January 2014

Household Food Insecurity And Iron Deficiency Anemia In Mexican Women Of Reproductive Age

Nils Clement Fischer
Yale University, nils.fischer@yale.edu

Household Food Insecurity and Iron Deficiency Anemia in Mexican Women of Reproductive Age

<u>Abbreviated Title:</u> Food Insecurity and Anemia in Mexican Women [1 2]

Nils C. Fischer[3], Rafael Perez-Escamilla, **PhD[3],** Teresa Shamah-Levy, **PhD[4]**

*Corresponding author:
Nils C. Fischer, MPH candidate 2014
47 College Street
New Haven CT 06510.
nils.fischer@yale.edu , Phone: (978) 407-9140

[1] Supported by funding from the Overlook International Foundation
[2] Author disclosures: N. Fischer, R. Perez-Escamilla, T. Shamah, no conflicts of interest.
[3] Yale School of Public Health, New Haven, Connecticut, USA
[4] National Institute of Public Health, Cuernavaca, Mexico

Abstract

Iron Deficiency Anemia (IDA) is a major cause of maternal mortality. Our objective was to investigate the association of household food insecurity (HFI) with IDA in a nationally representative, cross-sectional sample from Mexico of women of reproductive age (12-49 years old). We tested the association between HFI and IDA among 16,944 women of reproductive age using multiple logistic regression. HFI was measured using the Latin America and the Caribbean Food Security Scale (ELCSA). IDA was measured with capillary hemoglobin using HemoCue photometer and defined using WHO standards. Multivariate analyses showed that adjusted odds for IDA were 33% and 36% higher among women living in moderately and severely food insecure households (vs. food secure households), respectively. We conclude that HFI is a risk factor for IDA. Reducing HFI may be an effective strategy to reduce the risk of IDA among Mexican women.

Key words: iron deficiency, anemia, food security, nutrition surveys, Mexico

Introduction

Household Food Insecurity (HFI) is defined as a lack of access to a diet of sufficient quality and quantity necessary for a productive and healthy life (1, 2). HFI is highly prevalent in Mexico, according to the 2012 Mexican National Health and Nutrition Survey (ENSANUT 2012), almost one third of all households' experienced moderate or severe insecurity (3). The Latin American and Caribbean Food Security Scale (ELCSA) is a well-validated experience based scale that has been used in much of Latin America and the Caribbean (1, 2). Studies, with scales similar to ELCSA, have shown that HFI is significantly associated with a variety of adverse health outcomes including diabetes, hypertension, and other chronic diseases, along with stress and maternal depression (4-10). At a time when Mexican women have stronger obligations than men in terms of child-rearing and now also play an important role as household income earners, a growing number of studies suggest that they may be especially vulnerable to the negative consequences of HFI (10, 25).

In the 2010 Global Burden of Disease report, Iron Deficiency Anemia (IDA) was globally ranked as the third leading cause of disability(11) accounting for a substantial proportion of the burden of disease both in Mexico and the rest of the Latin American and Caribbean region (12). According to ENSANUT 2012, the prevalence of anemia in Mexico was 11.6% in non-pregnant women and 17.9% in pregnant women (13). These numbers are especially concerning as anemia is linked to maternal morbidity and mortality, in addition to lifelong cognitive, behavioral, and other negative health effects on the newborn (14,15). Biologically, women are at a heightened risk for anemia, and it is estimated that pregnant anemic women are 5.7 times more likely to have infants who are anemic (16, 17).

To the best of our knowledge, this is the first study to investigate the association between HFI and IDA in a nationally representative sample of women of reproductive age in a middle-income country. Three studies conducted in the US have found an association between HFI and IDA among children and adolescents (18-20). A likely pathway is diet, as empirical evidence indicates that HFI results in suboptimal food and nutrient intakes (21, 26-28). In response to the high rates of maternal mortality caused by IDA, the study attempts to examine the relationship between HFI and IDA in a nationally representative cross-sectional sample of Mexican women of reproductive age. Findings from these analyses may have strong public health implications for reducing IDA, as the Government engages in large scale interventions to address HFI.

Methods

Data was drawn from the 2012 Mexican National Health and Nutrition Survey (ENSANUT 2012), a probabilistic survey with a complex sampling design including clustering and stratification. ENSANUT 2012 is nationally representative of the population in rural and urban areas of the 4 regions of Mexico: northern, central, Mexico City (and the metropolitan municipalities) and the Southern region. Sampling was drawn from the 2005 census and incorporates new localities detected in the 2010 census. The data was collected in 50,528 households between October 2011 and May 2012, with a response rate of 87%. The households interviewed represent 29,429,252 households in Mexico based on the 2010 Census and subsequent population growth estimates. From these households, our analytical sample was composed of 18,753 women of reproductive age (12-49 years old).

Household Food Insecurity Measurement

HFI was measured with the well validated Latin American and Caribbean Food Security Scale (ELCSA) (2). The scale includes 15 questions that assess poverty-related food insecurity household experiences, ranging from being worried about not having access to enough food all the way to going without food for a whole day, during the 3 months preceding the survey. Eight questions in the scale apply to food insecurity affecting adults and/or the household as a whole, while the remaining seven refer to food insecurity affecting minors (under 18 years of age). The questions are responded as yes, no, don't know, or refused. An additive score based on the number of ELCSA questions affirmed is then used to classify households as either food secure or into three mutually exclusive food insecurity severity categories (mild moderate or severe food insecurity) using standard cut-off points.

