Trends in the prevalence of metabolic syndrome and its components in Mexican adults, 2006-2018

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Abstract

Objective. To examine trends in the prevalence of metabolic syndrome (MS) and its components. **Materials and methods.** Data from 27 800 Mexican adults who participated in Ensanut 2006, 2012, 2016 and 2018 were analyzed. Linear regression was used across each Ensanut period to assess temporal linear trends in the prevalence of MS. Logistic regression models were obtained to calculate the percentage change, p-value for the trend and the association between the presence of MS and the risk of developing type 2 diabetes mellitus (T2DM) over 10 years using the Finnish Diabetes Risk Score (FINDRISC) and cardiovascular disease (CVD) using Globorisk. **Results.** The prevalence of MS in Mexican adults according to the harmonized definition was: 40.2, 57.3, 59.99 and 56.31%, in 2006, 2012, 2016 and 2018 respectively (*p* for trend <0.0001). In 2018, 7.62% of metabolic syndrome cases had a significant risk for incident DM2 and 11.6% for CVD**. Conclusion.** It is estimated that there are 36.5 million Mexican adults living with metabolic syndrome, of which 2 million and 2.5 million have a high risk of developing T2DM or cardiovascular disease respectively, over the next 10 years.

Keywords: metabolic syndrome; prevalence; trends; Ensanut

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Resumen

Objetivo. Examinar las tendencias en la prevalencia del síndrome metabólico (SM) y de sus componentes. **Material y métodos.** Se analizaron datos de 27 800 adultos mexicanos que participaron en las Ensanut 2006, 2012, 2016 y 2018. Se utilizó regresión lineal en cada periodo de Ensanut para evaluar las tendencias lineales temporales en la prevalencia del SM. Se obtuvieron modelos de regresión logística para calcular el cambio porcentual, P para la tendencia y las asociaciones entre la SM con el riesgo de desarrollar en 10 años diabetes mellitus tipo 2 utilizando la *Finnish Diabetes Risk Score* (FINDRISC) y enfermedad cardiovascular utilizando Globorisk. **Resultados.** La prevalencia de SM en adultos mexicanos según la definición armonizada fue: 40.2, 57.3, 59.99 y 56.31%, en 2006, 2012, 2016 y 2018 respectivamente (*p* para tendencia <0.0001). En 2018, 7.62% de los casos de síndrome metabólico tenían un riesgo significativo de DM2 incidente y 11.6% de ECV. **Conclusión.** Se estima que los adultos mexicanos con síndrome metabólico son 36.5 millones; de ellos, dos millones tienen un alto riesgo de desarrollar DMT2 en los próximos 10 años y 2.5 millones enfermedades cardiovasculares.

Palabras clave: síndrome metabólico; prevalencia; tendencia; Ensanut

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The Metabolic Syndrome (MS) identifies individuals at increased risk of developing type 2 diabetes mellitus (T2DM)[1-4] and cardiovascular disease (CVD).[1,5,6] The principle cause of this condition is related to environmental factors (overweight and obesity, physical inactivity, and high carbohydrate diets) and genetic predisposition.[6-8] It is a cluster of cardio-metabolic risk factors, including abdominal obesity, hyperglycemia, dyslipidemia and elevated blood pressure.[6]

The prevalence in the adult population in different countries is estimated to be between 20 and 40%[8-10] depending on the definition applied. In 2006, using the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III),[11] the American Heart Association; National Heart, Lung and Blood Institute (AHA/NHLBI),[2] and the International Diabetes Federation (IDF)[12] criteria, the prevalence of the MS in Mexican adults aged 20 years or older, was 36.8, 41.6 and 49.8%, respectively.[13]

A growing trend in the prevalence rates of the MS has been reported in many countries.[14] However, in US adults, the prevalence of the MS has been stable for the last 15 years.[15-17] This is because the prevalence of certain MS components has decreased, such as hypertriglyceridemia,[15,17] fasting hyperglycemia, and high blood pressure,[18] whereas the prevalence of abdominal obesity has greatly increased.[15,16]

In this study, the trends in the prevalence of the MS and its components are explored in the Mexican population aged 20 years or older, using the harmonized definition proposed by the IDF, the AHA/NHLBI, and other international associations.[19] In addition, an estimation of the size of the population with a greater risk of developing T2DM and CVD, using the Finnish Diabetes Risk Score (FINDRISC) and Globorisk scores, is explored with the data from the National Health Surveys of 2006, 2012, 2016, and 2018.

