Child malnutrition in Mexico in the last two decades: prevalence using the new WHO 2006 growth standards

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Abstract

Objective. To describe preschool malnutrition prevalence and trends in Mexican children for the 1988, 1999 and 2006 Mexican National Nutrition Surveys using WHO-2006 standards and National Center for Health Statistics/WHO (NCHS/WHO) references. **Material and Methods.** Prevalence of undernutrition (< minus 2 z-score for weight/age, height/age and weight/height) and overweight (> plus 2 z-score for weight/height) were calculated. **Results**. Height/age and weight/height have increased over time (*p*< 0.05). Using WHO-2006 standards, stunting in children less than 5 years years old was 26.9%, 21.5% and 15.5% in 1988, 1999 and 2006, respectively; values for wasting were 6.2%, 2.1% and 2.0%, respectively. Wasting in the very young (< 6 mo) in 2006 is high (4.9%). Overweight increased from 1988 to 1999 (6.1% to 7.5%) and stabilized in 2006 (7.6%). Gaps among ethnic and socioeconomic groups have decreased over time. **Conclusions**. Stunting has decreased markedly but continues to be the main malnutrition problem. Overweight has emerged as a public health problem in the young. Lower NCHS/WHO estimates previously published underestimated true prevalence. Length deviations in attained height after 12 months indicate poor infant feeding practices, probably coupled with early infections. Results reinforce the need to improve the quality of nutrition programs and to promote adequate lactation and infant feeding practices in Mexico.

Key words: child malnutrition; wasting; overweight; obesity; Mexico; WHO

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Resumen

Objetivo. Describir las prevalencias y tendencias de malnutrición en preescolares mexicanos, según resultados de las Encuestas Nacionales de Nutrición 1988, 1999 y 2006, usando estándares de la Organización Mundial de la Salud de 2006 y referencias del National Center for Health Statistics/World Health Organization (NCHS/WHO). **Material y métodos**. Se calcularon prevalencias de desnutrición (puntaje z < -2 para talla/edad, peso/edad, y peso/talla) y de sobrepeso (> +2z peso/talla). **Resultados**. La talla/edad y el peso/talla han aumentado con el tiempo (*p*< 0.05). Usando los estándares de la OMS de 2006, el desmedro en menores de cinco años de edad era de 26.9, 21.5 y 15.5% en 1988, 1999 y 2006, respectivamente. Los valores de emaciación fueron 6.2, 2.1 y 2.0%. La emaciación en 2006 en los menores de seis meses de edad fue de 4.9%. El sobrepeso aumentó de 1988 a 1999 (6.1 a 7.5%) y se estabilizó en 2006 (7.6%). Las diferencias entre grupos étnicos y socioeconómicos disminuyeron con el tiempo. **Conclusiones**. El desmedro disminuyó marcadamente, pero continúa siendo el principal problema de malnutrición. El sobrepeso emergió como problema de salud pública en niños. Las estimaciones de desnutrición en preescolares previamente publicadas usando las referencias del NCHS/WHO subestimaban las verdaderas cifras. Las desviaciones en la talla alcanzada a partir de los 12 meses de edad revelan prácticas de lactancia y alimentación infantil pobres, probablemente aunadas a infecciones tempranas. Estos resultados refuerzan la necesidad de mejorar la calidad de los programas de nutrición y de promover prácticas adecuadas de alimentación infantil en México.

Palabras clave: malnutrición preescolar; desmedro; sobrepeso; obesidad; México; OMS

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The National Center for Health Statistics/World Health Organization (NCHS/WHO) growth reference has been recommended since the late 1970s for evaluating child growth and for international comparisons.[1] However, this reference does not adequately represent early childhood growth because it was derived based on children who were mixed-fed, with a large proportion of formula-fed infants,[2] and formula-fed infants grow differently than their breast-fed counterparts. Differences in growth vary according to age and sex, but in general, breast-fed infants < 6 months are heavier and track on length as compared to formula-fed infants. After 6 months of life, breast-fed babies are lighter than formula-fed children and still track in length –except between 24 and 36 months, when they are taller. In addition, the distributions of weight and height in breast-fed and formula-fed babies differ. As a result of differences in growth trajectories and distributions, references based on populations with different feeding modes will yield dissimilar prevalences of malnutrition when applied to the same group of children.

The new WHO 2006 child growth standards were developed to evaluate the growth of healthy children. These standards were derived from a MultiCenter Growth Reference Study (MCGRS) conducted between 1997 and 2003. In this study, information on 8 440 children aged 0-71 months was collected from countries around the world representing widely diverse ethnic and cultural backgrounds. Participating countries were Brazil, Ghana, India, Norway, Oman and the United States. The MCGRS selected healthy children living in environments likely to favor the achievement of their full genetic growth potential, who were fed following WHO recommendations, particularly in regards to breast feeding, and whose mothers were non smokers.[3] Therefore, the WHO 2006 standards represent adequate growth better than the previous NCHS/WHO references and are more appropriate to identify deviations from normal growth due to malnutrition.

Results from the MCGRS show that the growth of children within the study sites is strikingly similar regardless of their widely different ethnic (genetic) diversity. This finding supports the view that most of the variability in growth in children less than 5 years old is related not to genetics but to environmental factors such as feeding mode, health conditions and care, and exposure to environmental contaminants (tobacco, lead, etc.), among others.[4]

The prevalence of malnutrition in Mexico[5-7] has been estimated and published using the previous NCHS/WHO references. Thus, it is expected that prevalences of undernutrition and excess weight using the new WHO 2006 standards will differ from previous published prevalences. Malnutrition will not have changed; only our appreciation of it will. Given the normative nature of the WHO 2006 standards, estimates derived from them are more appropriate to identify the magnitudes of the different forms of malnutrition in Mexico than previous NCHS/WHO references that included mixed-fed measures.

Evaluation of the nutritional status of children is a crucial part of the national agenda in terms of health and equity. National representative surveys offer data that is useful for planning and adjusting policy and programs in accordance with health objectives. Thus, the most appropriate estimates should be made available for central as well as for local planning. The objectives of this paper are to describe the prevalences and trends of the different forms of malnutrition in Mexican children less than 5 years of age based on the WHO 2006[8] standards using data from the three national probabilistic nutrition surveys (1988, 1999 and 2006), and to compare such prevalences and trends with those that have been published using the previous NCHS/WHO references.

Material and Methods

The methods employed in the data collection of all three surveys have been described in detail elsewhere.[6,7,9]

Subjects

For the purpose of the present analysis, national data from children 0 to < 5 years of age from the three Mexican National Nutrition Surveys conducted in 1988, 1999 and 2006 will be analyzed.

Sampling

Multi-stage cluster and stratified random sampling selection methods were used in all three surveys. Data collected in the three national surveys were representative at the national and regional (four regions) levels. Data from 1999 and 2006 are also representative of rural and urban locations, and for the first time the 2006 survey had a 32-state-level statistical representation.

All three surveys included children under 5 years of age. Data collected in other age groups are not used in this analysis.

