The double burden of undernutrition and excess body weight in Mexico[1–4]

Maria F Kroker-Lobos, Andrea Pedroza-Tobías, Lilia S Pedraza, and Juan A Rivera

ABSTRACT

Background: In Mexico, stunting and anemia have declined but are still high in some regions and subpopulations, whereas overweight and obesity have increased at alarming rates in all age and socioeconomic groups.

Objective: The objective was to describe the coexistence of stunting, anemia, and overweight and obesity at the national, household, and individual levels.

Design: We estimated national prevalences of and trends for stunting, anemia, and overweight and obesity in children aged <5 y and in school-aged children (5–11 y old) and anemia and overweight and obesity in women aged 20–49 y by using the National Health and Nutrition Surveys conducted in 1988, 1999, 2006, and 2012. With the use of the most recent data (2012), the double burden of malnutrition at the household level was estimated and defined as the coexistence of stunting in children aged <5 y and overweight or obesity in the mother. At the individual level, double burden was defined as concurrent stunting and overweight and obesity in children aged 5–11 y and concurrent anemia and overweight or obesity in children aged 5–11 y and in women. We also tested if the coexistence of the conditions corresponded to expected values, under the assumption of independent distributions of each condition.

Results: At the household level, the prevalence of concurrent stunting in children aged <5 y and overweight and obesity in mothers was 8.4%; at the individual level, prevalences were 1% for stunting and overweight or obesity and 2.9% for anemia and overweight or obesity in children aged 5–11 y and 7.6% for anemia and overweight or obesity in women. At the household and individual levels in children aged 5–11 y, prevalences of double burden were significantly lower than expected, whereas anemia and the prevalence of overweight or obesity in women were not different from that expected.

Conclusions: Although some prevalences of double burden were lower than expected, assuming independent distributions of the 2 conditions, the coexistence of stunting, overweight or obesity, and anemia at the national, household, and intraindividual levels in Mexico calls for policies and programs to prevent the 3 conditions.

Am J Clin Nutr 2014;100(suppl):1652S–8S.

Keywords Mexico, double burden, overweight and obesity, undernutrition, children, women nutrition policy

INTRODUCTION

Undernutrition has declined, whereas excess body weight is increasing globally. Stunting in children aged <5 y has decreased by 35% globally, and wasting has declined by 11% during the past 2 decades (1). The obesity epidemic, which started in most high-income countries in the 1970s and 1980s, has extended to many lower-middle-income countries. By 2008, an estimated 1.96 billion adults and 170 million children aged <18 y globally were overweight or obese (2). In high-income countries, undernutrition is no longer a public health problem and thus obesity is the major concern. However, in several lower-middle–income countries, including most Latin American countries, relatively high prevalences of undernutrition and excess body weight coexist and thus the double burden of undernutrition and obesity are of public health concern (3).

Mexico has experienced a nutrition transition characterized by a decrease in the prevalence of different forms of undernutrition (4) and anemia (5) in children aged <5 y, whereas excess body weight (overweight/obesity) has increased in all age groups (6, 7). Despite the decline of stunting and anemia in the past 25 y, both conditions are still high in some regions and subpopulations, whereas obesity is widespread; therefore, undernutrition and obesity coexist in the Mexican population. Although deficiencies and conditions of excess comprising the double burden of malnutrition might seem opposite to one another, they share environmental conditions and behaviors and can co-occur at the household and individual level (8).

National programs and policies such as the Human Development Program "Oportunidades" (9), a subsidized milk distribution program (Liconsa) (10), and recently, the National Crusade against Hunger (11) have or are attempting to address undernutrition and food insecurity. On the other hand, other strategies such as the National Agreement for Obesity Prevention [Acuerdo Nacional para la Salud Alimentaria (ANSA)] (12, 13) statutory regulations designed to secure the availability and accessibility of healthy foods and safe water and to reduce access to unhealthy foods such as sugar-sweetened beverages (SSBs) in Mexican schools; the National Strategy to Prevent and

[1] From the Center for Nutrition and Health Research, National Institute of Public Health, Cuernavaca, Mexico.

[2] Presented at the IUNS 20th International Congress of Nutrition held in Granada, Spain, 15 September 2013.

[3] DSM Nutritional Products provided travel funds for meeting attendants, and the Inter-American Development Bank provided funds for the publication of the supplement.

[4] Address correspondence to JA Rivera, Center for Nutrition and Health Research, National Institute of Public Health, Av Universidad 655, Santa María Ahuacatitlán, 62100, Cuernavaca, Morelos, Mexico. E-mail: jrivera@insp.mx.

First published online October 29, 2014; doi: 10.3945/ajcn.114.083832.

Control Overweight, Obesity, and Diabetes; and taxation of SSBs and unhealthy foods have been implemented or will be applied to tackle the obesity epidemic (14–16). However, it is not clear to what extent these programs integrate actions to tackle the double burden. This article presents an overview of the coexistence of undernutrition (stunting and anemia) and excess body weight (overweight or obesity) at the national, household, and intraindividual levels in Mexico over a 24-y period to ascertain the degree to which nutrition programs and policies in Mexico include the double burden as part of their scope and objectives.

SUBJECTS AND METHODS

Subjects

We analyzed anthropometric and hemoglobin data in preschool-aged children (<5 y), school-aged children (5–11 y), and females of reproductive age (12–49 y) from 1988, 1999, 2006, and 2012 nationally representative nutrition surveys. The sample size of the surveys ranged from 13,000 to 49,000 households. A detailed description of the sampling and the data collection methods are presented elsewhere (17–22).