Materials and methods

Data from the *Encuesta Nacional de Salud y Nutrición* (Ensanut) 2006, 2012, 2016 and 2018 was analyzed. The Ensanut surveys are part of the National Health Survey System. These surveys are cross-sectional studies of the civilian, noninstitutionalized Mexican population with probabilistic, multistage, stratified, and a cluster sampling design. Population characteristics, sampling procedure, and other methodological details from each survey can be consulted in other publications.[20-23]

Ensanut 2006 was conducted between October 2005 and May 2006. A total of 47 152 households participated. 45 446 adult subjects aged 20 or older, who answered a questionnaire, and underwent blood pressure and anthropometric measurements; 30% of these subjects (randomly selected) supplied fasting blood samples. Thus, a sub-sample of 6 613 blood samples, randomly selected, nationally representative, were sent to the *Instituto Nacional de Salud Pública* (INSP) laboratory.[20]

The Ensanut 2012 was conducted between October 2011 and May 2012. Information was obtained from 50 528 households (Response Rate (RR)= 87%). Adult questionnaires were applied to 46 303 subjects and anthropometric measurements were carried out in all. Fasting blood samples, blood pressure, and physical activity questionnaires were obtained from 30% of these subjects (randomly selected). Hence, from those a sub-sample of 10 072 adults, fasting blood samples, were sent to the INSP-laboratory.[21]

For Ensanut 2016, conducted from May to September 2016, members of 9 479 households were interviewed (RR=77.9%). From these, 8 412 subjects answered the adult questionnaire (RR=91.9%). All were asked about their physical activity and anthropometric and blood pressure measurements were also taken. For the biochemical analysis, a random subsample of 60% of the adults was selected, of these 4 023 agreed to give a fasting blood sample (RR=71.6%).[22]

The Ensanut 2018 was conducted between July 2018 and February 2019, and included information from 44 069 households, (RR=87%) and 43 070 adults (RR=97%). All were asked about their physical activity. Anthropometric measurements were obtained from a random subsample of 16 256 adults. And of these 13 162 provided a blood sample.[23]

Adults who had complete and valid anthropometric data, blood pressure measurements with fasting blood samples including glucose, triglycerides, total cholesterol and HDL-C measurements were analyzed. Pregnant women, women with gestational diabetes, persons with less than eight hours of fasting, and those with missing glucose, triglycerides, total cholesterol and HDL-C results were excluded. Adults with biologically implausible blood pressure and body mass index values were also excluded.

The final sample was 5 457, 8 419, 3 530 and 10 394 adults from Ensanut 2006, 2012, 2016, and 2018 respectively, this represents 45, 56, 64 and 64.8 million adults, respectively.

Blood samples were collected from the antecubital vein after an eight hour fast and analyzed at a central certified laboratory: Ensanut 2006 and 2012 were analyzed at INSP laboratory, and Ensanut 2016 and Ensanut 2018 were analyzed at *Instituto Nacional de Ciencias Médicas y de la Nutrición Salvador Zubirán* (INCMNSZ) laboratory. Blood samples were used to measure serum fasting glucose, high-density lipoprotein cholesterol,

low-density lipoprotein cholesterol (HDL-C, LDL-C), total cholesterol, and triglycerides using enzyme or radioimmunoassay methods.

Blood pressure

In Ensanut 2006 blood pressure measurements were taken using the mercury sphygmomanometer TXJ-10; for subsequent surveys, Ensanut 2012, 2016, and 2018, electronic sphygmomanometers (Omron HEM-907 XL) were used. Consequently, measurements of blood pressure of Ensanut 2006 are not directly comparable to measurements of Ensanut 2012 and onwards. In order to have comparable measurements for all Ensanut surveys, we created a prediction model for systolic and diastolic pressures; for instance, $Y_{HEM,SYS} = f_{SYS}(X_{TXJ,SYS}) + E$, where $Y_{HEM,SYS}$ is a measurement with sphygmomanometer HEM-907 of the systolic pressure that corresponds to a measurement with sphygmomanometer TXJ-10 ($X_{TXJ,SYS}$).The prediction model was generated using a subsample of 3 656 individuals for whom both measurements were available (HEM sphygmomanometer and TXJ sphygmomanometer). Estimated models f_{SYS} and f_{DY} were used to simulate values for the diastolic and systolic pressures; these values were generated by adding the predicted value f (X_{TXJ}) and the error term E. Details of the models are given below.

Simulation of Blood Pressure Digital (BPD) systolic values

The range of $X_{HEM,SYS}$ (BPM, Blood pressure Mercury) values were split in three intervals (<=110), (110 130) and (>=130), and the mean (m) and variance (v) of the difference between $X_{HEM,SYS}$ (Mercury sphygmomanometer) and $Y_{HEM,SYS}$ (Digital sphygmomanometer) were estimated . Then, values of BPD systolic with the equation: $X_{HEM,SYS}$ + Normal_error (mean=m, standard deviations=d), where (m,v) are the (mean,variance) estimated in the seven intervals were simulated. Thus, BPD systolic simulated values were interpreted as the BPD-value that corresponds to BPM-value. The distribution of simulated BPD-values and observed BPD-values were compared; these coincided almost perfectly. The estimated vectors of mean and standard deviations were m = (2.69,0.65,1.62), d = (8.1,9.3,11.9).

