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ORIGINAL ARTICLE

Household food insecurity and its association with anaemia in Mexican children: National Health and Nutrition Survey 2012

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Abstract

Objectives To assess the association between household food insecurity (FI) and the presence of anaemia among Mexican children who were between 12 and 59 months old, and to determine whether this association differs by geographical regions.

Methods We analysed 7468 children of ages between 12 and 59 months, based on data from the 2012 National Health and Nutrition Survey (*ENSANUT 2012*). Haemoglobin was measured in capillary blood. Household FI levels were defined according to the Latin American and Caribbean Food Security Scale. An ordinal logistic regression model was developed to assess the relationship between FI and anaemia. The interaction between geographical regions and FI was determined.

Results The highest proportion of anaemia occurred in children with severe household FI (24.3%), compared to those from households with food security (21.2%). Children from severe FI households have a higher adjusted prevalence of anaemia than those from households with food security. FI and anaemia were associated mainly among children residing in the southern region of Mexico.

Conclusions Our findings can contribute to a better understanding of FI and anaemia in children and to strengthen interventions to address these problems.

Keywords Anaemia · Food security · Preschool children · Mexico · Nutrition survey · Food supply

Introduction

Childhood anaemia is one of the comorbidities caused largely by insufficient consumption of iron, vitamin A, B-6 (pyridoxine), B-12 (cobalamin), B-2 (riboflavin) and folic acid (OMS 2004) and has been associated with increased infant morbidity and mortality (UNICEF, WHO 2014). In the population from 6 to 59 months old, around 46% globally and 29.1% in Latin America suffer from anaemia (WHO 2015).

In addition to the factors related to the consumption of nutrients, it is known that anaemia has multiple causes related to adverse environmental and socio-demographic conditions such as lack of access to health services, poverty

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and food insecurity; this last one is a condition defined as lack of access to healthy food containing the nutrients required for a healthy and active life (FAO 2017). The importance of these causes varies by region (USAID 2003; Iglesias et al. 2019).

Currently, the number of studies documenting the association between food insecurity and anaemia in children has increased. However, results of previous studies are contradictory. Systematic review and a recently published meta-analysis documented that age and other variables in the population have a significant impact on this association (Moradi et al. 2018). In a multi-ethnic sample of infants, food insecurity increased the risk of anaemia because of their rapid growth rates and inadequate intakes of dietary iron (Park et al. 2009). However, in children and adolescents, food insecurity did not show any effect on the risk of anaemia, possibly because mothers provide maternal care and full meals for their children by reducing their own intake (Speirs et al. 2016).

Some studies explained that surveillance for anaemia is challenging and requires a simultaneous understanding of the epidemiology of its underlying causes (Kassebaum et al. 2014); these studies also suggest the need to study risk factors at a fine geographical scale because determinants of haemoglobin vary both between and within countries (Stevens et al. 2013).

In Mexico, as in many Latin American countries, there is high economic inequality, as well as unequal access to basic services and health care, which is manifested in the welfare of specific population groups. The regions with the greatest economic backwardness in Mexico have a minimum level of development in education, health, and infrastructure, which affects the well-being of their population (Moreno 2008). Regions within Mexico have been defined in order to study health and nutrition problems and have been used in previous epidemiologic analyses to make comparisons (Rivera et al. 2002, 2008). These regions are composed of states that share geographic proximity, in addition to having similar socioeconomic and health characteristics.

Approximately one-third of Mexican households suffer from food insecurity in its most severe stages (Mundo-Rosas et al. 2013). Despite a gradual decline over the past decades, anaemia still affects a large proportion of children under five years of age (23.3%) and remains one of the main public health problems in Mexico's agenda (De la Cruz-Góngora et al. 2018). The southern region of the country is one of the most affected by food insecurity (33.9%) and the prevalence of anaemia in children (23.7%) (Gutiérrez et al. 2012).

