

Prevalence of iron deficiency was stable and anemia increased during 12 years (2006-2018) in Mexican women 20-49 years of age

Fabiola Mejía-Rodríguez, MSc,⁽¹⁾ Salvador Villalpando, MD, PhD,⁽¹⁾ Teresa Shamah-Levy, PhD,⁽²⁾ Armando García-Guerra, MSc,⁽¹⁾ Ignacio Méndez-Gómez Humarán, DSc,⁽²⁾ Vanessa De la Cruz-Góngora, PhD.⁽¹⁾

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Abstract

Objective. To compare the prevalence of women 20-49 years of age with iron deficiency anemia (IDA), iron deficiency with no anemia (IDNA), and non-ID anemia (NIDA) in comparison during 2006, 2012 and 2018, and their association with sociodemographic characteristics and nutritional status. **Materials and methods.** Ensanut 2006, 2012 and 2018-19 are comparable for measurements of anemia (hemoglobin) and Iron deficiency (ID, by ferritin). Both measurements combined were compared with year of surveys and other dependent variables using a multinomial regression. **Results.** In 2006, the total prevalence of anemia was 14.9% and ID 29.0%, the prevalence of IDA was 8.35%, of IDNA 20.5%, and NIDA 6.6%; in 2012, the total prevalence of anemia was 13.3%, ID was 9.6%, IDA 8.6%, IDNA 21.0% y NIDA 4.7%; in 2018 total prevalence of anemia was 21.4%, of ID 25.7%, IDA 10.5%, IDNA 15.2% and NIDA 10.9%. **Conclusions.** The

Resumen

Objetivo. Comparar la proporción de mujeres de 20 a 49 años con anemia por deficiencia de hierro (ADH), con deficiencia de hierro (DH) con deficiencia de hierro sin anemia (DHSA) y anemia no DH (ANDH) durante 2006, 2012 y 2018, y sus asociaciones con características sociodemográficas y estado nutricional. **Material y métodos.** Las Encuestas Nacionales de Salud y Nutrición de 2006, 2012 y 2018-19 usan métodos comparables para medir anemia (hemoglobina capilar) y deficiencia de hierro (DH, ferritina sérica). Ambas mediciones combinadas se compararon por año de encuesta y variables de control mediante regresión multinomial. **Resultados.** En 2006 la prevalencia global de anemia fue de 14.9% y DH de 29.0%, la de ADH de 8.35%, la de DHSA 20.5%, y ANDH 6.6%; en 2012 la prevalencia global de anemia fue de 13.3%, la de DH 29.6%, de ADH 8.6%, DHSA 21.0% y ANDH 4.7%; en 2018 prevalencia global de anemia fue de 21.4%, de

(1) Centro de Investigación en Nutrición y Salud, Instituto Nacional de Salud Pública. Cuernavaca, Morelos, Mexico.

(2) Centro de Evaluación de Encuestas, Instituto Nacional de Salud Pública. Cuernavaca, Morelos, Mexico.

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Corresponding author: Salvador Villalpando. Centro de Investigación en Nutrición y Salud, Instituto Nacional de Salud Pública, Av. Universidad 655, col. Santa María Ahuacatlán. 62100 Cuernavaca, Morelos, México.
email: svillalp@insp.mx

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total prevalence of anemia increased 6.5 pp between 2006 and 2018, IDNA reduced, IDA had no significant changes, the mayor increase (4.3 pp) occurred in NIDA.

Keywords: anemia; ferritin; hemoglobin; women; national surveys

DH 25.7%, ADH 10.5%, 15.2% y ANDH 10.9%. **Conclusiones.** La presencia global de anemia aumentó 6.5 pp entre 2006 y 2018; la de DHSa disminuyó; ADH no tuvo cambios significativos y el aumento mayor fue de ANDH.

Palabras clave: anemia; ferritina; hemoglobina; mujeres; encuestas nacionales

Globally, one third of reproductive age women are anemic and almost one half are iron deficient (ID).¹⁻³ A surveillance system at population level is recommended to meet evolution of the global burden of anemia, according to the sustainable development goals (SDG-2.2).^{4,5}

In México, ID changed very little (24.8 to 29.4%) from 2006 to 2012, in non-pregnant population (20-49 years of age).⁶ Nevertheless, the prevalence of anemia in non-pregnant women at the national level fluctuated from 2006 (15.5%) through 2012 (11.6%) and 2016 (18.3%); worsening in very poor non-pregnant women in 2018 (34.3%), although this was a national survey examining the lower tertile of socioeconomic level.^{1,7-10} These results are annoying, since the Federal Government was running at the same time several programs that included a micro-nutrient supplement: *Prospera* (a conditional cash transfer program with a nutritional component) and *Liconsa*, (a program that distributes a micronutrients fortified milk at subsidized prices), both including one RDA of iron. Also a Food Aid Program (PAL, cash transfer), all of them reported positive results for iron status indicators.¹¹⁻¹³

The most relevant consequences of anemia and iron deficiency anemia (IDA) in women are increments in infection episodes, maternal and fetal mortality, especially in those without access to medical services, multiple pregnancies and older than 35 years.¹¹⁻¹⁴ Because this surprising bounce in the prevalence of anemia the objective of this paper is to study the proportion of women 20-49 years of age with IDA, ID with non-anemia (IDNA), and non-ID anemia (NIDA) in comparison with woman non-ID with non-anemia (NIDNA) during 2006, 2012 and 2018, and their associations with sociodemographic characteristics and nutritional status. This information will help decision-makers to reevaluate the national strategies to tackle it.^{7,15-19}

