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# Anemia in Mexican women: A public health problem

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está disponible en: <http://www.insp.mx/salud/index.html>

## Abstract

**Objective.** The purpose of this study is to quantify the prevalence and distribution of anemia among women of childbearing age (12 to 49 years) participating in the 1999 National Nutrition Survey (NNS-1999). **Material and Methods.** The survey had a probabilistic design and was representative at the national level, of urban and rural areas and four regions: North, South, Center, and Mexico City. Hemoglobin concentration was determined in capillary blood samples using a portable photometer (HemoCue), in 17 194 women, 697 of whom were pregnant. **Results.** The overall prevalence of anemia was 27.8% in pregnant women and 20.8% in non-pregnant women. Higher prevalences were observed in rural as compared to urban areas, both in pregnant (28.0% vs 27.7%) and non-pregnant (22.6% vs 20.0%) women, but the differences were not statistically significant ( $p > 0.05$ ). Women in the South had the greatest prevalence (23.2%), followed by those in the North (20.9%), Center (20.6%), and Mexico City (16.4%). Non-pregnant indigenous women had a prevalence of 24.8%, while in non-indigenous women the prevalence was 20.4%. **Conclusions.** Anemia in women of childbearing age is a growing public health problem that justifies the implementation of interventions for its prevention and control. The English version of this paper is available too at: <http://www.insp.mx/salud/index.html>

Key words: nutrition surveys; anemia; pregnant women; hemocue; hemoglobin; Mexico

## Resumen

**Objetivo.** Cuantificar la prevalencia y distribución de anemia de las mujeres en edad fértil (12 a 49 años de edad) captadas en la Encuesta Nacional de Nutrición 1999 (ENN-99). La Encuesta tuvo un diseño probabilístico y es representativa del ámbito nacional mexicano, de zonas urbanas y rurales y de cuatro regiones: norte, centro, Ciudad de México y sur. **Material y métodos:** La concentración de hemoglobina se determinó en sangre capilar mediante un fotómetro portátil (HemoCue) en 17 194 mujeres, de las cuales 697 estaban embarazadas. **Resultados.** La prevalencia de anemia en el ámbito nacional fue de 27.8% para mujeres embarazadas y 20.8% para no embarazadas. Se encontró una mayor prevalencia en zonas rurales que en urbanas, tanto en mujeres embarazadas (28.0% vs 27.7%) como en no embarazadas (22.6% vs 20.0%) pero las diferencias no fueron estadísticamente significativas ( $p > 0.05$ ). La región sur presentó la mayor prevalencia de anemia (23.2%), seguida de la región norte (20.9%), la centro (20.6%) y la Ciudad de México (16.4%). Las mujeres no embarazadas indígenas presentaron una prevalencia de anemia de 24.8%, mientras que en las no indígenas fue de 20.4%, no siendo esta diferencia estadísticamente significativa. **Conclusiones.** La anemia en mujeres en edad fértil es un problema de salud pública que justifica la implantación de programas de prevención y control. El texto completo en inglés de este artículo también está disponible en: <http://www.insp.mx/salud/index.html>

Palabras clave: encuestas nutricionales; anemia; mujeres embarazadas; hemocue; hemoglobina; México

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Anemia is the most frequent nutritional-related disease worldwide, affecting half of children and pregnant women and between 20 and 25% of non-pregnant women in developing countries.<sup>1</sup> Both nutritional and non-nutritional factors may cause anemia. The most common nutritional cause is iron deficiency. Other nutritional causes are deficiencies of vitamin B<sub>12</sub>, folic acid, and vitamin A.<sup>2-4</sup> Among the non-nutritional causes of anemia are intestinal parasitic infections such as uncinariasis and trichinosis.<sup>5-8</sup> Other causes include hemodilution during pregnancy, concurrent acute and chronic infections, and menstrual bleeding.<sup>9,10</sup> Iron deficiency also has deleterious effects on the immune response, exercise endurance, cognitive ability, and psychosocial development.<sup>11,12</sup>

