

Vitamin D status in Mexican women at reproductive age, Ensanut 2018-19

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Abstract

Objective. To describe the prevalence of deficiency (VDD) and insufficiency (VDI) of vitamin D (VD), by sociodemographic factors, obesity and physical activity in a probabilistic sample of Mexican women participating in Ensanut 2018-19. **Materials and methods.** In 1 262 women aged 20 to 49 years, the prevalence of VDD/IVD was estimated and the factors associated with it were evaluated with a multinomial regression model. **Results.** The prevalence of VDI was 46.1% and of VDD was 31.6%. The probability of presenting VDI and VDD was higher for residents of urban areas, in tertiles 2 and 3 of socioeconomic status, and with obesity, while was lower in women with moderate physical activity. **Conclusion.** The prevalence of vitamin D in Mexican women continues to be a public health problem in Mexico despite the high availability of sunlight in the country. It is necessary to promote healthy sun exposure in the population and consider fortifying foods with vitamin D.

Keywords: vitamin D deficiency; 25-OH-D; sociodemographic factors; vitamin D insufficiency; women at reproductive age; obesity; physical activity

Resumen

Objetivo. Describir la prevalencia de deficiencia (VDD) e insuficiencia (VDI) de vitamina D (VD) por factores sociodemográficos, obesidad y actividad física, en una muestra probabilística de mujeres mexicanas participantes de la Encuesta Nacional de Salud y Nutrición 2018-19. **Material y métodos.** En 1 262 mujeres se estimó la prevalencia de VDD y VDI y se evaluaron los factores asociados con ellas con un modelo de regresión multinomial. **Resultados.** La prevalencia de VDI fue de 46.1% y de VDD fue 31.6%. La probabilidad de presentar VDI y VDD fue mayor en residentes de áreas urbanas, en terciles más altos de nivel socioeconómico y con obesidad, mientras que fue menor en mujeres con actividad física moderada. **Conclusión.** La prevalencia de VDI y VDD en mujeres mexicanas continúa siendo un problema de salud pública en México a pesar de la alta disponibilidad de luz solar en el país. Es necesario fomentar en la población una saludable exposición solar y considerar la fortificación de alimentos con vitamina D.

Palabras clave: deficiencia de vitamina D; 25-OH-D; factores sociodemográficos; insuficiencia de vitamina D; mujeres en edad reproductiva; obesidad; actividad física

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Vitamin D deficiency (VDD) was found as a public health problem in children associated with rickets.¹ Subsequently, high prevalence of insufficiency (VDI) and VDD were observed in both, children and women at reproductive age in different countries.²⁻⁴

VDD used to be prevalent in countries with limited seasonal sun exposure, in populations with pigmented skin-colored races, those remaining in roofed areas, or population subgroups using cloths covering most of the body surface.⁵⁻⁷ However, recently countries with extensive sun exposure throughout the year revealed a high prevalence of VDD.⁸

In women at reproductive age, factors such as breastfeeding and the habitual use of sunscreen to protect against skin cancer are factors that could aggravate VDD.⁹⁻¹¹ It is important to prevent and treat VDD to avoid health consequences for women pregnant or lactating and their offspring.¹²⁻¹⁴

In Mexico, according to the 2012 National Nutrition and Health Survey (*Encuesta Nacional de Salud y Nutrición*, Ensanut), the prevalence of VDI and VDD in women at reproductive age was 49.8 and 36.8% respectively.¹⁵ VDI and VDD prevalence were higher in women from the highest tertile of socioeconomic level, urban areas, and in indigenous population.

Furthermore, VDD has been directly associated with various chronic outcomes in adults¹⁶ and inversely with low-level inflammation indicated by C-Reactive Protein (CRP).¹⁷ In Mexican women, the chronic diseases associated with VDD were diabetes, obesity, and high total cholesterol.¹⁸

The objective of this study is to describe the prevalence of VDI and VDD in a probabilistic sample of Mexican women participating in Ensanut 2018-19 and to study its association with sociodemographic factors, obesity, physical activity, and inflammation.