A multistage, random, cluster-sampling procedure was used to draw the sample from each survey. All surveys were representative at the national and regional level; the 1999 survey was also representative for rural and urban areas, whereas the 2006 and 2012 surveys were, in addition, representative at the state level. Weight and height outliers were defined for children at 5 SDs above or below the reference mean. No further data cleaning was conducted on BMI in children. For mothers, BMIs (in kg/m^2) <10 or >58 were used as the lower and upper limits to consider the data valid. At the household level, we excluded mothers with missing BMI data, those who were pregnant or breastfeeding, and women who had no children or no data on their <5-y-old child. At the individual level, we included school-aged children and woman with complete weight, height, and hemoglobin data.

Study design

By using the 1988, 1999, 2006, and 2012 nationally representative nutrition surveys, we estimated the magnitude of and trends for stunting, anemia, and excess body weight in preschool-aged (<5 y), school-aged children (5–11 y), and women (20–49 y). To estimate the double burden of malnutrition at the household and intraindividual levels, we used data from the 2012 National Health and Nutrition Survey [Encuesta Nacional de Salud y Nutrición (ENSANUT) 2012] only. At the household level, we estimated the prevalence of double burden, defined as the coexistence of a stunted child (<5 y) and an overweight or obese mother. At the individual level, the concurrent prevalences of stunting and excess body weight within individuals were assessed in school-aged children ("intraindividual concurrent stunting and excess weight"), and the concurrent prevalences of anemia and excess body weight ("intraindividual concurrent anemia and excess weight") were estimated in school-aged children and girls and women of reproductive age.

We defined stunting, wasting, and underweight by using <2 z scores as the cutoff for each indicator: length- or height-for-age, weight-for-length or -height, and weight-for-age, respectively, for each age (mo) and sex in children aged <5 y (23). BMI, calculated by dividing the weight (kg) by the square of height (m^2), was used as the indicator for excess body weight (overweight/obesity) and was defined according to WHO 2006 and 2007 references (23) by using weight-for-height z score (>2 SDs ≤3) for overweight and (>3 SDs) for obesity in children aged <5 y, BMI-for-age z score (>1 SD ≤2) for overweight and (>2 SDs) for obesity for children and adolescents aged 5–19 y, and BMI (>25 and < 30) for overweight and (≥30) for obesity in adults aged >20 y. Anemia was defined with the use of the sex and age WHO cutoffs, adjusting for altitude over sea level, by using the Cohen and Haas equation (24).

Statistical analysis

At the national level, we estimated prevalences and 95% CIs for stunting (in children <5 y), anemia (in school-aged children and women), and excess body weight for children (birth to age 11 y) by sex and for females of reproductive age (12–49 y). Trends were evaluated statistically by using chi-square tests for trend.

At the household level, we calculated the expected prevalence of stunting in <5-y-old children and overweight or obesity in their mothers by multiplying the prevalence of overweight or obese mothers by the prevalence of stunted preschool-aged children and dividing the product by 100.

We then estimated the expected prevalence of stunting and excess body weight in school-aged children and of anemia and excess body weight in both school-aged children and reproductive-age females. Expected prevalences were also estimated as explained previously for the household-level double burden.

We compared the expected prevalence with the observed prevalence of double burden conditions at the household and individual levels to determine whether the coexistence of undernutrition and obesity is larger than what would be expected solely on the basis of the prevalences of each separate condition in the population (25). Prevalences and 95% CIs were estimated and compared by using a chi-square test from which P values were obtained. All analyses were adjusted for the complex sample design by using the "SVY" module of Stata 12 (StataCorp).

RESULTS

The sample sizes for the analysis of trends at the national level are provided in the legend for **Figure 1**. For national prevalences in 2012, the sample sizes were as follows: 10,658 preschool-aged children, 16,351 school-aged children, 13,992 adolescents, and 37,580 adults aged ≥20 y. For the household-level analysis of double burden, we included 4777 households in which anthropometric data were available for both mothers and children aged <5 y.

For the analysis of double burden at the intraindividual level, a total of 11,638 children and adolescents (<20 y), 12,734 women aged 20–49 y, and 12,758 adults >60 y had plausible hemoglobin data. Of these, 13,679 children aged 5–11 y and 17,925 girls and women aged 12–49 y had anthropometric and anemia data. The sample sizes for the actual analysis were as follows—school-aged children: the coexistence of stunting and excess body weight, n = 16,351, and the coexistence of anemia and excess body weight, n = 13,679; women: the coexistence of anemia and overweight or obesity, n = 17,925.