The extent to which anemia affects the health of mothers and of their newborns is not completely established, but some studies suggest that anemia during pregnancy has adverse effects on both the mother and the fetus.<sup>13,14</sup> Moreover, severe anemia greatly increases the risk of maternal death.<sup>10,14</sup> Insufficient maternal iron stores are reflected in low iron stores in the newborn, leading to increased risk of iron deficiency in the first months of life. Iron deficiency may also have long-term consequences on the health of both mother and child. For example, iron deficiency anemia is associated with birth weight and pre-term birth.

The most recent information on the extent and distribution of anemia in Mexico was reported in the 1988 National Nutrition Survey.<sup>15</sup> The present study was designed to quantify the prevalence and describe the distribution of anemia in women aged 12 to 49 years, at the national level, by urban and rural areas and by region, and to assess the trend in anemia prevalence comparing the findings from this study to those of the 1988 National Nutrition Survey.

## Material and Methods

### Sample design and procedures

Data for this analysis were obtained from the 1999 National Nutrition Survey (NNS-1999).<sup>16</sup> A general description of the NNS-1999 methods is included elsewhere in this issue. In summary, the NNS-1999 assembled a probabilistic sample of 21 503 households, representative at the national level, stratified by urban (pop ≥ 2 500) and rural residency (population <2 500), and by four geographic regions of Mexico: (North,

Center, Mexico City, and South).<sup>\*</sup> Families were selected according to a sampling frame developed by INEGI (acronym from its Spanish name: Mexican National Institute of Statistics, Geography and Information).

Sampling procedure for NNS-1999 followed a multistage, stratified, cluster design. The survey included diverse data collection strategies for different age groups. In each household, data were collected from all children <5 years of age and school-age children (5-11 years), but only from one woman aged 12-49 years.

Only one woman between the ages of 12 and 49 was selected from those living in a given household. Data obtained from 18 312 women aged between 12 and 49 years were retrieved for this analysis, including those subjects having information available on hemoglobin concentrations, physiological status (pregnant, lactating, non-pregnant non-lactating), ethnic background, socioeconomic status (SES), maternal parity, education, employment, and maternal literacy. For this analysis, indigenous background of a family was operationally defined as at least one woman 12-49 years of age who spoke a native language. The socioeconomic level was graded using principal components analysis. Selected variables were flooring material, availability of running water, ownership of household electrical appliances (washing machine, refrigerator, television, radio, and stove). This index explained 51.6% of the generalized variance of the set of variables included. The distribution of this index was divided into tertiles to classify SES into high, medium, and low strata. Parity was stratified into three categories: women with less than three children, three to five children, and more than five children. Maternal education was stratified into five categories: no education, primary, secondary, high school or equivalent, and completed college education. Employment status was stratified into three categories: paid job, student, and housewife. Maternal literacy was divided into two cat-

\* North (Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo León, Sonora and Tamaulipas), Center (Aguascalientes, Colima, Guanajuato, Jalisco, México (excludes urbanised counties and localities adjacent to Mexico City), Michoacán, Morelos, Nayarit, Querétaro, San Luis Potosí, Sinaloa, Zacatecas), Mexico City (includes Federal District and urbanised counties from the state of México). South (Campeche, Chiapas, Guerrero, Hidalgo, Oaxaca, Puebla, Quintana Roo, Tabasco, Tlaxcala, Veracruz, Yucatán)

egories: literate was defined as the ability to read or write a message, and illiterate otherwise. Some cases were excluded from the analysis when information on hemoglobin concentration or physiological status was not available.

Informed consent letters were obtained from women prior to their participation in the survey. The NNS-1999 protocol was approved by the Ethics Committee of the National Health Public Institute, Mexico.