Materials and methods

Study design

The *Encuesta Nacional de Salud y Nutrición* (Ensanut) 2006, 2012, 2018-19 are originally designed as a poly-etapic, population-based-, probabilistic surveys of

national representativeness, by urban and rural, and four regions: North, Center, Mexico City and South. The methodological details of all Ensanut's and sampling characteristics and procedures related to these surveys have been previously described.²⁰⁻²²

Demographic and socioeconomic information was collected using *ad hoc* questionnaires.²⁰⁻²² We analyzed the information of non-pregnant women aged 20-49 years participating in Ensanut of 2006, 2012, 2018-19, who had available data on hemoglobin (Hb) and serum ferritin (sferritin). These serum data come from 30% of the samples of non-pregnant women and were distributed as follows: 2 049 (2006), 3 649 (2012) and 1 414 (2018-19) women.²⁰⁻²²

Capillary hemoglobin

Hb concentration was measured in capillary blood, using a HemoCue Hb301+ (Angelholm, Sweden) in Ensanut 2006, and Hb201+ in Ensanut 2012 and 2018-19.²³

Biochemical analysis of serum ferritin and C - reactive protein

Venous blood samples were obtained from an antecubital vein directly into an evacuated tube, and spin down "in situ" at 3 000 g in a portable centrifuge (Hettingen Tuttlingen, Germany).²³ Serum samples were stored in cryovials and frozen immediately into liquid nitrogen (-169°C) Dewar's until delivery to the Biochemistry Nutrition Laboratory within *Instituto Nacional de Salud Pública* (INSP), Cuernavaca, Morelos where they were stored in a -75°C freezer until determinations.²³ The ferritin concentrations were measured in Ensanut 2006 using commercial kits in an immunoanalyzer spectrometer (Opus BN100, Dade Behring Inc, Germany), and in Ensanut 2012 and 2018-19 in an chemoluminescence microparticle immunoassay autoanalyzer Architect (Abbott Lab, Michigan, III USA).²⁴ C-Reactive Protein (CRP) was measured using ultrasensitive monoclonal antibodies in the same Opus BN100 immunoanalyzer and Architect equipment. Quality control of measurements used the Reference Standard Serum NIST 968E of the National Institute of Standards and Technol-

ogy. The variability of sferritin in 2006, 74.6 ± 4.9 mg/L, (c.v.=4.9%); in 2012 76.4 ± 4.7 mg/L, (c.v.=6.0%); and 2018= 48.3 ± 7.3 ug/dL, (c.v.= 8.9%); for CRP in 2006= 1.2 ± 0.05 mg/dL, (c.v.=2.2%); in 2012= 1.2 ± 0.05 mg/dL, and 2018= 4.87 ± 6.23 mg/L, (c.v.=0.77)

Definition of anemia and iron deficiency

Anemia was defined when Hb concentration was <12.0 g/dL, adjusted by altitude above sea level ($>1\ 000$ m) as by Cohen-Hass.^{25,26} Pregnant women were excluded, because sample size was insufficient for national representation. ID was defined when sferritin was <15 ug/dL, after adjusting for inflammation using CRP concentrations as by Thurham.^{27,28}

By combining anemia and ID status, four groups mutually exclusive resulted: 1) iron deficiency anemia (IDA); 2) iron deficiency with non-anemia (IDNA); 3) non-iron-deficiency anemia (NIDA) and 4) non-iron-deficiency non-anemia (NIDNA).

Health, sociodemographic, and anthropometric variables

Age was stratified into 20-34 and 35-49 years categories. Indigenous ethnicity was defined if the head of the household self-reported as a speaker of an indigenous language. Dwelling was classified as urban for localities $\geq 2\ 500$ habitants and rural otherwise. The height was measured in a stadimeter (Seca model-206, Hamburg, Germany), with a 220 cm and a precision of 1 mm. The body weight was measured using an electronic balance (Seca model-874, Hamburg, Germany; 200kg and a precision of 100g).^{29,30} The body mass index (BMI) was calculated as weight/height² and categorized by WHO criteria.^{31,32}

One household wellbeing index (HWB), was calculated, through a principal component analysis including household characteristics.^{20-22,33} The first component, with a 51% of total variability and a lambda value of 4.08, was categorized into tertiles representing the poorer people (#1) and the better off layer of the population (#3).³³ Affiliation to a medical service were: Mexican Institute of Social Security (*Instituto Mexicano del Seguro Social*, IMSS); National Institute of Security and Social Services for State workers (*Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado*, ISSSTE), Medical Services for workers of a Mexican Oil Company (*Petróleos Mexicanos*, Pemex), Ministries of Army (*Secretaría de la Defensa Nacional*, Sedena), Marine (*Secretaría de Marina*, Semar), People Insurance, IMSS-Prospera and private insurance. All food assistance programs including women as their targets were included.

Ethical considerations

Ensanut 2006, 2012 and 2018-19 were approved by the Ethical, Research and Biosecurity, Committees. Participation of individuals was voluntary and registered under an informed consent letter.

Statistical analysis

Means and prevalence were tabulated with 95% confidence intervals (95%CI) and estimates based on contingency tables. The associations of IDA, IDNA and NIDA with dependent variables had as reference the women NIDNA through multinomial regression models and relative risk ratio (RRR) was calculated. Significance was set at $\alpha=0.05$. All analysis considered the survey design, and was done using the statistical software Stata SE, v15.1 (Stata Corp) 2017.