Data collection

Variables used for these analyses were: anthropometric measures of weight, length (in children under 2 years old) and height (in children ≥ 2 years of age), sociodemographic variables such as age, sex, and ethnicity (indigenous if at least one woman in the household spoke an indigenous language [in 1999 and 2006] or households in municipalities where indigenous languages were spoken in 40% or more households [in 1988], non-indigenous otherwise), and a living conditions index which will be described below.

Anthropometric measurements: Weight and recumbent length (in children under 2 years of age) or standing height (in children 2 to < 5 years old) were obtained using standard anthropometric methodology.[9] Weight was measured to the nearest 100 g using an electronic scale (Tanita, Model 1583, Tokyo, Japan), length (to the nearest millimeter) using a locally made measuring board of 1.3 meters, and standing height using a stadiometer with capacity to measure up to 2 meters and precision of 1 mm (Dyna-Top, model E-1, Mexico City, Mexico). The measurements were obtained by anthropometrists who were trained and standardized in all measurements using standard techniques.[9,10] The birth date was reported by the mother and verified in a large proportion of children using birth certificates or vaccination cards, which are considered reliable sources of the date of birth in Mexico.

Data processing

Living conditions index (LCI): The LCI was obtained using the first component resulting from a Principal Components Analysis.[11] The variables employed were housing conditions and accumulated wealth. The score resulting from the factor analysis was either used as a continuous variable or divided into living conditions tertiles (LCTs) in different analyses. In the 1988 survey, the variables in the model were floor material, availability of piped water, sewage, availability of bathroom, and head of family's formal education. The first component explained 57.9% of the total variance. In the 1999 survey, the variables in the model were floor material, availability of piped water, possession of refrigerator, washing machine and stove as well as the number of electric appliances in the household (radio, TV, video player, telephone and computer). The first component explained 56% of the total variance. In the 2006 survey, the variables in the model were floor material, ceiling material, total number of rooms in the household, possession of refrigerator, washing machine and stove as well as a number of electric appliances in the household (radio, TV, video player, telephone and computer). The first component explained 46% of the total variance.

Anthropometric indices and indicators of malnutrition: Anthropometric measurements, age, and sex of the children studied were used to calculate z-scores for weight/age, height/age, and weight/height in accordance with the NCHS/WHO references[1] and the WHO 2006 standards.[8] The prevalence of the different forms of undernutrition (stunting, wasting and underweight) were calculated using minus 2 z-scores for each indicator (length- or height-for-age, weight-for-length or height- and weight-for-age) at specific cutoff points for age and sex. Prevalence of overweight or obesity, hereafter referred to as prevalence of overweight, was defined as weight for length/height above plus 2 z-Scores. For simplicity, hereafter length/height will be referred to as height regardless of whether the actual measurement was length or height.

Statistical analyses

*Epi Info** was used with the NCHS/WHO references to calculate medians and standard deviations (*SD*) of the anthropometric indices and prevalences of the different forms of malnutrition. To obtain prevalence of malnutrition with the WHO 2006 standards we used the macro procedures provided by WHO 2006.‡ We report means and *SD* of the anthropometric indices as well as prevalence and standard errors for the different types of malnutrition. Test for trend of malnutrition indicators were performed with a linear regression for age group, ethnicity and level of conditions index, controlling for year of survey and sample design. Differences in means and proportions were tested using the linear combination test (lincom command in Stata 9.0).

Informed consent

For the 1999 and 2006 surveys, informed consent from participants and approval from the Ethics Committee at the National Public Health Institute (INSP) were obtained. The national survey conducted in 1988 obtained internal approval from the Ministry of Health.

Results

Information was obtained from 13 236 (1988), 17 716 (1999), and 48 304 households (2006) in each survey. Results from the first two surveys have been published elsewhere.[6,7]

Tables I, II and III present data by age for children less than 5 years old studied in the 2006, 1999 and 1988

* The module Nutstat is a nutrition anthropometry program included as a key feature in EpiInfo, and we used the CDC-WHO 1978 growth reference. http://www.cdc.gov/epiinfo/

‡ For calculation with WHO-2006 standards, we used the macros offered in their website (http://www.who.int/childgrowth/software/en/) in Stata. Statistical Software: Release 9.0. College Station, TX: Stata Corporation, USA 2005.

Table I

AGE AND ANTHROPOMETRY USING THE WHO 2006 STANDARDS, BY ETHNICITY, RESIDENCE AND LIVING CONDITIONS IN CHILDREN AGED LESS THAN 5 YEARS. MEXICO, ENSANUT 2006

Age (mo)	*n**	*N‡ (1000)*	*Proportion*
0 - 5	458	627	7
6 - 11	665	873	9
12 - 23	1457	1 724	18
24 - 35	1555	1 838	20
36 - 47	1741	2 234	24
48 - 59	1831	2 117	22
0 to 59	7 707	9 413	100
Ethnicity§			
Indigenous	861	1 052	11
Non-indigenous	6 845	8 361	89
Residence			
Rural	2 334	2 469	26
Urban	5 373	6 943	74
Anthropometry Age (mo)	*Age Mean ± SD*	*Height Mean ± SD*	*Weight Mean ± SD*
0 - 5	3.9±2.2	61.4±7.4	6.5±2.0
6 - 11	9.0±3.0	69.8±7.1	8.4±2.0
12 - 23	18.1±4.9	79.2±7.3	10.6±2.1
24 - 35	30.2±5.5	88.6±8.4	12.9±3.3
36 - 47	42.1±6.0	96.2±10.0	15.0±4.1
48 - 59	54.1±4.6	102.9±8.6	17.1±3.9
0 to 59	32.4±27.4	88.3±23.3	13.1±5.9
Indigenous	33.22±#	86.64±#	12.62±#
Non indigenous	31.79±23.8	88.57±19.0	13.15±5.6
Living conditions index			
Low	32.37±24.4	87.18±19.4	12.73±5.4
Medium	32.24±23.3	88.94±20.3	13.20±5.6
High	31.22±26.0	88.93±22.5	13.35±6.7
Rural	33.01±22.0	87.87±18.4	12.93±5.2
Urban	31.58±24.5	88.52±20.9	13.15±6.1
	Height/age z-score	*Weight/age z-score*	*Weight/height z-score*
0 - 5	-0.48±2.4	-0.11±1.8	0.47±2.1
6 - 11	-0.49±2.2	-0.14±1.8	0.27±1.9
12 - 23	-0.77±2.0	-0.05±1.5	0.44±1.5
24 - 35	-0.80±2.0	-0.15±1.7	0.39±1.8
36 - 47	-0.84±2.1	-0.17±1.9	0.47±2.0
48 - 59	-0.78±1.7	-0.17±1.5	0.46±1.6
0 to 59	-0.75±2.4	-0.13±1.9	0.43±1.8
Indigenous	-1.39±#	-0.53±#	0.38±#
Non indigenous	-0.66±2.3	-0.08±1.8	0.43±1.8
Living conditions index			
Low	-1.16±2.4	-0.39±1.8	0.38±1.6
Medium	- 0.66±2.0	-0.09±1.6	0.39±1.7
High	-0.41±2.0	0.10±1.9	0.48±2.1
Rural	-1.06±2.5	-0.33±1.8	0.42±1.6
Urban	-0.63±2.3	-.063±1.9	0.43±1.9

