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Stature in adults as an indicator of socioeconomic inequalities in Mexico

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ABSTRACT

Objective. *To estimate the association between stature in Mexican adults and some sociodemographic factors.*

Methods. *We studied a sample of 30 970 subjects, using anthropometric data from the 2012 National Health and Nutrition Survey (ENSANUT 2012). The first quartile was used as the cutoff to define short stature. We analyzed differences among stature strata for sociodemographic variables by using the Kruskal-Wallis test. We estimated odds ratios to measure the association between stature and sociodemographic variables, controlling for potential confounders.*

Results. *Persons from the southern region of the country were some three times as likely to be of short stature than were subjects in the northern region. The stature difference between the Mexican states with the highest and the lowest average stature was larger than the average difference in stature between Mexico and the United States of America. Adults who had had less than six years of schooling presented the highest prevalence of short stature, regardless of sex, region of the country, place of residence (rural or urban), or the proportion of indigenous language speakers in a state. In addition, the stratum with the highest marginalization (percentage of the population lacking education and services, with a low income, and living in a small community) showed the highest prevalence of short stature.*

Conclusion. *In Mexico, adults who are of short stature have unequal living conditions when compared to those of average or high stature, and this could drive increases in health inequity.*

Keywords Socioeconomic factors; body height; adult; indigenous population; Mexico.

Stature reached at adulthood is a useful biological measure to estimate some factors related to long-term health and well-being of a population (1). Adult stature results from a combination of multiple factors, notably including genetics, age, weight at birth, nutrition at an early age, physical activity, diseases contracted during life, social and economic conditions, gender-related circumstances, and the environment (2-7).

In Mexico, stature in adults has been studied, but with different aims and different cutoffs. For example, Vargas-Ancona in 1994 (8) and Lopez-Alvarenga in 2004 (9) researched the prevalence of individuals with short stature (SS). The Vargas-Ancona study reported a prevalence of SS of 76% for women ≤ 151 cm and of 58% for men ≤ 164 cm for individuals from Yucatan, a state in southern Mexico.

In contrast, Lopez-Alvarenga found an overall SS prevalence of 20.7% (women ≤ 150 cm and men ≤ 160 cm), with a higher prevalence in women than in men (25.8% vs. 13.6%), in six Mexican cities in the center and north of the country. The same SS cutoffs as those of the Lopez-Alvarenga research were applied in a study about the ability of body mass index (BMI) to detect obesity-associated morbidity in subjects with a normal or

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short stature (10). In addition, those same cutoffs are still used in the Official Mexican Standard (Norma Oficial Mexicana) to define SS in adults (11).

There is no internationally accepted criterion to define SS in adults. Some authors have used the 3rd, 5th or 10th percentile (5, 12-14), and others have used a fixed number to establish cutoffs (9, 10). The first quartile (Q1) has also been used as cutoff for short stature (4, 15-20).

In countries with an indigenous population, such as Mexico, being indigenous should be analyzed to avoid confounding with short stature. Most of the indigenous population are below the national average stature. According to Mexico's 2015 Intercensal Survey, the country had an estimated 7.4 million indigenous people (including 3.8 million women), representing 7% of the population aged 3 years and older (21).

In regards to socioeconomic factors, some authors have found an association between SS and low socioeconomic status, as measured by family income (3) and education level achieved and type of employment (22). These associations have continued even though average height has increased in recent decades (23).

Using data from the early and late twentieth century, Schick and Steckel (24) found that taller individuals and populations earn more money than their shorter counterparts. This result is due, in large part, to a strong correlation between adult height and accumulating human capital. Furthermore, they attribute this outcome to the significant association between adult height and both cognitive and noncognitive abilities.

In Mexico, little is known regarding the social inequalities related to stature. Therefore, the objective of this population-based study was to estimate the association between stature in Mexican adults and some sociodemographic factors.

MATERIAL AND METHODS

To relate stature in adults with sociodemographic variables, we used data from the 2012 National Health and Nutrition Survey (ENSANUT 2012), a population-based survey that was conducted in Mexico by the Health Ministry. Because most of the indigenous population have a stature below the national average, we used data from the 2015 Intercensal Survey (21) to analyze the indigenous population (people who speak an indigenous language) as a potential confounder. Detailed descriptions of the design and coverage of the two surveys are available (25, 26).

Statistical analysis

We used statures equal or below the 25th percentile (Q1) as the criterion for short stature.

Percentages for each variable were analyzed by quartile and sex. We generated a variable for the prevalence of indigenous language speakers for each state of the country. The sample was divided into quartiles by the prevalence of indigenous language speakers. We estimated the cutoff value for indigenous population from Q4 (75th percentile) of prevalence of indigenous language speakers.

The following variables with their respective categories were considered from the ENSANUT 2012 data: geographic region, locality, socioeconomic status (SES) (27), years of schooling, marginalization (percentage of the population lacking education and services, with a low income, and living in a small community), and, BMI (weight in kg/height in m^2). For the BMI, we applied the internationally established categories of underweight, normal weight, overweight, and obesity, based on the cutoffs set by the World Health Organization (WHO): < 18.5 kg/m^2 (underweight); 18.5 to 24.9 kg/m^2 (normal weight); 25.0 to 29.9 kg/m^2 (overweight); and ≥ 30.0 kg/m^2 (obesity).

