The prevalence of anemia decreased in Mexican preschool and school-age children from 1999 to 2006

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Abstract

Objective. To compare the distribution of anemia in children, based on information from Mexican National Health and Nutrition Survey 2006 (ENSANUT 2006) and Mexican National Nutrition Survey 1999 (ENN-99), and examine the association of anemia with potentially explanatory variables. **Material and Methods.** Adjusted prevalence and means as well as associations with potentially explanatory variables were assessed by multiple linear and logistic regression models for complex samples. **Results**. From 1999 to 2006, the prevalence of anemia decreased 13.8 percentage points (pp) in toddlers and 7.8 pp in children 24-35 months of age; it also decreased 0.7 pp/year in urban and rural populations, 1.8 pp/year in indigenous and 0.61 pp/year in non-indigenous toddlers, 1.5 pp/year in children 5-8 years of age and 0.78 pp/year in children 9-11 years of age. In toddlers served by *Oportunidades*, Hb was inversely associated with indigenous ethnicity (p=0.1) and they had a lower risk of anemia (OR=0.002). In school-age children, age (OR=0.98), affiliation to Liconsa (OR=0.42) and living in the central region (OR=0.56) were protective factors for anemia. **Conclusions**. The national prevalence of anemia in Mexico has decreased in the past seven years, especially in toddlers. Being a beneficiary of Liconsa or *Oportunidades* was protective for anemia.

Key words: anemia; preschool children; food fortified; Mexico

Villalpando S, Shamah-Levy T, García-Guerra A, Mundo-Rosas V, Domínguez C, Mejía-Rodríguez F. La prevalencia de anemia disminuyó en niños prescolares y escolares mexicanos entre 1999 y 2006. Salud Publica Mex 2009;51 supl 4:S507-S514.

Resumen

Objetivo. Comparar la distribución de la anemia en niños con base en la información de la Encuesta Nacional de Nutrición 2006 (ENSANUT 2006) y la Encuesta Nacional de Nutrición 1999 (ENN 99). Asimismo, examinar la asociación de la anemia con variables potencialmente explicativas. **Material y métodos**. Se calcularon las prevalencias y las medias ajustadas, así como las asociaciones mediante modelos de regresión múltiple lineal y logística para muestras complejas. **Resultados**. Entre 1999 y 2006 la anemia disminuyó 13.8 puntos porcentuales (pp) en lactantes de 12-23 meses de edad y 7.8 pp en los de 24-35; 0.7 pp/año en prescolares urbanos y rurales, 1.8 pp/año en indígenas y 0.61 pp/año en no indígenas; 1.5 pp/año en niños de 5-8 años y 0.78 pp/año en los de 9-11 años. En preescolares beneficiarios de *Oportunidades* la Hb se asoció negativamente con indigenismo (p=0.1) y tuvieron un riesgo menor para anemia (OR=0.002). En niños escolares la edad (OR=0.98), ser beneficiario de Liconsa (OR=0.42) y vivir en la región centro (OR=0.56) resultaron ser factores protectores contra la anemia. **Conclusiones**. La prevalencia de anemia disminuyó en México durante los pasados siete años, especialmente en lactantes. Ser beneficiario de *Oportunidades* y de Liconsa fue protector para el riesgo de anemia.

Palabras clave: anemia; niños preescolar; niños; alimentos fortificados; México

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The 1999 Mexican National Nutrition Survey (ENN-99) pinpointed anemia as one of the most pressing nutritional problems nationwide.[1] It was especially high (50%) in preschoolers 12- 24 months of age, and as high as 20% in school-age children. In addition, the prevalence of iron deficiency was 70% in preschoolers and 39% in school-age children.[2] Iron deficiency was the most frequent cause of anemia (62.2%); other deficiencies associated with anemia in children were folate (11.7%) and vitamin A (40.6%).[3]

The major known risk for children with iron deficiency anemia (IDA) is more acute infections, and for older ages poor school performance and limited capacity for physical work. These are the main reasons that justify the public health concern about such a high prevalence of anemia. Further, when IDA is not corrected before three years of age the damage caused to children's mental capacities might be irreversible.[4]

In the seven years that have elapsed between the ENN-99 and the most recent Mexican National Health and Nutrition Survey 2006 (ENSANUT 2006), several public nutritional interventions have been carried out aiming to reduce and control the prevalence of anemia and micronutrient deficiencies. The largest intervention is the distribution of fortified foods by social programs: pap by *Oportunidades* and fortified milk by the Social Milk Supply Program, Liconsa. The efficacy and effectiveness of these programs to reduce and control anemia have proven successful.[5-7]