* Sample size
‡ Expanded population
§ Missing information of ethnicity in one family
# Adjusted standard deviation with design effect not presented because of lack of sample size

Table II

AGE AND ANTHROPOMETRY USING THE WHO 2006 STANDARDS, BY ETHNICITY, RESIDENCE AND LIVING CONDITIONS IN CHILDREN AGED LESS THAN 5 YEARS. MEXICO, ENN 1999

Age (mo)	*n**	*N‡ (1000)*	*Proportion*
0 - 5	715	998	9
6 - 11	762	1 002	10
12 - 23	1 489	1 991	20
24 - 35	1 481	2 088	21
36 - 47	1 592	2 068	20
48 - 59	1 551	2 011	20
0 to 59	7 590	10 158	100
Ethnicity			
Indigenous	834	1 140	11
Non-indigenous	6 756	9 018	89
Residence			
Rural	3 018	3 140	30
Urban	7 140	4 450	70
Anthropometry Age (mo)	*Age Mean ± SD*	*Height Mean ± SD*	*Weight Mean ± SD*
0 - 5	3.12±2.2	59.82±7.6	6.01±2
6 - 11	8.87±2.3	69.72±5.7	8.49±1.7
12 - 23	17.78±4.5	78.33±6.9	10.52±2.2
24 - 35	29.95±5.2	87.19±8.6	12.8±3.0
36 - 47	42.09±4.5	94.79±8.6	14.85±3.2
48 - 59	53.43±4.2	101.51±8.1	16.65±3.4
0 to 59	29.97±21.5	85.42±19.4	12.44±5.5
Indigenous	29.87± §	82.25± §	11.53± §
Non-indigenous	29.97±21.3	85.81±17.4	12.55±4.72
Living conditions index			
Low	29.74±16.6	82.88±14.0	11.66±3.7
Medium	30.15±21.6	86.07±18.1	12.58±5.2
High	29.86±24.1	87.34±21.4	13.10±5.9
Rural	29.88±13.9	83.46±14.3	11.86±4.0
Urban	29.99±23.8	86.24±20.3	12.67±5.7
	Height/age z-score	*Weight/age z-score*	*Weight/height z-score*
0 - 5	-0.21±2.0	-0.02±1.7	0.29±1.9
6 - 11	-0.46±2.0	-0.09±1.4	0.32±1.4
12 - 23	-0.99±2.2	-0.11±1.7	0.51±1.6
24 - 35	-1.15±2.2	-0.21±1.8	0.58±1.7
36 - 47	-1.17±2.0	-0.28±1.6	0.61±1.4
48 - 59	-1.04±1.8	-0.32±1.5	0.48±1.4
0 to 59	-0.94±2.8	-0.2±2.1	0.5±1.7
Indigenous	-1.80± §	-.075± §	0.41± §
Non-indigenous	-0.82±2.6	-0.12±1.83	0.50±1.7
Living conditions index			
Low	-1.60±2.4	-0.63±1.8	0.40±1.4
Medium	-0.81±2.0	-0.12±1.5	0.48±1.6
High	-0.32±1.9	0.23±1.6	0.61±1.7
Rural	-1.46±2.6	-0.52±1.9	0.46±1.3
Urban	-0.71±2.4	-0.05±1.9	0.51±1.8

* Sample size
‡ Expanded population
§ Adjusted standard deviation with design effect not presented because of lack of sample size

Table III
AGE AND ANTHROPOMETRY USING THE WHO 2006 STANDARDS, BY ETHNICITY, RESIDENCE AND LIVING CONDITIONS IN CHILDREN AGED LESS THAN 5 YEARS. MEXICO, ENN 1988

Age (mo)	*n**	*N‡ (1000)*	*Proportion*
0 - 5	640	750	9
6 - 11	743	900	11
12 - 23	1 366	1 647	20
24 - 35	1 553	1 873	22
36 - 47	1 445	1 756	21
48 - 59	1 190	1 447	17
0 to 59	6 937	8 373	100
Ethnicity			
Indigenous	445	614	7
Non-indigenous	6 492	7 759	93
Residence			
Rural	1 200	1 842	22
Urban	5 737	6 532	78
Anthropometry Age (mo)	*Age Mean ± SD*	*Height Mean ± SD*	*Weight Mean ± SD*
0 - 5	2.55±2.0	58.91±6.7	5.48±1.8
6 - 11	8.56±2.2	69.26±6	8.2±1.8
12 - 23	17.68±4.2	78.19±7.3	10.25±2.1
24 - 35	30.13±4.5	87.22±9.3	12.34±2.7
36 - 47	42.45±4.3	93.98±8.2	14.1±2.8
48 - 59	53.59±3.8	99.78±8.4	15.53±3.3
0 to 59	29.53±17.9	84.57±17.5	11.79±4.6
Indigenous	30.10± §	81.56± §	10.94± §
Non-indigenous	29.48±17.5	84.79±15.5	11.85±3.9
Living conditions index			
Low	29.15±18.2	82.18±16.4	11.17±4.2
Medium	29.56±17.2	85.99±13.8	12.08±3.7
High	29.66±18.7	87.67±16.2	12.70±4.6
Rural	29.05±18.24	82.40±17.85	11.31±4.43
Urban	29.65±17.65	85.17±16.21	11.92±4.44
	Height/age z-score	*Weight/age z-score*	*Weight/height z-score*
0 - 5	0.11±2.1	-0.15±1.5	-0.28±2.0
6 - 11	-0.48±2.4	-0.32±1.7	0.05±1.6
12 - 23	-1.02±2.3	-0.34±1.5	0.21±1.6
24 - 35	-1.19±2.5	-0.55±1.7	0.13±1.8
36 - 47	-1.41±2.0	-0.71±1.5	0.18±1.6
48 - 59	-1.43±1.9	-0.85±1.6	0.04±1.7
0 to 59	-1.06±3.0	-0.54±2.0	0.1±1.9
Indigenous	-2.11± §	-1.22± §	-0.003± §
Non-indigenous	-0.97±3.1	-0.48±1.9	0.10±1.7
Living conditions index			
Low	-1.63±2.6	-0.87±1.9	0.09±2.1
Medium	-0.65±1.9	-0.32±1.5	0.06±1.6
High	-0.23±1.7	0.04±1.3	0.22±1.6
Rural	-1.60±3.2	-0.80±2.1	0.14±2.3
Urban	-0.90±2.5	-0.45± 1.9	0.08±1.7

* Sample size
‡ Expanded population
§ Adjusted standard deviation with design effect not presented because of lack of sample size

surveys, respectively. The total number of children for each survey were 7 707 (2006), 7 590 (1999) and 6 937 (1988). Between 16% and 24% were distributed among each 12-month age category. Anthropometric data in the 2006 survey (Table I) show that, on average, height-for-age was three quarters of a *SD* (-0.75±2.4) below and weight-for- height was almost half a *SD* above (0.43±1.8) the median values for the WHO 2006 standards. Seven percent of children in the 1988 survey and 11% in the 1999 and 2006 surveys were indigenous.