Materials and methods

Study population: We selected a nationally representative subsample of 1 539 women aged 20-49 and 1 262 with complete information, out of a total sample of 23 574 women participating in Ensanut 2018-19, a probabilistic survey designed to represent the national, urban and rural population.¹⁹ Detailed description of the sampling was published previously.²⁰

Sociodemographic information. The sociodemographic information was collected using validated questionnaires. Socioeconomic status was constructed using the characteristics and possessions of the household, in a principal component analysis. The first component, representing 51% of total variability with a lambda of 4.08,

was divided into tertiles to classify socioeconomic status (WBI) into low, medium and high.²¹ Localities with less than 2 500 inhabitants were defined as rural, otherwise urban. The country was divided into three regions as in previous Ensanut: North, Center (includes Mexico City) and South. A person was defined as indigenous when one of the members of the household spoke an indigenous language.

Anthropometry. Bodyweight was measured using an electronic balance Seca model-874, (200 kg and a precision of 100 g, Hamburg, Germany) and the height using a stadiometer Seca model-206 (220 cm and a precision of 1mm Hamburg, Germany), as by Lohman's²² and standardized as by Habitch.²³ Obesity was based on BMI, classified as by the World Health Organization guidelines.²⁴

Blood samples. Fasting blood samples were drawn from a sample of Mexican women between the winter of 2018 and the spring of 2019, and between the latitudes 14°54' and 32°31' N. Blood samples were withdrawn from an antecubital vein and collected in evacuated tubes. Serum was spun-down *in situ* at 3 000 g. Serum samples were stored in codified cryovials and preserved in liquid N, until delivered to the Central Nutrition lab at National Institute of Public Health (*Instituto Nacional de Salud Pública*, INSP), Cuernavaca, Mexico, and preserved at -70°C in a freezer until determinations.

Serum 25-hydroxyvitamin-D was measured by chemiluminescent microparticle immunoassay and CRP using ultrasensitive monoclonal antibodies in an automatic analyzer (Architect CI8200, Abbott Lab, Michigan, III USA). Intra- and inter-assay CV's for 25OH vitamin-D were 1.34 and 3.69%; and for CRP, were 4.6%, and 1.2%, respectively. Quality measurement control was performed using the Serum NIST 968E of the National Institute of Standards and Technology.²⁵ VDD was defined when serum 25-OH-D was <50 nmol/L (<20 ng/mL) and VDI when was 51-75 nmol/L.²⁶ Acute inflammation was defined when CRP was higher than 5 mg/dL.²⁷

Statistical analysis. The prevalence of VDI and VDD was reported as proportions and 95%CI. The comparisons among sociodemographic characteristics were made by chi-square test and a multinomial logistic regression model was fitted adjusting by the survey design using the module SVY of STATA SE v14 (College Station, USA, 2013).* The significance level was established with an alpha <0.05.

* StataCorp. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC, 2014..

Ethical aspects. The Ensanut 2018-19 protocol was reviewed and approved by the Committees for Research, Ethics, and Biosecurity of the National Institute of Public Health, Cuernavaca, Mexico. Informed consent letters were signed by the participants.

Results

Characteristics of the sample

Serum 25-hydroxyvitamin-D (25-OH-D) were analyzed in 1 262 women with complete sociodemographic information, representing 25 million of Mexican women at reproductive age.

In the sample, 5.9% reported to speak an indigenous language, 39.7% have obesity, 16.7% were classified as inactive, 13.5% moderately active and 69.7% active according to WHO recommendations for physical activity. Living in rural areas 21.6%, 30.6% living in the South, 50.3% in the Center and 19% in the North regions. The prevalence of acute inflammation was 30.1% (table I).

The total prevalence of VDI was 46.1% (95%CI: 41.7-50.6) and of VDD 31.6% (95%CI: 26.9-36.6). By dwelling, in rural areas VDI was 42.2% (95%CI: 36.6-48.1) and for VDD 21.2% (95%CI: 16-27.6), and in urban areas VDI was 47.2% (95%CI: 41.8-52.6) and for VDD 34.4% (95%CI: 28.8-40.5) ($p<0.05$). By region, the prevalence of VDI was higher in the North (50.2%, 95%CI: 40.5-60.0) and the prevalence of VDD higher in the center (37.7%, 95%CI: 30.4-45.6, $p<0.05$). VDI was higher in the tertile 2 (48.8%, 95%CI: 31.8-56.0), and VDD in tertile 3 (41.3%, 95%CI: 31.7-51.6) of WBI, respectively ($p<0.05$) (table II).

We compared the prevalence of VDI and VDD in Ensanut 2012 and 2018-19 and were not statistically different. The overall prevalence of VDD in 2012 was 36.7% (95%CI: 36.7-40.2) and 31.6% (95%CI: 26.9-36.6) for 2018-19 (data not shown).