Considering the high levels of FI and anaemia in Mexico and its impact on the attainment of optimal growth and development during the first years of life, the objectives of the present work were to assess the association between household FI levels and the presence of anaemia among Mexican children aged 12 to 59 months and to determine whether this association differs by geographical regions.

Methods

Study design and population

Data were drawn from the 2012 Mexican National Health and Nutrition Survey (*ENSANUT-2012*, Spanish acronym). The ENSANUT-2012, which is representative at the national and regional levels, used a cross-sectional, multistage probabilistic design with data disaggregated by region (North, Center and South). Details of the survey design and methodology have been published elsewhere (Gutiérrez et al. 2012, op cit).

In each of the households selected for the *ENSANUT*, a child between 12 and 59 months of age was randomly chosen to obtain a capillary haemoglobin measurement (Gutiérrez et al. 2012, op cit). Our analysis included 7468 children who were between 12 and 59 months old. The presence of anaemia was determined by measuring their capillary haemoglobin concentrations (Hb). Household food insecurity and its levels were estimated using the Latin American and Caribbean Food Security Scale (*ELCSA*, Spanish acronym). So far in Mexico, no other health and nutrition survey has been conducted that has such a robust sample size to make estimates in population sub-groups.

Analytical variables

Household food security (FS): We used the Latin American and Caribbean Food Security Scale (*ELCSA*) to measure FS, because it captures the experiences of all the household members (children and adults) during FS and food insecurity periods. The *ELCSA* questionnaire contains 15 items, each with two response options: "yes" or "no" (questions of the *ELCSA* are described in Appendix 1). The questions are addressed to the head of household or the person in charge of preparing the household meals. The reference period for each item is three months prior to application. *ELCSA* methodology classifies households into four categories (Appendix 3): food security, mild food insecurity, moderate food insecurity and severe food insecurity, according to the number of positive responses obtained and the presence of household members under 18 years of age (Pérez-Escamilla et al. 2007).

The *ELCSA* has demonstrated internal consistency in assessing the associations of food insecurity with health

outcomes and nutrition in the Mexican population (Shamah-Levy et al. 2014), and it has been validated in the US, Latin American and Mexican populations (Pérez-Escamilla et al. 2004; Álvarez et al. 2008).

Anaemia Capillary blood samples were drawn by finger prick and measured in a Portable Photometer HemoCue®. Haemoglobin concentration (Hb) was adjusted by altitude for each location (Cohen and Haas 1999). Anaemia was defined using the cut-off point recommended by the World Health Organization (WHO): Hb $<$ 110 g/L (OMS 2011).

Well-being conditions A well-being index was generated using a principal component analysis based on variables related to socioeconomic factors, housing conditions and family as well as household items: type of floor, wall and ceiling materials; the number of rooms used for sleeping; basic service infrastructure including water source and water disposal; the possession of an automobile, the number of household goods (refrigerator, washing machine, microwave, stove and water heater) and the number of electrical appliances (television, cable, radio, phone and computer). The first principal component was selected; it included 40.5% of the total variance with an eigenvalue of 3.24. Well-being conditions were obtained using the index distributional tertiles as class levels (Resano-Pérez et al. 2003).

Area of residence Localities were classified as rural ($<$ 2500 population) and urban ($\geq$ 2500 population).

Region of residence The 31 Mexican states and the capital, Mexico City, were grouped into three regions: North, Central-Mexico City and South (the states of each region are previously described).

Head of household gender The head of household's gender (male or female) was also included.

Parental educational level Parental educational level was classified into four groups: no education, basic education, high school and graduate or higher level.

Indigenous status: This variable was constructed at the household level. Children were considered indigenous if one of their parents spoke an indigenous language.

Nutritional status Three indices were constructed by measuring the length/height and weight of the children in centimetres and kilograms, respectively: length/height for age (H/A), length/height for weight (H/W), weight for age (W/A) and body mass index (BMI) for age. The indices were converted to z scores using the WHO growth standards-2006 (Blossner et al. 2011). Stunting, wasting and being underweight were defined where children registered z scores <-2. The cut-off point for overweight was a BMI z score $>+2$ standard deviations from the WHO growth standards (WHO 2006).