We described the data by quartiles according to the relative frequency distribution. We then performed the Kruskal-Wallis test to analyze differences, as well as the chi-squared test of homogeneity of odds ratio (OR) and the test for linear trend of the log odds to analyze the prevalence of SS for each category of variables and the trend in this association. Confounding and interaction analyses by indigenous condition were performed using the Mantel-Haenszel odds ratio test (OR_{M-H}).

The OR for SS was calculated for the categories of schooling variable using the OR_{M-H} test, controlling by sex, region, place of residence (rural or urban), and indigenous condition. ORs were calculated for each state, and the mean of prevalence was used as reference in order to show Mexican states below and above the mean.

Average stature and prevalence of SS was described according to the distribution of the relative frequency by state, both for the total sample and for each sex. The SS distribution was presented in a map, for assessment. All analyses were performed using the Stata 13.0 software (StataCorp, College Station, Texas, United States). The critical p value was set at < 0.05.

Ethics and consent to participate

The ENSANUT 2012 procedures were reviewed and approved by the ethics, research, and biosecurity committees of the National Institute of Public Health of Mexico, in particular with regard to confidentiality and nondisclosure of information. For each instrument and population group, a consent form that specified that the subjects were informed and participating voluntarily was issued by the National Institute of Public Health of Mexico.

RESULTS

We considered 31 000 subjects with complete data and who were aged 20 to 59. We excluded 30 cases for having a stature under 130 cm or over 200 cm. The final sample had 30 970 subjects, of whom 18 331 (59.2%) were women.

Regarding stature, the following groups were established for women: ≤ 148.5 cm (Q1), 148.6 to 153.1 cm (Q2), 153.2 to 157.8 cm (Q3), and ≥ 157.9 cm (Q4). For men, the following groups were formed: ≤ 161.1 cm (Q1), 161.2 to 166.0 cm (Q2), 166.1 to 171.0 cm (Q3), and ≥ 171.1 cm (Q4). For both women and men, the lowest quartile (Q1) was considered as the cutoff point to determine SS.

Four categories were established for indigenous language prevalence by state: ≤ 1.4% (Q1); 1.5% to 2.7 % (Q2); 2.8 % to 11.2% (Q3); and ≥ 11.3 % (Q4). Indigenous population was defined as falling into Q4.

Table 1 shows the percentages of the population by quartile and socioeconomic factors for the total population and by sex. For example, for the first category of the age factor for women (20 to 29 years), 18.6% of women in that age group were in Q1, 21.9% in Q2, 25.9% in Q3, and 33.6% in Q4. Given that the lowest quartile (Q1) was considered as the cutoff point to determine SS, we can say that for the first age category for women, 18.6% of them were of short stature. In contrast,

TABLE 1. Socioeconomic factors and percentages, with 95% confidence intervals (CIs), of adults by quartiles of stature, for total, women, and men, in study of stature in adults and socioeconomic inequalities in Mexico