Adjustment of BPD diastolic values

The procedure of adjustment was similar; but the range of BPM values was split in four intervals: (<70), 70, (70,90) and (>=90). The estimated vectors of mean and standard deviations were m =(1.34,0.0,-3.2, -6.76), d=(6.8,7.2,7.9,9.7).

All values of SBP greater than or equal to 80mmHg and DBP greater than or equal to 50mmHg were considered valid. The classification used to categorize blood pressure was that described in the Joint National Report for the Diagnosis of Arterial Hypertension (JNC 8).[24] Adults with a SBP <140 mmHg and a DBP <90 mmHg were classified as normotensive, and all adults who reported having previously received a diagnosis of arterial hypertension from a healthcare professional, or presented values of SBP ≥140 mmHg or DBP ≥90 mmHg were considered hypertensive. An adult with arterial hypertension was considered under control when the SBP was <140 mmHg and the DBP <90 mmHg.

Body mass index

Valid measurements were considered for all height values between 1.3 m and 2.0 m, and body mass index (BMI) values between 10 and 58 kg/m^2. Data outside these ranges for height and for BMI, were excluded from the analysis.

Waist circumference

For the analysis of waist circumference, values between 50 and 200 cm were included.

Physical activity

The short version of the international physical activity questionnaire (IPAQ)[25] was applied to a sub-sample of adults from the four surveys, to obtain minutes per week of moderate to vigorous physical activity in adults (20-69 years). This questionnaire asks about the minutes of vigorous and moderate-intensity activity and walking performed in free time, at work, during transportation and at home for the last seven days, in minimum intervals of 10 minutes. The IPAQ can be used to assess adherence to the WHO physical activity recommendations.[26] Vigorous or moderate active (more than 150 minutes per week), and no-activity (less than 150 minutes per week) were analyzed as a dichotomous variable.

Metabolic syndrome definition

The harmonized definition of the metabolic syndrome (MS) was proposed in 2007.[19] The MS was defined as having three or more of the following five criteria; waist circumference ≥90 cm in men and ≥80 cm in women for Latin-American populations, elevated triglycerides ≥150 mg/dl or medical treatment for elevated triglycerides

(TG); low HDL-cholesterol <40 mg/dl in men and <50 mg/dl in women; elevated SBP ≥130 mm Hg or elevated DBP ≥85 mm Hg or medical treatment for arterial hypertension and elevated fasting plasma glucose ≥100 mg/dl or medical treatment for T2DM.

FINDRISC

J Lindström and J Tuomilehto[27] designed the Diabetes Risk Score to identify, without laboratory tests, individuals at increased risk for T2DM; the aim being to include these persons in interventions to prevent the development of the disease. Even though the aim of this score is to predict T2DM, it is used, and has been validated in several populations to assess whether a person has undiagnosed T2DM. This score includes age, BMI, waist circumference, history of antihypertensive drug treatment and high blood glucose, physical activity, and daily consumption of fruits.

Globorisk

The Mexican Society of Cardiology and the 2016 Diagnosis and treatment of dyslipidemia Clinical Practice Guideline from the Mexican Social Security Institute (*Instituto Mexicano del Seguro Social*, IMSS)[28] recommend that all individuals over 40 years of age should be evaluated for cardiovascular risk, using the Globorisk scale.[29] This instrument is the only one that has been validated in the Mexican population. This score includes gender, diagnosis of T2DM, current smoking habit, systolic blood pressure, total cholesterol, and age. The score stratifies patients at low risk (<1%), moderate risk (1 to 5%), and high or very high risk (6 to 15%) for the development of cardiovascular disease over the next 10 years.[30]

Household wealth index

The Household wealth index is an index that evaluates the condition of the dwelling, the number of rooms utilized, building material of the wall, roof and floor, as well as water installations and household possessions (car, TV, pay TV, radio, refrigerator, stove, washing machine, computer, micro-waves, telephone). Indigenous ethnicity was defined as any indigenous language spoken by the adult. Area of residence was classified as rural for localities with <2 500 inhabitants and urban if otherwise.

Statistical analysis

The prevalence of the MS, and its components, are expressed in terms of percentages. Data from the 2010 and 2020 National Census and the 2005 and 2015 *intercensal* survey were used for estimation of nationwide case numbers.