Statistical analysis

Prevalences of anaemia were obtained according to the household food insecurity categories and the covariables of interest (sex, age, indigenous status, region of residence, area, well-being conditions and nutritional status).

An ordinal logistic regression model was developed to assess the relationship between food insecurity and anaemia. The final model was adjusted by age, head of household gender, parental educational level, indigenous status, region of residence and tertiles of well-being conditions. The effect of interactions between geographical regions and food insecurity was checked.

The level of significance was defined as $P < 0.05$. Estimates were adjusted for complex survey design (use of sampling weights and clustered samples) using the SVY module from the Stata 12 Statistical Software (StataCorp. 2011. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP.).

Results

The prevalence of households with food insecurity was 76.1%, and the prevalence of anaemia in children was 22.8% (data not shown). Table 1 shows the prevalence of anaemia in the study population by socio-demographic and nutritional status, as well as by health characteristics. The prevalence of anaemia increased slightly as food insecurity increased: 21.2% in household food security and 24.3% in households with severe food insecurity. The highest prevalence of anaemia occurred in children with severe food insecurity (24.3%). The prevalence of anaemia decreased with increasing age of children. This was lower in the northern region (19.9%) in comparison with the central-Mexico City and southern regions (23.6%, $p = 0.048$ and $p = 0.028$, respectively). Nationwide, children living in the lowest tertile of well-being conditions had a higher prevalence of anaemia (26.2%) than those in the higher tertile of well-being. The prevalence of anaemia was also higher among indigenous children (27.0%) who had stunting (31.4%) and underweight (33.8%).

Table 2 presents the logistic regression model for the association between food insecurity and anaemia among Mexican children between ages 12 and 59 months. Anaemia was significantly associated with food insecurity and region, showing a differential pattern (interaction) described in Fig. 1. Protective factors for anaemia were children's age and medium and high tertiles of well-being conditions. As children were older, the prevalence of

Table 1 Prevalence of anaemia in Mexican children between ages 12 and 59 months, by socio-demographic, nutritional and health characteristics

	Whole children population			Anaemic children[a]		
	Sample n = 7468	%	$CI_{95\%}$	Sample n = 1706[b]	%	$CI_{95\%}$
Household food security						
Security	1657	23.9	22.3–25.6	367	21.2	18.5–24.2
Mild food insecurity	3418	44.8	43.1–46.4	777	23.2	21.1–25.5
Moderate food insecurity	1512	20.4	19.1–21.8	346	23.1	19.6–26.9
Severe food insecurity	881	10.9	9.9–12.0	216	24.3	20.5–28.5
Sex						
Male	3761	50.3	48.6–52.0	896	24.0	22.0–26.2
Female	3707	49.7	48.0–51.4	810	21.6	19.4–23.9
Age group (months)						
12–23	1746	23.1	21.7–24.5	626	36.6	33.4–39.9
24–35	1860	24.7	23.3–26.1	479	25.0	21.8–28.5
36–47	1930	25.7	24.3–27.2	334	17.7	15.3–20.4
48–59	1932	26.6	25.0–28.2	267	13.8	11.7–16.2
Indigenous populations						
Yes	902	8.4	7.4–9.6	237	27.0	22.8–31.7
No	6566	91.6	90.4–92.7	1469	22.4	20.9–24.1
Region						
North	1841	21.6	20.5–22.8	386	19.9	17.7–22.4
Center and Mexico City	3039	48.9	47.3–50.5	655	23.6	20.1–26.5
South	2588	29.5	28.2–30.8	665	23.6	21.5–25.9
Area						
Urban	4568	74.5	73.1–75.8	1005	22.3	20.4–24.4
Rural	2900	25.5	24.2–26.9	701	24.3	22.2–26.6
Tertile of well-being conditions						
Low tertile	2998	32.1	30.4–33.9	766	26.2	23.9–28.7
Mild tertile	2628	35.4	33.6–37.1	584	21.9	19.7–24.3
High tertile	1842	32.5	30.5–34.7	356	20.5	17.5–23.7
Nutritional status						
Wasted[b]	95	67.8	0.9–1.8	27	28.7	16.4–45.1
Stunted[c]	1025	13.5	12.5–14.6	303	31.4	27.4–35.6
Underweight[d]	198	2.1	2.1–3.2	72	33.8	26.2–42.4
Overweight[e]	736	10.0	9.0–11.0	157	21.1	17.3–25.5