### Definition of anemia

Anemia was defined as the concentration of hemoglobin at sea level <12.0 g/dl in non-pregnant women and <11.0 g/dl in pregnant women.<sup>17</sup> For localities >1 000 m above sea level, hemoglobin values were adjusted according to the method proposed by Cohen and Hass.<sup>18</sup> These authors derived a hemoglobin-altitude curve from previously published data of mean hemoglobin concentrations of non-anemic women of childbearing age at various altitudes. They assumed that the mean hemoglobin concentration of the iron-sufficient population at sea level was not significantly different from the mean up to 1 000 meters above the sea level. Four data points were used from 1 000 to 4 800 meters.

The curve which best fitted the hemoglobin-altitude for non-anemic women of childbearing age was:

$$\text{Hemoglobin (g/l)} = 120 + 16.3 \times [\exp^{(0.00338 \times (\text{altitude} - 1000))}]$$

$$(R^2 = 0.995, p < .05)$$

The assumed coefficient of variation of 0.061 of the adjusted estimated hemoglobin values is then used to calculate the hemoglobin cutoff point at the 2.5 percentile of normal distribution. Using the results from the mean-hemoglobin equation above, the hemoglobin cutoff to estimate anemia is calculated as follows:

$$\text{Hb cutoff} = \text{Mean Hb} - [(0.061 \times \text{Mean Hb}) \times 1.96]$$

This model can be used to estimate the prevalence of iron-deficiency anemia in women of childbearing age, including the period of pregnancy, at altitudes up to 4 800 m.

Data on altitude of our study communities were obtained from the INEGI database.<sup>19</sup>

### Hemoglobin measurements

Blood hemoglobin was determined in a sample of capillary blood obtained by fingerprick, using the second drop of blood obtained and measured by a portable photometer (HemoCue, Angelholm, Sweden). This test

is based on a reaction occurring in a plastic cuvette containing a dry reactant (sodium deoxycholate, sodium nitrite, and sodium azide). This reaction converts hemoglobin into azide methemoglobin, which is measured at a wavelength of 565 nm in the portable photometer. The photometer is previously calibrated with a reference cuvette equipped with a red filter, calibrated against the international hemoglobin standard<sup>20</sup> as recommended by the International Committee of Standardization in Hematology.

There was one photometer for each of the 21 field teams. Photometers were calibrated twice each week during fieldwork, recording the readings of the control cuvette at the beginning and end of each day. If the variation was >0.3 g/dl, the photometer was serviced. The intra-observer variability was assessed by duplicate measurements of a blood sample, once every 20 subjects screened. There were 582 duplicate human blood measurements and 273 measurements of the reference cuvette available for variability analysis per team. The average difference between duplicates was  $0.03 \pm 0.99$  g/dl,  $p = 0.36$  for human blood and  $-0.024 \pm 0.36$  g/dl,  $p = -0.27$  for the duplicates of the reference cuvette.

Values of hemoglobin <4.5 g/dl and >18.5 g/dl were considered as outliers and excluded from the analysis. Women with hemoglobin values <9 g/dl were treated with ferrous sulfate tablets, and excluded from the analysis. The final sample size for analysis was 16 497 women, 697 of whom were pregnant at the time of the interview.

For analysis purposes, women were categorized as pregnant or non-pregnant. Since the distribution of the hemoglobin data was not different between non-pregnant, non-lactating and lactating women, these two were merged into the category of non-pregnant women.

### Statistical analysis

Descriptive data analysis are presented as prevalence of anemia and mean hemoglobin concentrations with their 95% confidence intervals (CI). The probability of being anemic was evaluated through a logistic regression model for complex surveys. The independent variables in the model were those that have been documented to be associated with anemia: indigenous background, socioeconomic status, maternal education, employment status and maternal literacy.<sup>21-26</sup> Expansion factors were calculated based on the characteristics of the national population in 1995.

Regression models for the analysis of potential predictors of anemia were constructed with data from non-pregnant women only.

