.56	0.066	(0.97, 2.51)	1.03	0.95	(0.39, 2.71)
Folate	1.22	0.72	(0.42, 3.58)	2.17	0.36	(0.42, 11.24)
Vitamin B12	1.33	0.47	(0.61, 2.91)	1.51	0.49	(0.47, 4.9)
Copper tertile (second tertile is the reference)						
1st tertile Cu	1.04	0.89	(0.61, 1.76)	1.39	0.54	(0.49, 4)
3rd tertile Cu	1.34	0.34	(0.73, 2.45)	3.64	0.02	(1.28, 10.4)
Sex (female)	0.79	0.33	(0.49, 1.27)	0.49	0.13	(0.20, 1.23)
Age (years)	0.72	0.005	(0.57, 0.9)	0.62	0.002	(0.46, 0.84)
Tertile SES (first tertile is the reference)						
2nd tertile SES	0.44	0.006	(0.24, 0.8)	0.52	0.16	(0.21, 1.3)
3rd tertile SES	0.73	0.48	(0.31, 1.75)	0.81	0.82	(0.13, 5)
Dwelling (rural vs urban)	1.15	0.61	(0.67, 1.96)	1.02	0.96	(0.46, 2.25)
Beneficiary of social programs						
Liconsa	1.38	0.30	(0.75, 2.55)	1.14	0.78	(0.45, 2.91)
Oportunidades	1.73	0.16	(0.80, 3.74)	2.05	0.41	(0.38, 11.02)
Region (center is the reference)						
Northern	0.77	0.49	(0.37, 1.6)	0.72	0.56	(0.24, 2.18)
Mexico City	5.50	<0.001	(1.81, 1.67)	5.37	<0.001	(9.63, 2.99)
Southern	0.80	0.45	(0.44, 1.45)	0.50	0.12	(0.20, 1.21)
CRP>5	1.34	0.37	(0.70, 2.57)	1.57	0.46	(0.47, 5.2)

in these children could be associated with low intensity inflammation;[35] they had higher CRP concentrations (data not shown). Excluding anemic subjects with overweight/obesity (6.47%) or adjusting for it, did not change the association of log CRP to lower Hb with unexplained anemia. Thus, the contribution of chronic inflammation as a cause of anemia in this study was considered minimal. It is possible that ferritin values, especially those in the neighborhood of the cut-off point were inflated by acute inflammation,[36] resulting in underestimation of ID. Additionally, s-copper was positively associated with CRP; thus, it is possible that some of the higher values of copper concentration were inflated by acute inflammation and lead to misclassification of some children. Excluding children with s-ferritin values around cut-off value (12-22 ug/dL) the associations between CRP and the third tertile of copper concentrations with Hb concentrations were no longer significant, but the association of zinc deficiency with Hb remained significant, giving support to the misclassification hypothesis in cases of unexplained anemia. Other copper indicators should be considered to assess copper status that are not affected by inflammation.[37]

Some limitations in our study should be considered. This study did not measure vitamin A. The ENN-99 showed that ID children with or without anemia had more frequently low serum retinol,[9] but its potential contribution as a cause of nutritional anemia in this study was not estimated.

In summary, iron deficiency continues to be the main cause of nutritional anemia in preschool children, while vitamin B12 and folate deficiency contribute in a low proportion. S-copper and CRP explained part of the variability of others causes of anemia. Further research is necessary to understand the causes that are behind the unexplained anemia.

Declaration of conflict of interests. The authors declare that they have no conflict of interests.

Table IV
Multiple linear regression models for hemoglobin concentrations to explain its variability in all children and stratifying by explained and unexplained causes of anemia. ENSANUT 2006