National Health and Nutrition Survey. Mexico, 2012

[a]Anaemia: Haemoglobin concentration < 110 g/L). This subsample of the anaemia children group is included within the whole sample (first columns), because they represent the target group

[b]< − 2 weight for length/height z score

[c]< − 2 length/height for age z score

[d]< − 2 weight for age z score

[e]> + 2 body mass index z score

anaemia significantly decreased ($p < 0.001$), and children in the medium and high tertile of well-being conditions had a lower prevalence of anaemia.

Figure 1 presents the adjusted prevalence for anaemia including the differential association of anaemia with food insecurity and region (interaction) based on the multiple logistic regression model. Only in the southern region, the increase in anaemia prevalence was associated with an increase in food insecurity.

The adjusted prevalence of anaemia was higher in children from households with severe food insecurity

Table 2 Ordinal logistic regression for anaemia and associated variables among Mexican children between 12 and 59 months*

Model adjusted[a]	Anaemia[£]		
	OR	CI (95%)	*p**
Age (months)	0.64	0.60, 0.69	<0.001*
Household food security			
Security	1		
Mild food insecurity	0.76	0.53, 1.09	0.14
Moderate food insecurity	0.69	0.44, 1.08	0.11
Severe Food insecurity	0.66	0.40, 1.10	0.11
Region			
North	1		
Center and Mexico City	0.97	0.66, 1.42	0.87
South	0.68	0.44, 1.04	0.07
Interaction: Food security and region			
Food security			
North	1		
Mild food insecurity			
Center and Mexico City	1.43	0.87, 2.34	0.16
Mild food insecurity			
South	1.67	1.02, 2.74	0.04*
Moderate food insecurity			
Center and Mexico City	1.31	0.70, 2.45	0.39
Moderate food insecurity			
South	2.03	1.13, 3.64	0.02*
Severe food insecurity			
Center and Mexico City	1.53	0.77, 3.02	0.22
Severe food insecurity			
South	2.49	1.27, 4.87	0.01*
Tertile of well-being conditions			
Low tertile	1		
Mild tertile	0.82	0.68, 0.97	0.04*
High tertile	0.75	0.58, 0.98	0.04*
Parental education level			
None	1		
Elementary	1.07	0.85, 1.35	0.56
High school	1.01	0.80, 1.26	0.99
Graduate or higher	1.06	0.71, 1.56	0.79
Household head gender			
Female	1.14	0.92, 1.40	0.23
Indigenous			
Yes	1.19	0.92, 1.56	0.19

National Health and Nutrition Survey. Mexico, 2012

*Significant contribution to anaemia prevalence ($p < 0.05$)

[£]Anaemia: Haemoglobin concentration < 110 g/L

[a]Model adjusted for age, region, tertile of well-being conditions, parental education level, household head gender and indigenous population