Data entry was done using a Clipper-based program using formats that included range and contingency validation checks (V. 5.01, 1999; Nantucket<sup>TM</sup> Corporation, San Francisco, CA, USA). A descriptive analysis was run in SPSS for Windows (v. 10, 1999; SPSS Inc, Chicago, IL, USA). Regression models were adjusted using Stata statistical software (v. 7.0, 2001; Stata Corp., College Station, TX, USA).

## Results

The final sample for the present analysis was composed of 17 194 registries of the original NNS-1999 sample due to the exclusion of 1 119 observations (6.1%), either because they were incomplete or outliers. The age distribution and the socioeconomic characteristics of the excluded cases were not different from those of the final sample, either by region, or by urban and rural distribution.

At the national level, the mean hemoglobin concentration for pregnant women was 11.9 g/dl (median= 12.0 g/dl) and non pregnant women was 13.1 g/dl (median=13.2 g/dl). The mean hemoglobin values for urban and rural pregnant women were identical and were slightly lower in rural areas for non-pregnant women. Mean hemoglobin values were higher in Mexico City than in other regions for both pregnant and non-pregnant women. The lowest mean values for pregnant and non-pregnant women were found in the North and South (Table I).

The overall prevalence of anemia was 27.8% (95%CI 23.7, 31.8%) for pregnant women and 20.8% (95%CI 19.9, 21.7%) for non-pregnant women. The

prevalence of anemia in pregnant urban women was not different from that of rural women (27.7 vs. 28.0%). Non-pregnant rural women had a greater prevalence of anemia than their urban counterparts (22.6 vs. 20.2%). (Table II).

Due to small sample sizes, regional prevalences for rural areas are not presented in Mexico City for either pregnant and non-pregnant women nor in the north for pregnant women.

In urban and rural non-pregnant women, the highest prevalence of anemia was found in the South (urban 22.6% and rural 24.0%) and Mexico City has the lowest prevalence in urban areas.

The overall prevalence of anemia among non-pregnant women of indigenous ancestry was 24.8% in comparison with 20.4% in non-indigenous women. For non-pregnant indigenous women, the highest prevalence (39.9%) was found in the North and the lowest in the South (Table III).

The crude odds ratio for anemia was 1.51 for the older age category (95%CI 1.33, 1.71), 1.49 for women with no schooling (95%CI 1.12, 1.98), 1.97 for the highest category of parity (95%CI 1.67, 2.31), 1.26 for illiterate mothers (95%CI 1.06, 1.49), 1.52 for low socioeconomic level (95%CI 1.34, 1.72), and 1.29 for indigenous background (95%CI 1.11, 1.51) (Table IV).

After adjusting for the effect of cluster sampling and for potential confounders using the logistic regression model, women living in the South and in the North had a greater risk of anemia than those living in Mexico City ( $p = 0.005$ ). Significant risk factors were greater parity ( $p < 0.0001$ ) and having a medium or low socioeconomic level ( $p < 0.0001$ ) (Table V). The logistic model

Table I  
MEAN, MEDIAN AND 95% CI OF HEMOGLOBIN (G/DL) IN WOMEN 12 TO 49 YEARS OLD  
ACCORDING TO PHYSIOLOGICAL CONDITION BY REGION, AREA, AND NATIONAL LEVEL PARTICIPATING  
THE NATIONAL NUTRITION SURVEY. MEXICO, 1999