Average height-for-age z-score decreases with increasing child age in all three surveys. Analyses of changes over time in the first 6 months of life indicate a decreasing trend, from the 1988 survey, length-for-age was normal (0.11 ± 2.1), it was lower in 1999 (-0.21 ± 2.0) and lowest in the 2006 (-0.48 ± 2.4) survey (test for trend $p < 0.01$).

From 12 months on, the opposite is observed; for each age category, height-for-age z-score is increasingly higher in consecutive surveys (test for trend $p< 0.01$). The largest positive difference between surveys occurred mostly in the 12-47 month range and from the 1999 to the 2006 survey (test for trend $p< 0.01$).

Indigenous children have considerably lower height-for-age z-scores than those who are non-indigenous, but the gap between the groups has decreased over time (test for trend $p< 0.05$). In 1988, height-for-age z-scores for indigenous children was 1.14 score points lower than those who were non-indigenous, while in 2006 this difference was 0.73 z-score points.

For the indigenous children, height-for-age z-score increased 0.31 points and 0.41 units from 1988 to 1999 and 1999 to 2006, respectively (test for trend $p< 0.01$). For non-indigenous children, changes over these same periods were smaller and relatively constant from survey to survey, increasing 0.15 and 0.16 z-score points, and were also statistically significant (test for trend $p< 0.01$).

Similarly, the gap between LCI has become increasingly smaller over time; from 1.4 z-score units between extremes of LCI in 1988 to almost half this figure (0.75 points) between extremes in the 2006 surveys (test for trend $p< 0.01$). Most of the increase in mean height-for-age z-score values has been observed in children in the low LCI.

Regarding weight-for-height z-scores, differences over time and within groups are smaller than those observed for height-for-age z-scores. Weight-for-height seems relatively constant in the first 5 years of life, but has been consistently higher in consecutive surveys, from close to the norm in 1988 (0.1±1.9 z-scores) to almost one-half of a *SD* (0.43±1.8) (test for trend $p< 0.01$) above the median reference value in 2006. Non-indigenous have had slightly higher values than indigenous children, by

Table IV

PREVALENCE OF MALNUTRITION* OVER TIME IN MEXICAN CHILDREN AGED LESS THAN 5 YEARS, USING THE NCHS/WHO REFERENCE AND THE WHO 2006 STANDARDS

	NCHS/WHO references			*WHO 2006 standards*		
	1988	*1999*	*2006*	*1988*	*1999*	*2006*
	%	%	%	%	%	%
Underweight						
0 to 5 mo	1.8 (0.6)[‡]	1.1 (0.5)	1.7 (0.8)	6.3 (1.2)	4.7 (0.9)	4.8 (1.4)
6 to 11 mo	9.7 (1.7)	5.6 (1.1)	5.2 (1.2)	10.0 (1.8)	5.3 (1.1)	4.6 (1.1)
12 to 23 mo	16.0 (1.3)	10.7 (1.0)	6.5 (0.8)	10.1 (1.0)	6.4 (0.8)	2.5 (0.5)
24 to 35 mo	16.2 (1.2)	8.1 (0.9)	5.7 (0.9)	11.5 (1.0)	5.7 (0.8)	4.3 (0.8)
36 to 47 mo	15.4 (1.3)	8.0 (0.9)	5.2 (0.9)	11.5 (1.1)	6.0 (0.8)	3.2 (0.7)
48 to 59 mo	15.3 (1.4)	6.1 (0.7)	3.7 (0.7)	12.9 (1.3)	5.1 (0.7)	2.7 (0.6)
< 5 y	13.9 (0.7)	7.3 (0.4)	4.9 (0.4)	10.8 (0.6)	5.6 (0.4)	3.4 (0.3)
Ethnicity						
Indigenous	30.1 (3.4)	17.3 (1.6)	9.0 (1.4)	25.0 (2.8)	14.0 (1.8)	6.3 (1.2)
Non-indigenous	12.5 (0.7)	6.0 (0.4)	4.5 (0.4)	9.7 (0.6)	4.6 (0.4)	3.1 (0.3)
Living Conditions Index						
Low	21.4 (1.3)	13.6 (0.9)	7.5 (0.8)	17.1 (1.0)	10.3 (0.9)	5.3 (0.7)
Medium	8.2 (0.7)	5.5 (0.7)	4.3 (0.6)	5.7 (0.6)	4.6 (0.6)	2.6 (0.6)
High	4.5 (0.7)	2.2 (0.4)	3.1 (0.6)	3.2 (0.6)	1.6 (0.4)	2.4 (0.5)
Residence						
Rural	19.7 (1.7)	11.7 (0.9)	6.6 (0.8)	15.5 (1.6)	8.7 (0.8)	4.9 (0.6)
Urban	12.2 (0.7)	5.4 (0.5)	4.4 (0.4)	9.5 (0.6)	4.3 (0.4)	2.9 (0.4)
Stunting						
0 to 5 mo	4.1 (0.9)	5.2 (1.1)	9.4 (0.3)	8.3 (1.2)	9.1 (1.4)	14.0 (3.0)
6 to 11 mo	15.0 (1.9)	10.4 (1.3)	11.5 (1.7)	17.5 (2.1)	14.0 (1.5)	12.8 (1.7)
12 to 23 mo	23.7 (1.5)	21.4 (1.4)	14.1 (1.6)	25.6 (1.5)	24.5 (1.4)	16.1 (1.6)
24 to 35 mo	22.1 (1.6)	18.1 (1.4)	11.3 (1.3)	29.8 (1.8)	25.6 (1.6)	16.6 (1.6)
36 to 47 mo	26.6 (1.7)	20.7 (1.5)	13.3 (1.6)	32.2 (1.7)	25.5 (1.6)	16.9 (1.8)
48 to 59 mo	31.0 (1.8)	18.4 (1.3)	13.3 (1.3)	33.4 (1.9)	20.0 (1.3)	14.2 (1.3)
< 5 y	22.6 (1.0)	17.4 (0.8)	12.6 (0.7)	26.9 (1.0)	21.5 (0.9)	15.5 (0.8)
Ethnicity						
Indigenous	48.3 (3.3)	43.5 (2.9)	29.0 (2.6)	55.0 (3.4)	49.2 (2.9)	34.1 (2.8)
Non-indigenous	20.5 (1.0)	14.1 (0.7)	10.5 (0.7)	24.6 (1.0)	18.0 (0.7)	13.2 (0.8)
Living Conditions Index						
Low	36.1 (1.4)	33.2 (1.6)	20.1 (1.5)	41.2 (1.4)	39.5 (1.6)	25.7 (1.7)
Medium	11.8 (0.9)	12.6 (0.9)	10.4 (1.1)	15.2 (1.0)	17.0 (1.1)	12.5 (1.2)
High	5.0 (0.8)	5.0 (0.6)	6.6 (0.8)	7.0 (0.9)	6.6 (0.7)	8.2 (0.9)
Residence						
Rural	36.2 (2.3)	31.5 (1.7)	19.8 (1.6)	41.7 (2.3)	37.1 (1.8)	24.1 (1.9)
Urban	18.7 (0.8)	11.4 (0.7)	10.0 (0.7)	22.7 (0.9)	14.9 (0.8)	12.5 (0.8)