Results

General characteristics

More than 70% of women had overweight obesity; between 20.6% and 29.4% lived in rural dwelling and ~30% lived in the South (table I). In 2006, 40.3% were beneficiaries of *Prospera* and 24.6% in 2018-19 (table I). In 2012, 13 and 22.2% of women received iron and folate supplement, and 4.9% and 9.5% in 2018-19, respectively (table I).

The total prevalence of ID was 29.0% in 2006, 29.6% in 2012 and 25.7% in 2018-19; anemia was 14.9%, 13.3% and 21.4% respectively, increasing 8.1 percentage points from 2012 to 2018-19 ($p<0.05$). The prevalence of ID showed a non-significant trend to decline through the evaluated years (2006-2018). The proportion of women with CRP >5 was lower ($p<0.05$) in 2012 (20.5%) than in 2006 (28.4%) and 2018-19 (30.5%) (figure 1).

Differences in the proportion of women (≥ 35 years) between survey's year ($p<0.005$) by age group in 2012 for IDA (62.2%) and for NIDA (48.5%), in 2018-19 (44.6%) for IDNA, for urban (84.0%) NIDA compared with other year (tables II, III).

IDA

Although the prevalence of IDA increased through years, the differences were not significant (figure 1). In the adjusted multinomial model was found that being beneficiary of Liconsa was negatively associated with the prevalence of IDA (RRR=0.297 [95%CI: 0.13-0.64], $p=0.002$) and affiliated to private medical service (RRR=0.195 [95%CI: 0.03-0.97], $p=0.047$) (table IV).

Table I
PROPORTION OF CHARACTERISTICS OF INTEREST IN NON-PREGNANT WOMEN AGED 20 TO 49 YEARS.* MÉXICO, ENSANUT 2006, 2012 AND 2018-19

Characteristics	2006			2012			2018-19		
	n (sample)	N (Thousands)	Expansion % (95%CI)	n (sample)	N (Thousands)	Expansion % (95%CI)	n (sample)	N (Thousands)	Expansion % (95%CI)
Age (years)									
20 to 34	1 240	12 327.4	51.8 (48.5-55.1)	1734	12 721.8	56.7 (53.4-59.9)	704	14 644.4	54.3 (49.9-58.5)
35 to 49	1 223	11 451.7	48.2 (44.8-51.4)	1916	9 713.7	43.3 (40.0-46.5)	710	12 344.6	45.7 (41.4-50.0)
Indigenous									
Yes	578	5 158.5	21.7 [§] (18.5-25.2)	329	1 101.2	4.9 (3.9-6.0)	120	1 497.2	5.5 (4.1-7.3)
No	1 885	18 620.6	78.3 (74.7-81.4)	3 321	21 334.4	95.1 (93.9-96.0)	1 294	25 491.9	94.5 (92.6-95.8)
BMI (kg/m ²)									
<18.5	32	439.2	1.9 (0.9-3.4)	49	287.8	1.3 (0.8-2.0)	15	366.4	1.4 (0.7-2.6)
18.5 to 24.9	649	6 594.1	27.9 (24.7-31.3)	944	6 244.2	28.2 (25.1-31.3)	302	6 638.7	24.9 (21.2-28.9)
25 to 29.9	895	8 728.4	36.9 (33.5-40.5)	1 274	7 521.0	33.9 (30.6-37.3)	498	9 054.2	33.9 (29.8-38.3)
>=30	871	7 861.6	33.3 (30.0-36.7)	1 359	8 122.0	36.6 (33.5-39.8)	580	10 615.6	39.8 (35.3-44.4)
Household wealth index [‡]									
T I	1 085	8 872.3	37.4 (34.0-40.9)	1 289	5 413.7	24.1 [§] (21.8-26.5)	558	8 369.9	31.0 (27.4-34.7)
T II	884	8 226.4	34.7 (31.4-38.0)	1 288	7 265.4	32.4 (29.3-35.6)	507	9 136.0	33.9 (29.9-37.9)
T III	485	6 610.3	27.9 (24.4-31.6)	1 073	9 756.5	43.5 [§] (39.8-47.2)	349	9 483.2	35.1 (30.6-39.9)
Number of pregnancies									
None	281	4 097.1	17.2 (14.3-20.4)	538	3 948.9	17.6 (15.2-20.2)	250	6 495.3	24.1 (19.9-28.7)
1 to 3	1 219	11 839.6	49.8 (46.2-53.2)	2 013	13 284.8	59.2 [§] (55.9-62.4)	853	15 618.3	57.9 (53.1-62.4)
4 to 6	749	6 128.1	25.8 (23.1-28.5)	952	4 651.1	20.7 (18.4-23.2)	283	4 538.9	16.8 (13.9-20.1)
>7	214	1 714.3	7.2 (5.7-9.0)	147	550.7	2.5 (1.9-3.2)	28	336.5	1.2 (0.8-2.0)
Number of abortions									
None	1 733	15 571.8	79.4 (76.3-82.0)	2 451	14 780.3	79.9 (76.8-82.5)	912	16 123.3	78.7 (74.6-82.2)

(continúa...)