Region/area	Pregnant women					Non-pregnant women					All women		
	Sample number	Expansion* number (thousands)	Mean	95%CI	Median	Sample number	Expansion* number (thousands)	Mean	95%CI	Median	Mean	95%CI	Median
North	208	160.6	11.7	(11.34, 12.06)	11.7	5 059	3 838.3	13.0	(12.91, 13.05)	13.1	12.9	(12.86, 13.00)	13.0
Center	211	277.8	11.9	(11.67, 12.19)	11.9	4 645	6 014.4	13.1	(13.08, 13.21)	13.3	13.1	(13.02, 13.16)	13.3
Mexico City	59	137.6	12.3	(11.84, 12.74)	12.3	1 538	3 186.1	13.5	(13.35, 13.56)	13.5	13.4	(13.30, 13.51)	13.5
South	219	269.7	11.8	(11.53, 11.99)	11.7	5 254	6 492.9	13.0	(12.89, 13.01)	13.0	12.9	(12.84, 12.96)	13.0
Urban	397	592.6	11.9	(11.70, 12.09)	11.9	10 283	14 372.3	13.1	(13.10, 13.19)	13.3	13.1	(13.04, 13.14)	13.2
Rural	300	253.0	11.9	(11.65, 12.10)	12.0	6 213	5 159.5	13.0	(12.92, 13.04)	13.1	12.9	(12.86, 12.99)	13.1
National	697	845.6	11.9	(11.74, 12.04)	12.0	16 496	19 531.8	13.1	(13.06, 13.14)	13.2	13.1	(13.01, 13.08)	13.2

\* Estimated number using expansion factors without adjusting for women who did not have valid hemoglobin values

Table II  
**PREVALENCE (%) OF ANEMIA\* IN 12- TO 49-YEAR-OLD WOMEN ACCORDING TO PHYSIOLOGICAL STATUS, AREA, AND REGION PARTICIPATING THE NATIONAL NUTRITION SURVEY. MEXICO, 1999**

Region	Urban				Rural				National	
	Sample number	Expansion <sup>‡</sup> number (thousands)	%	95%CI	Sample number	Expansion <sup>‡</sup> number (thousands)	%	95%CI	%	95%CI
<b>Pregnant women</b>										
North	124	132.3	32.3	(21.96, 42.60)	84	— <sup>§</sup>	—	—	—	—
Center	111	185.9	27.5	(16.77, 38.28)	100	91.9	28.1	(16.62, 39.55)	27.7	(19.90, 35.52)
Mexico City	53	134.3	20.1	(9.05, 31.10)	6	—	—	—	—	—
South	109	140.2	30.8	(22.16, 39.39)	110	129.5	28.9	(19.13, 38.76)	29.9	(23.57, 36.22)
Total	397	592.6	27.7	(22.44, 32.89)	300	253.0	28.0	(21.34, 34.62)	27.8	(23.69, 31.82)
<b>Non-pregnant women</b>										
North	3 170	3 215.5	20.5	(18.47, 22.62)	1 889	622.8	22.8	(19.78, 25.80)	20.9	(19.14, 22.68)
Center	2 624	4 204.7	20.6	(18.50, 22.70)	2 021	1 809.7	20.5	(18.52, 22.58)	20.6	(19.05, 22.12)
Mexico City	1 460	3 149.1	16.3	(13.82, 18.71)	78	—	—	—	—	—
South	3 029	3 803.1	22.6	(20.72, 24.49)	2 225	2 689.8	24.0	(21.41, 26.50)	23.2	(21.64, 24.69)
Total	10 283	14 372.3	20.2	(19.11, 21.22)	6 213	5 159.5	22.6	(21.05, 24.19)	20.8	(19.95, 21.68)
<b>All women</b>										
North	3 294	3 347.8	21.0	(18.97, 23.05)	1 973	651.2	22.9	(19.82, 26.06)	21.3	(19.58, 23.07)
Center	2 735	4 390.6	20.9	(18.81, 22.97)	2 121	1 901.6	20.9	(18.79, 23.03)	20.9	(19.37, 22.43)
Mexico City	1 513	3 283.3	16.4	(14.05, 18.79)	84	—	—	—	16.5	(14.16, 18.85)
South	3 138	3 943.3	22.9	(21.04, 24.76)	2 335	2 819.3	24.2	(21.56, 26.81)	23.4	(21.89, 24.97)
Total	10 680	14 964.9	20.5	(19.43, 21.50)	6 513	5 412.5	22.9	(21.25, 24.50)	21.1	(20.24, 21.97)