In the multinomial logistic regression model the probability of VDI and VDD was higher in women with obesity (RRR: 1.45, $p=0.064$ and RRR: 1.91, $p=0.017$) than in non-obese, lower in women with moderate activity (RRR: 0.048, $p=0.036$ and RRR: 0.41, $p=0.038$), lower in a rural dwelling (RRR: 0.58, $p=0.015$ and RRR: 0.54, $p=0.033$), and higher in the second tertile of WBI (RRR: 1.66 and 2.42, $p<0.05$).

Acute inflammation was inversely and marginally associated with VDD (RRR: 0.57, $p=0.07$). No differences were observed among the prevalence of VDI or VDD by age group or indigenism (table III). Also, the association among VDI and VDD with anemia, iron deficiency and cardiovascular risk factors as diabetes, high total cholesterol, high triglycerides, and HDL-cholesterol

Table I
CHARACTERISTICS AND DISTRIBUTION OF THE WOMEN AGED 20-49 Y OLD PARTICIPANTS OF THE ENSANUT 2018-19. MEXICO

Variable	Subgroup	% (95%CI)
n sample	= 1 262	
n expanded	= 25 312 000	
Age in years	20 to 29	37.8 (33.3-42.3)
	30 to 39	30.2 (26.5-34.2)
	40 to 49	32.0 (27.8-36.5)
Indigenism	No	94.0 (91.8-95.6)
	Yes	5.9 (4.3-8.1)
Obesity	No	60.3 (55.4-64.9)
	Yes	39.7 (35.0-44.5)
Physical activity	Inactive	16.7 (13.6-20.4)
	Moderate active	13.5 (10.9-16.7)
	Active	69.7 (65.6-73.4)
Area	Urban	78.4 (75.9-80.6)
	Rural	21.6 (19.3-24.0)
Region	North	19.0 (17.2-21.1)
	Center	50.3 (47.2-53.3)
	South	30.6 (28.1-33.2)
SES	Tertile 1	30.8 (27.0-34.8)
	Tertile 2	33.5 (29.3-37.9)
	Tertile 3	35.7 (31.0-40.7)
Acute Inflammation	CRP <5 mg/dL	69.9 (65.2-74.1)
	CRP ≥5 mg/dL	30.1 (25.8-34.8)

CI: Confidence Interval; BMI: body mass index, CRP: c-reactive protein. SES: Socioeconomic-status

concentrations were explored and non-statistical relationships were found (data not shown).

We estimated in a subsample of 98 women which had information available of the diet and serum 25-OH-D, the of vitamin D, the mean was 2.56 mcg / day (95%CI: 1.41-3.71) and was not different among VD status (data not shown).

Discussion

According to the findings of our study, the prevalence of VDI and VDD in Mexican women remain a public health nationwide problem, despite the availability of intense sunlight within the country, being more prevalent in women living in urban dwelling, in the middle tertile of WBI, with obesity, and lower in those who practice moderate physical activity in comparison to inactive women.