Continue…

Continuation…

	NCHS/WHO references			WHO 2006 standards		
	1988	1999	2006	1988	1999	2006
	%	%	%	%	%	%
Wasting						
0 to 5 mo	5.2 (1.2)	1.8 (0.5)	0.2 (0.1)	11.8 (1.7)	4.4 (0.8)	4.7 (1.4)
6 to 11 mo	4.6 (0.9)	2.1 (0.6)	3.9 (1.4)	6.1 (1.1)	1.9 (0.6)	4.5 (1.5)
12 to 23 mo	7.2 (0.9)	3.1 (0.5)	2.2 (0.4)	4.5 (0.7)	2.8 (0.5)	1.9 (0.4)
24 to 35 mo	6.0 (0.8)	1.9 (0.6)	2.5 (0.7)	6.2 (0.7)	2.0 (0.6)	2.8 (0.7)
36 to 47 mo	4.7 (0.8)	0.7 (0.2)	0.6 (0.2)	5.2 (0.8)	0.8 (0.2)	1.0 (0.3)
48 to 60 mo	6.1 (1.0)	1.4 (0.4)	0.6 (0.3)	6.5 (0.9)	1.5 (0.4)	0.7 (0.3)
< 5 y	5.8 (0.4)	1.8 (0.2)	1.5 (0.2)	6.2 (0.4)	2.1 (0.2)	2.0 (0.3)
Ethnicity						
Indigenous	5.3 (1.2)	2.2 (0.5)	2.3 (1.1)	5.1 (1.2)	2.9 (0.5)	3.3 (1.2)
Non-indigenous	5.8 (0.4)	1.7 (0.2)	1.4 (0.2)	6.2 (0.4)	1.9 (0.2)	1.9 (0.2)
Living Conditions Index						
Low	5.4 (0.6)	2.2 (0.3)	1.7 (0.3)	5.7 (0.6)	2.6 (0.3)	2.3 (0.4)
Medium	6.5 (0.7)	2.1 (0.4)	1.4 (0.3)	6.5 (0.7)	2.5 (0.4)	1.8 (0.4)
High	4.5 (0.9)	0.9 (0.3)	1.5 (0.5)	5.3 (0.9)	1.1 (0.3)	2.0 (0.6)
Residence						
Rural	5.4 (0.9)	1.8 (0.3)	1.8 (0.4)	6.7 (0.9)	2.2 (0.3)	2.0 (0.4)
Urban	5.8 (0.4)	1.7 (0.3)	1.5 (0.2)	6.0 (0.4)	2.0 (0.2)	2.0 (0.3)
Overweight and obesity						
0 to 5 mo	3.3 (1.1)	8.2 (2.1)	10.2 (2.7)	4.0 (1.1)	8.2 (2.1)	8.7 (2.4)
6 to 11 mo	5.4 (0.9)	5.4 (0.9)	4.6 (0.9)	5.5 (0.9)	7.0 (1.0)	5.8 (1.0)
12 to 23 mo	4.4 (0.6)	6.8 (0.9)	5.4 (0.8)	6.3 (0.8)	8.1 (0.9)	7.7 (1.0)
24 to 35 mo	3.1 (0.6)	3.4 (0.6)	3.1 (0.5)	6.9 (0.9)	8.5 (1.0)	7.9 (0.9)
36 to 47 mo	3.3 (0.6)	5.0 (0.8)	5.3 (0.7)	6.1 (0.8)	7.3 (0.9)	9.5 (0.01)
48 to 60 mo	4.3 (0.7)	4.6 (0.7)	5.0 (0.7)	6.2 (0.9)	6.2 (0.8)	5.5 (0.7)
< 5 y	3.9 (0.3)	5.3 (0.4)	5.1 (0.3)	6.1 (0.4)	7.5 (0.4)	7.6 (0.4)
Ethnicity						
Indigenous	2.3 (0.8)	3.5 (0.7)	3.4 (0.6)	4.8 (1.4)	5.8 (1.1)	5.5 (1.3)
Non-indigenous	4.0 (0.3)	5.5 (0.4)	5.3 (0.4)	6.2 (0.4)	7.8 (0.5)	7.8 (0.5)
Living Conditions Index						
Low	3.1 (0.4)	4.2 (0.5)	3.8 (0.5)	5.1 (0.6)	6.2 (0.6)	6.2 (0.7)
Medium	3.4 (0.4)	5.3 (0.6)	5.6 (0.7)	5.3 (0.6)	7.6 (0.7)	8.0 (0.7)
High	6.6 (0.9)	6.5 (0.9)	5.9 (0.7)	8.8 (1.1)	8.9 (1.0)	8.6 (0.9)
Residence						
Rural	3.9 (0.8)	4.4 (0.4)	3.6 (0.4)	6.8 (1.1)	6.7 (0.5)	6.7 (0.8)
Urban	3.9 (0.3)	5.6 (0.5)	5.6 (0.4)	5.9 (0.4)	7.9 (0.6)	7.9 (0.5)

* Source: 1988, 1999 and 2006 Mexican National Health and Nutrition Surveys
‡ Standard errors presented in parentheses

less than 0.1 z-score points, and this gap was maintained between the first and the last survey (the difference in gaps between surveys is not statistically significant).

Results for mean weight-for-height z-scores by living conditions reveal that children from the highest tertile are heavier than those in the lowest tertile (lincom test $p < 0.05$), but on average, all tertiles have been above the norm.

Prevalence of malnutrition by age categories for the three surveys using the WHO 2006 standards show that stunting has been consistently above 8% in early infancy (0-5 months) since the first survey (table IV). In accordance with results from the z-scores. These data also show that while the rates of undernutrition have become smaller over time in children 6 to 59 months of age, stunting has increased from 8.3% in 1988 to 13.8% in 2006 (tests for trend $p < 0.01$), in infants less than 6 months old.

Overall undernutrition (low weight-for-age) has decreased and overweight has increased over time (test for trend $p < 0.01$) in Mexican children, as can be observed in Table IV and Figure 1. Regardless of the reference used, stunting has been the main undernutrition problem throughout the 18-year period included in these analyses, and continues to be so in 2006. In contrast, wasting has not been a generalized public health problem since 1999, although it continues to be high in the first year of life, as observed in Table IV. The prevalence of overweight (> plus 2 *SD* weight/height) increased from 1988 to 1999 and appears to have stabilized in the last seven years (test for trend $p < 0.01$). Estimates of the prevalence of malnutrition using the NCHS/WHO references underestimate wasting, stunting and overweight, while it overestimates the prevalence of underweight in most age groups. There are a few exceptions to these findings: wasting particularly in the 12-23 month category, is not underestimated with the NCHS/WHO references, nor is overweight in the 0-5 month category of the last two surveys. The 2006 survey prevalence in children less than 5 years old using the NCHS/WHO references underestimates stunting by 2.9 percentage points (pp), wasting by 0.5 pp and overweight by 2.4 pp, while underweight is overestimated by 1.5 pp ($p < 0.01$ in all lincom tests).

