

State-level prevalence of anemia in women of reproductive age. Ensanut 2006, 2012 and 2018-19

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Abstract

Objective. To compare the prevalence of anemia and iron deficiency, at state level in non-pregnant women between 20 and 49 years of age from the *Encuesta Nacional de Salud y Nutrición* (Ensanut, in Spanish) 2006, 2012 and 2018-19. **Materials and methods.** The Ensanut 2006, 2012 and 2018-19 have a probabilistic design. Hb in capillary blood was measured by HemoCue Hb201 and ferritin by venous sample. Anemia was diagnosed with Hb<120g/L and iron deficiency with Ferritin<15ng/mL. **Results.** At the national level, anemia increased 6.1 ($p<0.05$) percentage points (pp) from 2006 to 2018-19. Baja California Norte, Campeche, Colima, Chiapas, Quintana Roo, Sinaloa and Sonora, went from low prevalence (5 to 19.9%) to moderate (20 to 39.9%); in Yucatán and Tamaulipas it went from low to severe (>40). In Guanajuato, State of Mexico and Querétaro it was reduced from 2006 to 2018-19 ($p<0.05$). **Conclusions.** Anemia continues to be a public health problem that requires actions at the state level, considering level of wellbeing index, food programs and affiliation to medical Services insurance.

Palabras clave: anemia; women; nutrition surveys; Mexico

Resumen

Objetivo. Comparar la prevalencia de anemia y deficiencia de hierro a nivel estatal, en mujeres no embarazadas entre 20 y 49 años de la Encuesta Nacional de Salud y Nutrición (Ensanut) 2006, 2012 y 2018-19. **Material y métodos.** La Ensanut 2006, 2012 y 2018-19 tiene diseño probabilístico. La Hb en sangre capilar se midió por HemoCue Hb201 y la ferritina por muestra venosa. Se diagnosticó anemia con Hb<120g/L y deficiencia de hierro con Ferritina<15ng/mL. **Resultados.** A nivel nacional, la anemia aumentó 6.1 ($p<0.05$) puntos porcentuales (pp) de 2006 a 2018-19. Baja California Norte, Campeche, Colima, Chiapas, Quintana Roo, Sinaloa y Sonora, pasaron de prevalencia baja (5 a 19.9%) a moderada (20 a 39.9%); en Yucatán y Tamaulipas pasó de baja a severa (>40). En Guanajuato, Estado de México y Querétaro se redujo de 2006 a 2018-19 ($p<0.05$). **Conclusiones.** La anemia sigue siendo un problema de salud pública que requiere acciones a nivel estatal, considerando nivel de bienestar, programas de ayuda alimentaria y afiliación a servicios de salud.

Palabras clave: anemia; mujeres; encuesta nacional; México

Anemia is caused by a low concentration of Hb and most frequently is due to iron deficiency.¹ The iron deficiency anemia is a global health problem, most affected are small children and women at reproductive age, especially if pregnant in this case is associated with

20% perinatal mortality and 10% of maternal mortality in low income countries.²⁻⁴ Iron deficiency anemia is also associated with a larger risk of spontaneous abortion, fetal mortality, prematurity and low birth weight and negative effects on the physical and mental development.^{5,6}

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A reduction in the prevalence of anemia in non-pregnant women from 20 to 49 year of age from 2006 (16.4%) through 2012 (11.6%), in Mexico, with an unexplainable increase in *Encuesta Nacional de Salud y Nutrición* (Ensanut, by its acronym in Spanish) 2016 (18.3%).⁷ The prevalence of anemia has been higher in the south in comparison to the north of the country, thus, the governmental interventions have been directed mostly towards the south zone.⁸ Nevertheless, the prevalence of anemia increased in the Ensanut 2018-19 in the north of the country to 27.2% in 20-34 and to 35.4% in 35-49 years old non-pregnant women, while in the south zone increased to 18.4% in 20-34 and to 26.8% in 35-49 year old non-pregnant women. Due this unexpected increase in the north region, is necessary to better scrutinize the differential increase of the prevalence of anemia among the States belonging to each region and some factors that may contribute to the differential increase among the States of both region of the country.^{7,9} Mainly because anemia significantly decreases productivity and quality of life, which results in economic losses for nations.⁴

Thus, the objective of this study is to compare the prevalence of anemia and iron, depletion at State level in non-pregnant from the Ensanut 2012 and 2018-19.

Materials and methods

Study design and participants

The information herein analyzed come from the Ensanuts 2006, 2012 and 2018-19 that are National Survey with cross-sectional design, representative at National level, at urban and rural dwelling and four geographical regions of the country: North, Center, Mexico City and South. Further details are documented elsewhere.¹⁰⁻¹² Capillary blood samples were obtained from 20 480 non-pregnant women 20 to 49 years old in 2006; 17 116 in 2012 and 13 154 in 2018.¹³ Venous blood samples were collected in 30% of total participants within each of the three surveys. The serum ferritin was measured in an Architect chemiluminescence microparticle immunoassay autoanalyzer (Architect 1200 Abbott Lab, Michigan, III USA). The quality control of the measurements was performed using the Reference Standard Serum NIST 968E of the National Institute of Standards and Technology. Intra- and inter-assay CVs for ferritin were 3.18, 3.98 and 4%, respectively.¹⁴

Hemoglobin concentration in capillary blood was measured with a portable photometer Hemo-Cué (HemoCue Hb301, Ängelholm, Sweden to 2006; Hemo Cue Hb201, Ängelholm, Sweden to 2012 and 2018-19)

using the second drop of blood obtained from a middle finger puncture.¹³ Hb concentrations <4.5g/dL and >18.5 g/dL were considered implausible and excluded from calculations.