(continuación)														
I	347	3 230.2	16.5	(13.9-19.3)	512	2 831.1	15.3	(12.8-18.1)	198	3 264.0	15.9	(12.9-19.4)		
>2	100	819.6	4.2	(3.1-5.5)	149	893.6	4.8	(3.7-6.3)	54	11 064	5.4	(3.5-8.1)		
Locality														
Urban	1 570	16 778.9	70.6	(66.2-74.5)	2 349	17 818.2	79.4	(77.0-81.6)	949	21 172.8	78.4	(75.6-80.9)		
Rural	893	7 000.2	29.4 [§]	(25.4-33.7)	1 301	4 617.4	20.6	(18.3-22.9)	465	5 816.2	21.6	(19.0-24.3)		
Region														
North	295	3 148.6	13.2 [§]	(11.0-15.7)	914	4 861.6	21.7	(19.7-23.6)	233	5 324.3	19.7	(17.2-22.4)		
Center	1 152	8 317.3	35.0	(30.8-39.3)	1 305	6 446.9	28.7	(26.0-31.5)	494	8 539.9	31.6	(28.2-35.2)		
CDMX	81	3 737.7	15.7	(12.7-19.2)	119	4 761.9	21.2 [§]	(17.8-25.0)	46	4 557.9	16.9	(13.6-20.7)		
South	935	8 575.5	36.1	(32.4-39.8)	1 312	6 365.2	28.4	(25.9-30.9)	641	8 567.0	31.7	(28.6-35.0)		
Affiliation to medical service														
IMSS	588	6 328.2	26.6 [§]	(23.4-30.0)	891	6 464.0	28.8	(25.5-32.2)	408	8 443.7	31.4	(27.2-35.9)		
ISSSTE	84	720.3	3.0	(2.2-4.1)	165	1 034.1	4.6	(3.5-6.0)	66	1 542.0	5.7	(3.5-9.0)		
Popular insurance	585	3 676.0	15.5	(12.3-19.1)	1 885	8 802.6	39.3	(36.0-42.5)	735	12 290.4	45.7	(41.4-50.1)		
Private or other Institution	85	961.7	4.0 [§]	(2.5-6.4)	45	486.2	2.2	(1.2-3.7)	19	639.6	2.4	(1.1-5.0)		
No affiliated	1 118	12 082.0	50.8 [§]	(46.0-55.0)	662	5 638.9	25.1	(22.1-28.4)	180	3 948.9	14.7	(11.8-18.1)		
Beneficiary of Social Programs														
PAL	9	92.8	0.4	(0.1-0.9)	62	344.7	1.6 [§]	(1.0-2.4)	-	-	-	-		
Liconsa	143	2 257.3	9.5	(7.0-12.7)	62	290.1	9.2	(4.2-18.8)	116	2 250.9	8.4	(5.9-11.6)		
Prospera	1 290	9 586.0	40.3 [§]	(36.4-44.2)	219	404.9	12.8	(10.2-15.9)	457	6 616.0	24.6	(21.3-28.2)		
Iron supplement	-	-	-	-	551	2 758.9	13.0	(11.1-15.0)	96	1 312.3	4.9 [§]	(3.5-6.6)		
Folic acid supplement	-	-	-	-	969	4 716.6	22.2	(19.4-25.2)	171	2 554.4	9.5 [§]	(7.50-11.9)		

* Estimates adjusted by the survey sample design

† Household wealth index: Tertile 1: worst conditions and Tertile 3: best conditions.

‡ Comparisons between survey years within anemia categories, $p < 0.05$, based on contingency tables adjusted by survey design

§ ISSSTE: Instituto Mexicano del Seguro Social; IMSS: Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado.

Pali: Food aid program

CI: confidence interval

Ensanut: Encuesta Nacional de Salud y Nutrición

IDNA

Lower prevalence of IDNA was observed in women in 2018-19 (15.2%) compared with 2012 ($p<0.05$) (figure 1). In the multinomial model beneficiaries of ISSSTE (RRR=0.424 [95%CI: 0.19-0.92], $p=0.032$) and Liconsa (RRR=0.481 [95%CI: 0.25-0.89], $p=0.021$) were negatively associated with IDNA; and positively with normal (RRR=5.139 [95%CI: 1.68-15.7], $p=0.004$) to overweight (RRR=3.665, [95%CI: 1.19-11.2], $p=0.004$) (table IV).

NIDA

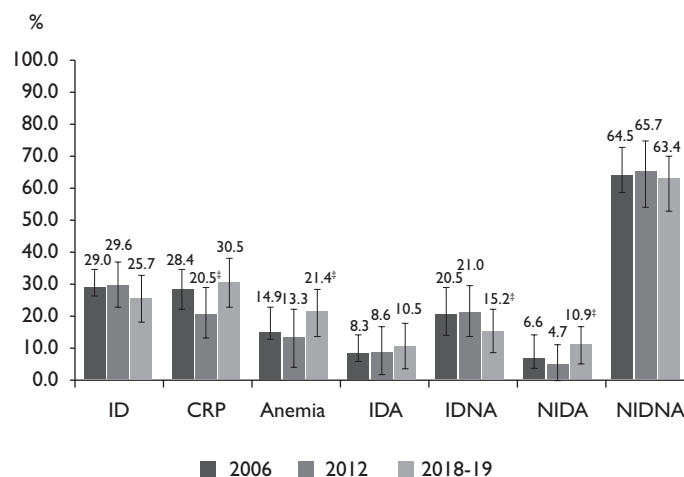
The prevalence of NIDA was greater ($p<0.05$) in 2018 (10.9%) compared with 2006 (6.6%) or 2012 (4.7%), (figure 1). In the multinomial model, a significant rising in the prevalence of NIDA was observed in 2018-19 (RRR=2.398 [95%CI: 1.48-3.87], $p<0.01$) and was positively associated with a larger number of pregnancies (RRR=2.651 [95%CI: 1.23-5.69], $p=0.013$), BMI of 18.5 to 24.9 kg/m² (RRR=7.021 [95%CI: 1.47-33.5], $p=0.015$), and no affiliated to medical services (RRR=2.616 [95%CI: 1.61-4.25], $p<0.01$) (table IV).