Table II
PREVALENCE OF VDI AND VDD IN MEXICAN WOMAN AT REPRODUCTIVE AGE. MEXICO, ENSANUT 2018-19

Variable	Subgroup	Normal % (95%CI)	Vitamin D insufficiency % (95%CI)	Vitamin D deficiency % (95%CI)	P
	Total	22.2 (18.8-26.2)	46.1 (41.7-50.6)	31.6 (26.9-36.6)	
Age in years	20 to 29 y	22.9 (16.9-30.3)	45.5 (38.1-53.2)	31.4 (24.1-39.8)	0.176
	30 to 39 y	28.1 (21.3-36.0)	43.9 (37.2-50.7)	27.9 (20.6-36.6)	
	40 to 49 y	15.8 (11.7-21.0)	48.9 (40.5-57.4)	35.2 (26.9-44.5)	
Indigenism	No	31.4 (18-48.8)	52.8 (37.8-67.2)	15.9 (8.4-27.8)	0.065
	Yes	21.7 (18.1-25.7)	45.7 (41.2-50.3)	32.6 (27.7-37.9)	
Obesity	No	24.4 (19.6-30.0)	45.4 (39.6-51.2)	30.1 (24.5-36.3)	0.38
	Yes	18.9 (14.6-24.1)	47.2 (39.8-54.7)	33.8 (25.9-42.6)	
Physical activity	Inactive	19.9 (13.9-27.6)	45.8 (36.5-55.4)	34.2 (24.9-44.9)	0.056
	Moderate active	36.2 (25.3-48.8)	39.5 (29.2-50.8)	24.2 (15.2-36.2)	
	Active	20.0 (16.0-24.8)	47.5 (41.9-53.0)	32.4 (26.5-38.9)	
Area	Urban	36.5 (30.7-42.7)	47.2 (41.8-52.6)	34.4 (28.8-40.5)	<0.001
	Rural	18.3 (14.4-23.1)	42.2 (36.6-48.1)	21.2 (16.0-27.6)	
Region	North	20.4 (13.9-28.8)	50.2 (40.5-60.0)	29.3 (20.8-39.5)	0.009
	Center	17.8 (12.9-24.1)	44.4 (37.5-51.6)	37.7 (30.4-45.6)	
	South	30.7 (24.3-37.9)	46.3 (40.8-51.9)	22.9 (16.3-31.1)	
SES	Tertile 1	35.0 (28.8-41.9)	46.0 (39.2-52.9)	18.9 (14.1-24.9)	<0.001
	Tertile 2	18.2 (14.0-23.2)	48.8 (41.8-56.0)	32.9 (26.1-40.5)	
	Tertile 3	15.0 (9.1-23.7)	43.7 (35.0-52.7)	41.3 (31.7-51.6)	
Inflammation	CRP <5 mg/dL	21.7 (17.4-26.7)	45.3 (40.0-50.7)	32.9 (27.4-38.8)	0.673
	CRP ≥5 mg/dL	23.5 (17.8-30.2)	47.9 (39.2-56.8)	28.5 (19.8-39.1)	

n sample= 1 262 n expanded= 25 312 000 Mexican women. CI: Confidence Interval. Vitamin D insufficiency (25-50 mg/dl), vitamin D deficiency (<50 mg/dl), BMI: body mass index, CRP: c-reactive protein, SES: socioeconomic-status. P values were obtained from chi² test.

In our study the prevalence of VDD was 31.6% and is in line with prevalence reported in woman from other countries or continents; for example, 23.8% of Colombian women aged 18-49 y old had 25-OH-D levels <50 nmol/L and was associated with obesity (OR: 1.36) and high wealth index (OR: 1.36)²⁸ for northern Taiwan adult woman the prevalence of VDD was 22.9% and was associated with physical activity (OR: 0.64),²⁹ for African adult population the prevalence of 25-OH-D <50 nmol/L was 35.6%, being higher for woman than for males and was associated with urban areas.³⁰ VDD is prevalent also in population from Northern Europe (20%), Western, Southern and Eastern Europe (30-60%).³¹ In our study strong and positive associations were also found among VDI and VDD for urban dwelling and WBI, and were consistent with Ensanut 2012 results.¹⁵ The higher prevalence in women that live in urban localities can be explain because have higher levels of air pollution³² and stay indoor for longer periods, and consequently are less exposed to sunlight.³³

Since the main source of VD is the sun exposure, light skin pigmentation is known as a protective factor against VDD.^{34,35} In Mexican population was documented that the skin pigmentation is associated with SES, being the category of white, having higher SES, in comparison with "moreno" skin.³⁶ In our study, tertiles 2 and 3 of WBI had higher risk of VDI and VDD even after summing the protective factor of the lighter skin color. Similar results were observed in Ensanut 2012 for VDD but not for VDI.¹⁵

A protective factor for VDI and VDD found in our study was the moderate physical activity. This finding is in line with other studies in women,^{37,38} suggesting that physical activity improves the regulatory role of the immune system and is associated with better neuromuscular performance and increased type II muscle fibers that improves Vitamin-D status.³⁷ Nevertheless, this association was not significant for active women.

In other countries, fortification of food products with VD the dietary intake is considered; in the United

Table III
MULTINOMIAL LOGISTIC REGRESSION MODEL TO ASSESS THE ASSOCIATION AMONG VITAMIN D DEFICIENCY AND INSUFFICIENCY IN MEXICAN WOMEN 20-49 YEARS, BY INDIVIDUAL AND SOCIODEMOGRAPHIC CHARACTERISTICS. MEXICO, ENSANUT 2018-19