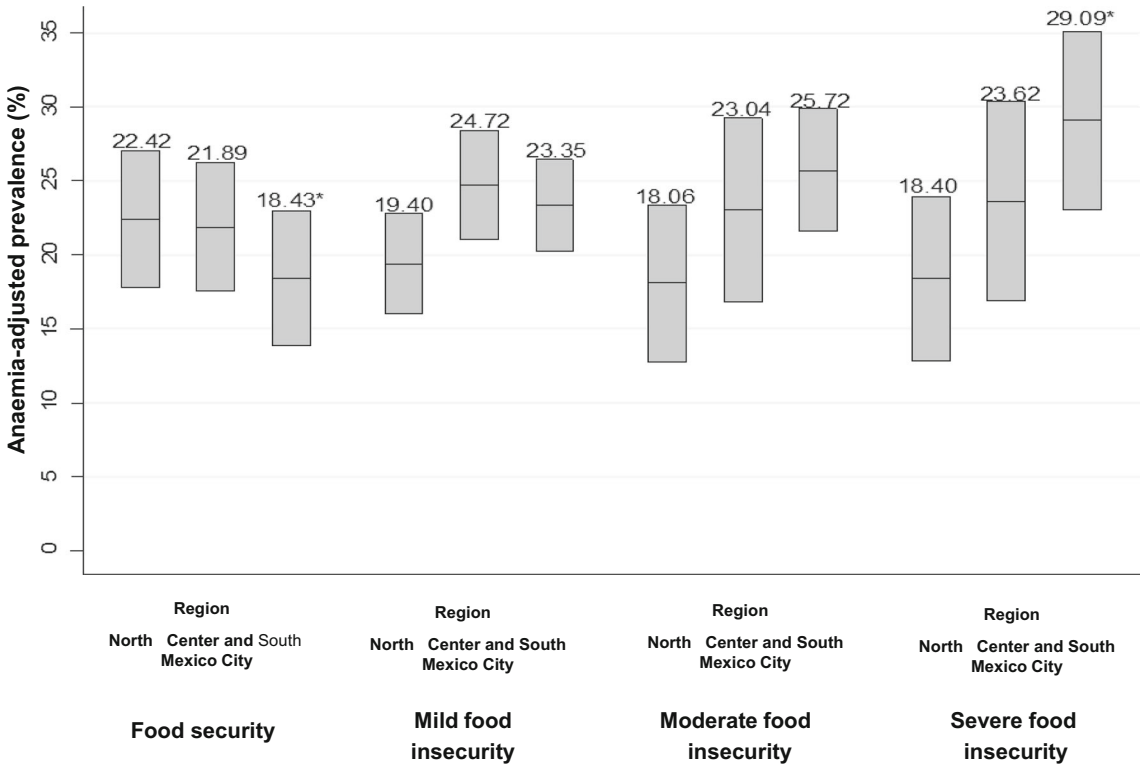
(29.0%, $CI_{95\%}$ 23.1, 35.1) in the South, than in those from FS households (18.4%, $CI_{95\%}$13.9, 23.0).

Discussion

Our findings demonstrated there is a relationship of food insecurity with anaemia mainly in children between 12 and 59 months of age living in the southern Mexican region.

Studies that have reported an association between food insecurity and anaemia in children were carried out in multi-ethnic and population groups that had low income (Metallinos-Katsaras et al. 2016; Park et al. 2009; Skalicky et al. 2006) or lived in extreme poverty (Hipgrave et al. 2014), conditions that possibly increased the nutritional and health vulnerability in these children, making them more likely to have malnutrition, diseases and anaemia. Our results coincide with the previous findings, since in the southern region of Mexico there was a greater proportion of localities with poverty, without potable water and sewage services and less access to health services (CONEVAL 2015). All of these poor conditions go along with high prevalence of anaemia, undernutrition and inadequate intake of folate, iron and vitamin A in children under five years of age (De la Cruz-Góngora et al. 2018, op cit; De la Cruz-Góngora et al. 2012; Rivera et al. 2008, op cit.). As a clear example of the contrasts existing between the different regions in the country, the prevalence of stunting within this age group is 8.8% in the urban areas of northern Mexico, but increases to 27.5% in the rural areas and to 33.5% in the indigenous communities of the South (Rivera et al. 2008, op cit).