Discussion

The most frequent causes of anemia has been iron deficiency, hookworm infestation, sickle-cell disorders,

thalassemia, schistosomiasis and malaria, however in Mexico except for iron deficiency the other causes are very uncommon, it was not surprising that, no changes occurred in the prevalence of IDA throughout 2006 to 2018-19. The effects of IDA on women at reproductive age are maternal and child mortality, physical performance, and referral to health-care professionals. Several chronic diseases are frequently associated with iron deficiency anaemia: chronic kidney disease, chronic heart failure, cancer, and inflammatory bowel disease.^{2,3,14-16} According to a systematic-analyses the prevalence of anemia in 2003-2005 in Nicaragua was 34.3% and in México 14.9%; in 2012 in Ecuador was 27.2% and México 13.3%.³⁴

During the same period, there was a significant increment in the prevalence of NIDA that may suggest the existence of other potentials causes of anemia that could be due to: a) Changes in the prevalence of folate and vitamin B12 deficiencies,^{35,36} nevertheless, we did not measure them in this age group, however we did it in children 1-11 years of age and the prevalence of both was reduced.^{6,37} b) Measurement error in Hb determination using HemoCué 201+ equipment in the last two surveys may introduce a bias between surveys, nevertheless, some studies had reported that this model had a better performance in comparison with other Hemocue models.^{38,39} This improvement of Hemocue could result in lower concentrations of Hb and will furnished a higher prevalence of anemia. c) We cannot discard a



* Estimates adjusted by the survey sample design. Ensanut 2006 [n sample=2 449, N Thousands=23 664.9], Ensanut 2012 [n sample= 3 649, N Thousands =22 433.8] and Ensanut 2018-19 [n sample= 1 414, N Thousands =26 989.1].

[‡] $p<0.05$, Multinomial regression adjusted by survey design

ID: Iron deficiency; CRP: C reactive protein; IDA: Iron deficiency anemia; IDNA: Iron deficiency without anemia; NIDA: non-iron deficient anemia; NIDNA: non-iron deficient without anemia

Ensanut: Encuesta Nacional de Salud y Nutrición

FIGURE 1. PREVALENCE OF IRON DEFICIENCY AND ANEMIA COMBINED IN NON-PREGNANT WOMEN AGED 20 TO 49 YEARS.* MÉXICO, ENSANUT 2006, 2012 AND 2018-19

Table II
PROPORTION OF NON-PREGNANT WOMEN AGED 20 TO 49 YEARS, ACCORDING IRON DEFICIENCY COMBINED WITH ANEMIA AND SOCIODEMOGRAPHIC CHARACTERISTICS. * MÉXICO, ENSANUT 2006, 2012 AND 2018-19