Variables

Independent Variable: The independent variable of interest was the degree of HFI. The mutually exclusive categories, "Mild Food Insecurity", "Medium Food Insecurity", and "Severe Food Insecurity" were determined by the additive score of 8 items with their recommended cutoff thresholds (2). "Household Food Secure" (score=0); "Mild HFI" (1-3); Moderate HFI (4-6); Severe HFI (7-8).

Outcome Variable: The main outcome variable was women's IDA status. Capillary hemoglobin concentrations were quantified by finger prick and analyzed with portable HemoCue photometers, (Hemocue Inc. k Angelholm, Sweden). In accordance with WHO recommendations, at sea level, anemia was defined as a concentration of hemoglobin < 12 g/dL for non-pregnant women and < 11 g/dL for pregnant women (22, 23). Hemoglobin concentrations were adjusted for altitude using the equation published by Cohen and Hass (24).

Covariates: Potential confounders considered in the univariate analyses and multiple regression models were age in years (categorical: 12-20, 21-30, 31-40, 41-49); highest attained education level (tertiles- less than secondary, secondary, higher than secondary); area of residence (rural/urban); socioeconomic level (tertiles) classified from the principal component representing household construction characteristics and family assets (i.e. car ownership, refrigerator, radio etc.) (25); number of pregnancies (categorical <2, 3-5, >5); BMI (<18, 18-24.9, 25-29.9, >=30 kg/m^2); Region (Northern, Central, Mexico City, and Southern); and Indigenous status (non-indigenous, indigenous based on language spoken). The inclusion of these confounder variables was based on the covariates that previous studies included when determining the association between HFI and chronic diseases, as well as on known risk factors for IDA (18).

Data Analyses

The sample for this study included 18,753 12-49 years old women, representing 34,705,499 women of reproductive age living in Mexico. Of the 18,753 women included in the original analytical sample, 16,944 of them (representing 30,854,460 women) did not have missing data for any of the variables of interest and were included in the multiple regression analyses. Thus the attrition rate due to missing data is 9.65%. The attrition bias analyses due to missing data are presented in Table 1. Overall, participants with missing data were more likely to be more food secure, of higher socio-economic status, urban, and of higher education. A discussion of the potential implications of this potential bias is included in the discussion section of the manuscript.

Statistical analyses

Univariate and multiple regression analyses were conducted using the “svy” module from STATA (version 12). Under this function the estimates for complex survey design were adjusted by incorporating an expansion factor, strata, and primary unit parameters, ensuring that our results were an accurate representation of the Mexican population. The population was characterized by comparing outcomes and covariates across IDA status (yes/no). Multiple binomial logistic regression was used to examine the independent association between HFI and IDA. In the model, the independent variable was HFI entered as a 4-level categorical variable**.** The covariates age, area of residence, socio-economic level, number of pregnancies, region, and indigenous status were also entered as categorical variables. BMI was entered as a categorical variable in the univariate analysis and as a continuous variable in the multivariate regression analysis, as no significant association (95% CI) was observed when BMI was entered as 4-level categorical variable.

For categorical variables, the univariate results were shown as percentages, along with their respective 95% confidence interval values. Results were considered statistically different across HFI categories if the 95% CI’s didn’t overlap (ie. corresponding to a p-value < 0.05). Multiple regression findings were presented using Adjusted Odds Ratios (AOR) and their corresponding 95% confidence intervals (95% CI). The findings were considered significant if the confidence intervals didn't include the value of 1. Collinearity in the multiple regression was not identified among any of the confounders (Variance Inflation Factor (VIF) for all variables was < 3; and the tolerance was 0.4 or greater).

Ethical considerations

Study participants signed a consent form before taking part in the survey. The ENSANUT 2012 survey and consent form was approved by the Ethics Committee of the National Institute of Public Health. All the information used in the analyses is unidentifiable public domain data, thus exempt from IRB review at the Yale School of Public Health.

Results

Sample characteristics and Univariate analyses: Household Food Insecurity and Iron Deficiency Anemia

The prevalence of women of reproductive age who had IDA was 11.83% (Table 2). Most of the households experienced mild, moderate, or severe food insecurity (43.36%, 18.84%, and 11.26%, respectively), and only 26.54% were food secure (Table 2). The prevalence of household food security (22.60% vs. 27.07 %) was lower among women with IDA than among women without IDA. However, with respect to their HFI severity profiles the IDA and non-IDA groups were not significantly different (Table 2). Mild HFI (42.34% vs. 43.50%) was lower among women with IDA than among women without IDA. By contrast, the prevalence of moderate (22.04% vs. 18.41%) and severe HFI (13.01% vs. 11.02%) tended to be higher among women with IDA than women without IDA although none of these differences were statistically significant (Table 2).

About a third of the women were educated past secondary school (35.61%), 35.57% finished just a secondary school, and 28.82% completed less than secondary school (Table 2). The association between women's education and IDA status was not statistically significant (Table 2). Though not shown in Table 2, only 2.62% had less than a primary school education (no education or just pre-school), 26.21% had just a primary school education, 35.61% were college educated (including technical/trade schools), and only 0.5% had masters/doctorate levels of education.