Socioeconomic factor	Total (N =30 970)			Women (n = 18 331) (stature in quartiles, % and 95% CI)					Men (n = 12 639) (stature in quartiles, % and 95% CI)				
	Percent	Mean	Q1 for both sexes	Q1	Q2	Q3	Q4	p[a]	Q1	Q2	Q3	Q4	p[a]
	%	(cm)	% (95% CI)	≤ 148.5	148.6 - 153.1	153.2 - 157.8	≥ 157.9		≤ 161.1	161.2 - 166.0	166.1 - 171.0	≥ 171.1	
Age													
20-29	25.8	160.3	18.4 (17.5-19.2)	18.6 (17.5-19.8)	21.9 (20.7-23.1)	25.9 (24.7-27.2)	33.6 (32.3-35.0)	0.000	18.0 (16.8-19.4)	22.6 (21.3-24.1)	26.9 (25.5-28.5)	32.4 (30.8-34.0)	0.000
30-39	30.1	158.4	23.1 (22.2-23.9)	22.6 (21.5-23.7)	25.0 (23.9-26.1)	26.8 (25.6-27.9)	25.7 (24.5-26.8)		23.8 (22.5-25.3)	24.7 (23.3-26.1)	26.0 (24.6-27.5)	25.4 (24.0-26.9)	
40-49	25.8	158.0	27.2 (26.2-28.2)	27.5 (26.2-28.8)	25.9 (24.7-27.2)	24.1 (22.9-25.4)	22.5 (21.3-23.7)		26.7 (25.3-28.3)	25.5 (24.1-27.1)	24.5 (23.0-26.0)	23.3 (21.8-24.7)	
50-59	18.3	156.9	33.2 (32.0-34.4)	32.9 (31.3-34.5)	29.3 (27.8-30.9)	22.5 (21.1-24.0)	15.3 (14.1-16.6)		33.6 (31.7-35.5)	27.3 (25.5-29.1)	22.2 (20.6-23.9)	16.9 (15.5-18.5)	
Region													
North	22.9	161.5	12.2 (11.4-13.0)	12.1 (11.1-13.2)	22.0 (20.7-23.3)	28.8 (27.4-30.2)	37.1 (35.6-38.6)	0.000	12.3 (11.2-13.5)	22.4 (21.0-23.9)	29.7 (28.1-31.3)	35.6 (34.0-37.3)	0.076
Center	34.6	159.8	17.2 (16.5-17.9)	16.5 (15.6-17.4)	24.2 (23.1-25.2)	29.2 (28.1-30.4)	30.1 (29.0-31.2)		18.2 (17.1-19.4)	23.7 (22.5-25.0)	27.4 (26.1-28.8)	30.7 (29.3-32.1)	
Mexico City	4.8	159.2	19.5 (17.6-21.6)	19.1 (16.7-21.9)	28.7 (25.8-31.7)	25.5 (22.7-28.5)	26.7 (23.9-29.7)		20.1 (17.1-23.4)	25.0 (21.7-28.5)	26.4 (23.1-30.1)	28.5 (25.1-32.3)	
South	37.7	155.3	40.0 (39.2-40.9)	39.7 (38.5-40.8)	27.5 (26.5-28.6)	19.3 (18.4-20.2)	13.5 (12.8-14.4)		40.6 (39.2-42.0)	27.6 (26.3-28.9)	19.7 (18.5-20.8)	12.1 (11.2-13.1)	
Locality													
Rural	33.9	157.2	31.3 (30.4-32.2)	31.1 (30.0-32.3)	26.1 (25.1-27.2)	22.5 (21.5-23.6)	20.2 (19.2-21.2)	0.000	31.6 (30.2-33.0)	25.7 (24.4-27.0)	23.3 (22.0-24.6)	19.5 (18.3-20.7)	0.000
Urban	66.1	159.1	21.4 (20.8-22.0)	21.3 (20.6-22.0)	24.7 (24.0-25.5)	26.5 (25.7-27.2)	27.5 (26.7-28.3)		21.5 (20.7-22.4)	24.5 (23.6-25.4)	26.1 (25.2-27.0)	27.9 (27.0-28.9)	
Socioeconomic status													
Low	33.8	155.9	37.5 (36.6-38.4)	37.7 (36.5-38.9)	27.0 (25.9-28.1)	20.7 (19.7-21.7)	14.6 (13.7-15.5)	0.000	37.1 (35.7-38.6)	27.8 (26.5-29.2)	20.8 (19.6-22.0)	14.3 (13.3-15.4)	0.000
Medium	33.5	158.6	23.2 (22.4-24.0)	22.5 (21.5-23.6)	26.1 (25.0-27.2)	26.9 (25.8-28.0)	24.5 (23.4-25.6)		24.2 (22.9-25.5)	24.7 (23.5-26.1)	26.6 (25.2-27.9)	24.5 (23.2-25.8)	
High	32.7	161.0	13.3 (12.6-13.9)	13.2 (12.4-14.1)	22.4 (21.4-23.5)	27.9 (26.8-29.0)	36.5 (35.3-37.7)		13.4 (12.4-14.4)	22.1 (20.8-23.3)	28.1 (26.8-29.5)	36.5 (35.0-37.9)	
Years of schooling													
< 6	5.5	152.3	53.9 (51.5-56.2)	54.5 (51.5-57.4)	25.5 (23.0-28.1)	13.5 (11.6-15.6)	6.6 (5.3-8.2)	0.000	52.8 (48.8-56.8)	21.6 (18.4-25.1)	17.5 (14.6-20.8)	8.1 (6.2-10.7)	0.000
6 - 9	64.2	157.5	28.0 (27.4-28.7)	27.5 (26.7-28.3)	26.9 (26.1-27.7)	25.1 (24.3-25.9)	20.5 (19.8-21.2)		28.9 (27.9-29.9)	26.9 (26.0-27.9)	24.2 (23.3-25.2)	20.0 (19.1-20.9)	
> 9	30.3	161.6	12.6 (11.9-13.3)	12.1 (11.2-13.0)	21.3 (20.2-22.4)	27.6 (26.4-28.8)	39.1 (37.8-40.4)		13.2 (12.2-14.3)	21.3 (20.1-22.6)	28.1 (26.7-29.5)	37.4 (35.9-38.9)	
Level of marginalization													
Low	61.9	159.3	20.6 (20.0-21.2)	20.5 (19.7-21.2)	24.8 (24.0-25.6)	26.6 (25.8-27.4)	28.2 (27.4-29.0)	0.000	20.8 (19.9-21.7)	24.2 (23.3-25.2)	26.5 (25.5-27.5)	28.5 (27.6-29.6)	0.000
High	38.1	157.2	31.6 (30.7-32.4)	31.5 (30.4-32.6)	25.9 (24.9-27.0)	22.7 (21.7-23.7)	19.9 (19.0-20.9)		31.7 (30.4-33.0)	26.0 (24.8-27.2)	22.9 (21.7-24.1)	19.4 (18.3-20.5)	
BMI													
Underweight	1.0	160.4	14.6 (11.2-19.0)	15.1 (11.0-20.5)	17.4 (12.9-23.1)	25.7 (20.3-31.9)	41.7 (35.4-48.4)	0.000	13.6 (8.2-21.7)	21.4 (14.5-30.4)	30.1 (22.0-39.7)	35.0 (26.3-44.7)	0.204
Normal	25.7	159.6	23.5 (22.6-24.5)	21.9 (20.7-23.2)	22.3 (21.1-23.6)	25.2 (23.9-26.6)	30.6 (29.2-32.0)		25.5 (24.1-26.9)	24.6 (23.2-26.0)	25.2 (23.8-26.6)	24.8 (23.4-26.3)	
Overweight	38.6	158.8	25.4 (24.6-26.2)	25.1 (24.0-26.2)	26.5 (25.4-27.6)	24.7 (23.7-25.8)	23.7 (22.7-24.8)		25.9 (24.7-27.1)	25.1 (23.9-26.3)	24.9 (23.8-26.1)	24.1 (23.0-25.3)	
Obesity	34.7	157.5	25.6 (24.8-26.5)	26.8 (25.8-27.8)	25.9 (24.9-27.0)	25.5 (24.4-26.5)	21.8 (20.9-22.8)		23.4 (22.1-24.8)	25.0 (23.6-26.4)	25.2 (23.8-26.6)	26.4 (25.0-27.8)	

Source: Prepared by the authors, based on data from 2012 National Health and Nutrition Survey (ENSANUT 2012).