\* Adjusted for altitude: pregnant women <11 g/dl (sea level), non-pregnant women <12 g/dl (sea level)

<sup>‡</sup> Estimated number using expansion factors without adjusting for women who did not have valid hemoglobin values

<sup>§</sup> Not presented due to small sample size

Table III  
**PREVALENCE (%) OF ANEMIA\* IN NON-PREGNANT WOMEN IN A NATIONAL PROBABILISTIC SAMPLE, BY REGION AND INDIGENOUS BACKGROUND**

Region	Indigenous				Non-indigenous			
	N (Sample)	N (Expanded) <sup>‡</sup>	%	95% CI	N (Sample)	n (Expanded) <sup>‡</sup>	%	95% CI
North	163	74.2	39.9	(29.03, 50.78)	4 896	3 764.2	20.5	(18.76, 22.31)
Center	179	227.8	27.0	(20.54, 33.50)	4 466	5 786.6	20.3	(18.74, 21.92)
Mexico City <sup>§</sup>	40	—	—	—	1 498	3 091.6	16.2	(13.74, 18.73)
South	1 097	1 298.0	23.8	(20.76, 26.92)	4 157	5 195.0	23.0	(21.27, 24.72)
National	1 479	1 694.5	24.8	(22.15, 27.43)	15 017	17 837.3	20.4	(19.53, 21.35)

\* Adjusted for altitude: <12 g/dl in non-pregnant women, above sea level

<sup>‡</sup> Estimated number using expansion factors without adjusting for women who did not have valid hemoglobin values

<sup>§</sup> Not presented due to small sample size

el was originally adjusted for indigenous background, maternal education, employment status and maternal literacy, but none of these variables were statistically significant, and were therefore removed from the model presented in Table V.

## Discussion and conclusions

Our findings documented that anemia in women is a serious public health problem in Mexico, affecting about one fifth of non-pregnant women of reproduc-

Table IV  
**PREVALENCE (%) AND CRUDE RISKS FOR ANEMIA\* AMONG NON-PREGNANT WOMEN IN A NATIONAL PROBABILISTIC SAMPLE, BY URBAN OR RURAL AREA, AGE, PARITY, SCHOOLING AND LITERACY, SOCIOECONOMIC INDEX, AND INDIGENOUS BACKGROUND PARTICIPATING THE NATIONAL NUTRITION SURVEY, MEXICO, 1999**

	<i>n</i> (Sample)	<i>n</i> (Expanded) <sup>‡</sup>	Anemia (%)	Odds ratios Crude	95% CI	<i>p</i>
Area						
Urban	10 114	14 143.8	20.1	1.00		
Rural	6 025	5 003.6	22.5	1.16	(1.03, 1.30)	0.014
Region						
Mexico City	1 526	3 162.4	16.5	1.00		
North	4 966	3 775.1	21.0	1.34	(1.09, 1.65)	0.006
Center	4 494	5 838.5	20.4	1.30	(1.06, 1.59)	0.011
South	5 153	6 371.5	23.1	1.53	(1.26, 1.86)	<0.0001
Age (years)						
12 to 18	4 222	4 830.9	16.9	1.00		
19 to 35	7 613	9 162.3	21.2	1.32	(1.17, 1.49)	<0.0001
36 to 49	4 304	5 154.3	23.5	1.51	(1.33, 1.71)	<0.0001
Parity (# children)						
0	6 253	7 471.7	16.3	1.00		
1 to 2	4 200	5 208.3	22.7	1.51	(1.34, 1.71)	<0.0001
3 to 5	4 289	4 958.8	23.3	1.57	(1.39, 1.77)	<0.0001
>5	1 397	1 508.5	27.6	1.97	(1.67, 2.31)	<0.0001
Schooling						
Professional	536	842.4	16.9	1.00		
None	4 539	5 020.7	23.2	1.49	(1.12, 1.98)	0.0070
Elementary	5 408	5 967.3	21.1	1.32	(0.99, 1.75)	0.0570
Middle school	3 937	4 941.8	19.7	1.21	(0.91, 1.60)	0.1900
High school	1 663	2 306.5	18.2	1.10	(0.82, 1.47)	0.5240
Maternal literacy						
Literate	14 856	17 655.1	20.5	1.00		
Illiterate	1 197	1 378.4	24.4	1.26	(1.07, 1.49)	0.0060
Occupation						
Employed	3 700	4 805.7	20.3	1.00		
Unemployed	12 373	14 253.3	21.0	1.04	(0.94, 1.16)	0.4420
Socioeconomic index						
High	5 751	7 868.3	17.3	1.00		
Medium	5 170	5 815.9	22.1	1.36	(1.20, 1.54)	<0.0001
Low	5 218	5 463.2	24.2	1.52	(1.34, 1.72)	<0.0001
Indigenous ethnicity						
Non-indigenous	14 686	17 476.8	20.3	1.00		
Indigenous	1 453	1 670.6	24.8	1.29	(1.11, 1.51)	0.0010