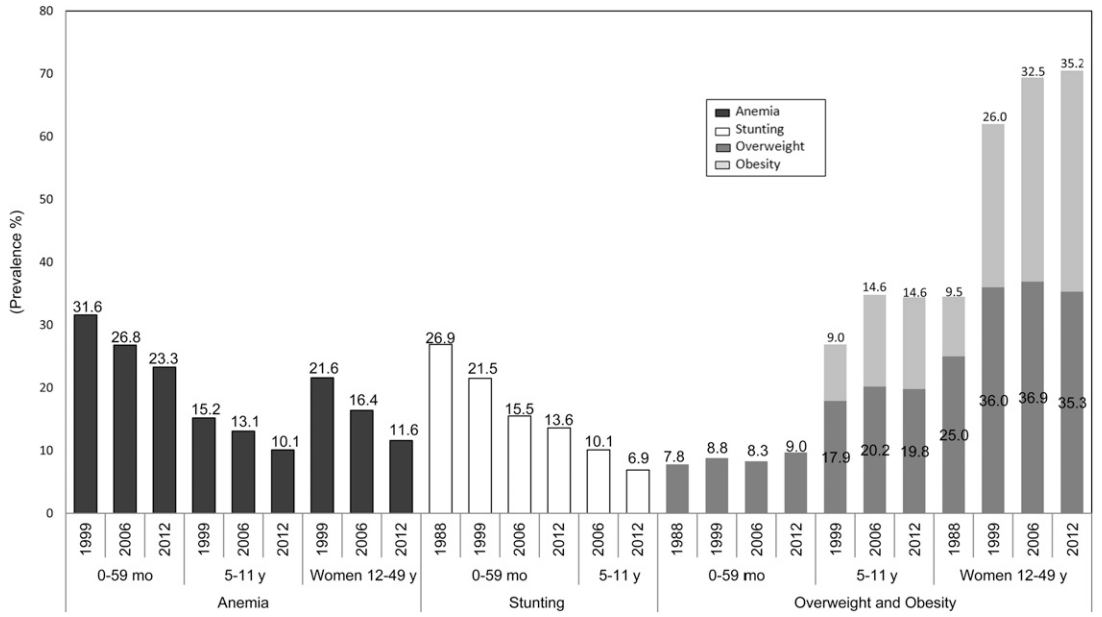

FIGURE 1 Prevalences of and trends for anemia, stunting, and overweight/obesity in children aged <5 y and in school-aged children and for anemia and overweight/obesity in women aged 20–49 y from 1988 to 2012. Sample sizes were as follows—children aged <5 y: anemia (1999, n = 5201; 2006, n = 6618; 2012, n = 7570), stunting and overweight (1988, n = 6937; 1999, n = 7590; 2006, n = 7707; 2012, n = 10,658); school-aged children: anemia (1999, n = 10,218; 2006, n = 14,666; 2012, n = 13,866), stunting (2006, n = 15,111; 2012, n = 16,351), overweight (1999, n = 11,338; 2006, n = 15,111; 2012, n = 16,351); females aged 12–49 y: anemia (1999, n = 16,497; 2006, n = 20,610; 2012, n = 18,118); women aged 20–49 y: overweight (1988, n = 16,864; 1999, n = 12,798; 2006, n = 14,556; 2012, n = 14,570). All P-trend < 0.01 (chi-square test).

A steady and significant decline in the prevalence of stunting, underweight, and anemia in the past 25 y accompanied by a consistent increase in the prevalence of overweight and obesity in all studied age groups are shown in Figure 1. In preschool-aged children, decreases of 49.4% from 1988 to 2012 and 26.3% from 1999 to 2012 were observed in the prevalences of stunting and anemia, respectively, which amounted to a 2%/y decline in both conditions. In contrast, an increase of 47.5% from 1988 to 2012 in the combined prevalence of overweight and obesity was found. Similar trends were found in school-aged children for stunting, anemia, and overweight or obesity. In women (20–49 y), the increase in overweight and obesity from 1988 to 2012 was 104% (4.3%/y), obesity increased by 270% (11%/y) in the same period of time, whereas the prevalence of anemia in females aged 12–49 y decreased by 46% from 2006 to 2012 (3.6%/y). All trends were significant (P-trend < 0.01).

Prevalences using the ENSANUT 2012 data were 13.6% for stunting, 23.3% for anemia, and 9.0% for overweight in children aged <5 y. Prevalences in school-aged children were 6.9%, 10.1%, and 34.4% for stunting, anemia, and overweight or obesity, respectively, and 10.1% and 34.9% for anemia and overweight or obesity in adolescents. Sex differences in the prevalences of children and adolescents were small.

In adults aged ≥20 y, high prevalences of overweight and obesity were observed, with large differences between age categories, as follows: 64.4%, 81.5%, and 70.2% for those aged 20–39 y, 40–59 y, and ≥60 y, respectively. Females had higher prevalences of obesity, whereas males had higher prevalences of overweight across age groups. We also found anemia in 11.9% and 16.2% of the 20–49-y and the 40–59-y groups, respectively, and in 16.5% of adults (both sexes) aged ≥60 y **(Table 1)**. Less than 2.0% of adolescents and women were thin (data not shown).

At the household level, we found that in 64% of the households mothers were overweight or obese, and in 14.2% of the households children <5 y were stunted. In 8.4% of the households we found the coexistence of an overweight or obese mother with a stunted child <5 y. This proportion of households with the double burden is lower than expected (9.1%; P = 0.039), assuming independence of the proportions of households with overweight or obese mothers and with stunted children (**Table 2**). Stratified analysis at the regional level showed that in the urban south region of the country, the coexistence of stunting in children <5 y and excess body weight in their mothers was observed in 13.4% of households (data not shown). This proportion was lower than expected (15.5%), assuming independence of the occurrence of each condition.

At the individual level, in school-aged children, we found that 34.4% were overweight or obese and 7.0% were stunted. The double burden of overweight/obesity and stunting was found in 1.0% of these children, which was lower than expected (2.3%; P < 0.001), assuming independence in the prevalences of each condition. Also in school-aged children, prevalences of 34.1% for overweight/obesity and 9.9% for anemia were found. The prevalence of the double burden was 2.9%, which was also lower than expected assuming independence in the prevalences of each condition (3.4%; P < 0.001). At the individual level in females aged 12–49 y we found that 61.7% were overweight or obese and 11.6% were anemic. The double burden of anemia and overweight or obesity was present in 7.6%, higher than expected assuming independent distributions of each condition (7.2%; P = 0.03). We analyzed separately the double burden of obesity and anemia (Table 2). The coexistence of both conditions was 3.4%, which was not different (P = 0.893) than the expected value assuming independent distributions of each condition (3.3%).