[a] Kruskal-Wallis test.

for the last age category (50 to 59 years), 32.9% of women in that age group were in Q1, 29.3% in Q2, 22.5% in Q3, and 15.3% in Q4. Thus we can say that 32.9% of women from 50 to 59 years old had SS.

Age

When we compared the age groups, we found that the group aged 50 to 59 was almost two times as likely to have SS as the group aged 20 to 29 (OR 2.2; 95% confidence interval (CI) = 2.0-2.4). The prevalence of SS by age group had a positive trend. When we controlled for indigenous status, we found a 32% higher probability of having SS for each increase in the age group category ($OR_{adjusted}$ 1.32; 95% CI = 1.29-1.36).

Regions

In the analysis by regions, we found that the southern region had the highest prevalence of SS for both sexes combined (40.0%, 95% CI = 39.2%-40.9%). This represents a difference greater than 25 percentage points when compared to the northern region (12.2%, 95% CI = 11.4%-13.0%). When we calculated the adjusted odds ratio with the indigenous component, the subjects from the southern region had nearly three times the odds of having SS in comparison to those in the northern region ($OR_{adjusted}$ 3.1; 95% CI = 2.8-3.5), and two times that of the center region ($OR_{adjusted}$ 2.1; 95% CI = 1.9-2.3).

Locality

When comparing by locality, almost one-third of the inhabitants of rural areas have SS (31.3%, 95% CI = 30.4%-32.2%), in contrast to just one-fifth of the inhabitants of urban areas (21.4%, 95% CI = 21.3%-21.5%).

Socioeconomic status

By socioeconomic status, the highest prevalence of SS for both sexes was found in those with low SES (37.5%, 95% CI = 36.6%-38.4%), while in those with high SES it was lower than 14% (13.3%, 95% CI = 12.6%-13.9%). There was a negative trend between SES and the prevalence of SS.

When the data were adjusted for the indigenous component, subjects with the lowest socioeconomic status had some three times the odds of having SS than did those with the highest socioeconomic status ($OR_{adjusted}$ 3.1; 95% CI = 2.9-3.5), and 77% more probability in relation to those in the middle socioeconomic status ($OR_{adjusted}$ 1.77; 95% CI = 1.63-1.92). No interaction was observed when the analysis of socioeconomic status was adjusted for the indigenous component (p = 0.329).

Schooling

In regards to schooling, the prevalence of SS among adults who had less than six years of schooling was higher than 50% for both sexes: 54.5% (95% CI = 51.5%-57.4%) in women and 52.8% (95% CI = 48.8%-56.8%) in men. This contrasts sharply with the prevalence for the group that had more than nine years of schooling, whose prevalence for both sexes was lower than 14%: 12.1% (95% CI = 11.2%-13.0%) in women and 13.2% (95% CI = 12.2%-14.3%) in men.

We found a negative trend between the prevalence of SS and years of schooling. When controlling for the indigenous component, no interaction (p = 0.48) or confounding (OR_{crude} 0.38; 95% CI = 0.36-0.40 vs. $OR_{adjusted}$ 0.40; 95% CI = 0.38-0.42) was found. The odds of having SS were more than six times as high among subjects who had less than six years of schooling as compared to the odds for those who had more than nine years of schooling ($OR_{adjusted}$ 6.8; 95% CI = 5.8-8.0), and almost three times as high as for those who had from six to nine years of schooling ($OR_{adjusted}$ 2.6; 95% CI = 2.3-3.0). Of the total sample, 64% (95% CI = 63.7%-64.7%) reported having from six to nine years of schooling, and only 5.5% (95% CI = 5.2%-5.7%) had less than six years of schooling.

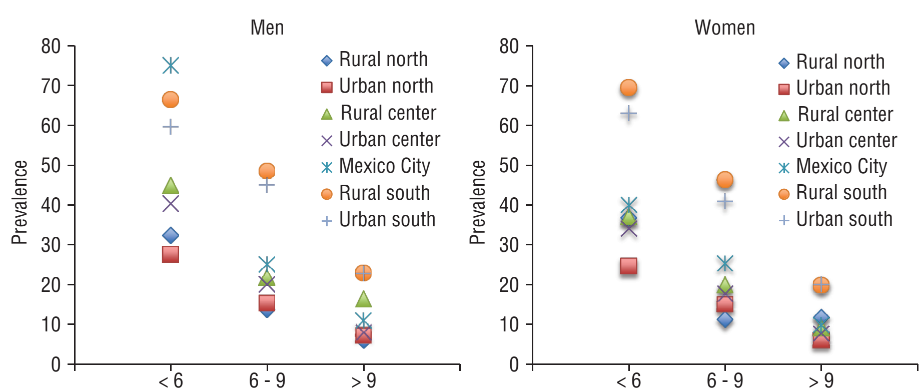
When we used -2 standard deviations (SDs) and the 5th percentile as cutoffs, the trend of the above results was not modified.