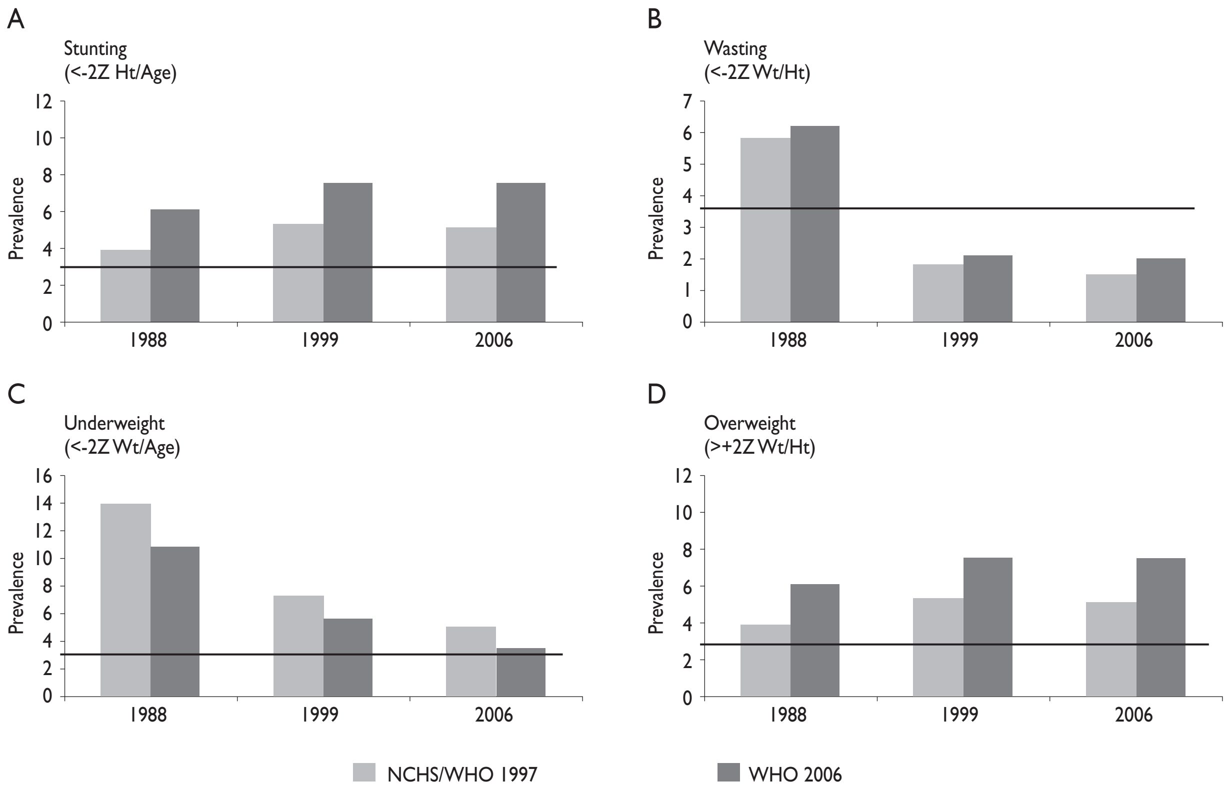

FIGURE 1. PREVALENCE OF MALNUTRITION IN MEXICAN CHILDREN IN 1988, 1999 AND 2006 USING THE NCHS/WHO REFERENCES AND THE WHO-2006 GROWTH STANDARDS

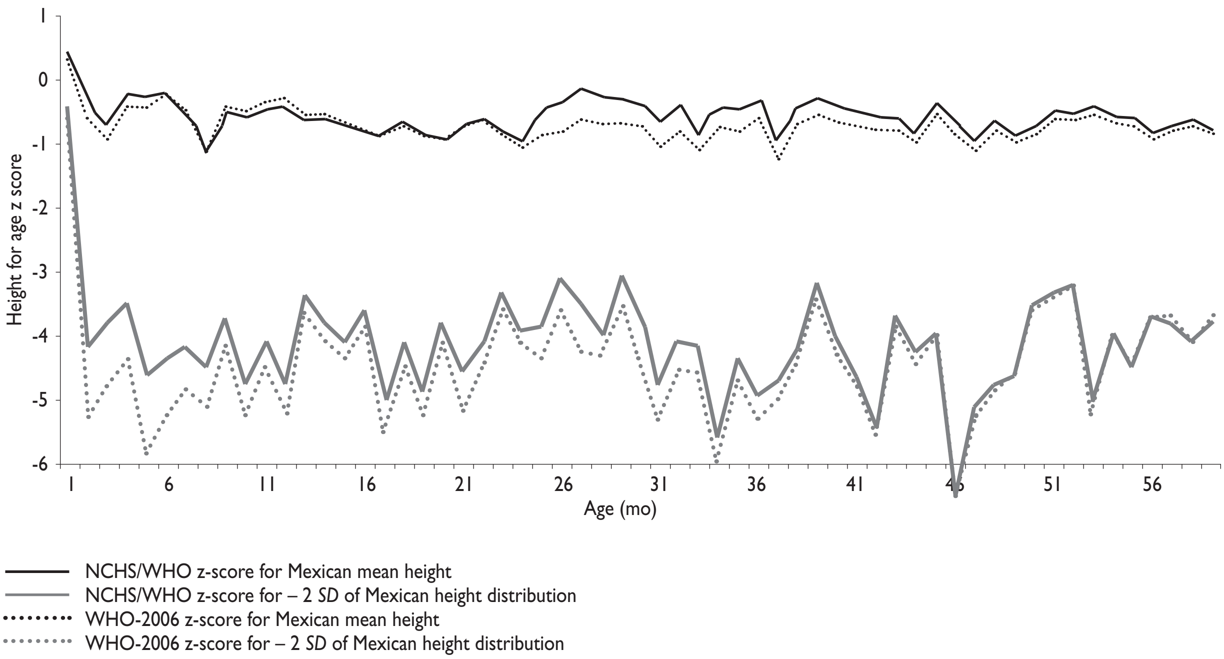

FIGURE 2. HEIGHT-FOR-AGE Z-SCORES OF MEXICAN CHILDREN IN 2006 BASED ON TWO GROWTH REFERENCES, NCHS/WHO AND THE WHO 2006: ONE POPULATION, TWO PERSPECTIVES

The greatest differences between estimates from NCHS/WHO references and 2006 WHO standards are observed in the youngest age category (< 5 months), where prevalence is 2 to 3 times higher for underweight and about 20 times higher for wasting (0.2% *vs.* 4.7%) according to 2006 WHO relative to the HCHS/WHO estimates.

To understand the effect that different population distributions have on z-score values and estimated rates of malnutrition, Figure 2 presents height-for-age z- scores of Mexican children using the NCHS/WHO and WHO 2006 growth references. For each reference, the z-score corresponding to mean value as well as the value at minus 2 *SD* for the Mexican population distributions are plotted. Figure 3 shows similar values for weight-for-height z-scores.