TABLE 1
Prevalences of underweight, overweight, obesity, and anemia by age group and sex in a Mexican population (ENSANUT 2012)[1]

		Undernutrition,[2] % (95% CI)			Weight-for-age, BMI-for-age, or BMI, % (95% CI)		Anemia[3]	
Age group and sex	*n*	Wasting/thinness BMI-for-age or BMI	Stunting	Underweight	Overweight[4]	Obesity[5]	*n*	% (95% CI)
<5 y								
Total	10,658	1.6 (1.3, 2.0)	13.6 (12.6, 14.7)	2.8 (2.4, 3.3)	7.1 (6.3, 7.8)	1.9 (1.4, 2.3)	7570	23.3 (21.8, 24.8)
Male	5314	1.8 (1.3, 2.5)	15.1 (13.8, 16.6)	2.8 (2.2, 3.6)	7.2 (6.1, 8.4)	1.8 (1.2, 2.3)	3819	24.4 (22.4, 26.6)
Female	5344	1.4 (1.0, 1.9)	12.1 (10.8, 13.5)	2.8 (2.2, 3.4)	7.0 (6.0, 8.0)	2.0 (1.4, 2.6)	3751	22.1 (19.9, 24.5)
5–11 y								
Total	16,351	1.5 (1.2, 1.8)	6.9 (6.2, 7.6)	1.5 (1.2, 1.8)	19.8 (18.8, 20.9)	14.6 (13.7, 15.6)	13,866	10.1 (9.3, 10.9)
Male	8195	1.3 (0.9, 1.7)	6.6 (5.8, 7.4)	1.3 (0.9, 1.7)	19.5 (18.1, 21.0)	17.4 (16.0, 18.8)	6938	10 (9.0, 11.2)
Female	8156	1.7 (1.3, 2.1)	7.2 (6.3, 8.2)	1.7 (1.3, 2.1)	20.2 (18.8, 21.6)	11.8 (10.8, 12.8)	6928	10.1 (9.1, 11.3)
12–19 y								
Total	13,992	1.9 (1.6, 2.3)	—	—	21.6 (20.5, 22.8)	13.3 (12.5, 14.2)	11,638	5.6 (4.9, 6.4)
Male	7041	2.4 (1.9, 3.1)	—	—	19.6 (18.2, 21.1)	14.5 (13.3, 15.8)	5792	3.6 (3.0, 4.4)
Female	6951	1.4 (1.1, 1.8)	—	—	23.7 (22.1, 25.5)	12.1 (10.9, 13.4)	5846	7.7 (6.6, 9.0)
20–39 y								
Total	16,762	1.7 (1.4, 2.0)	—	—	36.3 (35.2, 37.4)	28.1 (27.0, 29.2)	—	—
Male	6896	1.3 (0.9, 1.9)	—	—	38.3 (36.6, 40.0)	25.2 (23.6, 26.9)	—	—
Female	9866	2 (1.6, 2.6)	—	—	34.4 (33.0, 35.9)	30.7 (29.3, 32.2)	8774	11.9 (10.9, 13.0)
40–59 y								
Total	13,641	0.4 (0.3, 0.6)	—	—	41.8 (40.4, 43.2)	39.7 (38.3, 41.1)	—	—
Male	5739	0.4 (0.2, 0.7)	—	—	46.8 (44.8, 48.8)	31.9 (30.0, 33.8)	—	—
Female	7902	0.4 (0.3, 0.6)	—	—	37.3 (35.4, 39.1)	46.8 (45.0, 48.7)	3960	16.2 (14.3, 18.2)[6]
≥60 y								
Total	7177	1.5 (1.1, 2.0)	—	—	40.2 (38.4, 42.1)	30 (28.2, 31.8)	6379	16.5 (15.1, 18.1)
Male	3327	1.6 (1.1, 2.2)	—	—	46.4 (43.5, 49.3)	20.7 (18.6, 23.1)	2927	17.8 (15.8, 20.1)
Female	3850	1.4 (0.9, 2.2)	—	—	34.9 (32.5, 37.3)	38.1 (35.6, 40.6)	3452	15.4 (13.5, 17.5)

[1]ENSANUT, Encuesta Nacional de Salud y Nutrición (National Health and Nutrition Survey) (22).
[2]Undernutrition: weight-for-height, weight-for-age, and height-for-age *z* scores < −2 SDs are used for children aged <5 y; BMI-for-age *z* scores < −2 SDs are used for children aged 5–19 y; and BMI (in kg/m^2) <18.5 was used for those aged ≥20 y (23).
[3]Anemia: WHO cutoffs for sex and age group, adjusted by using the Cohen and Haas equation (24).
[4]Overweight: Weight-for-height *z* score >2 SDs for children aged <5 y, BMI-for-age *z* score >1 SD for children aged 5–19 y, and BMI ≥25 and <30 in adults aged ≥20 y.
[5]Obesity: weight-for-height *z* score >3 SDs for children aged <5 y, BMI-for-age *z* score >2 SDs for children aged 5–19 y, and BMI ≥30 for adults aged ≥20 y.
[6]This prevalence corresponds to women 40–49 y of age.