\* <12 g/dl in non-pregnant women (adjusted for altitude above sea level)

‡ Estimated number using expansion factors without adjusting for women who did not have valid hemoglobin values

tive age and over one fourth of pregnant women. The serious functional consequences of this deficiency demand the design and implementation of public iron supplementation and food fortification programs as

the most effective strategies to reduce iron-deficiency anemia.

Data presented here show a persistently high prevalence of anemia in Mexico among pregnant and non-



Table V  
**LOGISTIC REGRESSION MODEL FOR ANEMIA\* CONSIDERING  
 COMPLEX SAMPLING VARIANCE AMONG NON-PREGNANT  
 WOMEN IN A NATIONAL PROBABILISTIC SAMPLE,  
 PARTICIPATING THE NATIONAL NUTRITION SURVEY.  
 MÉXICO, 1999**

Independent variables	Odds ratio	95% confidence interval	p
Region			
Mexico City	1.0		
North	1.3	(1.05, 1.59)	0.014
Center	1.2	(0.98, 1.46)	0.086
South	1.3	(1.09, 1.63)	0.005
Parity			
None	1.0		
1-2 children	1.5	(1.36, 1.73)	<0.0001
3 to 5 children	1.5	(1.37, 1.75)	<0.0001
>5 children	1.8	(1.51, 2.09)	<0.0001
Socioeconomic index <sup>†</sup>			
High	1.0		
Medium	1.3	(1.15, 1.48)	<0.0001
Low	1.4	(1.22, 1.59)	<0.0001

\* <12 g/dL (sea level)

<sup>†</sup> Normalized index (factorial analysis)

pregnant women. Furthermore, based on the 1988 National Nutrition Survey, the prevalence of anemia increased from 15.4 to 20.8% in women of childbearing age and from 18.2 to 27.8% in pregnant women,<sup>15</sup> representing an increment of 35.0 and 52.7% respectively. Several factors may account for the growing prevalence of anemia. Methodological differences between the two surveys may partially explain these differences. Hemoglobin was measured on site in the NNS-1999 by finger-prick capillary testing using a portable photometer, but was not determined on site in the 1988 survey. Also, venous blood was used in 1988 and capillary blood in 1999. Therefore, results of the two surveys may not be comparable. Transportation and storage of the 1988 samples might have influenced hemoglobin concentration values. Also, hemoglobin concentration in capillary blood may be more variable than in venous blood because inclusion of extracellular fluid would decrease the concentration of components present in the red cell fraction<sup>27</sup>, and the amount of extracellular fluid present in finger-prick samples is likely to be very sensitive to the technician's handling of the patient's finger.