Anemia (variable dependent) was defined as hemoglobin concentration (Hb) of <12g/L for non-pregnant women, adjusted by altitude.^{15,16} Iron deficiency (ID, variable dependent) was defined as levels of serum ferritin adjusted by CRP of <12 µg/L in women.¹⁷

Covariates

Wellbeing index

A wellbeing index was generated by a principal components analysis based on the characteristics and possessions of households, number of rooms availability of running water and sewerage, having an automobile, fridge, stove, washing machine, microwave equipment, TV set, cable, phone and radio set. The first component was selected, it accumulated a total variability of 51% with a lambda value of 4.08; it was divided into tertiles, representing tertile one the group with higher shortages and tertile three with the lesser shortages.¹⁸ This index has been used throughout the Ensanut series.¹⁹

Programs furnishing food aid

Beneficiaries was considered if any member of the family was beneficiary of the cash transfer program named *Prospera* or received fortified milk *Liconsa* during previous year.

Affiliation to medical services insurance

Medical services as referred by the family head were grouped into five categories: a) *Instituto Mexicano del Seguro Social* (IMSS); b) *Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado* (ISSSTE); c) *Seguro Popular*; d) IMSS *Prospera*; e) Private services and others: Medical Services for the Mexican Oil Company (Pemex), Medical Services for the Army Ministry (Sedena), for the Marine Ministry; and e) Without any affiliation.

Ethical aspects

The non-pregnant women participating in the surveys signed an informed consent form, following a detailed explanation of the procedures, risks and benefits of the survey. The Research, Ethics and Biosecurity Committees of *Instituto Nacional de Salud Pública* approved the protocol of the Surveys.

Statistical analysis

The percentage distribution of the characteristics of non-pregnant women aged 20 to 49 years and prevalence were calculated considering surveys design. Using a logistic regression model the effects of time were evaluated using an interaction with the years in which each survey was carried out by each of the 32 States of the Country and adjusted by covariables (wellbeing index, programs furnishing food aid and affiliation to medical services insurance) and adjusted for multiple comparisons using Bonferroni's method.

Results

In table I are depicted the sociodemographic characteristics of non-pregnant women of 20-49 years of age by national and regional division. The distribution of food aid programs was not different at national level in the three Surveys. However, the proportion of women affiliated to Popular Insurance in 2018-19 was higher (43.5%, IC 41.3, 45.7); in the zone South (56.4%, IC 52.7, 59.9) the prevalence was higher in the Center zone (43.6%, IC 40, 47.2). In this same sense, the number of unaffiliated in the same regions was reduced.

Table I
PERCENTAGE DISTRIBUTION OF THE CHARACTERISTICS OF NON-PREGNANT WOMEN AGED 20 TO 49 YEARS, AT THE NATIONAL LEVEL AND BY REGION. MEXICO, ENSANUT 2006, 2012, 2018

	Survey		
	2006 n(sample)= 13 495 N(Expanded)= 23 747 901 % (CI95%)	2012 n(sample)= 12 261 N(Expanded)= 24 583 929 % (CI95%)	2018-19 n(sample)= 5 649 N(Expanded)= 27 727 972 % (CI95%)
National			
Wellness condition			
Low	31.0 (29.1, 32.9)	25.3 (23.7, 26.8)	30.2 (28.2, 32.3)
Middle	33.7 (32.0, 35.3)	33.3 (31.8, 34.9)	34.5 (32.3, 36.7)
High	35.3 (33.1, 37.4)	41.4 (39.4, 43.3)	35.2 (32.8, 37.6)
Prospera	25.6 (23.7, 27.5)	18.3 (16.0, 20.8)	25.3 (23.4, 27.2)
Liconsa	9.0 (7.5, 10.7)	9.9 (8.0, 12.1)	8.3 (7.1, 9.7)
Affiliation to medical service			
IMSS	28.4 (26.7, 30.2)	29.3 (27.7, 30.9)	35.0 (32.7, 37.4)
ISSSTE	5.0 (4.2, 5.8)	5.1 (4.5, 5.6)	5.3 (4.2, 6.5)
Seguro Popular	10.8 (9.5, 12.1)	40.8 (39.1, 42.4)	43.5 (41.3, 45.7)
Private or other	3.7 (3.0, 4.3)	1.6 (1.2, 2.0)	1.7 (1.1, 2.4)
No affiliated	52.1 (50.1, 54.0)	23.3 (21.8, 24.7)	14.5 (12.9, 16.1)
Northern			
Wellness condition			
Low	18.0 (15.3, 20.9)	15.1 (13.3, 17.0)	16.8 (14.2, 19.5)
Middle	39.7 (36.4, 43.1)	34.1 (31.5, 36.7)	38.4 (34.3, 42.4)
High	42.3 (38.0, 46.5)	50.8 (47.8, 53.7)	44.9 (40.6, 49.1)
Prospera	10.3 (7.9, 13.3)	8.4 (6.2, 11.0)	13.6 (11.3, 16.2)
Liconsa	2.0 (1.2, 3.0)	5.9 (3.8, 8.8)	3.2 (2.1, 4.5)
Affiliation to medical service			
IMSS	43.6 (40.0, 47.2)	44.0 (40.9, 47.0)	52.1 (47.9, 56.2)
ISSSTE	5.5 (3.9, 7.6)	4.6 (3.7, 5.6)	5.5 (3.8, 7.7)
Seguro Popular	8.5 (6.4, 11.1)	28.3 (25.8, 30.8)	26.7 (23.2, 30.5)
Private or other	3.0 (2.1, 4.1)	2.1 (1.4, 2.9)	2.1 (1.0, 4.0)
No affiliated	39.3 (36.1, 42.5)	21.0 (18.9, 23.1)	13.5 (10.6, 17.1)