Liconsa is a federal social assistance program aiming to improve the nutritional status of low-income families by providing milk fortified with iron, zinc and other micronutrients at subsidized prices, intended for children 0.5-15 years of age, pregnant and breastfeeding women, peri- and postmenopausal women, populations with chronic illnesses and adults older than 60 years. Currently, the program distributes about 3.14 million liters of milk per day in 1 800 municipalities, benefiting roughly 6.0 million individuals. The milk is sold at subsidized prices through specific stores, allowing daily portions of 400 mL of whole milk per eligible individual.[8]

In addition, *Oportunidades* is a program whose target are families and communities living in extreme poverty and uses conditional cash transfers linked to education, health and nutritional strategies. Its main purpose is to promote the development of human capital. The basic package of health services includes monitoring nutrition and child growth as well as the distribution of complementary pap fortified with iron, zinc and other micronutrients to children 6 to 24 months of age.[9]

Since the aforementioned programs are focused on the population in severe poverty, they include those with a higher risk of developing nutritional deficiencies. It is plausible to assume that their interventions, and perhaps some other unidentified improvements in the social and economic situation in Mexico, might have a positive impact on the overall prevalence of anemia, especially in younger children.

The objective of this investigation is to describe the frequency and distribution of anemia in children 1-11 years of age using the ENSANUT 2006 and to compare them with the data reported in the ENN-99, as well as to examine the association between affiliation with social programs that distribute foods fortified with iron and other micronutrients –namely *Oportunidades* and fortified milk Liconsa– with Hb concentrations and the prevalence of anemia in the population of ENSANUT 2006.

The results presented herein will enable the description of trends in the prevalence of anemia in Mexico in addition to providing relevant information for decision-makers to reexamine the policies and programs designed to reduce the prevalence of anemia and its serious consequences.

Material and Methods

Information for the present analysis was extracted from the ENN-99 and ENSANUT 2006 databases. The methodology for both probabilistic surveys has been published in detail elsewhere.[10,11] Briefly, the sampling procedure included a randomized selection of households, stratified by clusters, from the National Household Sampling Frame designed by the National Institute of Statistics, Geography and Informatics (INEGI, per its abbreviation in Spanish).[12] For the purpose of this analysis, data were selected only for children younger than 12 years of age who had a complete set of information on hemoglobin concentration, birthdate, gender, socioeconomic status, ethnicity, breastfeeding practices and whether or not the subject was beneficiary of any food assistance program.

Socio-economic level classification was based on a principal component analysis of household characteristics and assets. Children were defined as indigenous when at least one woman 12-49 years of age in the household spoke a native language,[10] and as urban when dwelling in communities with more than 2 500 inhabitants; otherwise they were considered as rural. Children were defined as beneficiaries of food assistance programs if regularly receiving fortified foods from social programs, as by statement of the mother.

Children were stratified into the following age categories: 12-24, 25-36, 37-46, 47-60 months and 5-8 and 9-11 years of age. The country was divided arbitrarily

into four regions: northern, central, Mexico City and southern, following the same criteria used in the ENN-99. The northern region included the states of Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo León, Sonora and Tamaulipas. The central region included the states of Aguascalientes, Colima, Guanajuato, Jalisco, México, Michoacán, Morelos, Nayarit, Querétaro, San Luis Potosí, Sinaloa and Zacatecas. The Mexico City region included the Federal District and the metropolitan area. The southern region included the states of Campeche, Chiapas, Guerrero, Hidalgo, Oaxaca, Puebla, Quintana Roo, Tabasco, Tlaxcala, Veracruz and Yucatán.

The concentration of hemoglobin (Hb) in capillary blood was measured by fingerprick using a portable photometer. The determination of Hb was based on the reaction of a mixture of dry sodium desoxicolate, sodium nitrite and sodium azide embedded in the internal surface of a plastic cuvette with hemoglobin, which is converted into metahemoglobin azide. The absorbance is read in the portable photometer (HemoCue, Angelholm, Sweden) at two different wavelengths (570 and 880 nm) to compensate for the turbidity of the sample.[13,14]

Hb concentrations of children living >1 000 m above sea level were adjusted in accordance with the equation published by Cohen and Hass.[15] Hb values lower than 5 g/dL or higher than 18.5 g/dL were considered spurious and excluded from the analysis, as published previously.[1]

Anemia was defined as a concentration of Hb <110g/L for children 12 to 71 months and Hb <120 g/L for children 6 to 11 years of age, as recommended by the International Nutritional Anemia Consultative Group (INACG) in 1989[16] and by WHO.[17]

Parents or legal guardians were carefully informed about the nature of the survey and the procedures involved, as well as their potential risks; then they signed an informed consent letter. Children gave their assent when appropriate. The protocols for both surveys (1999 and 2006) were reviewed and approved by the Research, Ethics and Biosecurity Committees of the National Institute of Publich Health (Instituto Nacional de Salud Pública –INSP) in Cuernavaca, Mexico.