Age standardized prevalence was estimated by the direct method using the 2020 world population as the standard.[30] Simple linear regression was used to assess temporal linear trends in prevalence of MS and its components (dependent), total and stratified by sex. The percentage of change (odds percentage increase or decrease), and *p*-value for trend (linearity of the logit) using logistic regression model were obtained. Associations between the metabolic syndrome and its components with the predicted 10-year risk for developing T2DM, using the FINDRISC, and CVD, using the Mexico tables from the Globorisk, were evaluated using odds ratios (ORs) with 95% confidence intervals (CIs) obtained from multiple logistic regression models. Individual weighted factors were used for the statistical analysis, and the survey's complex sampling design was taken into account to obtain variances. All analyses were carried out using svy commands from Stata 14.*

The Research, Ethics and Biosecurity Committee from the INSP, Cuernavaca, Mexico, approved protocols, from Ensanut 2006, 2012, 2016, and 2018. All participants signed informed consent.

Results

Study population characteristics were stratified by year of the survey are shown in table I. Differences between surveys were observed in the prevalence of abdominal obesity (72.2% in 2012 and 81.4% in 2018), current smoking status (22% in 2006 and 15.9%, in 2018), diagnosed diabetes (6.9% in 2006 and 10.6% in 2018), and diagnosed arterial hypertension (14% in 2016 and 20.5% in 2018). Differences in mean values were observed in plasma glucose (104.3 mg/dl in 2006 and 98.6 mg/dl in 2018), HbA1c (11.2% in 2006 and 5.5% in 2018), total cholesterol (169 in 2006 and 186.7 in 2016), triglycerides (116.4 in 2006 and 178.6 in 2012), and LDL-C (98.4 in 2006 and 112.3 in 2016).

Table II and figure 1 display temporal trends in the MS and its individual components, overall and stratified by gender. Temporal trends were evident for increasing prevalence of MS (p <0.0001), waist circumference (p<0.0001), high triglyceride levels (p<0.001), and low HDL levels (p<0.001). There was a further temporal trend for a decreasing prevalence of high blood pressure (p<0.01). There were no significant trends for hyperglycemia. The crude and age-adjusted prevalence of MS in

* Stata Corp. College Station, TX, USA

Table I

SOCIODEMOGRAPHIC AND HEALTH RELATED CHARACTERISTICS OF THE STUDY POPULATION BY SURVEY YEAR. MEXICO, ENSANUT 2006, 2012, 2016 AND 2018

	2006	*2012*	*2016*	*2018*
Sample size	5 457	8 419	3 530	10 394
Population in thousands	45 028	56 166	64 296	64 806
Characteristics	*% (95%CI)*	*% (95%CI)*	*% (95%CI)*	*% (95%CI)*
Sex				
Men	45.7 (43.6,47.8)	47.5 (45.3,49.7)	48.2 (44.5,51.9)	46 (44.3,47.6)
Women	54.3 (52.2,56.4)	52.5 (50.3,54.7)	51.8 (48.1,55.5)	54 (52.4,55.7)
Age (years)				
20-39	53.8 (51.7,55.9)	49.9 (47.5,52.2)	48.6 (45.4,51.8)	40.1 (38.3,41.8)
40-59	31.6 (29.8,33.5)	34.8 (32.6,37.0)	35.1 (32.2,38.1)	39.4 (37.9,41.0)
60 and more	14.6 (13.2,16.0)	15.3 (13.9,16.9)	16.3 (14.3,18.5)	20.5 (19.1,22.0)
Area of residence				
Urban	78.8 (76.0,81.4)	79.1 (76.6,81.3)	77.1 (73.7,80.2)	77.7 (75.0,80.2)
Rural	21.2 (18.6,24.0)	20.9 (18.7,23.4)	22.9 (19.8,26.3)	22.3 (19.8,25.0)
Education level				
None	9.7 (8.7,11.0)	7.8 (6.8,8.9)	6.5 (5.3,7.9)	5.8 (5.2,6.5)
Basic	39.7 (37.6,41.8)	34.8 (32.7,36.9)	29 (26.1,32.1)	27.1 (25.7,28.6)
Medium school	23.4 (21.8,25.1)	27.2 (25.2,29.3)	29.8 (26.9,32.9)	27.4 (25.8,28.9)
High school	15.5 (13.9,17.2)	15.3 (13.8,16.9)	16.9 (14.3,19.8)	21 (19.5,22.5)
Bachelor's degree	11.7 (10.0,13.6)	15 (13.1,17.1)	17.8 (14.1,22.2)	18.7 (17.3,20.3)
Indigenous (yes)	6.3 (5.2,7.7)	6.5 (5.4,7.9)	6.8 (5.0,9.2)	6.4 (5.4,7.6)
Tertile of household wealth index				
T1 low	37 (34.9,39.2)	33.3 (31.0,35.6)	21.3 (18.5,24.3)	29.7 (27.8,31.6)
T2 medium	53.2 (51.1,55.3)	40.5 (38.0,43.1)	30.8 (27.9,33.9)	32.8 (31.2,34.4)
T3 high	9.8 (8.3,11.4)	26.2 (24.0,28.7)	47.9 (43.9,51.9)	37.5 (35.5,39.6)
Geographic region				
North	30.4 (27.1,33.8)	22.5 (19.9,25.4)	25.7 (22.5,29.3)	18.2 (16.5,20.1)
Central	24.1 (20.8,27.9)	29.4 (26.2,32.8)	29.6 (26.0,33.5)	34.7 (31.7,37.8)
Mexico city	20.5 (16.4,25.3)	19.7 (15.6,24.5)	18.3 (15.5,21.5)	14.6 (12.4,17.3)
South	25 (22.0,28.3)	28.3 (25.3,31.6)	26.3 (22.8,30.2)	32.4 (29.8,35.2)
Current smoker	22 (20.0,24.0)	19.2 (17.3,21.3)	19.9 (16.8,23.5)	15.9 (14.6,17.3)
Former smoker	12.1 (10.8,13.7)	18.1 (16.1,20.3)	37.9 (34.6,41.3)	12.5 (11.6,13.6)
Overweight	40.3 (38.3,42.3)	36.7 (34.9,38.6)	39.3 (36.4,42.3)	40.8 (39.2,42.4)
Obese	29.2 (27.3,31.0)	33.7 (31.9,35.6)	36.4 (32.7,40.3)	36.6 (35.1,38.2)
Abdominal obesity*	74 (72.1,75.8)	72.2 (69.8,74.5)	78.5 (75.7,81.0)	81.4 (80.1,82.6)
Diabetes				
Previously diagnosed	6.9 (5.9,8.1)	9 (7.8,10.3)	9.5 (8.2,11.1)	10.6 (9.7,11.6)
With medical treatment	92.4 (85.8,96.1)	89.3 (85.0,92.5)	89.8 (83.9,93.6)	85 (81.8,87.8)
Hypertension				
Previously diagnosed	16.1 (14.6,17.6)	16.5 (15.1,18.1)	14 (12.0,16.2)	20.5 (19.2,21.9)
With medical treatment	58.4 (53.1,63.5)	72.5 (66.2,78.0)	75 (67.6,81.2)	71 (67.9,73.9)