Differences in the prevalence of anemia may also be explained partly by changes in the dietary patterns of the population. For instance, based on the economic difficulties experienced in Mexico during the last ten years, we speculate that recently, diets of a vast section of the population include lower amounts of animal-based foods. Rivera *et al*<sup>28</sup> found that the purchase of meat and meat-products decreased in the 14 year period from 1984 to 1998. The lack of public health interventions to prevent and treat iron deficiency may contribute to the increase in the prevalence of anemia. It was not until 1998 that nutritional interventions were implemented to decrease micronutrient deficiencies among poor women in Mexico. Specifically, the Program for Education, Health and Nutrition (Progres, now called Oportunidades), which distributes fortified foods to low-income pregnant and lactating women, as well as the fortification of wheat and corn flours with iron and other micronutrients and the distribution by the Ministry of Health of multiple micronutrient supplements to pregnant women in predominantly indigenous communities.

The highest prevalence of anemia found in pregnant women should be interpreted cautiously, since it may be due in part to the hemodilution occurring during the last trimester of pregnancy. The cut-off criteria to diagnose anemia is lower for pregnant women in order to correct for overdiagnosis; however, during the first trimester and partially during the second trimester when hemodilution has little effect on the levels of hemoglobin, overcorrection must occur. We did not apply specific cut-off points for each trimester of pregnancy, because we did not have individual information about the length of gestation.

The greatest prevalence of anemia was found in indigenous women living in rural zones. It is well known that indigenous populations are the poorest in Mexico and have the lowest availability of social support resources.<sup>29</sup>

It is puzzling that the prevalence of anemia in the North, considered the most developed area of the country, was comparable to that found in the South, which is considered the least developed. This phenomenon was also observed in the 1988 survey and needs further research.

The prevalence of anemia in Mexico is lower than that observed in other developing countries where it is approximately 44.0% in non-pregnant women and 56.0% in pregnant women, and higher than that reported for developed countries, where it is approximately 12.0% in non-pregnant women and 18.0% in pregnant women.<sup>30</sup> However, other countries with comparable economic development such as Chile and Costa Rica



have achieved a prevalence similar to that of developed countries.<sup>30</sup> Such an achievement was reached by sustained nutritional interventions, resembling those that must be undertaken in Mexico in order to reduce the prevalence of anemia.

This study identified some risk factors associated with anemia in women such as older age, multiparity,<sup>31,32</sup> lower socioeconomic status, indigenous background and being a resident of rural areas. Most of these factors are closely related to both poverty and anemia, as has been reported in other studies.<sup>14,31-34</sup>

The increased prevalence of anemia associated with parity could be due to a progressive depletion of nutritional stores during pregnancy, that has been documented in women of other developing countries.<sup>34-36</sup>

Additional variables not evaluated in this analysis should be taken into account, such as dietary factors including intake of foods with lower iron biodisponibility and cigarette smoking.

This study provides information on the prevalence of anemia among women of childbearing age in a nationwide representative sample that included urban and rural areas of the four regions of Mexico. Anemia in women of childbearing age is a serious public health problem in Mexico, affecting not only populations living under harsh conditions but also groups with higher socioeconomic status. Its prevalence has shown increasing trends over the past 10 years, although methodologies differ between surveys and may not be comparable. The problem should be approached through aggressive interventions targeted at groups at risk in order to rapidly reduce the prevalence of anemia, thus limiting its negative short- and long-term effects on other health outcomes.

As mentioned before, several interventions aimed at reducing micronutrient deficiencies were implemented shortly after the 1999-NNS. It is therefore expected that anemia prevalence may have been reduced. Some but not all of these programs are currently being evaluated and it is likely that the next National Nutrition Survey will be able to assess changes in the prevalence of anemia in the population after the implementation of these interventions. In the meanwhile, several strategies may be launched simultaneously, such as the fortification of foods other than wheat and corn flours and in addition existing programs should be strengthened.

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