Statistical analysis

Descriptive results are presented as proportions, means, 95% confidence intervals and standard deviations. The association between affiliation with social programs distributing foods fortified with iron and other micronutrients –namely, *Oportunidades* and fortified milk Liconsa– and Hb concentrations as well as the prevalence of anemia from ENSANUT 2006 were analyzed by either linear or logistic multiple regression models for complex samples controlling for the ENSANUT sample design.[11] The socio-economic level was included in the model as a dummy variable (using the highest level as reference) in order to estimate difference between tertiles. Besides socio-economic status, the covariables included in the model were those identified to be potential confounders such as age, gender, geographic region, indigenous ethnicity and urban condition.

Models for Hb concentration and anemia were estimated for two age groups defined as: a) preschool age children (12-24 months of age) and b) school-age children (6-11 years of age). All covariables listed previously were included in each model. Estimated coefficients (or Odd Ratios), standard errors, 95% confidence intervals and *p* values are presented.

Sample size calculations

The calculations to estimate the sample size for ENSANUT 2006 were based on the ability to detect a prevalence of 8.1% with a confidence level of 95%, a no response rate of 20% and a design effect of 1.7 (based on estimations from the National Nutrition Survey 1999, ENSANUT 2006 and the National Health Survey 2000), resulting in sample sizes of 1 476 households for each one of the 32 states. In 13 states the number of households surveyed was increased to 1 620 to assure a minimum of 300 households served by the social program *Oportunidades*.

Procedures were performed using the computational software SAS V9.1 (SAS Institute. Proprietary Software Release 9.1 TS Level 1M3. Cary, NC: SAS, 2002-2003) and STATA 9.2. (College Station, Texas, USA, Stata Corp., 2006).

Results

Valid information ENN-99 was available for 5 201 children younger than 5 years of age representing, by expansion, 6.04 million children and for 10 218 children 6-11 years of age representing 11.54 million children from ENSANUT 2006, there was valid information available for 6 618 children younger than 5 years of age representing 7.86 million children and 14 666 children 5-11 years of age representing 15.75 million children.

The overall unadjusted prevalence of anemia in preschool and school-age children decreased in the seven years elapsed between ENN-99 and ENSANUT 2006. It decreased 13.8 percentage points (pp) in infants 12-23 months old and 7.8 pp in toddlers 24-35 months; that is, 1.9 pp/year and 1.1 pp/year,

respectively. Nevertheless, in 2006 the prevalence remained very high for both age groups, at 40.5% and 28.3%, respectively (Table I). Urban and rural preschoolers showed similar reductions in the prevalence of anemia between 1999 and 2006 (≈ 5pp). The prevalence of anemia decreased at different rates by geographic regions; north, center and Mexico City reduced their prevalence at a rate of about 1pp/year, but the southern region did so at a rate of 0.5 pp/year. Indigenous preschoolers were able to reduce their prevalence of anemia at a rate of 1.8 pp/year in contrast with 0.61 pp/year for their non-indigenous counterparts (Table I). However, the major change occurred in indigenous preschoolers living in urban localities (4.0 pp/year) that in their rural counterparts (1.4 pp/year). Both rural (2.1 pp/year) and urban (1.8 pp/year) non-indigenous preschoolers had similar reductions.

Table I

PREVALENCE OF ANEMIA IN CHILDREN UNDER 11 YEARS OF AGE, BASED ON CHARACTERISTICS FROM TWO MEXICAN NATIONAL NUTRITION SURVEYS