These figures show that the average height-for-age and weight-for-height z- scores obtained for the mean values of Mexican children between references are generally similar, although in some age groups the difference can reach about half of a z-score. The differences are slightly more pronounced for height-for-age than for weight-for-height. In contrast, the differences in z-scores between references observed in the lower tails of the Mexican distribution are much larger in most age categories. Moreover, the z-scores estimated with the WHO 2006 standards lie further below the z-scores estimated using the NCHS/WHO references. This is observed particularly in the first 12 months for height-for-age, and in the first 6 months for weight-for-height.

Figure 4 shows average and minus 2 *SD* (or the 3rd percentile) for attained growth (cm) for the three different populations: those pertaining to the NCHS/WHO references, those in the WHO 2006 standards and those of Mexican children in the ENSANUT 2006. Mean length at birth is very similar in the three populations, but Mexican children depart downwards from the growth curves of both references between about 3 to 6 months and abruptly separate at about 12 months of age. In addition, at almost every age the minus 2 *SD* value for the Mexican distribution lies far below the height values at the 3rd centile of both reference distributions.

Discussion

The 18 year span data from the three National Nutrition Surveys show that rates of preschool undernutrition have decreased, and those of overweight have increased in Mexico.

Improvements in average attained growth have been consistent over time and especially noticeable from the 1999 to the 2006 surveys. Both average height-for-age and prevalence of stunting data have improved,

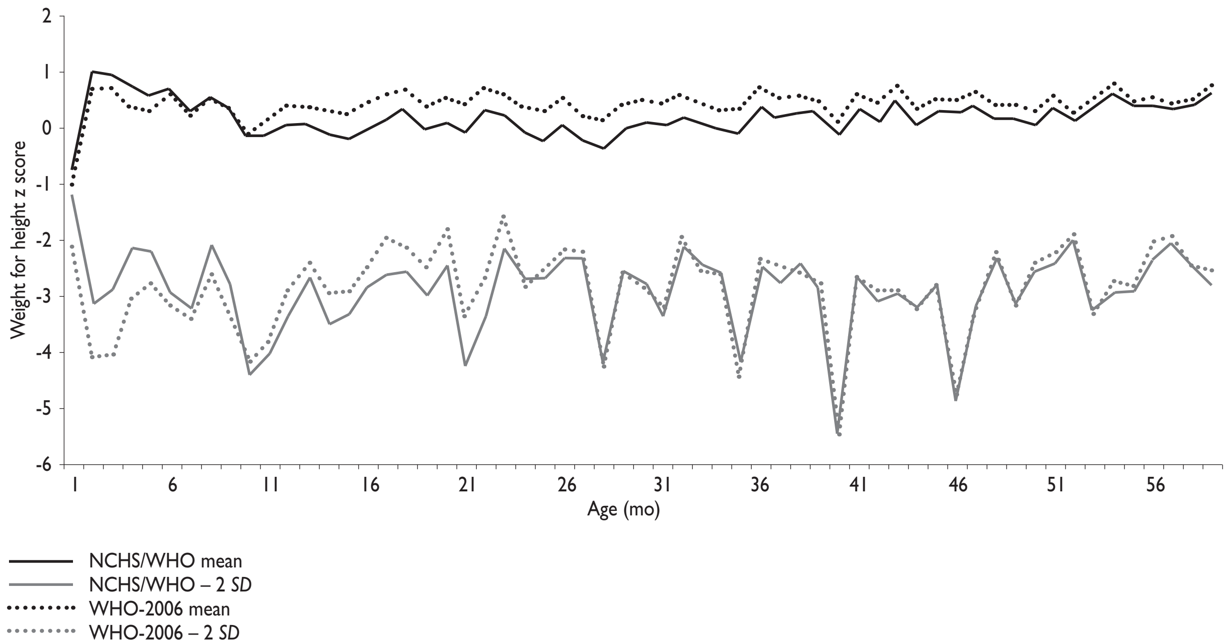

FIGURE 3. WEIGHT-FOR-HEIGHT Z-SCORES OF MEXICAN CHILDREN IN 2006 BASED ON TWO GROWTH REFERENCES, NCHS/WHO AND THE WHO 2006: ONE POPULATION, TWO PERSPECTIVES

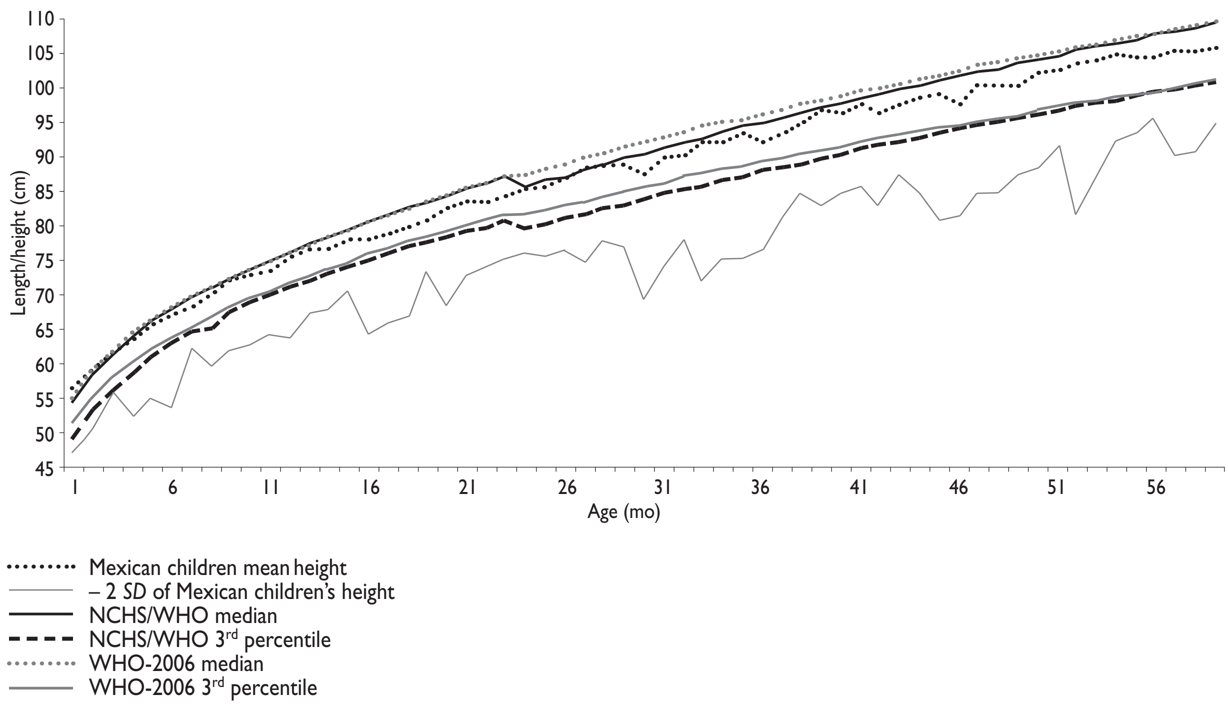

FIGURE 4. HEIGHT-BY-AGE OF THREE DIFFERENT POPULATIONS: US NCHS/WHO, MULTI-ETHNIC WHO 2006, AND MEXICAN CHILDREN IN 2006

indicating clear reductions in child undernutrition. These improvements have occurred especially in children from the lowest living condition tertile and the indigenous population, the poorest population in Mexico. These changes imply that reductions in inequity have occurred in the country. However, despite the reductions in stunting among the poor, the gaps between children living in high *vs.* low living conditions remain large. In addition, average improvements, though a national success, have not occurred across all age groups. Specifically, reductions in growth deficits are not observed in the youngest infants. In fact, average attained height-for-age of babies less than 5 months of age have been decreasing from a normal value in 1988 (z-score of 0.11) to a deficit of almost half a *SD* (-0.48) in the same age range in 2006.