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Center						
Wellness condition						
Low	28.6	(25.4, 31.9)	20.3	(18.1, 22.5)	25.2	(21.9, 28.8)
Middle	35.3	(32.8, 37.8)	36.8	(34.4, 39.3)	36.0	(32.9, 39.2)
High	36.1	(32.3, 40.0)	42.9	(39.9, 45.8)	38.8	(35.0, 42.6)
Prospera	31.9	(27.7, 36.4)	18.0	(14.4, 22.2)	24.5	(21.4, 27.8)
Liconsa	6.1	(4.8, 7.6)	8.6	(6.0, 12.1)	10.1	(8.0, 12.6)
Affiliation to medical service						
IMSS	27.5	(24.5, 30.5)	31.4	(28.9, 34.0)	36.1	(32.4, 39.8)
ISSSTE	3.4	(2.5, 4.5)	4.9	(3.9, 6.0)	5.1	(3.4, 7.4)
Seguro Popular	14.7	(12.0, 17.7)	41.7	(38.8, 44.5)	43.6	(40.0, 47.2)
Private or other	2.4	(1.7, 3.2)	1.0	(0.5, 1.6)	1.7	(0.9, 3.0)
No affiliated	52.0	(48.5, 55.4)	21.1	(19.2, 23.0)	13.5	(11.3, 16.0)
Mexico City						
Wellness condition						
Low	13.7	(10.0, 18.3)	14.7	(11.3, 18.8)	13.7	(9.3, 19.5)
Middle	33.3	(28.0, 39.0)	30.0	(25.0, 35.4)	37.5	(29.7, 45.9)
High	53.0	(46.8, 59.0)	55.2	(48.6, 61.6)	48.8	(39.9, 57.7)
Prospera	1.9	(0.8, 4.3)	5.0	(1.9, 12.2)	8.4	(4.3, 15.6)
Liconsa	29.2	(23.6, 35.3)	21.7	(14.8, 30.5)	12.6	(8.1, 19.0)
Affiliation to medical service						
IMSS	31.0	(25.5, 37.0)	29.3	(24.4, 34.7)	38.1	(29.6, 47.3)
ISSSTE	6.9	(4.6, 10.2)	6.5	(4.9, 8.4)	5.0	(2.4, 10.0)
Seguro Popular	2.7	(1.2, 5.6)	30.3	(25.9, 35.0)	37.2	(29.5, 45.7)
Private or other	5.1	(3.0, 8.3)	2.5	(1.4, 4.3)	2.5	(0.7, 7.6)
No affiliated	54.2	(48.1, 60.1)	31.4	(26.4, 36.6)	17.1	(11.4, 24.8)
Southern						
Wellness condition						
Low	53.2	(49.5, 56.8)	42.8	(39.4, 46.1)	51.1	(47.2, 54.9)
Middle	28.4	(26.1, 30.8)	31.6	(29.2, 34.0)	29.4	(25.8, 33.1)
High	18.4	(16.0, 21.0)	25.6	(22.4, 29.0)	19.5	(16.2, 23.3)
Prospera	44.5	(40.1, 48.8)	32.0	(27.4, 36.9)	41.4	(38.0, 44.8)
Liconsa	3.3	(2.6, 4.0)	6.0	(4.1, 8.5)	7.5	(5.7, 9.6)
Affiliation to medical service						
IMSS	18.0	(16.2, 19.9)	18.1	(16.0, 20.3)	22.6	(19.4, 26.0)
ISSSTE	5.0	(3.9, 6.1)	4.7	(3.7, 5.7)	5.5	(3.8, 7.6)
Seguro Popular	13.7	(11.3, 16.3)	54.2	(51.5, 56.8)	56.4	(52.7, 59.9)
Private or other	4.4	(3.4, 5.4)	1.3	(0.7, 1.9)	0.9	(0.5, 1.5)
No affiliated	59.0	(56.2, 61.7)	21.8	(19.7, 24.0)	14.6	(12.5, 16.9)

CI: Confidence Interval; Ensanut: Encuesta Nacional de Salud y Nutrición.

IMSS: Instituto Mexicano del Seguro Social; ISSSTE: Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado; Prospera: cash transfer program (social inclusion program); Liconsa: fortified milk (parastatal company of the Mexican government).

The prevalence of anemia is presented in table II. At national level the prevalence increased significantly ($p<0.05$) by 6.1 percentage points (pp) from 2006 to 2018-19. By federal entity, a regional pattern is not shown. By State, Baja California North, Campeche, Colima, Chiapas, Quintana Roo, Sinaloa and Sonora, moved

($p<0.05$) from a lower prevalence (5 to 19.9%) to a moderate prevalence (20 a 39.9%); in the States of Yucatán and Tamaulipas passed ($p<0.05$) from a low to a severe prevalence (>40). In Zacatecas, increased significantly ($p<0.05$) by only 2 pp. In the States of Aguascalientes, Baja California South, Coahuila, Chihuahua, Ciudad

Table II
PREVALENCE OF ANEMIA (Hb<12g/dL) IN NON-PREGNANT WOMEN AGED 20 TO 49 YEARS BY STATE AND SURVEY YEAR. MEXICO, ENSANUT 2006, 2012, 2018