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	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)
Age (years)	41.0 (40.3,41.7)	41.5 (56.1,61.4)	42.0 (40.8,42.9)	45.0 (44.2,45.7)
Waist circumference	93.0 (92.5,93.68)	93.4 (95.6,99.9)	95.5 (94.5,96.6)	95.4 (94.8,95.9)
Glucose	104.3 (102.4,106.3)	103.0 (165.3,195.4)	102.9 (100.6,104.7)	98.6 (97.4,100.0)
Glycated hemoglobin	11.2 (10.7,11.7)	9.4 (9.11,9.79)	5.6 (5.55,5.70)	5.5 (5.47,5.56)
Cholesterol	169.0 (166.6,171.4)	184.0 (184.8,197.3)	186.7 (183.9,189.3)	183.6 (181.7,185.2)
Triglycerides	116.4 (113.5,119.2)	178.6 (196.1,228.5)	174.5 (165.6,183.5)	146.9 (145.0,148.9)
LDL-C	98.4 (96.4,100.3)	108.6 (104.4,114.0)	112.3 (109.5,115.0)	108.3 (106.7,109.6)
HDL-C	46.9 (46.3,47.6)	39.7 (38.0,40.6)	39.4 (38.5,40.0)	45.8 (45.3,46.3)
Systolic blood pressure	121.2 (120.6,121.9)	122.0 (131.1,136.4)	120.6 (119.6,121.6)	123.9 (123.2,124.5)
Dyastolic blood pressure	78.1 (77.6,78.6)	78.7 (80.6,83.5)	73.6 (73.2,73.9)	75.0 (74.7,75.2)

LDL-C: low-density lipoprotein cholesterol
HDL: high-density lipoprotein cholesterol
*Women >= 80 cm; Men >= 90 cm
Ensanut: *Encuesta Nacional de Salud y Nutrición*

2018 was 56.3% and 54.2% respectively (table II); this percentage represents approximately 36.5 million subjects. Men had a lower prevalence (53.17%, N=15.8 millions) compared with women (58.98%, N=20.6 million, p <.0001). An important increment in MS prevalence was found among subjects that speak an indigenous language; this increased from 37.23% in 2006 to 62.9% in 2018; the percentage change was 42.98% over a 12 year-period (table II).

Table III shows the results of multiple logistic regression models assessing the association between the metabolic syndrome and its components and the 10-year risk for developing T2DM (using the cut-off point at 15% of the FINDRISC score) using the Ensanut 2012 and 2018 data. Estimates were adjusted for sex and age. Previously diagnosed diabetes cases were excluded. The results revealed that the magnitude of association decreased from 2012 to 2018, except for high blood pressure. Nevertheless, in 2012 there were nearly one million adults with MS in Mexico and at high risk for developing T2DM over the next 10 years; this figure was two million in 2018.