We found that adults who had less than six years of schooling presented the highest prevalence of SS, regardless of sex, region of the country, place of residence (rural or urban), or the prevalence of indigenous language speakers in the state (Figure 1).

Level of marginalization

In the stratum with the highest marginalization, the prevalence of SS for both sexes combined was 31.6% (95% CI = 30.7%-32.4%). In comparison to the low-marginalization stratum (20.6%, 95% CI = 20.0%-21.2%), there was a difference of 11 percentage points.

FIGURE 1. Prevalence of short stature in Mexican adults, by categories of years of schooling in men and women, adjusted for region and residence, in study of stature in adults and socioeconomic inequalities in Mexico[a]



Source: [a] Prepared by the authors based on data from 2012 National Health and Nutrition Survey (ENSANUT 2012).

Body mass index

In the analysis of SS in relation to BMI categories, no interaction was found with the indigenous component (p = 0.40), but one was found for sex (p < 0.01). For the female group, the highest prevalence of SS was found in the obesity category (26.8%, 95% CI = 25.8%-27.8%), followed by the overweight category (25.1%, 95% CI = 24.0%-26.2%). For men, the highest prevalence of adults with SS was found in the overweight category (25.9%, 95% CI = 24.7%-27.1%), followed by the normal weight category (25.5%, 95% CI = 24.1%-26.9%). The sum of SS prevalences in the overweight and obesity categories was 50% for the total sample.

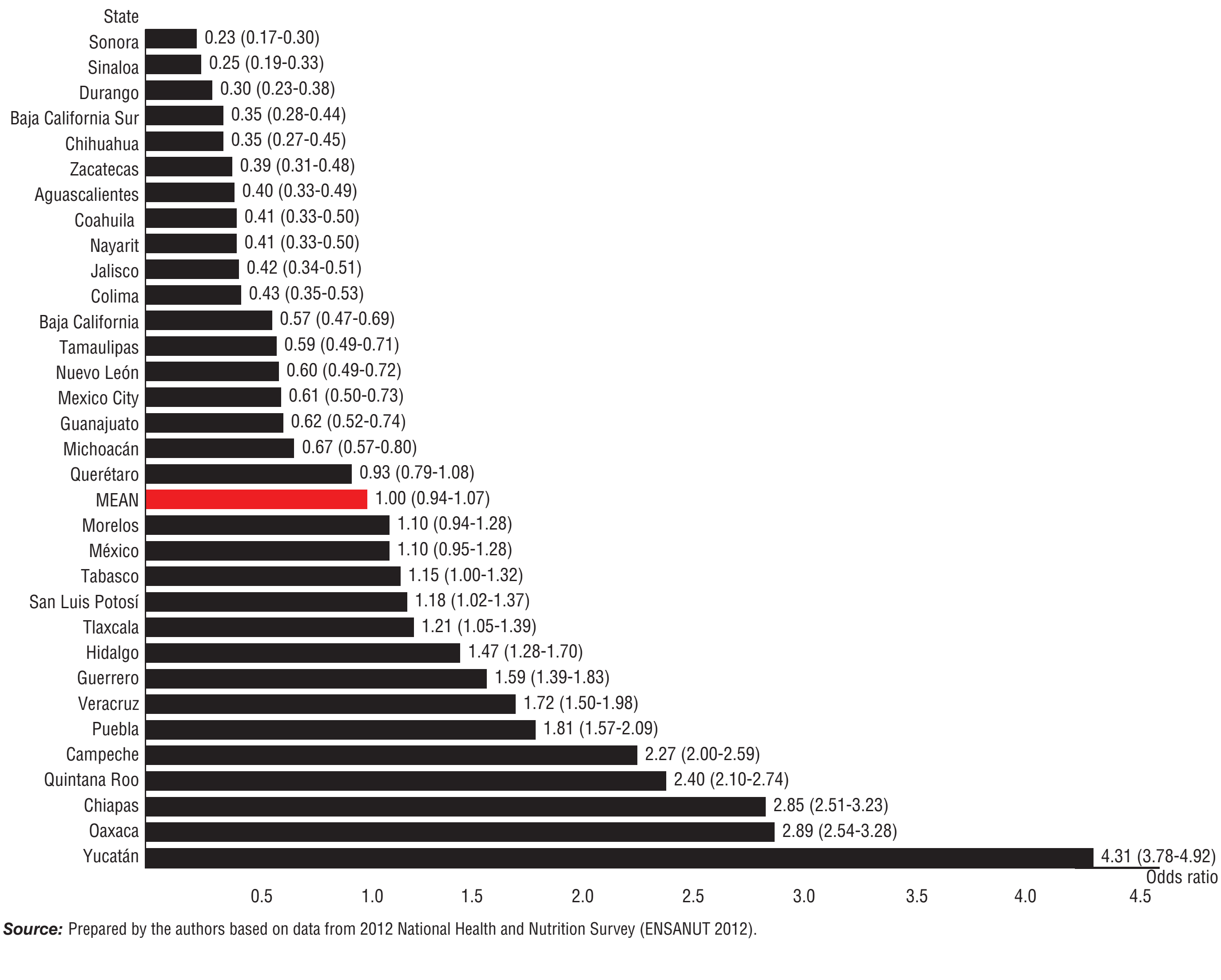
In both sexes, there were no statistically significant differences between BMI categories when analyzed by age group, locality, SES, schooling, and marginalization. We did not find significant difference by geographic region for the male group.