n sample	I 262	Vitamin D insufficiency		Vitamin D deficiency	
		RRR (95%CI)	p value	RRR (95%CI)	p
n expanded (thousands)	25 312				
Age in years	20 to 29	Ref.		Ref.	
	30 to 39	0.77 (0.46-1.28)	0.308	0.76 (0.38-1.5)	0.427
	40 to 49	1.36 (0.78-2.37)	0.282	1.3 (0.67-2.5)	0.436
Indigenism	No	Ref.		Ref.	
	Yes	1.29 (0.61-2.73)	0.509	0.84 (0.32-2.24)	0.729
Obesity	No	Ref.		Ref.	
	Yes	1.45 (0.98-2.14)	0.064	1.91 (1.12-3.25)	0.017
Physical activity	Inactive	Ref.		Ref.	
	Moderate active	0.48 (0.24-0.95)	0.036	0.41 (0.18-0.95)	0.038
	Active	0.97 (0.58-1.64)	0.915	0.8 (0.41-1.55)	0.510
Area	Urban	Ref.		Ref.	
	Rural	0.58 (0.38-0.9)	0.015	0.54 (0.3-0.95)	0.033
Region	North	Ref.		Ref.	
	Center	0.97 (0.53-1.77)	0.915	1.47 (0.72-3.03)	0.293
	South	0.74 (0.42-1.31)	0.299	0.76 (0.34-1.71)	0.514
SES	Tertile 1	Ref.		Ref.	
	Tertile 2	1.66 (1.01-2.74)	0.048	2.42 (1.38-4.25)	0.002
	Tertile 3	1.65 (0.83-3.29)	0.156	3.39 (1.5-7.65)	0.003
Inflammation	CRP <5 mg/dL	Ref.		Ref.	
	CRP ≥5 mg/dL	0.79 (0.52-1.21)	0.281	0.57 (0.31-1.06)	0.077

CI: confidence interval; Vitamin D insufficiency: 25-50 mg/dL, Vitamin D Deficiency; <50 mg/dL, SES: socio-economic status, CRP: c-reactive protein, RRR: relative risk ratio.

States most manufacturers fortify milk, margarine, breakfast cereals, pastries and other, in Finland, United Kingdom and New Zealand, margarine-type products are fortified, in Australia oil spreads, margarine, skim milks, yogurts, powdered milk and cheese are fortified.³⁹ Nevertheless, in other countries the average intake in women at reproductive age has been found also low, usually lower than 7 mcg/day, and their prevalence of VDI and VDD is highly prevalent as in Mexican women.⁴⁰⁻⁴⁴

We estimated the intake of VD in a subsample of 98 women with valid dietary data who also had a measure of 25-OH-D (data not shown). The mean intake of VD was 2.56 mcg/day (95%CI: 1.41-3.71) and did not differed by serum VD status. For 2012, the average of intake of vitamin D was 2.5 mcg/day, in both surveys the intake was very low compared with the 10 mcg/day recommended by the IOM.⁴⁵

The strengths of this study include the randomized sample with national representativeness and the quality of the 25-OH-D measurements. As limitations of the study, the models were not adjusted by sun exposure or nutritional supplements intake,⁴⁶ and secondly we hypothesized that possibly some associations were not statistically significant due to the smaller sample size in 2018 in comparison with Ensanut 2012 (n=4 162), for example differences by age group, indigenism and region.¹⁵ Also, non-statistical associations were found among VDI and VDD with anemia, iron deficiency and diabetes, high total cholesterol, triglycerides, and low HDL-cholesterol concentrations (data not shown).

These results suggest that the persistence of the high prevalence of VDD and VDI in Mexican women from 2012 to 2018 is due to a lack of interventions at public level such as fortification of food products and provision of supplements to populations at risk of VDD, to women

with high prevalence of obesity, and a higher WBI. It is necessary to promote not only healthy sun exposure in the population which consist in 5 to 15 minutes three times a week with approximately 20-25% of the body surface uncovered between the hours of 10 am to 3 pm, but as well promoting supplement consumption in doses from 400 to 2 000 UI.⁴⁶

Conclusions

The prevalence of VDI and VDD is still a public health problem in women at reproductive age in Mexico, more prevalent in obese women, living in urban areas, physically inactive and among those with better SES. It is necessary to promote healthy sun exposure in the population and consider fortifying foods with VD, as well as promoting or providing supplements to consume for the most vulnerable subpopulations.

Author contributions

Salvador Villalpando and Alejandra Contreras-Manzano designed the overall project, interpreted the data and drafted the manuscript; Rosario Rebollar developed the laboratory determination of 25-OH-D, Fabiola Mejía-Rodríguez and Mario Flores-Aldana critically reviewed the final version of the manuscript.

Declaration of conflict of interests. The authors declare that they have no conflict of interests.

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