A substantial proportion of women were overweight and obese (30.84% and 28.29%, respectively), 37.61% were in the normal weight range, and only 3.26% were underweight (Table 2). Women were more likely to have normal weight if they didn't have IDA vs. if they have had IDA (33.52% vs. 38.14%, respectively). By contrast, the prevalence of overweight was higher among the women with IDA (35.21% vs. 30.27%). There were no significant differences in the prevalence of underweight or obesity as a function of IDA status (Table 2).

Most women were between the ages of 12-20 (29.60%), 26.20% were between the ages of 21-30, 25.75% were between 31-40, and 18.44% were between 41-49 (Table 2). Women with IDA had an "older" age distribution compared to their counterparts without IDA. While there was no significant difference in the proportion of 21-30 year olds across IDA status, the proportion of 12-20 year olds was higher in the non-IDA group compared with their IDA counterparts (19.54% vs. 30.95%). By contrast a significantly higher proportion of 31-40 (31.09% vs. 25.04%) and 41-49 (24.46% vs. 17.63%) were in the IDA group (Table 2).

The majority of the women were in a high socio-economic category (40.25%), while 33.09% and 26.66% were in the medium and low categories, respectively (Table 2). A significantly higher prevalence of low socioeconomic women were in the IDA group (31.07% vs. 26.07%). The proportion of women in the middle socioeconomic group was not significantly different across IDA status. A significantly greater prevalence of women with a higher socio-economic profile was found in the non-IDA vs. the IDA group (40.99% vs. 34.78%)(Table 2).

About one third of the women had not been pregnant before (35.58%), only 4.19% had had > 5 pregnancies, 29.87% had had 1-2 pregnancies, and 30.37% had been pregnant 3-5 times (Table 2). Women without IDA were more likely to be nulliparous (22.68% vs. 37.31%). Although the prevalence of women with 1-2 pregnancies was not significantly greater among IDA women, there was a significantly greater number of women with 3-5 pregnancies (38.09% vs. 29.33%) and >5 pregnancies (5.68% vs. 3.99%) in the IDA vs. non-IDA group, respectively (Table 2).

About 18.55% of the women lived in Mexico City (and its surrounding metropolitan areas), 19.29% in the Northern, 29.99% in the Central, and 32.17% in the Southern regions (Table 2). The prevalence of women who lived in Northern and Mexico City regions was not statistically in the IDA and non-IDA groups. In the IDA group there was a lower prevalence of women who lived in the Central region compared to the non-IDA group (26.40% vs. 30.47%).

By contrast a higher proportion of IDA women lived in the Southern region (37.11% vs. 31.51%)(Table 2).

The vast majority of the women identified themselves as not being of indigenous ethnicity, based on language spoken criteria (94.07%), and the majority lived in urban areas (77.51%)(Table 2). The prevalence of both, ethnicity and urban (vs. rural) dwelling was not statistically different between the IDA and non-IDA group (Table 2).

IDA, Household Food Insecurity: Multiple regression analyses

The odds of having IDA were 33% higher among women living in moderate food insecure households and 36% higher among those living in severely FI households compared with their counterparts living in food secure households. For BMI, there was a slight protective association for IDA (AOR: 0.98 (95%CI: 0.97-0.99) for every increase in kg/m2). There was a strong association of IDA with age, as the odds of having IDA were 69% higher among 31-40 years old women and 91% higher among those 41-49 compared to women between the ages of 12-20. Women with 1-2, 3-5 and > 5 pregnancies had similar higher odds of IDA (1.55, 1.52, and 1.57, respectively) compared to women who had no pregnancies (Table 3). Women who lived in the Southern region at the time of the survey had 34% greater odds of being anemic compared to women who lived in the northern region (Table 3).

Education, socio-economic level, ethnicity and locality were not significantly associated with IDA (Table 3).

Discussion

Our findings suggest that HFI is an independent risk factor for IDA in Mexican women of reproductive age. It is important to note that the association was evident for medium and severe HFI but not for mild HFI, compared to food secure households. Our findings support results from three studies that have also identified HFI as a predictor of IDA among US children and adolescents using data from NHANES (18-20). To the best of our knowledge, this is the first study to ever examine the relationship of HFI and IDA in a nationally representative sample of women of reproductive age in a low or middle income country.

We hypothesize that HFI may lead to IDA in this sample of women from Mexico through three pathways. First, a lack of adequate consumption of foods rich in iron. Second through a diet lacking sufficient intake of micronutrients that may facilitate iron absorption and utilization (such as vitamin C, vitamin A, folate), and third by consuming large amounts of foods rich in phytonutrients such as phytic acid that may decrease the absorption of iron. Previous studies in the US examining HFI and micronutrient deficiencies, using scales similar to ELCSA, suggest that diets in food insecure households were lower in iron and other micronutrients, while higher in carbohydrates and fat (21, 26-28). Epidemiological studies in Mexico suggest that IDA is strongly linked to deficiencies in micronutrients that increase the bioavailability of iron, namely vitamin A, folate and vitamin C (29, 30). In a Mexican national survey from 1999 among Mexican women of Reproductive age, Villalpando et al. (29) noted that vitamin C deficiency was as high as 40%, with no differences found between rural and urban women. However these deficiencies affected more strongly women of a lower socio-economic status and also those who were older adults. Backstrand et al. (30) noted in a sample of women in rural central Mexico, that higher ascorbic acid intakes, but not higher heme-iron and non-heme iron predicted a lower risk of IDA among non-pregnant women. As corn is a main staple in Mexico, iron absorption may be inhibited by its high content of phytate (29). Thus, a higher quality diet, rich in other micronutrients, especially vitamin C is essential to counteract this negative effect (29).