Estimates of the prevalence of malnutrition differ using the recently developed WHO 2006 growth standards *vs.* the NCHS/WHO references.

Differences between estimates using both growth references depended on the age of the child and the indicator analyzed. For infants, z-scores estimated from the WHO-2006 standards are similar or slightly lower than estimates from the NCHS/WHO references, however, the variances are smaller in the WHO 2006 standards relative to the NCHS/WHO references. Thus, estimated prevalence below particular cutoff points below the mean (for example < minus 2 z-score) for height-for-age and weight-for-height are generally higher when using these WHO 2006 standards.[3] The opposite happens with weight-for-age and therefore the prevalence of underweight using the WHO 2006 standards are lower.

In Mexican children the difference in the estimations of malnutrition was particularly observed in the rates of child stunting and infant wasting. With the WHO 2006 standards, overall stunting in children aged less than 5 years in 2006 was 2.9 pp higher than previously estimated.[5] The magnitude of the difference in prevalence between the references and standards varies throughout childhood but it is generally higher for estimates using the 2006 WHO reference. The bias associated with the use of the former growth references was also observed in wasting. Although the overall prevalence of wasting for children aged less than 5 years as estimated with the WHO 2006 standards was only half of a pp higher relative to the old references, in the first 6 months of life the underestimation was more than 20-fold. This occurs not because attained weight in the WHO 2006 population is greater than weight in the previous NCHS/WHO references, but because the variance in attained weight at this early age is much smaller in the WHO-2006 standards than in the NCHS/WHO references. Therefore the newly estimated prevalence below minus 2 z-scores for weight/length is higher in Mexican infants.

We consider that the lower prevalence of wasting and stunting estimated using the NCHS/WHO references, relative to the WHO 2006 standards are underestimates of the true prevalence because, as mentioned in the introduction, the 2006 norms represent adequate growth better than the previous NCHS/WHO references and are more appropriate to identify deviations from normal growth due to malnutrition.

The underestimation in stunting of 2.9 pp is not trivial; when expanded to the population of children less than 5 years old it represents almost 274 thousand children and the underestimation of the prevalence of wasting of half a pp amounts to over 47 thousand children.

The underestimation in the rates of child malnutrition was expected. The WHO group[3] showed similar patterns of underestimations in malnutrition in children from a developing country (Bangladesh) when using the WHO 2006 standards. In Bangladesh, the rates of undernutrition as well as its underestimation were higher than in Mexico; the case was similar with respect to overweight.

Of particular relevance for public policy is the finding that the prevalence of wasting (weight-for-length < minus 2 z-scores) in young Mexican infants (< 6 months old) had been at or below the figures expected in a normal population in the last two national surveys (Table IV) when estimated with the NCHS/WHO references, therefore wasting was no longer considered a public health problem for that age group. There was one exception in 2006 when wasting in late infancy (6 - 11 months old) was 3.7%. However, when the WHO-2006 standards are used to evaluate infant nutritional status, it is clear that wasting has been a public nutrition problem in infancy (0 - 11 months old).

This concept is not new. Underestimation of malnutrition, particularly of wasting, using the NCHS/WHO references *vs.* breast-fed infants was documented well before the WHO 2006 standards were issued. The Report of the Expert Committee back in 1995 documented large underestimations of undernutrition rates among young Indian and Peruvian infants,[12] evidencing the different interpretation in the timing of growth faltering when estimated using a narrow variance distribution of breast-fed infants.

Differences observed among Mexican children over the last 20 years occurred in the expected direction given the prescriptive nature of child growth standards.[8] Our data show that there is a large variability in growth within Mexican children. This is expected given the large heterogeneity in the environmental, socioeconomic and health backgrounds and in infant feeding patterns across the country.

These new estimates point out nutritional problems in the earliest stages of life. Excess wasting in young infants underscore undesirably poor breastfeeding practices and largely heterogeneous environmental conditions in Mexico. Current (2006) infant feeding practices in Mexico have not yet been published, but previous national nutrition data (1999) show that median duration of lactation was 9 months, with only 20% of infants aged less than 6 months (at any given month) being exclusively breast-fed. At the end of 1 month of life, only 42% of infants were exclusively breast-fed, followed by a marked decline, reaching values under 5% at the end of the fifth month.[13] The large prevalence of undernutrition in early infancy identified in Mexican infants in 2006 most probably reflects adverse feeding practices and environmental conditions that need to be improved.

Although average length at birth is apparently at or above the 2006 norm (Figure 4) the minus 2 *SD* values of the length distribution during the first months of life falls below the 3rd centile of the 2006 norm. Therefore, maternal factors such as undernutrition and micronutrient deficiencies may play a role in explaining undernutrition during early infancy, although probably to a lesser degree than infant feeding practices.

Several large-scale programs in Mexico targeted to low-income households with young children are promoting appropriate complementary feeding through the distribution of fortified foods and through nutrition education. Although evidence suggests that these programs have been partially successful on the basis of their impact evaluation[14,15] and the reduction in stunting in Mexico in the last decade,[16] the clear departure of the mean height in Mexican children relative to the norm after 12 months of age in the 2006 survey suggests inadequate complementary feeding and probable negative effects of infections. Most of the large-scale programs have been evaluated and recommendations for improving their effectiveness have been formulated. It is important to implement those recommendations in order to improve the effectiveness of these actions. These data provide evidence for the need to revise current nutrition policy aimed at reducing undernutrition, and underscore the urgency to place lactation promotion and protection on the national health agenda and identify specific programmatic issues and areas for immediate action. Breastfeeding promotion has not been the emphasis of large-scale programs aimed at improving the nutritional status of young children in Mexico. Although several programs with broad coverage are promoting nutrition during pregnancy, there is a need for evaluating their operations and impact in order to ensure their effectiveness. Protecting and promoting adequate infant feeding practices, including exclusive breastfeeding for infants aged less than 6 months, followed by the introduction of adequate complementary feeding and a continuation of breastfeeding until 2 years of life or beyond (should the mother-infant couple so desire) would improve growth performance, especially in early childhood.

These new estimates reinforce the need to improve the quality of programs that address nutrition in order to reduce the gaps between socioeconomic groups and, particularly, point to the need to promote and protect lactation and infant feeding practices as a priority for Mexico's public policy agenda.

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