	IDA			IDNA			NIDA		
	2006	2012	2018	2006	2012	2018	2006	2012	2018
	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)
Age									
20 to 34	56.0 (45.1-66.3)	39.8 (27.0-54.2)	49.0 (33.9-64.3)	55.2 (48.3-61.9)	58.4 (51.6-64.8)	44.6 [‡] (32.3-57.7)	52.1 (35.7-68.1)	51.5 [‡] (41.5-61.4)	52.8 (41.6-63.7)
35 to 49	44.0 (33.7-54.9)	60.2 [‡] (45.8-73.0)	51.0 (35.7-66.1)	44.8 (38.1-51.7)	41.6 (35.2-48.4)	55.4 (42.3-67.7)	47.9 (31.9-64.3)	48.5 [‡] (38.6-58.5)	47.2 (36.3-58.4)
Indigenous									
Yes	23.4 (14.6-35.3)	4.4 (2.5-7.6)	3.9 (2.0-7.6)	19.3 (14.5-25.1)	5.2 (3.6-7.4)	5.3 (2.1-12.8)	37.1 (19.8-58.5)	5.1 (2.9-8.8)	5.0 (2.7-9.0)
No	76.6 (64.7-85.4)	95.6 (92.4-97.5)	96.1 (92.4-98.0)	80.7 (74.9-85.5)	94.8 (92.6-96.4)	94.7 (87.2-97.9)	62.9 [‡] (41.5-80.2)	94.9 (91.2-97.1)	95.0 (91.0-97.3)
BMI (kg/m ²)									
<18.5	2.5 (0.7-9.2)	0.9 (0.1-5.1)	1.5 (0.4-6.0)	0.8 (0.3-2.4)	2.7 (1.3-5.9)	0.1 (0.0-0.9)	0.2 (0.0-0.9)	1.2 (0.3-4.6)	0.2 (0.0-1.4)
18.5 to 24.9	27.6 (18.8-38.5)	24.3 (12.7-41.4)	30.0 (17.5-46.4)	32.6 (26.6-39.3)	37.4 (30.4-45.0)	26.7 (17.5-38.5)	30.4 (19.2-44.5)	32.9 (24.1-43.1)	29.9 (19.0-43.7)
25 to 29.9	37.8 (28.1-48.6)	37.3 (24.5-52.3)	34.9 (21.5-51.3)	31.0 (25.7-36.8)	30.8 (25.1-37.1)	30.6 (20.3-43.4)	46.6 (29.9-64.1)	30.9 (22.7-40.6)	31.2 (22.1-41.9)
>=30	32.1 (22.3-43.8)	37.4 (26.3-50.1)	33.6 (21.4-48.4)	35.6 (29.4-42.3)	29.1 (23.4-35.5)	42.5 (29.2-57.0)	22.8 (13.4-36.0)	35.0 (25.6-45.8)	38.7 (28.8-49.6)
Household wealth index [§]									
T I	39.5 (29.1-50.9)	29.8 (20.6-41.1)	40.1 (26.6-55.2)	37.9 (31.9-44.4)	28.2 (23.2-33.9)	29.6 (19.7-41.8)	40.2 (25.9-56.4)	26.9 (19.9-35.3)	33.3 (23.8-44.5)
T II	43.9 (32.9-55.6)	41.4 (28.4-55.8)	21.6 (13.3-32.9)	39.0 (32.8-45.6)	36.2 (29.7-43.2)	27.0 (17.9-38.7)	41.5 (24.6-60.7)	38.4 (29.0-48.7)	36.9 (26.8-48.3)
T III	16.6 (10.8-24.6)	28.8 (16.8-44.7)	38.4 (23.8-55.4)	23.1 (17.1-30.3)	35.6 (28.5-43.3)	43.4 (29.8-58.0)	18.3 (10.7-29.6)	34.7 (25.7-45.0)	29.8 (19.8-42.1)
Locality									
Urban	68.2 (58.3-76.7)	78.5 (70.5-84.8)	82.3 (73.6-88.6)	76.0 (70.7-80.6)	76.5 (71.9-80.5)	77.4 (67.2-85.2)	63.4 (42.1-80.5)	80.0 (72.6-85.8)	84.0 [‡] (77.2-89.1)
Rural	31.8 (23.3-41.7)	21.5 (15.2-29.5)	17.7 (11.4-26.4)	24.0 (19.4-29.3)	23.5 (19.5-28.1)	22.6 (14.8-32.8)	36.6 (19.5-57.9)	20.0 (14.2-27.4)	16.0 (10.9-22.8)
Region									
North	14.2 (9.0-21.5)	16.0 (10.8-23.2)	26.4 (16.0-40.3)	10.1 (7.4-13.6)	17.5 (13.7-22.0)	12.6 (6.7-22.5)	11.7 (6.1-21.4)	26.1 (18.7-35.2)	40.7 (30.4-51.8)
Center	38.1 (29.0-48.1)	25.0 (17.8-34.0)	20.5 (13.4-30.1)	31.2 (25.4-37.7)	31.4 (26.3-37.0)	38.4 (27.1-51.2)	37.7 (20.5-58.6)	31.7 (23.2-41.6)	20.8 (14.4-29.1)
CDMX	16.6 (8.2-30.7)	27.4 (13.7-47.3)	22.0 (10.3-40.9)	11.6 (7.3-17.9)	19.7 (13.0-28.8)	21.3 (9.0-42.3)	11.4 (3.8-29.6)	9.7 (3.8-22.4)	7.3 (2.6-19.0)
South	31.2 (23.2-40.5)	31.5 (22.7-41.9)	31.1 (19.2-46.2)	47.2 (40.7-53.7)	31.4 (26.5-36.7)	27.6 (19.4-37.8)	39.2 (25.3-55.0)	32.5 (24.5-41.7)	31.2 (22.7-41.1)

* Estimates adjusted by the survey sample design, CI: Confidence interval

[‡] Comparisons between survey years within anemia category, $p < 0.05$, based on contingency tables adjusted by survey design

[§] Household wealth index, Tertile I: worst conditions and Tertile 3: best conditions.

ID: iron deficiency, IDA: Iron deficiency anemia, IDNA: iron deficiency non-anemia, NIDA: non-iron deficient anemia.

BMI: Body mass index

Ensanut: Encuesta Nacional de Salud y Nutrición

Table III
PROPORTION OF NON-PREGNANT WOMEN AGED 20 TO 49 YEARS, ACCORDING TO IRON DEFICIENCY COMBINED WITH ANEMIA, GYNECOLOGICAL, AFFILIATION TO MEDICAL SERVICES AND SOCIAL PROGRAM. * MÉXICO, ENSANUT 2006, 2012 AND 2018-19