The multivariate regression showed a significant, protective association of higher BMI on anemia. These results were contrary to our univariate analyses, which suggested a greater prevalence of anemia among overweight individuals and a lower prevalence among normal individuals. The differences between the univariate and multivariate results may be explained by the fact that the multivariate model adjusted for confounding factors such as age and the number of pregnancies. Overall, the relationship between IDA and adiposity remain poorly understood from a biological perspective. Supporting our findings from the univariate analyses, a past epidemiological study from the National Nutrition Survey in 1999 (ENN1999) also noted a higher prevalence of IDA in obese Mexican women, citing adiposity related inflammation as a more probable cause of IDA rather than an inadequate dietary iron intake (31). Epidemiological studies in industrialized countries (i.e. US) show that obese individuals are at higher risk of IDA than normal weight individuals, although IDA prevalence is generally low in the selected populations (31, 34). In contrast, epidemiological studies in middle-income countries such as Mexico (Peru, China, and Egypt), have noted a similar inverse relationship found in our multivariate analysis between BMI and IDA (32, 33).

The strong association between IDA and age, confirms previous analyses of the Mexican ENSANUT 2012, that suggest a progressive depletion of iron stores in women as aging occurs (Table 2) (13). The odds of having IDA increased monotonically with parity, highlighting the need to improve iron-fortification among pregnant women (14).

Our findings indicate that IDA was not significantly limited to locality (rural or urban). Previous findings in Mexico have shown similar results, which point to a need to address IDA in both urban and rural areas (13). Factors that were not significantly associated with anemia included education level and socio-economic category, suggesting that IDA is a problem affecting all levels of Mexican society.

The Southern region had the highest rates of anemia which is consistent with findings from previous ENSANUT surveys (13). This Southern region also has the highest rates of poverty, rural dwellers, and indigenous populations.

Our study has four main limitations. First, our multivariate regression only used non-missing data and the percentage of the sample with "missing values" was 9.65%, due to participants with missing data on HFI (1.2% missing), weight (4.4% missing), and/or number of pregnancies (4.4% missing) (Table 1). Although IDA status was statistically similar between the missing and non-missing groups, there were statistical differences between most of the confounders (education, age, SES, number of pregnancies, region, and locality), thus the external validity of our results should be interpreted cautiously. Secondly, the time elapsed since the last pregnancy (i.e., the interpregnancy period) was not recorded, and it is possible that some women didn't know of their pregnancy status, thus we were unable to adjust for these key IDA confounders in our analyses. Third, as dietary data was only available for a small subsample of ENSANUT 2012, we did not examine this pathway. Finally, as ENSANUT 2012 is a cross-sectional survey, we cannot understand the true temporal sequence of events, thus the possibility of reverse causality cannot be ruled out. In this case, it is possible that IDA itself leads to HFI, as women with IDA may have an impaired tissue oxidative capacity that decreases their wellbeing and productivity, resulting in reduced financial stability and HFI.

In summary, interventions that target HFI may have a significant effect on public health in Mexico, as IDA is a serious cause of maternal mortality and disability in women of reproductive age.

References

1. Pérez-Escamilla R, Segall-Corrêa Ana. Food insecurity measurement and indicators. Revista de Nutrição, 2008;21(Suppl.), 15s-26s.

2. Comité Científico ELCSA. Escala Latinoamericana y Caribeña de Seguridad Alimentaria (ELCSA): Manual de uso y aplicación. Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO), Oficina Regional para América Latina, Chile, 2012.

3. Mundo-Rosas, V., Shamah-Levy, T., & Rivera-Dommarco, J. A. Epidemiología de la inseguridad alimentaria en México. Salud Pública de México. 2013;55.

4. Vozoris NT, Tarasuk VS. Household food insufficiency is associated with poorer health. J Nutr. 2003;133(1):120-6.

5. Seligman HK, Laraia BA, Kushel MB. Food insecurity is associated with chronic disease among low-income NHANES participants. J Nutr. 2010;140(2):304.

6. Rosas, L. G., Harley, K., Fernald, L. C., Guendelman, S., Mejia, F., Neufeld, L. M., & Eskenazi, B. Dietary associations of household food insecurity among children of Mexican descent: results of a binational study. Journal of the American Dietetic Association, 2009;109(12), 2001-2009.

7. Stuff JE, Casey PH, Szeto KL, Gossett JM, Robbins JM, Simpson PM, Connell C, Bogle ML. Household food insecurity is associated with adult health status. J Nutr. 2004;134(9):2330-5.

8. Hamelin AM, Beaudry M, Habicht JP. Characterization of household food insecurity in Québec: food and feelings. Soc Sci Med. 2002;54(1):119-32.

9. Whitaker, Robert C., Shannon M. Phillips, and Sean M. Orzol. "Food insecurity and the risks of depression and anxiety in mothers and behavior problems in their preschool-aged children." Pediatrics, 2006;118.3 e859-e868.