DISCUSSION

We documented a nutritional transition in Mexico during the past quarter of a century, characterized by the decline in undernutrition and anemia and the increase in excess body weight in all studied age groups. As shown in the latest national survey (2012), Mexico faces the double burden of high prevalences of overweight/obesity (33–82% across age groups) with the persistence of moderate to low prevalences of anemia (12–23%) and stunting (~14%). In >8% of the households a stunted child coexists with her overweight or obese mother. We also documented the double burden in the same individual: >7% of women are both anemic and overweight or obese. The coexistence of the double burden in school-aged children is much lower: 1% and 2.9% for overweight/obesity with stunting or with anemia, respectively.

The prevalences of the double burden at the household level and at the intraindividual level in school-aged children were lower than expected, whereas those in women were larger than what would be expected assuming independence of the distributions of each nutrition condition. Although all differences were significant, their relative magnitude was too small in most cases (<15% of the expected prevalence) in terms of public health relevance. In other words, the occurrence of each separate condition (overweight/obesity, stunting, anemia) at the household or individual level does not seem to influence the occurrence of the other conditions, and therefore the coexistence of both malnutrition conditions in the same household or individual appears to be solely the result of the magnitude of the separate prevalences in the population. The only exception was the coexistence of anemia and stunting in school-aged children in whom the difference between the expected and actual prevalence amounted to almost 60% of the expected prevalence. However, contrary to expectations, the expected prevalence was larger than the actual prevalence.

The hypothesis of a larger than expected prevalence of the coexistence of stunting and excess body weight at the household and individual levels arises from evidence that indicates that children who are stunted during the first 2 y of life are more likely to be overweight or obese later in life (26–29). On the other hand, the assumption of larger than expected prevalences of anemia and excess body weight is based on findings that low-income groups in Mexico purchase foods of lower cost per calorie than do those from higher income levels and that those low-cost-per-calorie foods are also of low nutritional quality, particularly in

TABLE 2
Assessment of the double burden of undernutrition or micronutrient deficiency and overweight/obesity at the household and individual level in Mexican children and women (ENSANUT 2012)[1]

	Stunting, % (95% CI)			Anemia, % (95% CI)		
	With	Without	Total	With	Without	Total
Household level						
Children aged <5 y						
Mother with overweight/obesity	8.4 (7.4, 9.6)[2]	55.6 (53.6, 57.5)	64.0 (62.1, 65.9)	—	—	—
Mother without overweight/obesity	5.8 (5.0, 6.8)	30.2 (28.4, 32.0)	36.0 (34.1, 38.0)	—	—	—
Total	14.2 (13.0, 15.6)	85.8 (84.3, 57.5)	100.0 (n = 4777)	—	—	—
P		0.039				
Individual level						
School-aged children (5–11 y)						
With overweight/obesity	1.0 (0.76, 1.2)[3]	33.5 (32.3, 34.7)	34.4 (33.3, 35.6)	2.9 (2.5, 3.4)[4]	31.2 (30.1, 32.4)	34.1 (32.9, 35.4)
Without overweight/obesity	5.9 (5.3, 6.6)	59.6 (58.4, 60.8)	65.6 (64.4, 66.7)	7.0 (6.4 ,7.7)	58.9 (57.7, 60.0)	65.9 (64.6, 67.1)
Total	6.9 (6.2, 7.6)	93.1 (92.4, 93.8)	100 (n = 16,351)	9.9 (9.2, 10.7)	90.1 (89.3, 90.9)	100 (n = 13,679)
P		0.001			0.001	
Women of reproductive age (12–49 y)						
With overweight/obesity	—	—	—	7.6 (7.0, 8.2)[5]	54.1 (52.9, 55.3)	61.7 (60.6, 62.9)
Without overweight/obesity	—	—	—	4.1 (3.6, 4.5)	34.2 (33.1, 35.3)	38.3 (37.1, 39.5)
Total	—	—	—	11.7 (10.9, 12.4)	88.3 (87.6, 89.1)	100 (n = 17,924)
P	—	—	—		0.0367	
With obesity	—	—	—	3.4 (3.0, 3.9)[6]	25.8 (24.8, 26.9)	29.3 (28.2, 30.4)
Without obesity	—	—	—	8.2 (7.6, 8.9)	62.5 (61.4, 63.6)	70.7 (69.6, 71.8)
Total	—	—	—	11.6 (10.9, 12.4)	88.3 (87.6, 89.1)	100 (n = 17,924)
P	—	—	—		0.893	

[1]All P values correspond to a chi-square test comparing expected prevalence with observed prevalence. ENSANUT, Encuesta Nacional de Salud y Nutrición (National Health and Nutrition Survey) (22).
[2–6]Expected values: [2]9.1%, [3]2.3%, [4]3.4%, [5]7.2%, [6]3.3%.

terms of protein and micronutrient contents (30). This would result in individuals from low-income households being overweight or obese as a result of the high intakes of cheap calories but also anemic or deficient in micronutrients given the low micronutrient quality of the food.

However, our results suggest that the conditions considered (undernutrition, including anemia and excess body weight) are virtually independent, and in one case the actual prevalence was lower than expected. Therefore, our results do not support the hypothesis that the coexistence of undernutrition and excess body weight would be higher than expected under the assumption of independent distribution of the 2 conditions. These results are probably driven by the high prevalence of excess body weight in all age groups studied in comparison with the prevalences of anemia and stunting and by the high prevalences of excess body weight in all socioeconomic groups in Mexico (31). The exception to this latter statement is the lower prevalence of excess body weight in school-aged children, which probably explains the lower than expected coexistence of excess body weight and stunting (typically occurring in the lower socioeconomic group).