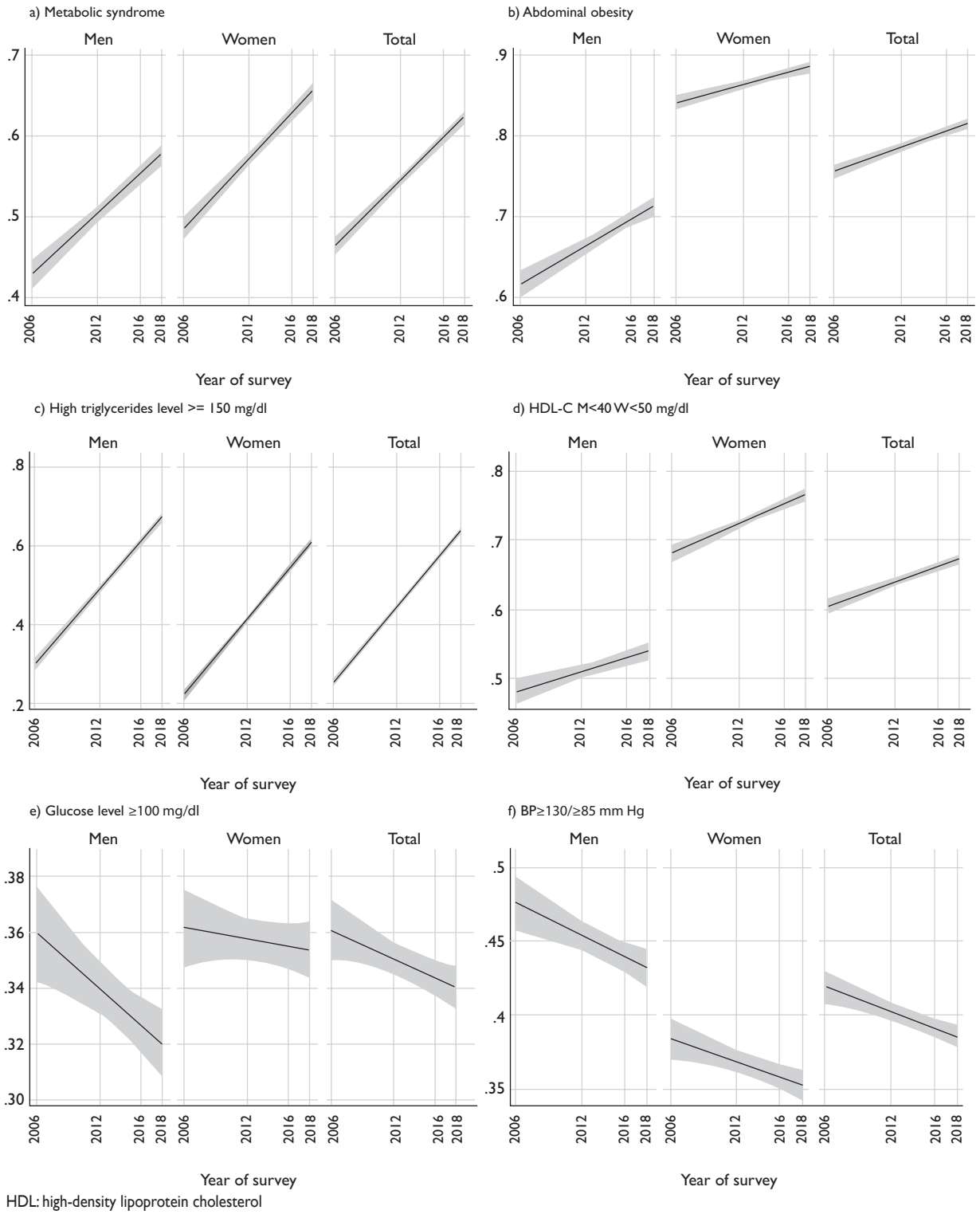
Adjusted multiple logistic regression models were developed to examine the association between the metabolic syndrome and its components and the 10-year risk for developing a major cardiovascular event (using the threshold 15% of the Mexican tables from the Globorisk score). Adults with MS were six times more likely to be at high risk of developing cardiovascular disease within the next 10-years. Glucose levels higher than 100 mg/dL were eleven times more likely to develop cardiovascular disease within 10-years (table IV). Adults with MS and a high risk of developing cardiovascular disease within the next 10-years were estimated as 1.5 million adults in 2012, and 2.5 million in 2018.