	Survey		
	2006 n(sample)= 13 495 N(Expanded)=23 747 901 % (CI95%)	2012 n(sample)= 12 261 N(Expanded)=24 583 929 % (CI95%)	2018-19 n(sample)= 5 649 N(Expanded)=27 727 972 % (CI95%)
National	18.2 (17.1, 19.3)	13.1 (12.1, 13.9)	19.2 (17.6, 20.8)
Aguascalientes	14.3 (10.5, 19.1)	8.9 (6.0, 12.8)	10.2 (6.5, 15.5)
Baja California Norte*‡	9.3 (5.3, 15.7)	12.2 (9.4, 15.6)	37.8 (25.5, 51.7)
Baja California Sur	23.7 (17.6, 30.9)	11.8 (8.4, 16.2)	24.1 (17.5, 32.2)
Campeche*§	17.0 (13.1, 21.7)	24.1 (19.7, 29.0)	36.3 (27.7, 45.7)
Coahuila	29.0 (23.6, 35.0)	9.8 (6.6, 14.4)	23.4 (15.8, 33.1)
Colima*‡§	23.1 (18.5, 28.2)	12.9 (9.2, 17.7)	34.0 (25.9, 43.1)
Chiapas*	16.3 (12.1, 21.3)	15.5 (11.2, 20.9)	25.8 (18.9, 34.0)
Chihuahua	17.2 (12.8, 22.5)	7.1 (4.4, 11.3)	24.9 (15.6, 37.2)
Ciudad de México	14.8 (11.5, 18.6)	13.9 (10.1, 18.7)	14.8 (8.2, 25.2)
Durango	19.4 (16.0, 23.4)	12.0 (8.7, 16.1)	17.3 (11.6, 25.0)
Guanajuato*§	24.1 (19.7, 29.1)	10.1 (7.0, 14.1)	8.9 (5.8, 13.3)
Guerrero	17.8 (14.8, 21.1)	14.3 (10.9, 18.5)	13.3 (7.9, 21.4)
Hidalgo	16.9 (12.8, 22.0)	15.7 (10.8, 22.3)	14.3 (10.0, 19.8)
Jalisco	16.9 (12.3, 22.5)	10.5 (6.8, 15.5)	9.1 (5.4, 14.6)
Estado de México*	26.2 (18.4, 35.6)	13.7 (10.7, 17.3)	9.1 (5.6, 14.3)
Michoacán	20.3 (16.2, 25.0)	15.0 (9.8, 22.0)	12.3 (7.9, 18.4)
Morelos	16.2 (11.7, 21.9)	12.7 (9.4, 16.9)	10.0 (5.5, 17.3)
Nayarit	14.2 (10.6, 18.6)	8.2 (5.4, 12.0)	29.1 (22.5, 36.6)
Nuevo León	17.0 (13.1, 21.7)	12.9 (9.4, 17.4)	24.3 (16.1, 34.8)
Oaxaca	14.4 (12.0, 17.1)	14.8 (11.7, 18.4)	20.4 (14.9, 27.1)
Puebla	17.8 (13.5, 23.0)	14.3 (10.1, 19.6)	11.5 (6.0, 20.6)
Querétaro*	18.6 (14.3, 23.8)	12.0 (9.0, 15.8)	6.4 (3.5, 11.0)
Quintana Roo*	22.0 (17.2, 27.4)	16.6 (13.2, 20.7)	35.8 (26.1, 46.7)
San Luis Potosí	16.8 (12.8, 21.5)	10.0 (6.8, 14.3)	19.6 (11.8, 30.7)
Sinaloa‡§	18.3 (14.0, 23.4)	9.4 (6.3, 13.6)	24.9 (18.8, 32.1)
Sonora‡	28.3 (22.8, 34.5)	15.5 (11.1, 21.2)	37.6 (29.6, 46.3)
Tabasco	19.6 (16.4, 23.2)	23.0 (18.2, 28.5)	21.7 (17.6, 26.3)
Tamaulipas*‡	17.3 (12.8, 22.7)	13.3 (10.0, 17.4)	50.1 (41.4, 58.8)
Tlaxcala	20.1 (16.5, 24.3)	17.1 (12.7, 22.4)	13.3 (9.0, 19.0)
Veracruz	22.1 (18.0, 26.7)	11.9 (8.9, 15.6)	27.4 (19.5, 37.0)

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Yucatán*‡	16.6 (12.5, 21.6)	16.6 (12.9, 20.8)	44.4 (36.7, 52.4)
Zacatecas‡	20.1 (15.7, 25.2)	8.1 (5.4, 11.8)	10.5 (6.7, 15.8)

Differences by logistic regression model adjusted by survey design, wellness condition, *Prospera* (cash transfer program [social inclusion program]), *Liconsa* (fortified milk [parastatal company of the Mexican government]), medical services.

* Significant differences ($p < 0.05$), 2006 vs. 2018-19

‡ Significant differences ($p < 0.05$), 2018 vs. 2012

§ Significant differences ($p < 0.05$), 2006 vs. 2012

CI: confidence interval; Ensanut: *Encuesta Nacional de Salud y Nutrición*

de México, Durango, Nayarit, Nuevo León, Oaxaca, San Luis Potosí and Veracruz, had increased but non-significant. In Guanajuato, State of México and Querétaro, there was a significant reduction in the prevalence of anemia from 2006 to 2018-19 ($p < 0.05$). In the States of Guerrero, Hidalgo, Jalisco, Michoacán, Morelos, Puebla, Tabasco y Tlaxcala non-significant fall in the prevalence were observed.

In table III is shown the prevalence of anemia by urban and rural dwelling, at State level. The small sample size in some States did not allow for comparison when adjusting by covariables. A significant increase, at national level, was observed from year 2006 to 2012 ($p < 0.05$), in rural areas and in urban areas from 2012 to 2018-19.