Despite the apparent independence of the occurrence of the conditions that characterize a double burden, the fact that undernutrition (including anemia) coexists with overweight and obesity at the national, household, and intraindividual levels should be recognized and public policies must be designed to address both conditions. Although the coexistence of undernutrition and excess body weight in households and within individuals at the national level was relatively low (1–8.4%), in the southern region the occurrence of both conditions was much higher (13.4%; data not shown), stressing the need to consider the double burden when designing nutrition policies and programs. The southern region is the poorest in the country and has the highest concentration of indigenous and rural areas. This shows the heterogeneity of the double burden, which, in turn, shows the diversity in the prevalences of undernutrition and excess body weight among different regions, urban/rural settings, indigenous and nonindigenous populations, and socioeconomic groups.

The apparent paradox of the coexistence in the same household or even within the same individual of stunting and overweight or obesity may be the result of the confluence of certain factors that participate in the natural history of these conditions. Growth stunting occurs during gestation and the first 2 y of life. Several factors, not necessarily related to food insecurity, play a role in the etiology of stunting, including the high demand for energy and nutrients for rapid growth; small gastric capacity, which necessitates frequent feeding; immaturity of the gastrointestinal system, which poses limitations to types and consistencies of complementary foods from 6 mo on; strong influences of culture and tradition on foods considered "adequate" for young children; and an immature immune system, which leads to infections in unclean environments. All of these factors could produce stunting even in food-secure households in which the intake of unhealthy, high-energy diets may result in excess weight gain in other family members and even in the same child later in life (31).

In Mexico, a large proportion of poor households have access to enough food to meet their energy requirements, although often their diets are of low quality, such as high-energy-dense foods and SSBs, which are low in micronutrients and fiber. These diets promote weight gain and can be deficient in key micronutrients. In these poor households, a stunted child can coexist with an overweight or obese

mother, who can also be anemic as a result of a high-energy, low-quality diet. A stunted and anemic child may start to gain weight after 2 y of age and can become an overweight and short-for-age school-aged child (with a history of stunting) who also may be anemic.

The coexistence of anemia and overweight/obesity may be explained by factors other than high-energy, low-micronutrient (particularly iron) diets, including increased iron requirements or impaired iron absorption in overweight or obese individuals. Inflammation in overweight or obese individuals may play a role through its regulation of hepcidin, which is higher in obese individuals and linked to subclinical inflammation, which may reduce iron absorption (32). In addition, inflammation may result in iron sequestration from reticuloendothelial macrophages due to the inhibition of the expression of ferroportin (32).

Cepeda-Lopez et al (33) examined the association between iron status and BMI in women of reproductive age in Mexico. In this cross-sectional study, obese women were more likely to have iron deficiency after adjustment for age, rural or urban residence, geographic region, parity, and iron intake (OR: 1.92; 95% CI: 1.23, 3.01); and serum iron concentrations had a significant inverse correlation with BMI ($r = -0.09$, $P = 0.003$). These results are consistent with our findings of a higher than expected prevalence of coexisting overweight/obesity and anemia in adult woman, assuming independence of the 2 conditions, and were significant. However, the difference between the predicted and actual prevalence of double burden was too small to be considered of public health significance. Moreover, the coexistence of anemia with obesity (BMI >30) in women was not different from the predicted value, assuming independent distributions of the 2 conditions, which is not consistent with the findings from Cepeda-Lopez et al (33).

The low prevalences of the double burden at the household and intraindividual levels, particularly the coexistence of overweight/obesity with anemia and stunting, respectively, in school-aged children, may be explained by the advanced stage of the nutrition transition in Mexico. As mentioned before, the prevalences of stunting and anemia have decreased substantially in the past decades and overweight/obesity has increased in this age group, although not as much as in adults; therefore, the expected prevalence of the double burden has decreased.

The presence of the double burden at the national level, and to a lesser extent at household and individual levels, calls for policies and programs to address this double burden. There is evidence that maternal age, formal education, and number of siblings are associated with the concurrent presence of stunting in children <5 y and overweight/obesity in mothers (34). On the other hand, in a study conducted in 2003 in rural areas of Mexico, maternal age, maternal height, maternal schooling, perceived social status, number of individuals in the household, and a poor sewage disposal system were associated with greater odds of stunting and the coexistence of stunting and excess weight in preschool-aged children (35). These results suggest that the double burden at household and individual levels has poverty as a common denominator. Programs and policies aimed at improving height and formal education may have a strong effect in the prevention of the double burden in the long term.

Since 1997, when the Oportunidades program (formerly Progresa) was created, Mexico has developed evidence-based policies for the prevention of undernutrition. Oportunidades is targeted to low-income families, children <2 y of age, and pregnant and lactating women and provides conditional cash transfers and micronutrient-fortified foods or supplements to all children aged 6–23 mo, to underweight children aged 2–4 y, and to pregnant and lactating women. Evaluations of the nutritional impact of the program have shown a positive effect on growth and a reduction in anemia (9). In recent years, the program has modified the food supplements distributed to reduce the amounts of calories while maintaining their micronutrient composition to avoid undesirable effects on weight gain. Moreover, the program is in the process of scaling up a strategy based on individual counseling that promotes breastfeeding and healthy complementary feeding and emphasizes the importance of promoting linear growth and avoiding excessive weight gain in preschool-aged children. Other programs such as a fortified milk distribution program (10) and a nutrition program targeted to isolated communities without health and education services have shown positive effects on the nutritional status of children (36). In addition to the programs aimed at preventing undernutrition, in 2010 the Mexican government implemented a multifaceted and multi-institutional national obesity prevention strategy in the form of an agreement with participation from several stakeholders, including government, civil society, academia, the media, and the food industry. The agreement (12) proposed 10 main action lines based on international recommendations (15). One of the main results of the agreement were statutory regulations designed to secure the availability and accessibility of healthy foods and safe water and to reduce access to unhealthy foods, including the banning of SSBs in Mexican schools (15). These statutory regulations are in the process of being evaluated.