10. Huddleston-Casas, C., Charnigo, R., & Simmons, L. A.. Food insecurity and maternal depression in rural, low-income families: a longitudinal investigation. Public Health Nutrition. 2009;12(08), 1133-1140.

11. Institute for Health Metrics and Evaluation. The Global Burden of Disease: Generating Evidence, Guiding Policy. Seattle, WA: IHME, 2013.

12. WHO. Benoist, B. D., McLean, E., Egll, I., & Cogswell, M. Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia. World Health Organization;2008.

13. Shamah-Levy, T., Villalpando, S., Mundo-Rosas, V., la Cruz-Góngora, D., Mejía-Rodríguez, F., & Méndez Gómez-Humarán, I. Prevalencia de anemia en mujeres mexicanas en edad reproductiva, 1999-2012. Salud Pública de México, 2013;55.

14. Goonewardene, M., Shehata, M., & Hamad, A. Anaemia in pregnancy. Best Practice & Research Clinical Obstetrics & Gynaecology, 2012;26(1), 3-24.

15. Walter, Tomas, et al. "Iron deficiency anemia: adverse effects on infant psychomotor development." Pediatrics. 2008;84.1: 7-17.

16. Allen, Lindsay H. "Anemia and iron deficiency: effects on pregnancy outcome." The American journal of clinical nutrition 2000;71.5: 1280s-1284s.

17. Colomer, Julia, et al. "Anaemia during pregnancy as a risk factor for infant iron deficiency: report from the Valencia Infant Anaemia Cohort (VIAC) study." Paediatric and Perinatal Epidemiology. 1990;4.2: 196-204.

18. Skalicky, A., Meyers, A. F., Adams, W. G., Yang, Z., & Frank, D. A. Child food insecurity and iron deficiency anemia in low-income infants and toddlers in the United States. Maternal and child health journal. 2006;10(2), 177-185.

19. Eicher-Miller, H. A., Mason, A. C., Weaver, C. M., McCabe, G. P., & Boushey, C. J. Food insecurity is associated with iron deficiency anemia in US adolescents. The American journal of clinical nutrition. 2009;90(5), 1358-1371.

20. Park, K., Kersey, M., Geppert, J., Story, M., Cutts, D., & Himes, J. H. Household food insecurity is a risk factor for iron-deficiency anaemia in a multi-ethnic, low-income sample of infants and toddlers. Public health nutrition. 2009;12(11), 2120.

21. Dixon, L. B., Winkleby, M. A., & Radimer, K. L. Dietary intakes and serum nutrients differ between adults from food-insufficient and food-sufficient families: Third National Health and Nutrition Examination Survey, 1988–1994. J Nutr. 2001;131(4), 1232-1246.

22. World Health Organization. The prevalence of anemia in women: a tabulation of available information. 2nd edition. Ginebra: WHO, 1992.

23. Yip R. Significance of an abnormally low or high hemoglobin concentration during pregnancy: special consideration of iron nutrition. Am J Clin Nutr 2000;72 Suppl:272S-279S.

24. Cohen JH, Hass JD. Hemoglobin correction factors for estimating the prevalence of iron deficiency anemia in pregnant women residing at high altitudes in Bolivia. Pan Am J Public Health. 1999;6(6):392-399.

25. Gutiérrez, J. P. Clasificación socioeconómica de los hogares en la ENSANUT 2012. salud pública de México. 2013;55.

26. Cristofar, S. P., & Basiotis, P. P. Dietary intakes and selected characteristics of women ages 19–50 years and their children ages 1–5 years by reported perception of food sufficiency. Journal of Nutrition Education. 1992;24(2), 53-58.

27. Tarasuk, V. S. Household food insecurity with hunger is associated with women's food intakes, health and household circumstances. J Nutr. 2001;131(10), 2670-2676.

28. Kaiser, Lucia L., et al. "Food security and nutritional outcomes of preschool-age Mexican-American children." Journal of the American Dietetic Association 2002;102.7:924-929.

29. Villalpando, S., Montalvo-Velarde, I., Zambrano, N., García-Guerra, A., Ramírez-Silva, C. I., Shamah-Levy, T., & Rivera, J. A. Vitamins A, and C and folate status in Mexican children under 12 years and women 12-49 years: A probabilistic national survey. Salud Publica de Mexico. 2003;45,508-519.

30. Backstrand, J. R., Allen, L. H., Black, A. K., de Mata, M., & Pelto, G. H. Diet and iron status of nonpregnant women in rural Central Mexico. The American journal of clinical nutrition. 2002;76(1), 156-164.

31. Cepeda-Lopez, A. C., Osendarp, S. J., Melse-Boonstra, A., Aeberli, I., Gonzalez-Salazar, F., Feskens, E., & Zimmermann, M. B. Sharply higher rates of iron deficiency in obese Mexican women and children are predicted by obesity-related inflammation rather than by differences in dietary iron intake. Am J Clin Nutr. 2011;93(5), 975-983.

32. Qin, Y., Melse-Boonstra, A., Pan, X., Yuan, B., Dai, Y., Zhao, J., ... & Shi, Z. Anemia in relation to body mass index and waist circumference among chinese women. Nutrition journal 2013;12(1), 10.

33. Eckhardt, C. L., Torheim, L. E., Monterrubio, E., Barquera, S., & Ruel, M. T. The overlap of overweight and anaemia among women in three countries undergoing the nutrition transition. European journal of clinical nutrition, 2008;62(2), 238-246.