The distribution of the prevalence of iron deficiency, measured as serum ferritin concentrations is shown in table IV. A significant increase in the prevalence of ferritin deficiency occurred in the States of Baja California South from 2006 through 2018-19. While in Tamaulipas and Tlaxcala a significant fall in the prevalence of ferritin deficiency was seen from 2006 through 2018-19 ($p < 0.05$).

Discussion

Anemia in women of childbearing age is a public health problem in Mexico that has shown significant increases in recent years, even though multiple efforts have been made to reduce it. Our results adjusted by covariables (wellbeing index, programs furnishing food aid and affiliation to medical Services insurance) show that in the analysis by federal entity, there is an increment in the prevalence of anemia, of mild intensity for public health interests (20 to 39.9%) to Baja California North, Campeche, Colima, Chiapas, Quintana Roo, Sinaloa and Sonora; the State of Zacatecas had a significant ($p < 0.05$) increase of 2 pp of anemia; the States passing from mild to severe were Yucatán and Tamaulipas (>40%). Nevertheless, the iron deficiency, as by ferritin, increased significantly in South Baja California and reduced its prevalence in Tamaulipas and Tlaxcala.

In other analyses, it has been shown at the national level and in a general way that the prevalence of anemia in non-pregnant women 20-49 years old age increased significantly by 6.1 pp, demonstrating which States contributed the most to this national increment, with the aim of focusing the health and nutrition public interventions aimed at this specific group of the population, because women of childbearing age are responsible for the optimal development of future generations.^{9,20}

The most frequent cause of anemia is iron deficiency, as by our results only one State Baja California South increased its prevalence of iron deficiency, this may be explained because anemia, is also produced by folate, vitamin B12, vitamin A deficiencies and other chronic non transmissible diseases.²¹ Unfortunately, only in Ensanut 2012 were measured folate, vitamin B12, but in Ensanut 2006 and 2018-19 were not measured.¹⁰⁻¹²

To our knowledge this the first article presenting the prevalence of anemia and iron deficiency at State level in Mexico, with the intention that anemia is addressed at the state level in different contexts. For this reason, is no possible to do comparison.

The reduction in the prevalence of anemia in some states was probably because food aid programs were active. The food aid programs as such *Prospera* (attending a large population of pregnant and lactating women from 1997 to 2018) and the fortified milk program *Liconsa* both, carrying out large programs directed to reduce poverty and with it reducing the prevalence of anemia.²²⁻²⁵ *Liconsa* in 2014 had a total of 1 095 860 beneficiaries and by 2017 it increased to 5 005 820 beneficiaries, nevertheless, its program continues its actions today.^{21,25} Unfortunately, *Prospera* ceased in 2018.

According to *Consejo Nacional de Evaluación de la Política de Desarrollo Social* (Coneval),²² from 1998 there was an increase in the number of people in poverty and 85% of the target population was served in 2016 and the program *Prospera* focused on those with the largest number of people in extreme multidimensional poverty, such as Chiapas, State of Mexico, Veracruz, Puebla, Guerrero and Oaxaca. This is not consistent with the

Table III
PREVALENCE OF ANEMIA (Hb<12g/dL) IN NON-PREGNANT WOMEN AGED 20 TO 49 YEARS BY STATE, SURVEY YEAR AND URBAN AND RURAL LOCALITIES. MEXICO, ENSANUT 2006, 2012, 2018