An initiative of the Mexican legislative branch to tax sodas and high-energy-dense foods was approved and its implementation began in 2014. Estimations of price elasticities show that the demand for soft drinks is responsive to price changes in Mexico: a 10% increase in the price of soft drinks is associated with a decrease in consumption of 10–13%, depending on the data sources used, indicating that taxing soft drinks is likely to reduce their intake (14). The Mexican federal government has launched a program called "Crusade against Hunger," with major emphasis on a reduction in food insecurity, including plans to strengthen the nutrition component of the program Oportunidades (11). When it was launched, the program did not take into account the fact that 7 of every 10 adults and 1 of every 3 children are overweight or obese in Mexico, including the low-income population who is the target of this program. Nonetheless, the program has been slowly including overweight/obesity as a concern. In addition, the president presented the National Strategy to Prevent and Control overweight, obesity, and type 2 diabetes, developed by the Ministry of Health, which will continue to regulate food and beverages in schools and will implement regulations for marketing food to children and for food labels. It remains to be seen whether the current government continues with policies and programs that address the double burden of malnutrition in Mexico. Despite all the advances, there is still the need to integrate nutrition programs around the notion of "healthy eating" and to include the promotion of physical activity during the different phases of the life course.

We thank Reynaldo Martorell for his comments on the final manuscript.

The authors' responsibilities were as follows—MFK-L: was in charge of the development of the overall research plan, statistical analysis, and writing the manuscript; AP-T and LSP: contributed to the statistical analysis and

made contributions to the manuscript; and JAR: designed the research, wrote the manuscript, and has primary responsibility for final content. All of the authors read and approved the final manuscript. None of the authors declared a conflict of interest.