Prevalence of short stature

The prevalence of SS was calculated for each state of the country (Additional File 1). We found that some states had a prevalence of SS for both sexes combined that was higher than 40%. This is the case with Campeche (42.8%, 95% CI = 40.0%-45.7%), Quintana Roo (44.1%, 95% CI = 41.1%-47.2%), Chiapas (48.4%, 95% CI = 45.5%-51.3%), Oaxaca (48.7%, 95% CI = 45.8%-51.7%), and Yucatan (58.6%, 95% CI = 55.7%-61.6%). In contrast, we found that some states had a prevalence of SS lower than 10%, such as Sonora (7.0%, 95% CI = 5.5%-8.9%), Sinaloa (7.5%, 95% CI = 5.9%-9.7%), and Durango (8.9%, 95% CI = 7.1%-11.0%). When we analyzed by state and sex, we found similar results. However, two more groups of SS prevalence lower than 10% were found: women from Baja California Sur (9.5%, 95% CI = 7.0%-12.9%) and men from Chihuahua (9.3%, 95% CI = 6.9%-12.4%).

When we compared, state by state, the average prevalence of SS for the sexes combined versus the overall average SS prevalence for Mexico, we found that the states of Campeche, Quintana Roo, Chiapas, and Oaxaca had more than two times the odds of having SS, and for Yucatan, it was more than four times. In contrast, Sonora and Sinaloa had odds that were one-quarter the national average (Figure 2).

FIGURE 2. Odds ratio, with 95% confidence interval, for short stature in adults in Mexico City and the states of Mexico, using the national mean as a reference category, in study of stature in adults and socioeconomic inequalities in Mexico



Source: Prepared by the authors based on data from 2012 National Health and Nutrition Survey (ENSANUT 2012).

Another result from this study was the determination of the average stature by sex and state. Surprisingly, the states with the highest and lowest average stature (Sonora and Yucatan, respectively), showed a difference of 9.8 cm among women and of 11 cm among men for this variable. Those differences are wider than the ones for the average stature in Mexico versus those for developed countries such as the United States: 9 cm for women and 10.2 cm for men (28, 29). These large differences within Mexico reflect the country's broad ethnic diversity (Additional File 2).

Indigenous condition

There are indigenous populations in all the states of the country, but with that prevalence differing from state to state. We analyzed the association between the prevalence of SS and the prevalence of indigenous language speakers (a feature considered a marker for the indigenous component). We found a positive association between them ($r_s = 0.88$, $p < 0.001$). This could suggest a confounding effect in the analysis. However, the trends in the prevalence of SS and the variables studied maintain their direction between categories when the analysis is carried out with adjustment for the prevalence of the indigenous component by state.

DISCUSSION

The objective of this population-based study was to estimate the associations between stature in Mexican adults and some sociodemographic factors.

As far as we know, this is the first study done for a Latin American country that identifies sociodemographic factors associated with stature by using a population-based analysis. We analyzed the data using -2 SDs, the 5th percentile, and Q1 (25th percentile) as cutoffs, and found that the trend for the results did not change.

As we mentioned earlier, there are no established international cutoffs to define SS in adults. We used the Q1 because it allows comparisons between different populations and within the same population over time. Our results about cutoffs (≤ 148 and ≤ 161 cm for women and men, respectively) are close to the cutoffs used previously by Vargas-Ancona (≤ 151 and ≤ 164 cm for women and men, respectively) and Lara-Esqueda (≤ 150 and ≤ 160 cm for women and men, respectively). However, the prevalences of SS by sex that we found in our study differ from the ones found by Vargas-Ancona (76.4% for women and 58.4% for men) and by Lara-Esqueda (25.8% for women and 13.6% for men). Our design and study population could explain these differences.

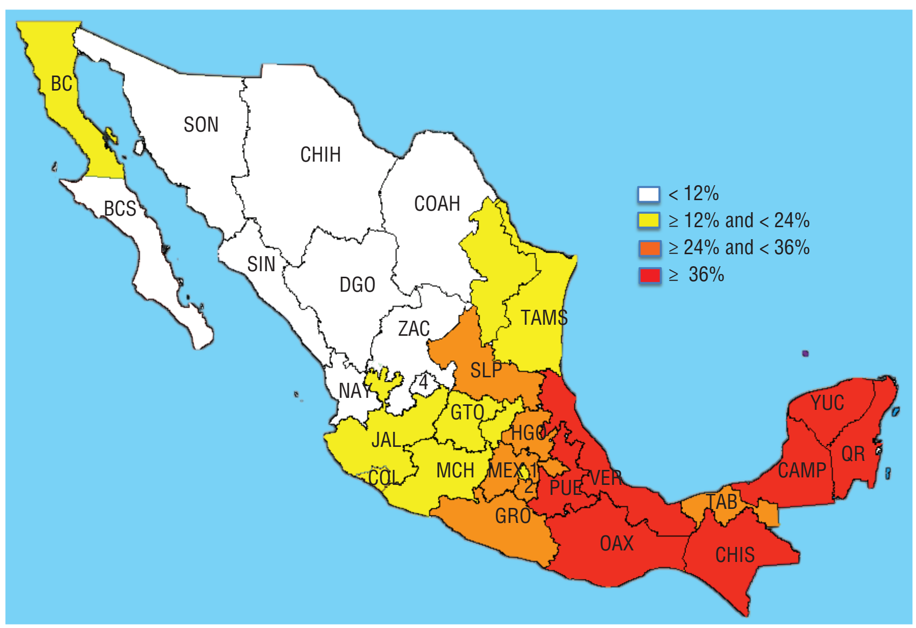
We found some social inequalities related to stature in adults. When we compared the prevalence of SS by age group, older people had a higher prevalence of SS. This is in line with previous research (30). The prevalence of SS could be overestimated in this study as a consequence of the process of decreased mineral bone density due to aging, even though the population we studied was less than 60 years old.