	Urban			Rural		
	2006* [‡] n (sample)=14 411 N(Expanded)= 25 429 837 % (CI95%)	2012* [§] n (sample)=11 827 N(Expanded)= 26 006 139 % (CI95%)	2018-19* [§] n (sample)=5 356 N(Expanded)= 30 134 958 % (CI95%)	2006* [‡] ^{&} n (sample)=6 065 N(Expanded)= 7 378 072 % (CI95%)	2012* [‡] n (sample)=6 273 N(Expanded)= 7 493 940 % (CI95%)	2018-19* [‡] ^{&} n (sample)=2 672 N(Expanded)= 8 597 577 % (CI95%)
National* [§]	17.9 (16.6, 19.3)	12.8 (11.7, 13.9)	19.2 (17.3, 21.1)	19.3 (17.4, 21.3)	14.0 (12.5, 15.6)	19.3 (16.8, 22.0)
Aguascalientes [°]	14.4 (10.0, 20.3)	7.8 (4.7, 12.4)	9.7 (5.8, 15.7)	14.0 (9.5, 19.8)	13.5 (8.7, 20.1)	12.5 (5.1, 27.2)
Baja California Norte [°]	9.3 (5.2, 16.1)	11.4 (8.4, 15.1)	36.9 (24.1, 51.7)	9.3 (1.6, 38.7)	20.6 (14.5, 28.2)	52.2 (31.2, 72.3)
Baja California Sur [°]	22.2 (17.1, 28.3)	11.9 (8.2, 16.8)	22.8 (15.9, 31.5)	31.5 (10.9, 63.2)	11.2 (4.6, 24.8)	34.6 (18.8, 54.6)
Campeche [°]	19.2 (14.7, 24.6)	24.9 (19.5, 31.1)	36.9 (26.9, 47.9)	10.4 (5.6, 18.3)	21.5 (15.3, 29.1)	34.0 (19.8, 51.8)
Coahuila [°]	28.2 (22.6, 34.4)	9.8 (6.3, 14.7)	23.0 (14.7, 34.0)	36.4 (19.9, 56.6)	10.8 (6.2, 18.0)	26.2 (16.9, 38.2)
Colima [°]	23.0 (18.0, 28.7)	12.1 (8.5, 16.9)	32.7 (23.8, 42.9)	24.0 (17.8, 31.3)	19.6 (7.6, 41.8)	43.9 (31.2, 57.3)
Chiapas [°]	13.2 (8.5, 19.9)	14.6 (8.7, 23.2)	29.0 (18.8, 41.7)	19.8 (13.7, 27.6)	16.7 (11.5, 23.6)	22.4 (14.3, 33.1)
Chihuahua [°]	16.2 (11.7, 22.0)	7.4 (4.4, 12.1)	26.9 (16.3, 40.9)	23.5 (12.5, 39.7)	5.2 (1.6, 15.1)	12.2 (5.7, 23.8)
Ciudad de México [°]	14.8 (11.5, 18.6)	13.9 (10.1, 18.7)	14.9 (8.2, 25.3)	0.0	0.0	0.0
Durango [°]	19.7 (15.3, 24.9)	11.7 (7.8, 17.1)	17.2 (10.3, 27.2)	19.0 (14.0, 25.0)	12.6 (8.2, 18.9)	17.7 (9.5, 30.3)
Guanajuato [°]	25.2 (20.6, 30.3)	8.2 (4.9, 13.3)	6.5 (3.4, 12.1)	21.7 (12.9, 34.0)	13.5 (8.6, 20.4)	14.1 (8.6, 22.2)
Guerrero [°]	19.2 (15.5, 23.6)	14.0 (9.3, 20.3)	14.6 (7.4, 26.6)	15.0 (11.2, 19.6)	14.9 (10.6, 20.4)	11.1 (5.1, 22.2)
Hidalgo [°]	16.8 (10.9, 24.9)	20.5 (13.2, 30.2)	12.5 (8.0, 18.7)	17.2 (12.8, 22.4)	10.2 (4.9, 19.8)	16.6 (9.7, 26.7)
Jalisco [°]	17.2 (12.3, 23.5)	9.8 (5.9, 15.7)	9.4 (5.4, 15.6)	13.4 (8.6, 20.1)	14.3 (7.9, 24.3)	6.3 (4.2, 9.2)
Estado de México [°]	28.8 (15.0, 47.9)	13.1 (9.8, 17.2)	8.2 (4.7, 13.6)	24.0 (17.5, 31.9)	17.8 (13.4, 23.2)	17.8 (6.0, 41.8)
Michoacán [°]	21.2 (16.2, 27.2)	15.8 (9.7, 24.7)	14.8 (8.8, 23.6)	17.8 (12.3, 24.9)	12.2 (5.8, 23.7)	7.3 (3.1, 15.8)
Morelos [°]	15.3 (10.5, 21.8)	13.1 (9.4, 17.9)	9.0 (4.7, 16.3)	22.6 (14.8, 32.9)	10.2 (5.5, 17.7)	15.6 (3.4, 48.6)
Nayarit [°]	13.2 (9.1, 18.6)	7.3 (4.1, 12.7)	25.2 (17.9, 34.1)	16.5 (10.6, 24.6)	10.3 (6.5, 15.7)	40.5 (27.7, 54.7)
Nuevo León [°]	16.8 (12.7, 21.8)	13.3 (9.6, 18.0)	24.7 (16.1, 35.9)	19.8 (11.9, 30.9)	7.8 (2.3, 22.7)	17.8 (6.9, 38.8)
Oaxaca [°]	14.2 (11.4, 17.5)	15.2 (11.0, 20.5)	20.1 (12.6, 30.6)	14.8 (10.8, 19.9)	14.3 (9.9, 20.1)	20.7 (13.8, 29.7)
Puebla [°]	18.6 (13.6, 24.8)	13.1 (8.2, 19.9)	13.4 (6.7, 25.0)	15.7 (9.0, 25.7)	17.9 (11.7, 26.3)	3.9 (1.3, 10.7)
Querétaro [°]	17.3 (12.0, 24.1)	12.4 (8.5, 17.6)	5.3 (2.2, 11.9)	22.1 (16.0, 29.7)	11.2 (7.3, 16.7)	9.3 (4.9, 16.7)
Quintana Roo [°]	19.7 (14.9, 25.5)	17.2 (13.6, 21.6)	34.2 (24.0, 46.0)	33.6 (24.8, 43.6)	11.3 (4.9, 23.5)	52.5 (31.3, 72.8)
San Luis Potosí [°]	16.6 (11.8, 22.7)	10.3 (6.6, 15.7)	20.7 (10.8, 35.8)	17.0 (11.1, 25.1)	9.0 (4.3, 17.8)	16.6 (10.5, 25.1)
Sinaloa [°]	18.3 (12.9, 25.1)	7.4 (4.5, 11.7)	21.3 (14.2, 30.6)	18.4 (12.6, 25.8)	14.6 (7.9, 25.2)	35.5 (27.1, 44.8)
Sonora [°]	30.3 (24.2, 37.1)	16.1 (11.3, 22.2)	39.3 (30.2, 49.0)	16.2 (7.7, 30.8)	10.2 (3.7, 25.2)	27.7 (17.5, 40.9)
Tabasco [°]	20.6 (16.3, 25.6)	22.5 (16.8, 29.3)	23.2 (17.4, 30.0)	18.1 (13.8, 23.2)	23.8 (15.9, 33.8)	19.5 (14.7, 25.2)
Tamaulipas [°]	16.8 (12.1, 22.7)	13.8 (10.2, 18.4)	52.3 (42.7, 61.6)	20.3 (10.6, 35.1)	9.7 (5.0, 17.6)	30.0 (19.0, 43.9)
Tlaxcala [°]	20.3 (16.1, 25.2)	18.0 (13.2, 24.0)	12.0 (7.6, 18.2)	19.3 (13.9, 26.1)	13.1 (5.7, 26.9)	19.2 (9.1, 35.8)
Veracruz [°]	21.9 (17.1, 27.5)	11.2 (7.92, 15.5)	27.6 (17.1, 41.2)	22.5 (15.5, 31.3)	13.2 (7.8, 21.4)	27.1 (17.2, 39.8)
Yucatán [°]	17.3 (12.8, 22.7)	17.3 (13.2, 22.3)	44.0 (35.1, 53.3)	11.6 (4.8, 25.4)	12.3 (7.8, 18.8)	46.4 (34.3, 58.8)
Zacatecas [°]	21.6 (15.9, 28.5)	9.2 (5.4, 15.3)	13.2 (7.8, 21.5)	18.2 (12.1, 26.3)	6.5 (3.8, 10.7)	6.7 (3.2, 13.3)