34. Cepeda-Lopez, A. C., Aeberli, I., & Zimmermann, M. B. Does obesity increase risk for iron deficiency? A review of the literature and the potential mechanisms. International Journal for Vitamin and Nutrition Research, 2010;80(45), 263-270.

Table 1. Characteristics of Missing Data compared to Sample Data n=16,944 (excluding all "missing" data)

Variable	Missing Data Characteristics	Sample Characteristics (excluding Missing)	
	n, (N Thousands), % ***[95% CI]***	***n, (N Thousands), %*** ***[95% CI]***	***P-Value***
Anemia (n=18,753)			P=0.135
Yes	238 (525.05) 13.63 [11.23-16.46]	2,049 (3,581.85) 11.61 [10.85-12.42]	
No	1571 (3,325.99) 86.37 [83.54-88.77]	14,895 (27,272.61) 88.39 [87.58-89.15]	
Total	1,809 (3851.04) 11.10 [10.24-12.01]	16,944 (30,854.46) 88.90 [88.00-90.00]	
Food Insecurity (N=18,527)			P=0.002
Food Secure	482 (1,093.45) 32.62 [28.88-36.58]	4,026 (7,985.59) 25.88 [24.66-27.14]	
Mild	674 (1,426.1) 42.53 [38.44-46.74]	7,535 (1,3405.30) 43.45 [42.16-44.74]	
Moderate	264 (503.14) 15.00 [12.44-17.99]	3,361 (5,942.30) 19.26 [18.23-20.33]	
Severe	163 (329.87) 10.00 [0.076-12.70]	2,022 (3,521.28) 11.41 [10.61-12.26]	
Total	1,583 (3,352.56) 9.80 [9.00-10.66]	16,944 (30,854.46) 90.20 [89.34-91.00]	
Education (n=18,753)			P = 0.000
<Secondary	564 (1,037.21) 26.93 [23.83-30.27]	5,607 (8,966.32) 29.06 [27.81-30.34]	
= Secondary	625 (1,176.55) 30.55	6,647 (11,167.52) 36.19	

	[27.24-34.08]	[35.06-37.34]	
>Secondary	620 (1,637.28) 42.52 [38.70-46.43]	4,690 (10,720.63) 34.75 [33.33-36.19]	
Total	1,809 (3,851.04) 11.10 [10.24-12.01]	16,944 (30,854.46) 88.90 [87.99-89.75]	
BMI (n=17,930)			P = 0.493
Low	66 (97.34) 4.22 [2.76-6.41]	682(983.54) 3.19 [2.84-3.58]	
Normal	425 (890.75) 38.59 [34.04-43.38]	6,261 (11,580.26) 37.53 [36.39-38.69]	
Overweight	261 (729.11) 31.60 [26.64-37.01]	5,195 (9,499.51) 30.79 [29.73-31.86]	
Obese	234 (590.46) 25.59 [21.03-30.75]	4,806 (8,791.16) 28.49 [27.42-29.59]	
Total	986 (2,307.66) 6.96 [6.18-7.83]	16,944 (30,854.46) 93.04 [92.18-93.82]	
Age Group (n=18,753)			P = 0.000
12 to 20	706 (1,129.81) 29.34 [26.46-32.39]	5,739 (9,143.72) 29.63 [28.63-30.66]	
21 to 30	470 (1,278.72) 33.20 [29.46-37.17]	3,419 (7,815.30) 25.33 [24.21-26.48]	
31 to 40	393 (1,129.81) 21.26 [18.14-24.75]	4,536 (8,119.56) 26.31 [25.28-27.38]	
41 to 49	240 (623.94) 16.20 [13.39-19.47]	3,250 (5,775.88) 18.72 [17.81-19.66]	
Total	1,809 (3,851.04) 11.10 [10.24-12.01]	16,944 (30,854.46) 88.90% [87.99-89.76]	
Socio Economic Level (N=18,753)			P = 0.000
Low	572 (891.77) 23.16 [20.19-26.42]	5,794 (8,362.08) 27.10 [25.68-28.58]	

Medium	592 (1,137.06) 29.53 [26.25-33.03]	5,893 (10,345.24) 33.53 [32.11-34.98]	
High	645 (1,822.20) 47.32 [43.05-51.63]	5,257 (12,147.14) 39.37 [37.64-41.13]	
Total	1,809 (3,851.04) 11.10 [10.24-12.01]	16,944 (30,854.46) 88.90 [87.99-89.76]	
Pregnancy (N=17,919)			P = 0.000
0	180 (357.62) 19.27 [15.74-23.36]	6,278 (11,280.00) 36.56 [35.47-37.66]	
1 to 2	438 (808.00) 43.53 [38.50-48.70]	4,401 (8,962.78) 29.05 [27.97-30.15]	
3 to 5	317 (637.96) 34.37 [29.73-39.33]	5,323 (9,294.45) 30.12 [29.07-31.20]	
>5	40 (52.48) 2.83 [1.79-4.43]	942 (1,317.23) 4.27 [3.88-7.00]	
Total	975 (1,856.07) 5.67 [5.09-6.33]	16,944 (30,854.46) 94.33 [93.67-94.92]	
Region (n=18,753)			P = 0.000
Northern	563 (808.13) 20.99 [18.63-23.55]	4,232 (5,887.80) 19.08 [18.27-19.92]	
Center	667 (1,004.62) 26.09 [23.04-29.38]	6,084 (9,403.67) 30.48 [29.38-31.60]	
Mexico City	181 (1,227.65) 31.88 [27.39-36.72]	831 (5,208.49) 16.88 [15.57-18.28]	
Southern	398 (810.64) 21.05 [18.36-24.02]	5,797 (10,354.51) 33.56 [32.36-34.78]	
Total	1,809 (3,851.04) 11.10 [10.24-12.01]	16,944 (30,854.46) 88.90 [87.99-89.76]	
Ethnicity (n=18,753)			P = 0.164
Non-Indigenous	1,684 (3,667.24) 95.23 [93.24-96.65]	15,539 (28,979.44) 93.92 [93.07-94.68]	