Discussion

The prevalence of the metabolic syndrome has shown an incremental trend over the 12 years covered by this report. Although the prevalence varies according to the criteria used for each definition, this finding was consistently observed. The prevalence of the MS in Mexican adults according to the harmonized definition was: 40.2, 57.3, 59.99, and 56.31%, in 2006, 2012, 2016, and 2018 respectively. Prevalence rates were higher in women than in men. Comparing the MS prevalence results, there was a 20.22% increase between 2006 and 2018; 18.09% in men and 22.23% in women. The most prevalent MS components was abdominal obesity, with a prevalence of 73.99, 72.2, 78.45, and 81.37%, in 2006, 2012, 2016, and 2018, respectively. The greatest percentage change for an individual component was found for hypertriglyceridemia (61.85%).

The frequency of abdominal obesity has increased from 33.3 million (12.5 million male and 20.5 million female) in 2006 to 52.7 million (21.7 men and 31 million women) in 2018. The rates of hyperglycemia were 14.7 and 20 million adults in 2006 and 2018, respectively. These increments are probably related to an unhealthy lifestyle (poor diet and sedentary habits) and aging of the population.

The trends observed in Mexico contrast with the data reported in other countries. For example, the prevalence of the metabolic syndrome (using ATPIII definition) remained unchanged in US adults in the National Health and Nutrition Examination Survey (NHANES) 2003-2004 to NHANES 2013-2014 (23.0%).[17] The most prevalent component was also abdominal obesity, which increased from 65.2% in 2003-2004, to 69% in 2013-2014.



HDL: high-density lipoprotein cholesterol
BP: blood presure
Ensanut: *Encuesta Nacional de Salud y Nutrición*

Figure 1. Trends in prevalence of metabolic syndrome and its components versus National Survey. Regression lines are shown with 95% confidence bands shaded. Mexico, Ensanut 2006, 2012, 2016 and 2018

Table II

Prevalence of metabolic syndrome and its components according to the harmonized criterion, by survey year. Mexico, Ensanut 2006, 2012, 2016 and 2018

	2006	*2012*	*2016*	*2018*	*Percentage of change over the 12 years*	*p of trend*
	% (95%CI)	*% (95%CI)*	*% (95%CI)*	*% (95%CI)*		
Waist circumference M>=90 cm,W>=80						
Total adjusted by age	75.1 (73.4,76.8)	72.7 (70.6,74.8)	78.4 (75.7,80.9)	79.8 (78.5,81.1)		
Total	73.99 (72.09,75.81)	72.21 (69.82,74.48)	78.49 (75.69,81.04)	81.37 (80.05,82.63)	18.26	<0.000
Men	62.26 (58.95,65.45)	60.58 (56.74,64.30)	67.74 (62.40,72.66)	72.91 (70.68,75.03)	20.33	<0.000
Women	83.87 (81.74,85.79)	82.73 (80.27,84.93)	88.49 (86.04,90.55)	88.57 (87.19,89.82)	18.57	<0.000
High Triglycerides level >=150 mg/dl or with medical treatment						
Total adjusted by age	23.6 (21.5,25.8)	48.5 (46.3,50.6)	57.7 (54.2,61.2]	59.0 (57.3,60.6)		
Total	22.84 (20.77,25.06)	48.15 (45.89,50.42)	58.13 (54.41,61.75)	60.11 (58.39,61.81)	61.85	<0.000
Men	27.76 (24.62,31.13)	54.62 (51.13,58.07)	62.09 (55.98,67.84)	65.03 (62.59,67.39)	59.85	<0.000
Women	18.71 (16.44,21.21)	42.30 (39.43,45.22)	54.43 (50.09,58.71)	55.92 (53.62,58.20)	65.12	<0.000
HDL-C M< 40 W< 50 mg/dl						
Total adjusted by age	49.5 (47.0,52.0)	73.4 (71.4,75.3)	76.0 (73.1,78.7)	56.0 (54.4,57.7)		
Total	50.02 (47.46,52.59)	73.62 (71.56,75.58)	76.28 (73.30,79.02)	56.20 (54.51,57.87)	4.64	<0.000
Men	38.29 (34.74,41.98)	66.14 (62.84,69.29)	70.27 (64.92,75.11)	43.14 (40.68,45.63)	2.05	<0.000
Women	59.89 (56.78,62.92)	80.38 (77.73,82.79)	81.87 (78.67,84.69)	67.30 (65.09,69.44)	7.92	<0.000
Glucose level ≥ 100 mg/dl or with medical treatment						
Total adjusted by age	34.2 (32.2,36.2)	36.5 (34.5,38.6)	32.7 (29.8,35.8)	28.5 (27.1,30.0)		
Total	32.32 (30.27,34.45)	35.75 (33.60,37.96)	32.45 (29.31,35.76)	30.47 (28.95,32.03)	-4.63	0.203
Men	32.45 (29.29,35.77)	32.92 (29.76,36.24)	31.60 (26.03,37.75)	28.75 (26.58,31.02)	-5.98	0.163
Women	32.22 (29.59,34.96)	38.30 (35.44,41.24)	33.24 (29.59,37.10)	31.93 (29.85,34.09)	-3.49	0.722
BP ≥130/≥85 mm Hg or with medical treatment						
Total adjusted by age	41.7 (39.8,43.7)	39.9 (37.9,41.9)	30.7 (28.2,33.3)	34.3 (32.7,35.9)		
Total	39.42 (37.38,41.50)	38.55 (36.38,40.76)	29.70 (26.85,32.72)	36.74 (35.06,38.45)	-6.56	<0.000
Men	45.04 (41.65,48.48)	40.15 (36.67,43.73)	32.74 (28.10,37.73)	40.24 (37.88,42.65)	-7.82	0.000
Women	34.69 (32.39,37.07)	37.10 (34.55,39.72)	26.87 (23.55,30.49)	33.76 (31.58,36.00)	-5.47	0.007
Metabolic syndrome (harmonized criteria)						
Total adjusted by age	42.28 (40.20,44.30)	58.11 (56.10,60.00)	60.18 (57.00,63.20)	54.20 (52.56,55.84)		
Total	40.25 (38.04,42.51)	57.31 (54.95,59.63)	59.99 (56.41,63.46)	56.31 (54.61,58.00)	20.22	<0.0000
Men	38.98 (35.73,42.34)	53.70 (50.07,57.29)	57.38 (51.42,63.13)	53.17 (50.74,55.59)	18.09	<0.0000
Women	41.32 (38.68,44.00)	60.57 (57.73,63.34)	62.41 (57.84,66.78)	58.97 (56.69,61.22)	22.23	<0.0000
Age (years)						
20-39	27.91 (25.20,30.79)	40.93 (37.96,43.96)	45.51 (40.14,50.99)	40.28 (37.89,42.72)	19.05	<0.0000
40-59	52.45 (48.82,56.05)	75.33 (72.51,77.94)	72.6 (68.83,76.07)	65.39 (62.96,67.74)	11.07	<0.0000
60 and more	59.33 (55.01,63.52)	69.63 (64.81,74.05)	75.97 (70.73,80.52)	70.17 (65.81,74.20)	15.74	<0.0000
Area of residence						
Urban	41.44 (38.81,44.11)	58.34 (55.52,61.12)	60.87 (56.35,65.21)	56.98 (54.90,59.03)	19.48	<0.0000
Rural	35.84 (32.35,39.49)	53.36 (49.87,56.829)	57.02 (52.86,61.09)	53.97 (51.47,56.45)	23.51	<0.0000
Speak indigenous language	37.23 (31.61,43.23)	53.13 (45.39,60.73)	59.49 (55.62,63.25)	62.9 (58.25,67.33)	42.98	<0.0000