Differences by logistic regression model adjusted by survey design, wellness condition, *Prospera* (cash transfer program [social inclusion program]), *Liconsa* (fortified milk [parastatal company of the Mexican government]), affiliation to medical services.

* Significant differences ($p<0.05$), urban 2006 vs. urban 2012; ‡ Significant differences ($p<0.05$), urban 2006 vs. urban 2018-19;

§ Significant differences ($p<0.05$), urban 2018-19 vs. urban 2012; # Significant differences ($p<0.05$), rural 2006 vs. rural 2012;

& Significant differences ($p<0.05$), rural 2006 vs. rural 2018-19; * Significant differences ($p<0.05$), rural 2018-19 vs. rural 2012;

° Not estimable, insufficient sample

CI: Confidence Interval; Ensanut: Encuesta Nacional de Salud y Nutrición

Table IV
PREVALENCE OF FERRITIN DEFICIENCY (FERRITIN<15UG/DL) IN NON-PREGNANT WOMEN AGED 20 TO 49 YEARS BY STATE AND SURVEY YEAR. ENSANUT 2006, 2012, 2018

	Survey		
	2006 n=2 449 N(Expanded) = 23 664 884 % (CI95%)	2012 n=3 649 N(Expanded) = 22 433 794 % (CI95%)	2018-19 n=1 414 N(Expanded) = 26 989 054 % (CI95%)
National	29.0 (25.9, 32.2)	29.6 (26.6, 32.7)	25.7 (21.5, 30.2)
Aguascalientes	27.3 (20.1, 35.7)	35.4 (26.5, 45.4)	29.0 (17.7, 43.7)
Baja California Norte	14.2 (6.7, 27.2)	17.6 (8.6, 32.3)	3.0 (0.4, 17.7)
Baja California Sur*‡	19.4 (10.9, 31.8)	13.1 (6.2, 25.5)	28.7 (15.3, 47.1)
Campeche	16.8 (11.1, 24.6)	32.2 (20.6, 46.4)	6.0 (2.1, 15.1)
Coahuila	55.2 (21.9, 84.3)	14.5 (6.2, 30.2)	34.0 (14.5, 61.0)
Colima	26.4 (17.5, 37.6)	29.4 (19.7, 41.2)	18.5 (8.1, 36.7)
Chiapas	22.7 (14.6, 33.5)	14.3 (8.1, 23.9)	18.9 (11.3, 29.7)
Chihuahua	0.0 (0, 0)	32.9 (21.3, 46.9)	24.4 (6.2, 60.9)
Ciudad de México	23.9 (15.4, 35.1)	29.2 (16.6, 45.9)	42.8 (23.2, 64.9)
Durango	20.1 (2.2, 73.3)	29.4 (19.7, 41.4)	25.5 (12.0, 46.0)
Guanajuato	65.3 (13.6, 95.7)	39.4 (29.5, 50.2)	29.1 (19.2, 41.4)
Guerrero	24.4 (3.2, 75.5)	30.7 (23.3, 39.1)	35.1 (20.6, 52.8)
Hidalgo	64.5 (13.6, 95.3)	48.0 (36.1, 60.1)	28.4 (15.4, 46.0)
Jalisco	30.6 (19.0, 45.1)	19.9 (12.2, 30.6)	17.9 (8.5, 33.6)
Estado de México	21.6 (11.5, 36.7)	32.4 (20.2, 47.5)	23.5 (9.9, 45.8)
Michoacán	23.5 (4.6, 65.9)	31.3 (22.9, 41.1)	39.1 (22.5, 58.7)
Morelos	39.0 (7.74, 83.0)	41.9 (31.4, 53.1)	25.3 (11.5, 46.6)
Nayarit	27.5 (19.6, 37.0)	31.2 (21.0, 43.4)	13.0 (6.3, 24.9)
Nuevo León	28.4 (18.1, 41.4)	16.6 (9.3, 27.8)	36.4 (18.9, 58.3)
Oaxaca	0.0 (0, 0)	34.2 (24.5, 45.3)	18.7 (10.8, 30.1)
Puebla	37.4 (27.1, 48.8)	45.2 (33.9, 57.0)	17.6 (7.4, 36.2)
Querétaro	34.3 (24.4, 45.7)	23.7 (14.5, 36.0)	44.2 (21.2, 69.9)
Quintana Roo	28.0 (18.9, 39.4)	20.3 (12.2, 31.7)	21.5 (11.0, 37.7)
San Luis Potosí	25.8 (19.5, 33.2)	24.1 (14.0, 38.1)	14.7 (5.7, 32.6)
Sinaloa	34.3 (24.1, 46.1)	33.2 (24.0, 43.8)	20.5 (10.1, 37.1)
Sonora	0.0 (0, 0)	33.2 (21.7, 46.9)	12.8 (4.8, 29.8)
Tabasco	0.0 (0, 0)	26.1 (14.0, 43.2)	14.5 (8.2, 24.2)
Tamaulipas*	29.0 (18.9, 41.5)	26.9 (18.6, 37.1)	23.1 (6.94, 54.8)
Tlaxcala‡§	47.2 (39.4, 55.0)	55.0 (44.3, 65.1)	20.8 (11.0, 35.7)
Veracruz	41.8 (33.5, 50.6)	32.8 (24.8, 41.8)	33.5 (14.2, 60.4)
Yucatan	28.8 (18.6, 41.6)	25.9 (16.7, 37.6)	19.3 (10.0, 33.7)
Zacatecas	24.5 (8.9, 51.6)	23.2 (14.9, 34.1)	35.6 (17.8, 58.3)