	IDA			IDNA			NIDA		
	2006	2012	2018	2006	2012	2018	2006	2012	2018
	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)
Number of pregnancies									
None	8.1 (4.1-15.2)	4.9 (2.4-9.7)	27.9 (14.0-47.9)	16.0 (10.7-23.1)	15.4 (11.2-20.8)	16.6 (8.6-29.8)	6.6 (2.7-15.4)	20.0 (12.4-30.7)	23.5 (13.7-37.3)
1 to 3	55.4 (44.2-66.1)	65.2 (50.4-77.6)	51.3 (36.0-66.5)	54.4 (47.0-61.6)	59.9 (53.0-66.4)	65.2 (52.6-75.9)	52.7 (37.0-67.9)	54.3 (44.6-63.7)	55.4 (43.4-66.9)
4 to 6	32.1 (22.2-43.8)	27.7 (15.9-43.7)	18.3 (10.8-29.2)	23.7 (19.0-29.2)	21.4 (16.5-27.4)	16.9 (10.9-25.2)	30.3 (19.6-43.8)	21.1 (14.9-29.0)	19.1 (12.2-28.5)
>7	7.7 (5.8-10.2)	2.3 (1.2-4.1)	2.4 (0.6-9.1)	10.3 (5.3-19.2)	3.3 (2.0-5.5)	1.3 (0.3-4.7)	4.5 (2.1-9.2)	4.5 (2.2-9.2)	2.0 (0.7-5.1)
Number of abortions									
None	79.4 (66.2-88.4)	87.1 (79.3-92.2)	69.5 (55.5-80.6)	81.7 (76.0-86.3)	80.1 (74.1-84.9)	88.4 (81.1-93.1)	77.9 (65.2-87.0)	75.1 [‡] (65.4-82.8)	78.8 (69.9-85.6)
1	18.1 (9.6-31.6)	8.7 (4.6-15.7)	21.0 (12.3-33.5)	16.2 (11.8-21.9)	16.0 (11.8-21.5)	7.7 (4.2-13.6)	19.1 (10.8-31.6)	19.6 (12.8-28.8)	19.1 (12.6-27.8)
>2	2.5 (0.8-7.6)	4.3 (2.0-9.1)	9.5 (3.6-22.9)	2.1 (1.0-4.0)	3.9 (1.9-7.8)	3.9 (1.6-9.3)	2.9 (1.1-7.6)	5.3 (2.5-11.3)	2.1 (0.7-5.9)
Affiliation to medical services									
IMSS	29.4 (20.4-40.3)	16.7 (11.1-24.4)	28.6 (17.6-42.9)	25.2 (19.1-32.5)	27.0 (21.6-33.1)	35.8 (22.5-51.7)	13.3 (7.5-22.4)	31.8 (23.4-41.7)	29.6 (21.5-39.3)
ISSSTE	2.4 (0.8-7.1)	2.6 (1.2-5.6)	11.3 (3.0-34.2)	1.7 (0.8-3.6)	4.6 (2.4-8.4)	2.7 (1.1-6.4)	3.5 (1.3-9.3)	4.2 (1.3-12.1)	3.5 (0.8-13.7)
Popular insurance	16.4 (9.2-27.4)	56.9 (44.6-68.4)	45.4 (31.4-60.2)	10.8 (7.8-14.7)	40.1 (34.1-46.3)	42.1 (30.3-54.7)	11.6 (6.6-19.7)	37.1 (28.7-46.4)	38.5 (28.5-49.6)
Private or other	1.9 (0.5-7.4)	0.2 (0.1-1.0)	0.0	2.3 (1.2-4.2)	3.4 (1.0-11.5)	3.1 (0.6-14.0)	4.7 (1.4-14.4)	4.3 (1.1-15.6)	0.7 (0.2-2.9)
No affiliated	49.9 (38.7-61.2)	23.5 (15.7-33.6)	14.7 (7.4-27.0)	60.0 (53.2-66.5)	24.9 (18.3-33.1)	16.3 (10.1-25.4)	66.9 (52.5-78.7)	22.7 (14.5-33.7)	27.7 (17.3-41.0)
Beneficiary of social programs									
PAL	-	2.1 (0.5-7.9)	4.7 (1.9-10.8)	0.1 (0.0-0.8)	1.7 (0.6-5.0)	7.4 (4.0-13.2)	-	0.1 (0.0-0.6)	7.6 (2.7-19.6)
Liconsa	1.2 (0.3-5.2)	1.2 (0.3-5.2)	3.8 (1.9-7.3)	4.3 (1.7-10.3)	4.3 (1.7-10.3)	5.0 (2.5-9.5)	8.8 (2.3-28.1)	8.8 (2.3-28.1)	3.3 (1.4-7.5)
Prospera	43.8 (33.7-54.4)	23.8 (12.0-41.7)	22.2 (14.4-32.6)	40.0 (33.8-46.6)	12.3 (6.5-22.1)	28.9 (20.0-39.8)	33.6 (21.5-48.3)	10.7 (4.9-21.9)	25.0 (17.0-35.2)
Iron supplement	-	10.6 (6.5-17.0)	2.4 (1.0-5.8)	-	16.2 (12.2-21.3)	5.8 (2.7-12.1)	-	13.5 (8.9-19.9)	4.3 (2.1-8.4)
Folic acid supplement	-	26.0 (14.0-43.1)	10.0 (5.5-17.4)	-	27.1 (20.6-34.9)	14.1 (8.0-23.5)	-	22.2 (15.2-31.2)	6.0 (3.3-10.6)

* Estimates adjusted by the survey sample design.

[‡] $p < 0.05$. Estimates based on contingency tables adjusted by survey design. Reference group: no iron deficient non-anemia (NIDNA)

IMSS: Instituto Mexicano del Seguro Social; ISSSTE: Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado.

PAL: Food aid program

ID: iron deficiency-IDA: iron deficiency anemia, IDNA: iron deficiency non-anemia, NIDA: non-iron deficient anemia.

CI: Confidence interval

Ensanut: Encuesta Nacional de Salud y Nutrición

Table IV
ASSOCIATION BETWEEN THE CATEGORIES OF IRON DEFICIENCY AND ANEMIA WITH THE VARIABLES OF INTEREST
IN NO PREGNANT WOMEN AGED 20 TO 49 YEARS.*,† MEXICO, ENSANUT 2006, 2012 Y 2018-19