	Children under 5 years of age						*Children 5-11 years of age*					
	ENN-1999			*ENSANUT 2006*			*ENN-1999*			*ENSANUT 2006*		
	Sample	*Expanded (thousands)*		*Sample*	*Expanded (thousands)*		*Sample*	*Expanded (thousands)*		*Sample*	*Expanded (thousands)*	
	n	*N*	*%*	*n*	*n*	*%*	*n*	*n*	*%*	*n*	*n*	*%*
Age groups (months)												
12 to 23	1 034	1 167.1	54.3	1 467	1 705.8	40.5	-	-	-	-	-	-
24 to 35	1 281	1 528.1	36.2	1 562	1 833.0	28.3	-	-	-	-	-	-
36 to 47	1 427	1 628.1	23.4	1 734	2 192.8	22.7	-	-	-	-	-	-
48 to 60	1 459	1 719.7	18.5	1 855	2 129.1	15.1	-	-	-	-	-	-
Age groups (years)												
5 to 8	-	-	-	-	-		5 971	6 757.7	29.7	7 918	8 497.5	20.8
9 to 11	-	-	-	-	-		4 247	4 789.1	19.4	6 748	7 260.9	14.7
Gender												
Girls	2 658	3 077.4	31.1	3 232	3 902.1	26.9	5 191	5 891.0	26.1	7 302	7 849.5	18.0
Boys	2 543	2 965.5	31.2	3 386	3 958.6	24.8	5 027	5 655.9	24.8	7 364	7 908.9	18.0
Socio-economic level												
Low	1 572	1 666.5	34.1	2 837	3 175.0	29.8	4 194	4 381.2	28.1	6 202	6 324.4	19.6
Medium	1 633	1 818.6	33.3	2 318	2 701.4	23.7	3 487	3 767.5	24.7	5 082	5 218.9	17.2
High	1 839	2 386.1	25.2	1 437	1 955.7	22.2	2 268	3 115.6	22.1	3 328	4 175.4	16.6
Locality												
Urban	2 928	4 113.6	30.2	4 573	5 777.3	25.1	5 596	7 661.0	24.2	9 801	11 374.5	17.5
Rural	2 273	1 929.3	33.1	2 045	2 083.4	27.6	4 622	3 885.9	27.8	4 865	4 384.0	19.2
Region												
Northern	1 540	1 094.2	30.2	1 384	1 536.6	23.5	3 103	2 183.3	30.0	2 999	2 920.8	18.6
Center	1 636	2 167.7	31.6	2 480	2 458.6	24.9	3 077	3 919.4	23.8	5 556	4 988.5	16.1
Mexico City	322	721.6	31.5	255	1 242.3	25.7	699	1 415.0	14.0	511	2 467.2	17.4
Southern	1 703	2 059.4	31.1	2 499	2 623.7	28.0	3 339	4 029.2	28.6	5 600	5 381.9	19.7
Ethnicity												
Non-indigenous	4 614	5 368.4	30.1	6 329	3 821.6	25.8	9 151	10 360.1	24.8	13 821	3 108.4	17.8
Indigenous	587	674.5	39.6	286	204.7	26.7	1 067	1 186.8	31.3	842	242.9	20.6

Changes in the prevalence of anemia in children 5-11 years of age

The overall unadjusted prevalence of anemia in children 5-8 years of age decreased 8.9 pp from 1999 to 2006 (1.5 pp/year) and 4.7 pp (0.78 pp/year) in children 9-11 years of age. There were no significant differences by gender or urban and rural dwelling. The decrease in the prevalence of anemia within 1999 and 2006 varied at a different rate by geographical region; in the northern, central and southern regions from 7.7-11.4 pp where as in Mexico City increased 3.4 pp.

Regression analysis

In a series of multiple linear regression models Hb concentrations were lower in the lower socio-economic level compared with the higher socio-economic level as a control variable (coefficient= -0.53, p=0.002). The interaction between being a beneficiary of *Oportunidades* and of indigenous ethnicity was negative and statistically significant (coefficient= -0.78, p=0.1). That is, indigenous children who were not beneficiaries of *Oportunidades* had a lower concentration of Hb (Table II). In school-age children no statistically significant associations were found between Hb concentrations and the covariables analyzed (data not shown).

In a series of linear logistic regression models in preschoolers 12-24 months of age it was found that the passage of age (OR= 0.93, 95% CI 0.89-0.98), living in the northern region (OR= 0.37, 95% CI 0.16, 0.83) and the interaction between being a beneficiary of *Oportunidades* and living in an urban area (OR=0.44, 95% CI 0.16, 1.22) were protective for anemia; while belonging to the lowest socio-economic level was a risk (OR= 2.21, p=0.002) (Table III). Being a beneficiary of Liconsa, living in rural areas and belonging to an indigenous family were not associated with the prevalence of anemia (Table III).