Logistic regression model adjusted by survey design, wellness condition, *Prospera*, *Liconsa*, affiliation to medical services.

* Significant differences ($p<0.05$), 2006 vs. 2012

‡ Significant differences ($p<0.05$), 2018-19 vs. 2012

§ Significant differences ($p<0.05$), 2006 vs. 2018-19

CI: Confidence Interval, Ensanut: Encuesta Nacional de Salud y Nutrición

increases in the prevalence of anemia in 2018 from Baja California North, Campeche, Colima, Chiapas, Quintana Roo, Sinaloa, Sonora Yucatán and Tamaulipas.

On the other hand, the average monthly consultations, pregnant and lactating women in control, and children under five years of age in nutritional control, had an increase from 1998 (1.360 million) to 2011 (3.469 million), however for 2017 there was an average of 2.7 million monthly consultations.²² In this sense, the program *Prospera* had an impact in the reduction of the prevalence of anemia in women in childbearing age.²²⁻²⁴ In the context of medical services to *Prospera* beneficiaries, were evidenced the deficiencies in medical service they receive.^{22,26-28} In the current context to general population, the situation has not improved in health services at national level, which represents a problem in the fight against anemia.²⁹

In economical context, Leon-Bon and colleagues,³⁰ showed that there was a 71% increase in the low economic well-being in the population from 2008 to 2019 and although it is known that the poverty rate is much higher in rural areas, the food basket (same products) in urban areas tends to be more expensive than in rural areas, on the other hand, the population living in poverty in Mexico is largely concentrated in urban municipalities, while the application of social programs is frequently more focused on rural areas. However, in 2004 it reached five million *Prospera* beneficiary households, including semi-urban and urban locations.²²

In addition, the presence of the pandemic of Covid probably brought an increase of the prevalence of anemia in the poorer states, nevertheless not all states with high prevalence in our study fall into this category.³¹

In the post-Covid stage, anemia and other micronutrients deficiencies should be placed in one of the first places of the public health agenda.³¹ Some studies have demonstrated that anemia and micronutrients deficiencies have aggravated the course and consequences of several infections and the micronutrient supplementation may have antiviral effect.³²⁻³⁴

Intersectoral and long-term actions are required that contribute to reduction of anemia and effective access to health services, availability of nutritious food and quality education, a home and community with minimal infrastructure and employment opportunities, better wages and therefore greater well-being for the families.

Given the cross-sectional nature of this study, in-depth studies within each state of Mexico are required to understand the causes of anemia, principally from Baja California North, Campeche, Colima, Chiapas, Quintana Roo, Sinaloa, Sonora Yucatán and Tamaulipas,

to channel public health efforts and reduce the burden of disease associated with anemia adapted to the specificities of certain contexts (rural, urban or regional) or specific population groups (indigenous). It is also essential to increase at local level the availability and access to healthy foods rich in iron, integrate actions to improve the quality and diversity of the diet, as well as monitor food fortification programs.^{24,34,35}

An unexpected finding was that the States in the Northern of Mexico: North Baja California, Sinaloa, Tamaulipas and Sonora; considered the zone with the better-off situation, had the highest prevalence of anemia up the mild status as public health problem.¹ Another possibility for the increase of anemia is the change of methodology for measuring Hb, in 2006 was used the HemoCue 301+ equipment and it was changed in 2012 and 2018 to the model 201+.³⁶⁻³⁸ At the same time the prevalence of iron deficiency did not change or diminished. Several relevant variables for the prevalence of anemia, as parity, tobacco smoking, intake of foods that facilitate or inhibit iron absorption such as fite, vitamins C, A, B12, folate and cooper were not available to be included in the analysis.³⁹

This analysis urges the importance of further study of the origin of anemia, from dietary causes including economic (poverty), biological, social, demographic (urbanization) factors at the local level and the likelihood of climatic conditions such as heat and how humidity affecting Hb measurements in the northern and southern states (adjacent to the sea) that showed greater and significant changes ($p < 0.05$).

Nevertheless, caution in the interpretation of this increase is recommended since we cannot discard measurement errors in Hb capillary determination.⁴⁰

The fortitudes of the Ensanut are among other to be population studies representative at the declared level, using the same methodology, cutoff points for Hb and ferritin and the sample collection were made by highly qualified personnel with large experience in executing population surveys.

In conclusion, anemia in women between 20 and 49 years of age continues to be a public health problem of great magnitude that is increasing. Comprehensive actions at state level are required for its control and eradication, evaluating, if it is necessary to supplement and supplement nutrients, food and nutritional education for the population at risk, deworming, among others. Therefore, identifying the main causes of anemia in this population is mandatory for timely intervention either through diet, fortified food, or micronutrient supplementation in those women at higher risk.

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

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