According to the above, the main finding of this work adds an extra dimension to the international literature on anaemia and its association with food insecurity. It shows that this association can be stronger in population groups with adverse conditions of poverty such as exposure to unhealthy environments and limited access to healthcare services, recurrent infections and inflammation (Hipgrave et al. 2014, op cit; Balarajan et al. 2011) and micronutrient deficient diets, like in the southern region of Mexico. We also noted that children in the middle and high tertiles of well-being conditions were less likely to present anaemia than those in the low tertile of these conditions. Thus, reports based on Mexican data have shown that in the higher tertile of well-being conditions, there is a higher percentage of energy consumed from healthy foods such as meat and dairy products (Aburto et al. 2016; Monsivais et al. 2012). Also, the favourable conditions of the home, such as a firm (non-earth) floor or access to water inside the house, have a favourable impact on children's health and lead to a lower risk of anaemia (Moradi et al. 2018, op cit).



National Health and Nutrition Survey (ENSANUT 2012). Mexico, 2012.
Anaemia: Hb concentration <110 g/L.
* Significant difference with severe food insecurity ($p<0.05$).

Fig. 1 Adjusted prevalence of anaemia according to logistic regression models, exploring the interaction between food insecurity categories and geographical regions. National Health and Nutrition Survey, Mexico, 2012

Another relevant finding was that in the southern region, children from households with severe food insecurity exhibited a higher prevalence of anaemia than those from food secure households. According to the conceptual framework of the *ELCSA*, severe food insecurity entails a significant deterioration in the quality and quantity of food consumed by families, children included (Segall-Corrêa et al. 2012). A study in Mexican children documented that those who live in moderate and severe food insecurity have less diversity of diet and consume fewer fruits and vegetables (Mundo-Rosas et al. 2014).

Our study has some limitations. We did not include dietary consumption as a control variable in statistical models, because dietary data were collected from a subsample of the surveyed population, and we were unable to include measurements for other iron status indicators that might have contributed to a better understanding of the relationship between food insecurity and iron deficiency anaemia. Also, we did not have complete information about the mothers of the analysed children, among other variables, for example their interest in childcare and other sociocultural aspects. Therefore, more research is required to understand the relationship between food insecurity and anaemia, considering these socioeconomic factors at a contextual level.

Our strengths are the data based on a probabilistic survey with national and regional representativeness, thus ensuring the internal validity of our results. Likewise, the sample size used in the analysis gave strength to the associations found among the different categories of food insecurity, when compared to previous studies. Also, the ELCSA is a valid tool to efficiently measure food insecurity in Mexico and in other Latin American (LA) countries (Pérez-Escamilla et al. 2004; Álvarez et al. 2008). Finally, our results showed the need to improve and adapt public health interventions in order to "eradicate extreme poverty and end hunger and ensure access, in particular for the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round" (United Nations 2015). In addition, to contribute to the recognition that different regions in the world are marked by distinct social conditions and cannot be accurately understood from a global standpoint (Monrroy 2015). Furthermore, food security, nutrition and health in children are affected by multiple factors and we need to consider the individual, family and societal dimensions (UNICEF 1998). The high prevalence of anaemia and other nutritional problems

among preschool children in Mexico and other LA countries leads to diminished human capital. Our findings can contribute to a better understanding of the problem and strengthen interventions to address anaemia in children and food security.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval and consent to participate The *ENSANUT-2012* protocol was approved by the Research Ethics Committee and the Research and Biosecurity Commissions of the National Institute of Public Health, in Mexico (*INSP*, Spanish acronym). The parents/custodians of the participating children were fully informed of the study objectives and procedures and signed an informed consent form authorizing the collection of data on their household socioeconomic and food insecurity conditions, as well as the measurement of their children's anthropometric characteristics and Hb concentrations. Funding was provided by the Health Ministry of Mexico for the 2012 National Health and Nutrition Survey.

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