Model	*All children*			*Non-anemic*			*Explained anemia*			*Unexplained anemia*		
n sample	*976*			*755*			*116*			*93*		
Population size	*603776.32*			*474,170.32*			*68,080.01*			*56,230.74*		
R-square	*0.1273*			*0.1039*			*0.3805*			*0.5026*		
	Coeficient value	*P*	*CI 95%*	*Coeficient value*	*P*	*CI 95%*	*Coeficient value*	*P*	*CI 95%*	*Coeficient value*	*P*	*CI 95%*
Copper tertile (second is the reference)												
1st tertile Cu	0.01	0.92	(-0.24, 0.27)	0.12	0.50	(-0.24, 0.49)	-0.67	0.02	(-1.24, -0.11)	-0.25	0.21	(-0.63, 0.14)
3rd tertile Cu	-0.30	0.065	(-0.63, 0.02)	-0.23	0.32	(-0.68, 0.22)	-0.45	0.055	(-0.9, 0.01)	-0.85	<0.001	(-1.31, -0.4
Micronutrient deficiency (yes *vs* not)												
Folate	-0.50	0.08	(-1.07, 0.07)	-0.96	0.01	(-1.67, -0.25)	-	-	-	-	-	-
Iron	-0.34	0.004	(-0.57, -0.11)	-0.33	0.07	(-0.70, 0.03)	-	-	-	-	-	-
Vitamin B12	0.04	0.85	(-0.37, 0.44)	0.34	0.21	(-0.19, 0.88)	-	-	-	-	-	-
Zinc	-0.10	0.41	(-0.35, 0.14)	-0.18	0.31	(-0.53, 0.17)	0.13	0.60	(-0.36, 0.62)	-0.40	0.03	(-0.75, -0.05
CRP (logaritm)	0.02	0.68	(-0.06, 0.1)	-0.01	0.92	(-0.12, 0.11)	-0.03	0.65	(-0.17, 0.11)	0.17	<0.001	(0.08, 0.26)
Age (years)	0.24	<0.001	(0.13, 0.36)	0.23	0.01	(0.06, 0.40)	0.42	0.001	(0.18, 0.66)	0.11	0.12	(-0.03, 0.24)
Sex (female)	-0.01	0.91	(-0.23, 0.2)	-0.21	0.17	(-0.52, 0.09)	-0.26	0.22	(-0.67, 0.16)	0.11	0.53	(-0.25, 0.48)
Tertil SES (lowest is the reference)												
2nd tertile NSE	0.32	0.02	(0.06, 0.58)	0.16	0.43	(-0.24, 0.56)	-0.07	0.80	(-0.63, 0.5)	-0.03	0.90	(-0.52, 0.46)
3rd tertile NSE	0.40	0.056	(-0.01, 0.8)	0.59	0.03	(0.06, 1.12)	1.06	0.01	(0.25, 1.87)	-0.001	1.00	(-0.50, 0.5)
Dwelling (rural *vs* urban)	0.02	0.84	(-0.21, 0.26)	0.17	0.33	(-0.18, 0.52)	0.03	0.89	(-0.43, 0.5)	-0.10	0.58	(-0.45, 0.26)
Beneficiary of social programs												
Liconsa	-0.08	0.71	(-0.49, 0.33)	0.37	0.07	(-0.03, 0.77)	-0.16	0.65	(-0.85, 0.53)	-0.22	0.49	(-0.87, 0.42)
Oportunidades	-0.07	0.65	(-0.37, 0.23)	0.10	0.65	(-0.33, 0.53)	-0.30	0.32	(-0.89, 0.3)	-0.05	0.86	(-0.58, 0.5)
Region (center is the reference)												
Northern	0.18	0.32	(-0.17, 0.53)	0.18	0.41	(-0.25, 0.61)	0.58	0.08	(-0.08, 1.23)	-0.50	0.03	(-0.94, -0.5)
Mexico City	0.51	0.14	(-0.16, 1.19)	0.39	0.42	(-0.55, 1.33)	-1.56	<0.001	(-2.51, -0.62)	-	-	-
Southern	0.24	0.13	(-0.07, 0.55)	0.34	0.09	(-0.06, 0.73)	0.11	0.71	(-0.46, 0.67)	0.31	0.08	(-0.04, 0.66
Intercept	11.35	<0.001	(10.61, 12.1)	10.87	<0.001	(9.73, 12.01)	10.14	<0.001	(8.86, 11.4)	10.68	<0.001	(9.23, 12.1)
/sigma				1.17	<0.001	(0.99, 1.36)	0.66	<0.001	(0.44, 0.87)	0.49	<0.001	(0.36, 0.61)

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