In a similar linear logistic regression model for school-age children it was found that the passage of age (OR= 0.98, 95% CI 0.97, 0.98), being a beneficiary of Liconsa (OR = 0.42, 95% CI 0.23, 0.76) and living in the central region (OR = 0.56, 95% CI 0.33, 0.94) had protective effects against anemia. The prevalence of

Table II

MULTIPLE LINEAR REGRESSION MODEL WITH HEMOGLOBIN CONCENTRATION OF CHILDREN YOUNGER THAN TWO YEARS OF AGE AS DEPENDENT VARIABLE, ADJUSTED FOR COMPLEX SAMPLES, DESIGN EFFECTS AND CLUSTERING*

Covariables	*Coefficient*	*Standard error*	*p value*	*95% Confidence interval*
Age (months)	0.11	0.18	0.526	-0.24, 0.48
Gender	0.12	0.11	0.269	-0.094, 0.339
Dwelling (urban/rural)	-0.01	0.15	0.941	-0.31, 0.29
Beneficiary of Liconsa	0.13	0.34	0.701	-0.53, 0.80
Beneficiary of *Oportunidades*	0.03	0.17	0.847	-0.30, 0.33
Multivitamins, minerals supplement	0.27	0.21	0.19	-0.13, 0.68
Indigenous ethnicity	0.47	0.33	0.15	-0.18, 1.13
Socio-economic level‡				
Low	-0.53	0.17	0.002	-0.87,-0.19
Medium	-0.22	0.17	0.18	-0.56, 0.10
Northern§ region	0.47	0.28	0.101	-0.09, 1.04
Central region	0.32	0.30	0.28	-0.26, 0.91
Southern region	0.30	0.28	0.292	-0.25, 0.86
Oportunidades X dwelling	0.38	0.28	0.18	-0.18, 0.95
Oportunidades X Indigenous ethnicity	-0.78	0.48	0.100	-1.74, 0.16
Constant	9.33	1.68	0.001	6.02, 12.64

* n=1 459
‡ Dummy variable: high socio-economic level
§ Dummy variable: Mexico City region

Table III

MULTIPLE LOGISTIC REGRESSION MODELS, WITH PREVALENCE OF ANEMIA AS THE DEPENDENT VARIABLE, ADJUSTED FOR COMPLEX SAMPLES, FOR DESIGN EFFECTS AND CLUSTERING

*Model 1. Children < 2 years of age**

Covariables	*Odds ratio*	*Linearized standard error*	*p value*	*95% confidence interval*
Age (months)	0.93	0.02	0.005	0.89, 0.98
Gender	0.97	0.16	0.87	0.69, 1.35
Dwelling (urban/rural)	0.98	0.19	0.94	0.66, 1.45
Beneficiary of Liconsa	0.99	0.64	0.9	0.27, 3.55
Beneficiary of *Oportunidades*	0.86	0.23	0.59	0.50, 1.44
Multivitamin, mineral suppl	0.89	0.43	0.81	0.34, 2.31
Indigenous ethnicity	0.80	0.36	0.62	0.33, 1.95
Socio-economic level‡				
Low	2.21	0.57	0.002	1.33, 3.67
Medium	1.40	0.34	0.16	0.87, 2.26
Northern§ region	0.36	0.15	0.01	0.16, 0.82
Central region	0.54	0.21	0.12	0.24, 1.18
Southern region	0.60	0.23	0.19	0.28, 1.29
Oportunidades X dwelling	0.44	0.22	0.11	0.16, 1.22

* *n*=1 459
‡ Dummy variable: high socio-economic level
§ Dummy variable: Mexico City region

*Model 2. Children 6- 11 years of age**

Covariables	*Odds ratio*	*Standard error*	*p value*	*95% confidence interval*
Age (months)	0.98	0.02.	0.0001	0.97, 0.98
Gender	1.05	0.11	0.6	0.84, 1.31
Dwelling (urban/rural)	0.92	0.11	0.5	0.72, 1.18
Beneficiary of Liconsa	0.42	0.12	0.004	0.23, 0.76
Beneficiary of *Oportunidades*	0.64	0.90	0.3	0.55, 4.84
Multivitamin, mineral suppl	0.78	0.23	0.4	0.43, 1.40
Indigenous ethnicity	0.87	0.18	0.5	0.57, 1.33
Socio-economic level‡				
Low	1.24	0.23	0.2	0.85, 1.81
Medium	1.06	0.18	0.7	0.76, 1.49
Northern§ region	0.78	0.20	0.3	0.4, 1.31
Central region	0.56	0.14	0.029	0.33, 0.94
Southern region	0.70	0.18	0.18	0.42, 1.18

* n=14 610
‡ Dummy variable: high socio-economic level
§ Dummy variable: Mexico City region

anemia was not associated in this analysis with gender, being beneficiary of *Oportunidades* and belonging to an indigenous family (Table III).