Some authors who have conducted multicenter studies that analyze the evolution of adult stature in Europe have reported a gradual increase in adult height in all countries (31). Unfortunately, in Mexico there is no previous data that allow comparisons over time. Also, with the cross-sectional data in this study, it not feasible to assess this possible secular trend. However, even assuming that there is a growing trend in stature, the associations found in our study seem be unaffected by the evolution of stature in adults.

The location of the states by SS prevalence shows a clear division of the country (Figure 3). The three cases that don't follow this general pattern—Baja California, Mexico City, and Tabasco—could be explained partly by the large number of immigrants who move to those areas due to the better job opportunities.

With socioeconomic status, we found an inverse relationship between the SS prevalence in adulthood and socioeconomic status. This result coincides with the findings of Steckel (3) and Castaño et al. (4), who showed that individuals who live in precarious economic conditions and belong to families that can't achieve food security reach a shorter stature than do those who have better living conditions. Furthermore, Subramanian et al. (1) demonstrated a highly significant positive association between stature and socioeconomic status. Their results showed that women in the two highest

FIGURE 3. Prevalence of short stature[a] in adults in Mexico City and the states of Mexico,[b] by category of prevalence, in study of stature in adults and socioeconomic inequalities in Mexico



Source: Prepared by the authors based on data from 2012 National Health and Nutrition Survey (ENSANUT 2012).
[a] Short stature is ≤ 148.5 cm for women and ≤ 161.1 cm for men.
[b] Mexico City and the states of Mexico are indicated in the map by either a number or an abbreviation. The four numbered locations are: 1, Mexico City; 2, Morelos; 3, Tlaxcala; and 4, Aguascalientes. The remaining states are: BC, Baja California; BCS, Baja California Sur; CAMP, Campeche; COAH, Coahuila; COL, Colima; CHIS, Chiapas; CHIH, Chihuahua; DUR, Durango; GTO, Guanajuato; GRO, Guerrero; HGO, Hidalgo; JAL, Jalisco; MEX, México; MICH, Michoacán; NAY, Nayarit; NL, Nuevo León; OAX, Oaxaca; PUE, Puebla; QRO, Querétaro; QR, Quintana Roo; SLP, San Luis Potosí; SIN, Sinaloa; SON, Sonora; TAB, Tabasco; TAMS, Tamaulipas; VER, Veracruz; YUC, Yucatán; and ZAC, Zacatecas.

economic quintiles were taller than those who were in the poorest quintiles.

The Wronka study (32) concluded that socioeconomic status was related to body height, and that variation in height was the result of the living conditions during the first years of life. In contrast, Singh et al. (23) found a weak association between income and stature, but the association could be modified by the effect of education.

Our results suggest that SS in the Mexican population is largely associated with factors related to educational opportunities. This finding is consistent with some prior studies. For example, Garcia et al. (31) showed that taller people tend to reach higher levels of education; Singh et al. (23) found a positive association between schooling and income in relation to stature; and Cavelaar et al. (33) found that individuals with less schooling were, on average, shorter than persons with more schooling. However, other studies have reported different results for the association between schooling and stature. Castaño et al. (4) did not find a relation between education and stature in Colombians. The Wyshak study (34) did not find a significant association between stature and income or education in a group of women between 49 and 79 years old in the United States.

We found a higher prevalence of SS in the stratum with the highest marginalization. This result suggests that SS individuals may have fewer opportunities to get better jobs. This association might have derived from other confounding variables that would generate fewer employment opportunities, as reported by Case and Paxon (15). Those researchers attribute the link between stature and income to the positive association between stature and cognitive capacity, although it is cognitive ability rather than height that is rewarded in the job market. The positive association between height and intelligence quotient (IQ) has also been documented (15).

Our SS prevalence results by SES, region, and locality were the opposite of obesity prevalence results reported in a study by Barquera et al. (35). Both studies used the same ENSANUT 2012 data. In our analysis by geographic region, the northern region had the lowest prevalence of SS (12.2%) but also the highest prevalence of obesity (37.3%). Urban areas showed the highest prevalence of obesity but conversely the lowest prevalence of SS. Furthermore, people with the lowest socioeconomic status and the least schooling had the lowest obesity prevalence, but the highest prevalence of SS. When we compare the prevalence of obesity by schooling categories, we found a difference of less than 7 percentage points between the highest prevalence and the lowest one. On the other hand, when we compare the prevalence of SS, we found more than 40 percentage points of difference between the highest and the lowest prevalence.

In SS populations, using BMI to diagnose obesity must be reevaluated (9), since stature may change the relationship between BMI and adiposity.

We found that 8 of the 10 states with the highest prevalence of SS in our research were below the average of abdominal obesity reported in the study by Barquera et al. (35). These results could strongly support proposals for modifying the cutoffs to determine obesity in Mexican adults with SS (9, 11) or for using other adiposity assessment methods.