Indigenous	125 (183.80) 4.77 [3.35-6.76]	1,405 (1,875.02) 6.08 [5.32-6.93]	
Total	1,809 (3,851.04) 11.10 [10.24-12.01]	16,944 (30,854.46) 88.90 [87.99-89.76]	
Locality (n=18,753)			P = 0.001
Urban	1,267 (3,166.29) 82.22 [79.42-84.71]	10,977 (23,734.03) 76.92 [75.91-77.90]	
Rural	542 (684.75) 17.78 [15.29-20.58]	5967 (7,120.43) 23.08 [22.10-24.09]	
Total	1,809 (3,851.04) 11.10 [10.24-12.01]	16,944 (30,854.46) 88.90 [87.99-89.76]	

Table 2. Description of the sample overall and by Iron Deficiency Anemia(IDA) status[a,b]. Mexico, ENSANUT 2012

Variable	All	IDA	Non-IDA
Food Insecurity (n=18,527) (N= 34,207,022)	*n, (N Thousands), % [95% CI]*	*n, (N Thousands), % [95% CI]*	*n, (N Thousands), % [95% CI]*
Food Secure	4,508 (9,079.04) 26.54 [25.35-27.77]	483 (917.23) 22.60 [19.85-25.62]	4,025 (8,161.82) 27.07 [25.77-28.42]
Mild	8,209 (14,831.39) 43.36 [42.12-44.61]	980 (1,718.08) 42.34 [39.15-45.59]	7,229 (13,113.32) 43.50 [42.16-44.84]
Moderate	3,625 (6,445.44) 18.84 [17.89-19.84]	478 (894.52) 22.04 [19.44-24.89]	3,147 (5,550.92) 18.41 [17.41-19.45]
Severe	2,185 (3,851.15) 11.26 [10.49-12.07]	321 (528.01) 13.01 [11.05-15.26]	1,864 (3,323.14) 11.02 [10.22-11.88]
Education (n=18,753) (N= 34,705,499)			
<secondary	6,171 (10,003.52) 28.82 [27.65-30.02]	870 (1,334.29) 32.49 [29.50-35.63]	5,301 (8,669.23) 28.33 [27.09-29.60]
=Secondary	7,272 (12,344.07) 35.57 [34.54-36.61]	849 (1,473.39) 35.88 [32.63-39.25]	6,423 (10,870.68) 35.53 [34.46-36.61]
>Secondary	5,310 (12,357.91) 35.61 [34.27-36.97]	568 (1,299.21) 31.63 [28.56-34.88]	4,742 (11,058.69) 36.14 [34.72-37.58]
BMI (n=17,930) (N=33162115)			
Low	748 (1,080.87) 3.26 [2.92-3.64]	75 (100.12) 2.60 [1.93-3.49]	673 (980.75) 3.35 [2.97-3.77]
Normal	6,686 (12,471.01) 37.61 [36.50-38.73]	738 (1,293.21) 33.52 [30.33-36.87]	5,948 (11,177.80) 38.14 [36.97-39.33]
Overweight	5,456 (10,228.62) 30.84 [29.80-31.91]	724 (1,358.33) 35.21 [31.97-38.59]	4,732 (8,870.29) 30.27 [29.19-31.38]
Obese	5,040 (9,381.61) 28.29 [27.26-29.35]	620 (1,106.21) 28.67 [25.51-32.06]	4,420 (8,275.40) 28.24 [27.16-29.35]
Age Group (n=18,753) (N=34,705,499)			