REFERENCES

1. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013;382:427–51.
2. Swinburn BA, Sacks G, Hall KD, McPherson K, Finegood DT, Moodie ML, Gortmaker SL. The global obesity pandemic: shaped by global drivers and local environments. Lancet 2011;378:804–14.
3. Uauy R, Monteiro CA. The challenge of improving food and nutrition in Latin America. Food Nutr Bull 2004;25:175–82.
4. Rivera JA, Cuevas L, González de Cosio T, Shamah T, García R. Desnutrición crónica en México en el último cuarto de siglo: análisis de cuatro encuestas nacionales. [Stunting in Mexico in the last quarter of century: analysis of four national surveys.] Salud Publica Mex 2013; 55(Suppl 2):161–9 (in Spanish).
5. de la Cruz-Góngora V, Villalpando S, Mundo-Rosas V, Shamah-Levy T. Prevalencia de anemia en niños y adolescentes Mexicanos: comparativo de tres encuestas nacionales. [Prevalence of anemia in Mexican children and adolescents: compararison of three national surveys.] Salud Publica Mex 2013;55(Suppl 2):S180–9 (in Spanish).
6. Barquera S, Campos-Nonato I, Hernández-Barrera L, Pedroza A, Rivera-Dommarco JA. Prevalencia de obesidad en adultos Mexicanos, 2000-2012. [Prevalence of obesity in Mexican adults, 2000-2012.] Salud Publica Mex 2013;55(Suppl 2):S151–60 (in Spanish).
7. Rivera JA, González de Cossio T, Pedraza LS, Aburto TC, Sánchez TG, Martorell R. Childhood overweight and obesity in Latin America: a systematic review. Lancet Diabetes Endocrinol 2014;2:321–32.
8. Doak CM, Adair LS, Monteiro C, Popkin BM. Overweight and underweight coexist within households in Brazil, China and Russia. J Nutr 2000;130:2965–71.
9. Rivera JA, Sotrés D, Habicht JP, Shamah T, Villalpando S. Impact of the Mexican Program for Education, Health and Nutrition (Progresa) on rates of growth and anemia in infants and young children: a randomized effectiveness study. JAMA 2004;291:2563–70.
10. Rivera JA, Shamah T, Villalpando S, Monterrubio E. Effectiveness of a large-scale iron-fortified milk distribution program on anemia and iron deficiency in low-income young children in Mexico. Am J Clin Nutr 2010;91:431–9.
11. Social Development Secretariat. Functioning and organization guidelines of the National Board of the Crusade against Hunger. Mexico City (Mexico): Secretaria de Desarrollo Social; 2013 (in Spanish).
12. Secretariat of Health. National agreement for health food: strategy against overweight and obesity. Mexico City (Mexico): Secretaría de Salud; 2010 (in Spanish).
13. Jacoby E, Rivera J, Hernandez-Cordero S, Gomes F, Garnier L, Castillo C, Reyes M. Legislation, children, obesity: standing up for children's rights in Latin America [commentary]. World Nutr 2012;3:483–516 [cited 2014 Aug 13]. Available from: http://www.wphna.org/htdocs/downloadsnov2012/12-11_WN3_Latin_American_law_pdf.pdf.
14. Colchero MA, Salgado JC, Unar M, Hernández-Avila M, Velasco-Bernal A, Carriedo A, Rivera-Dommarco JA. Economic aspects related to a soda tax in Mexico. Cuernavaca (Mexico): National Institute of Public Health; 2013 (in Spanish).
15. Secretariat of Public Education and Secretariat of Health. National agreement for healthy eating: strategy against overweight and obesity. Program of action in the school context. Mexico City (Mexico): Secretaría de Educación Pública y Secretaría de Salud; 2010 (in Spanish).
16. World Health Organization. Global strategy on diet, physical activity and health. Geneva (Switzerland): World Health Organization; 2004.
17. Sepúlveda-Amor J, Lezana-Hernandez M, Tapia-Conyer R, Valdespino J, Madrigal H, Kumate J. Estado de nutrición de niños en edad preescolar y mujeres en México: resultados de una encuesta nacional probabilística. Gac Med Mex 1990;126:207–24 (in Spanish).
18. Rivera JA, Sepúlveda-Amor J. Conclusions from the Mexican National Nutrition Survey 1999: translating results into nutrition policy. Salud Publica Mex 2003;45(Suppl 4):S565–75.
19. Rivera JA, Irizarry LM, González-Cossío T. Overview of the nutritional status of the Mexican population in the last two decades. Salud Publica Mex 2009;51(Suppl 4):S645–56.
20. Resano-Pérez E, Mendez-Ramirez I, Shamah-Levy T, Rivera JA, Sepúlveda-Amor J. Methods of the National Nutrition Survey 1999. Salud Publica Mex 2003;45(Suppl 4):S558–64.
21. Olaiz-Fernández G, Rivera-Dommarco J, Shamah-Levy T, Rojas R, Villalpando-Hernández S, Hernández-Ávila M, Sepúlveda J. Encuesta Nacional de Salud y Nutrición 2006. [National Health and Nutrition Survey 2006.] Cuernavaca (Mexico): Instituto Nacional de Salud Pública; 2006 (in Spanish).
22. Gutiérrez JP, Rivera-Dommarco J, Shamah-Levy T, Villalpando-Hernández S, Franco A, Cuevas-Nasu L, Romero-Martínez M, Hernández-Ávila M. Encuesta Nacional de Salud y Nutrición 2012. Resultados nacionales. 2a. ed. [National Health and Nutrition Survey 2012. National Results. 2nd ed.] Cuernavaca (México): Instituto Nacional de Salud Pública (MX); 2013.
23. World Health Organization. Child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. Geneva (Switzerland): World Health Organization; 2006.
24. Cohen J, Haas J. Hemoglobin correction factors for estimating the prevalence of iron deficiency anemia in pregnant women residing at high altitudes in Bolivia. Rev Panam Salud Pública 1999;6(6)392–9.
25. Dieffenbach S, Stein AD. Stunted child/overweight mother pairs represent a statistical artifact, not a distinct entity. J Nutr 2012;142:771–3.
26. Sawaya AL, Dallal G, Solymos G, de Sousa MH, Ventura ML, Roberts SB, Sigulem DM. Obesity and malnutrition in a shantytown population in the city of São Paolo, Brazil. Obes Res 1995;3(Suppl 2):107s–15s.
27. Doak C, Monteiro C, Popkin B. The coexistence of obesity and undernutrition in the same households is an emerging phenomena in lower income countries [abstract]. FASEB J 1999;13:673.2.
28. Popkin BM, Richards MK, Monteiro CA. Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. J Nutr 1996;126:3009–16.
29. Sawaya AL, Grillo LP, Verreschi I, Carlos da Silva A, Roberts SB. Mild stunting is associated with higher susceptibility to the effects of high-fat diets: studies in a shantytown population in São Paulo, Brazil. J Nutr 1998;128(Suppl):415S–20S.
30. Hernández Licona G, Minir Campa E, Aranda Balzázar R. Determinantes económicos: evolución del costo de las calorías en México. [Economic determinants: evolution in the cost of calories in Mexico.] In: Rivera JA, Hernandez M, Aguilar C, Vadillo F, Murayama C, editors. Obesidad en México. Recomendaciones para una política de Estado. [Obesity in Mexico. Recommendations for state policy.] Mexico City (Mexico): Academia Nacional de Medicina [National Academy of Medicine]; 2012:145–65 (in Spanish).
31. Rivera JA, Gonzalez de Cossio T. Pobreza, Nutrición y Salud. [Poverty, Nutrition and Health]. In: Los determinantes sociales de la salud en Mexico. [The social determinants oh health in Mexico]. Cordera R, Murayama C, editors. Mexico City (Mexico): Fondo de Cultura Economica [Economic Culture Fund]; 2012. p.269–320.
32. Cheng HL, Bryant C, Cook R, O'Connor H, Rooney K, Steinbeck K. The relationship between obesity and hypoferraemia in adults: a systematic review. Obes Rev 2012;13(2):150–61.
33. Cepeda-Lopez AC, Osendarp SJ, Melse-Boonstra A, Aeberli I, Gonzalez-Salazar F, Feskens E, Villalpando S, Zimmermann MB. 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):975–83.
34. Jehn M, Brewis A. A paradoxical malnutrition in mother child pairs: untangling the phenomenos of over and undernutricion in underveloped economies. Econ Hum Biol 2009;7:28–35.
35. Fernald LC, Neufeld LM. Overweight with concurrent stunting in very young children from rural Mexico: prevalence and associated factors. Eur J Clin Nutr 2007;61:623–32.
36. Leroy JL, Gadsden P, Rodríguez-Ramírez S, de Cossío TG. Cash and in-kind transfers in poor rural communities in Mexico increase household fruit, vegetable, and micronutrient consumption but also lead to excess energy consumption. J Nutr 2010;140:612–7.