Discussion

Evidence presented here shows that the prevalence of anemia in children decreased during the period elapsed between the two national surveys of 1999 and 2006 and that such a decrement was substantial in the age groups with higher initial prevalence, consequently more susceptible to improvement. Also present evidence that being a beneficiary of national social programs including nutrition interventions such as *Oportunidades* and Liconsa resulted protective against anemia in 12-24 month old toddlers and in school-age children.

The following apparently contradictory observations in the unadjusted comparisons need careful discussion.

1. The rate of decrease in the prevalence of anemia for the preschool age group between 1999 and 2006 was not different among the northern, central and Mexico City regions whereas it was lowest in the southern region; the southern region is considered the less developed of all four regions, and houses a large proportion of rural population.
2. The urban and rural preschoolers reduced their prevalence of anemia at a similar rate.
3. The indigenous preschoolers reduced their prevalence of anemia two-times faster than their non-indigenous counterparts in the same period.

However the largest improvement occurred in indigenous preschoolers living in urban localities compared to their rural counterparts. The cut-off for defining rural communities (<2 500 inhabitants) should be considered for interpreting these data. Further, in the logistic regression model there was a protective interaction between *Oportunidades* and the urban dwelling of its beneficiaries.

These findings were surprising because the benefits of the *Oportunidades* program, including an iron-fortified complementary pap intended for infants 6-24 months of age, started being distributed in 1999. In 2006, 74.9% of rural households within the country received those benefits.[18] The limited decrease in the prevalence of anemia in the southern region and rural areas may be explained firstly by a faulty efficacy or effectiveness of the complementary fortified pap distributed by the *Oportunidades* program. An evaluation of *Oportunidades* demonstrated a modest decrease of 10 pp in the prevalence of anemia after one year of intervention and showed no impact on the prevalence of iron deficiency.[5] It was also demonstrated that the iron compound used as a fortifier in the *Oportunidades* complementary food (hydrogen reduced iron) was poorly absorbed.[18] The complementary food was reformulated with an iron compound with improved absorption (ferrous gluconate) which proved to have better efficacy.[19] The reformulated complementary food started its public distribution at the end of 2004,[20] thus some impact should be expected in the ENSANUT 2006, especially in toddlers. The protective effect against anemia of being a beneficiary of *Oportunidades*, as shown by the logistic regression model, confirmed the positive impact of *Oportunidades* on urban toddlers; nevertheless, this regression analysis had a cross-sectional design and only included data from the 2006 survey and did not consider the longitudinal effect of the intervention.

The protective effect of the Liconsa program against the risk of anemia was noted in preschoolers under 5 years of age but not in toddlers 1-2 years of age (data not shown); the largest protection was seen in school-age children. Such positive effects were expected in both age groups because the largest population in Liconsa belongs to this age strata. We underscore that Liconsa targets mostly urban populations with medium to low socio-economic status. The design and the bioavailability of the iron fortificant in the admixture used to fortify the milk distributed by Liconsa were tested thoroughly before going public.[8,21]

No impact of *Oportunidades* was seen on the prevalence of anemia in school-age children, which incidentally was not expected because the nutritional interventions of this program are not targeted to this age group.

The decrease in the prevalence of anemia in low socio-economic toddlers and in school-age children and the protective effects shown by both *Oportunidades* and Liconsa programs make plausible the notion that they are the driving forces for much of the improvement in the prevalence of anemia. Other factors support such a conclusion, such as small changes in economic indicators throughout the examined period, e.g. the GINI´s index, and the proportion of population living in alimentary poverty,[22] as well as the limited increase in accessibility to health services.

In summary, the national prevalence of anemia in Mexico has decreased considerably in the past seven years, especially in young children who are most vulnerable to the disruption in physical and mental development that is associated with anemia and micronutrient deficiencies. Being a beneficiary of Liconsa and *Oportunidades* was protective against the risk of anemia, which

leads to the speculation that the fortification of milk with iron and other micronutrients and the distribution of fortified pap by *Oportunidades* to groups at high risk for anemia played a role in such a protection.

Specific impact evaluations of the social programs distributing fortified foods on the prevalence of anemia are in order, especially the impact of the fortified pap distributed by *Oportunidades* after it was reformulated with an iron compound with a better absorption.

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