12 to 20	6,445 (10,273.53) 29.60 [28.68-30.54]	564 (802.60) 19.54 [17.07-22.28]	5,881 (9,470.93) 30.95 [29.95-31.97]
21 to 30	3,889 (9,094.02) 26.20 [25.15-27.29]	471 (1,022.95) 24.91 [22.11-27.93]	3,418 (8,071.07) 26.38 [25.24-27.55]
31 to 40	4,929 (8,938.13) 25.75 [24.75-26.78]	728 (1,276.85) 31.09 [28.18-34.16]	4,201 (7,661.28) 25.04 [23.98-26.12]
41 to 49	3,490 (6,399.82) 18.44 [17.56-19.35]	524 (1,004.50) 24.46 [21.46- 27.73]	2,966 (5,395.33) 17.63 [16.71-18.59]
Socio Economic Level (N=18,753) (N=34,705,499)			
Low	6,366 (9,253.85) 26.66 [25.28-28.10]	908 (1,276.16) 31.07 [28.28-34.01]	5,458 (7,977.70) 26.07 [24.65-27.55]
Medium	6,485 (11,482.30) 33.09 [31.72-34.48]	785 (1,402.43) 34.15 [30.94-37.50]	5,700 (10,079.87) 32.94 [31.52-34.40]
High	5,902 (13,969.34) 40.25 [38.57-42.00]	594 (1,428.30) 34.78 [31.24-38.49]	5,308 (12,541.04) 40.99 [39.25-42.75]
Pregnancy (N=17,919) (N=32,710,526)			
0	6,458 (11,637.62) 35.58 [34.52-36.65]	533 (878.11) 22.68 [20.01-25.59]	5,925 (10,759.51) 37.31 [36.14-38.49]
1 to 2	4,839 (9,770.78) 29.87 [28.81-30.95]	662 (1,298.67) 33.54 [30.39-36.85]	4,177 (8,472.11) 29.38 [28.25-30.54]
3 to 5	5,640 (9,932.41) 30.37 [29.35-31.40]	837 (1,474.86) 38.09 [34.89-41.41]	4,803 (8,457.56) 29.33 [28.26-30.42]
>5	982 (1,369.72) 4.19 [3.81-4.60]	165 (219.99) 5.68 [4.59-7.02]	817 (1,149.72) 3.99 [3.60-4.42]
Region (n=18,753) (N=34,705,499)			
Northern	4,795 (6,695.92) 19.29 [18.56-20.05]	519 (702.57) 17.11 [15.26-19.13]	4,276 (5,993.36) 19.59 [18.80-20.40]
Center	6,751 (10,408.29) 29.99 [28.98-31.02]	696 (1,084.04) 26.40 [23.72-29.26]	6,055 (9,324.26) 30.47 [29.39-31.57]

Mexico City	1,012 (6,436.14) 18.55 [17.38-19.77]	118 (796.17) 19.39 [16.05-23.23]	894 (5,639.98) 18.43 [17.22-19.71]
Southern	6,195 (11,165.14) 32.17 [31.09-33.27]	954 (1524.12) 37.11 [34.16-40.17]	5,241 (9,641.02) 31.51 [30.37-32.67]
Ethnicity (n=18,753) (N=34,705,499)			
Non-Indigenous	17,223 (32,646.69) 94.07 [93.23-94.80]	2,052 (3,823.05) 93.09 [91.47-94.42]	15,171 (28,823.64) 94.20 [93.37-94.93]
Indigenous	1,530 (2,058.81) 5.93 [5.20-6.76]	235 (2,83.85) 6.91 [5.58-8.53]	1,295 (1,774.97) 5.80 [5.07-6.64]
Locality (n=18,753) (N=34,705,499)			
Urban	12,244 (26,900.32) 77.51 [76.57-78.42]	1,475 (3,141.08) 76.48 [74.00-78.81]	10,769 (23,759.24) 77.65 [76.64 -78.63]
Rural	6,509 (7,805.18) 22.49 [21.58-23.43]	812 (965.81) 23.52 [21.19-26.01]	5,697 (6,839.37) 22.35 [21.37 -23.36]

[a] Prevalence of anemia was 11.83%(n=2,287) for the sample (N=18,753).
[b] Pregnant women <11 g/dL. Non-pregnant women <12 g/dL (sea level)

Table 3. Household Food Insecurity, Anemia: Multiple binary logistic regression. Mexico, ENSANUT 2012

Characteristic	*Adjusted OR N=16,944 (95% CI)*
Food Insecurity	
Food Secure	1.00
Mild	1.16 (0.96 – 1.41)
Moderate	1.33 (1.05 – 1.68)
Severe	1.36 (1.04 – 1.77)
Education	
<Secondary	1.00
= Secondary	1.02 (0.83-1.24)
>Secondary	0.93 (0.74-1.17)
BMI	
(kg/m2)	0.98 (0.97-0.99)
Age Group	
12 to 20	1.0
21 to 30	1.31 (0.98 - 1.75)
31 to 40	1.69 (1.25-2.28)
41 to 49	1.91 (1.36-2.67)
Socio Economic Level	
Low	1.00
Medium	1.01 (0.85-1.20)
High	0.87 (0.69-1.08)
Pregnancy	
0	1.0
1 to 2	1.55 (1.20-1.99)
3 to 5	1.52 (1.15-2.01)
>5	1.57 (1.09-2.27)
Region	
Northern	1.00
Center	0.98 (0.81-1.19)
Mexico City	1.08(0.78-1.49)
Southern	1.34 (1.11-1.60)
Ethnicity	
Non-Indigenous	1.00
Indigenous	0.90(0.70-1.15)
Locality	

Urban	1.00
Rural	0.91(0.77-1.08)

Acknowledgments:

The authors thank Veronica Mundo Rosas, Ana Lozada-Tequeanes, Erik Rolando Lopez, and Ignacio Méndez-Gómez-Humarán from the National Institute of Public Health in Mexico for their help. R.P.E., T.S.L., N.C.F., designed research and N.C.F. performed the statistical analyses. T.S.L. provided essential the dataset for the research. T.S.L. and R.P.E supplied technical assistance and advice. N.C.F., R.P.E., and T.SL. wrote paper and N.C.F. had primary responsibility for the final content. All authors read and approved the final manuscript.