	IDA			IDNA			NIDA		
	RRR	(95%CI)	p value	RRR	(95%CI)	p value	RRR	(95%CI)	p value
Year of survey [‡]									
2006	Ref			Ref			Ref		
2012	0.671	(0.37-1.20)	0.178	1.109	(0.63-1.93)	0.716	0.888	(0.45-1.71)	0.725
2018	1.408	(0.91-2.17)	0.124	0.979	(0.68-1.40)	0.906	2.398	(1.48-3.87)	0.000
BMI (kg/m ²)									
<18.5	Ref								
18.5 to 24.9	0.967	(0.29-3.20)	0.956	5.139	(1.68-15.7)	0.004	10.459	(2.20-49.5)	0.003
25 to 29.9	0.760	(0.23-2.48)	0.649	3.085	(0.99-9.59)	0.052	8.472	(1.68-42.5)	0.010
>=30.0	0.654	(0.19-2.18)	0.490	3.665	(1.19-11.2)	0.023	7.021	(1.47-33.5)	0.015
Number of pregnancies									
None	Ref			Ref			Ref		
1 to 3	1.248	(0.63-2.44)	0.518	1.616	(0.95-2.74)	0.077	1.866	(1.06-3.27)	0.030
4 to 6	1.558	(0.76-3.15)	0.218	1.386	(0.77-2.47)	0.270	2.066	(1.13-3.74)	0.017
>7	1.179	(0.47-2.94)	0.724	1.130	(0.51-2.48)	0.762	2.651	(1.23-5.69)	0.013
Affiliation to medical services									
IMSS	Ref			Ref			Ref		
ISSSTE	1.681	(0.43-6.44)	0.448	0.424	(0.19-0.92)	0.032	0.889	(0.31-2.51)	0.824
Popular insurance	1.005	(0.56-1.77)	0.986	0.705	(0.42-1.16)	0.174	0.911	(0.57-1.44)	0.692
Private or other	0.195	(0.03-0.97)	0.047	0.716	(0.24-2.11)	0.545	0.894	(0.27-2.90)	0.851
No affiliated	1.307	(0.78-2.18)	0.307	1.432	(0.94-2.16)	0.087	2.616	(1.61-4.25)	0.000
Prospera									
No	Ref			Ref			Ref		
Yes	1.199	(0.82-1.74)	0.341	1.246	(0.89-1.74)	0.198	1.053	(0.57-1.93)	0.867
Liconsa									
No	Ref								
Yes	0.297	(0.13-0.64)	0.002	0.481	(0.25-0.89)	0.021	0.588	(0.29-1.18)	0.138
Locality									
Urban	Ref								
Rural	0.891	(0.61-1.28)	0.535	0.684	(0.48-0.97)	0.033	0.794	(0.41-1.53)	0.492
Region									
North	Ref			Ref			Ref		
Center	0.576	(0.35-0.94)	0.029	1.550	(1.00-2.40)	0.050	0.432	(0.25-0.74)	0.003
CDMX	1.055	(0.45-2.45)	0.900	1.425	(0.62-3.23)	0.397	0.217	(0.08-0.55)	0.001
South	0.725	(0.41-1.26)	0.260	1.656	(1.08-2.53)	0.021	0.530	(0.33-0.84)	0.008
Age (years)									
20 to 34	Ref			Ref			Ref		
35 to 49	1.069	(0.67-1.68)	0.775	1.176	(0.83-1.64)	0.348	1.103	(0.72-1.68)	0.651
Constant	0.154	(0.04-0.55)	0.004	0.037	(0.01-0.12)	0.000	0.008	(0.00-0.04)	0.000

* Multinomial logistic regression adjusted by survey design. Reference group: no iron deficient non-anemia (NIDNA)

† Ensanut 2006 (n sample=2 449, N [Thousands]=23 664.9), Ensanut 2012 (n sample= 3 649, N [thousands]=22 433.8) and Ensanut 2018-19 (n sample= 1 414, N [Thousands]=26 989.1)

BMI: body mass index

RRR: relative risk ratio

IMSS: Instituto Mexicano del Seguro Social

ISSSTE: Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado

Ensanut: National Health and Nutrition Survey

IDA: Iron deficiency anemia, IDNA: Iron deficiency non-anemia, NIDA: non-iron deficient anemia. CI: Confidence interval

real increment in the prevalence of anemia due to any known or unknown causes.

IDNA had a significative reduction in 2018-19, unfortunately it may go unrecognized for longer periods, until IDA is manifested.^{40,41} One of the most probable causes is vitamin A deficiency^{42,43} which impedes the mobilization of iron from the liver.

It is important to clarify the paradoxical trend to decrease in IDNA and the increase in NIDA. These may mean that ID is not the responsible for the increase in total anemia and that NIDA is part to better explain the difference in the prevalence of anemia; and the high number of pregnancies, overweight-obesity and not being affiliated with any medical health services significantly increase the risk of NIDA. Also it is important to pinpoint that there were differences also in the method to measure sferritin in 2006 versus 2012 and 2018-19, this could contribute to an unknown degree to the stability in ID. To confirm the stability in the prevalence of ID it would be desirable to have additional measures of others iron indicators as percent transferrin saturation, the soluble transferrin receptor (sTfr) or the ratio sTfr/log-ferr or hepcidin.^{40,41} Women beneficiaries of micronutrients fortified milk Liconsá had a lower probability to have IDA or IDNA which supports the stability in ID.

One of the fortitudes of this study is the use of three probabilistic surveys, using similar methodology for measuring consecutively the sferritin, the most specific test correlating with relative total body iron stores. If the increment of the prevalence of anemia were real, the supplementation programs have to resume, since in 2018 the federal programs *Prospera* and *PAL* to reduce poverty and malnutrition were erased from the public interventions.^{6,11,12} Also should be reenacted food and nutrition education programs based on dietary modifications, provision of iron-fortified foods, targeted iron supplementation, and control of infections, adapted to the special needs of rural and indigenous populations, to comply with the OMS recommendation to reduce 50% the prevalence of anemia in 2025.^{11,12,44,45}

In conclusion, the prevalence of iron deficiency remained stable or reduced; however, anemia has increased in 20-49 years of age women. The stability of ID suggests that a change in the prevalence of NIDA occurred probably because deficiencies of other micronutrients not measured in these surveys, or to byass introduced by the determinations of Hemocue.

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

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