We found an overlap between the states with the highest percentage of indigenous language speakers and the states with the highest prevalence of SS. The four states with the highest prevalence of SS (Yucatan (58%), Oaxaca (48%), Chiapas (48%), and Quintana Roo (44%)) are the same four states that have the highest percentage of indigenous language speakers: Oaxaca (32%), Yucatan (29%), Chiapas (28%), Quintana Roo (17%), Guerrero (15%), and Hidalgo (14%) (21). However, when adjusting the data for this variable, the direction of inequality between the categories of the studied variables remained.

The association between the prevalence of SS and geographical location (higher prevalence in the south than in the north) could be partially explained by the multiracial populations that have resulted from the intermixing of indigenous groups with colonizing groups.

Limitations

In order to avoid a confounding effect from race, we used the prevalence of indigenous language speakers as a proxy for this variable. However, this component was analyzed using state-level data, not individual-level information. In addition, these data about ethnicity or race came from a source other than ENSANUT 2012.

The associations between stature and sociodemographic factors could have been confounded by variables that we did not consider or by imperfect measurement of the confounders that were included in our analysis.

Furthermore, because of the cross-sectional design of the study, the secular trend in stature cannot be estimated, and causal inferences from our analysis cannot be made with certainty.

Conclusions

We found a higher prevalence of SS in more vulnerable groups: those with lower socioeconomic status, less schooling, and greater marginalization.

The genetic component plays an essential role in the presence of SS. Therefore, longitudinal studies are warranted in order to determine the association between stature and opportunities for education, health, and employment, as well as the trend in average stature both regionally and countrywide.

From this analysis, it is possible to consider stature as an inequality indicator mainly in regions with the highest prevalence of SS.

Moreover, this work underscores the ethnic diversity in Mexico, through the variability in population stature, and it suggests the possibility of establishing regional cutoffs for SS.

Further studies are needed to explore if similar associations are observed in other Latin American populations.

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RESUMEN

La estatura de los adultos como indicador de las desigualdades socioeconómicas en México

Objetivo. Establecer la asociación entre la estatura de los mexicanos adultos y algunos factores sociodemográficos.

Métodos. Sobre la base de datos antropométricos de la Encuesta Nacional de Salud y Nutrición de 2012 (ENSANUT 2012), estudiamos una muestra de 30 970 sujetos. Para definir la estatura baja, el umbral se estableció en el primer cuartil. Analizamos las diferencias entre los distintos estratos de estatura en relación con variables sociodemográficas utilizando la prueba de Kruskal-Wallis. Calculamos las razones de posibilidades para medir la asociación entre la estatura y las variables sociodemográficas, con control de posibles factores de confusión.

Resultados. Las personas de la zona meridional del país tenían alrededor de tres veces más probabilidades de ser de estatura baja que las personas de la zona septentrional. La diferencia entre los estados mexicanos con la estatura promedio más alta y la estatura promedio más baja fue mayor que la diferencia promedio respecto de la estatura entre México y los Estados Unidos de América. La prevalencia más alta de estatura baja se registró en los adultos con menos de seis años de escolaridad, independientemente del sexo, la zona del país, el lugar de residencia (rural o urbano) y la proporción de hablantes de lenguas indígenas en un estado. Además, la prevalencia más alta de estatura baja se observó en el estrato de población más marginada (porcentaje de habitantes sin escolaridad ni servicios, con ingresos bajos y que vivían una comunidad pequeña).

Conclusiones. En México, las condiciones de vida de los adultos de estatura baja son más desfavorables que las de los adultos de estatura media o alta, y esto podría contribuir a aumentar la inequidad en materia de salud.

Palabras clave Factores socioeconómicos; estatura; adulto; población indígena; México.

RESUMO

Estatura em adultos como indicador das desigualdades socioeconômicas no México

Objetivo. Estimar a associação entre a estatura em adultos mexicanos e fatores sociodemográficos.

Métodos. Foi estudada uma amostra de 30.970 indivíduos com base em dados antropométricos obtidos da Pesquisa Nacional sobre Saúde e Nutrição de 2012 (ENSANUT 2012). O primeiro quartil foi usado como valor de corte para definir baixa estatura. Foram analisadas as diferenças entre os estratos de estatura para as variáveis sociodemográficas com o uso do teste de Kruskal- Wallis. Foram estimados os odds ratios para medir a associação entre a estatura e as variáveis sociodemográficas, controlando-se os potenciais fatores de confusão.

Resultados. Os indivíduos da região sul do país apresentaram uma chance quase três vezes maior de ter baixa estatura em comparação aos indivíduos da região norte. A diferença de estatura entre os estados mexicanos com a estatura média maior e a estatura média menor foi maior que a diferença média em estatura entre o México e os Estados Unidos. Os adultos com menos de seis anos de escolaridade apresentaram a prevalência mais elevada de baixa estatura, independentemente do sexo, região do país, zona de residência (rural ou urbana) ou proporção de falantes de línguas indígenas em um estado. Além disso, o estrato com maior marginação (porcentagem de habitantes com carência de educação e serviços, de baixa renda e vivendo em uma pequena comunidade) apresentou a prevalência mais elevada de baixa estatura.

Conclusão. No México, os adultos com baixa estatura têm condições de vida desiguais comparados aos adultos com estatura média ou alta, contribuindo para maior iniquidade em saúde.

Palavras-chave Fatores socioeconômicos; estatura; adulto; população indígena; México.