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(continuation)

Tertile of household wealth index						
T1 Low	35.48 (32.22,38.87)	53.48 (50.05,56.87)	55.05 (50.22,59.79)	56.93 (54.58,59.24)	29.32	<0.0000
T2 Medium	43.56 (40.64,46.53)	59.68 (55.76,63.48)	60.47 (54.75,65.92)	57.71 (54.91,60.47)	19.83	<0.0000
T3 High	40.33 (33.33,47.75)	58.47 (53.40,63.38)	61.87 (55.36,67.97)	54.59 (51.38,57.77)	4.87	0.000
Geographic region						
North	39.5 (36.77,42.30)	55.01 (51.46,58.51)	56.48 (48.52,64.12)	56.87 (53.74,59.94)	25.59	<0.0000
Central	41.08 (36.56,45.76)	53.52 (49.90,57.10)	60.06 (52.89,66.82)	53.65 (51.29,55.99)	15.09	<0.0000
Mexico City	41.51 (34.32,49.08)	61.43 (51.91,70.14)	62.14 (53.40,70.15)	58.4 (50.59,65.80)	23.35	<0.0000
South	39.33(36.01,42.75)	57.58 (54.16,60.93)	61.84 (57.10,66.37)	57.9 (55.39,60.37)	22.83	0.001
Overweight	43.49 (39.96,47.09)	63.8 (60.93,66.58)	61.9 (55.79,67.65)	58.1 (55.34,60.80)	16.72	<0.0000
Obese	61.9 (58.20,65.46)	81.42 (78.76,83.82)	82.13 (75.83,87.07)	75.47 (73.07,77.72)	19	<0.0000
Diagnosed diabetes	81.7 (74.11,87.44)	91.39 (86.40,94.66)	90.48 (83.61,94.66)	92.79 (89.83,94.94)	35.38	0.001
Diagnosed hypertension	71.14 (66.39,75.46)	84.63 (80.97,87.69)	93.04 (88.84,95.73)	81.31 (78.12,84.13)	21.05	<0.0000

HDL: high-density lipoprotein cholesterol
BP: blood presure
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Table III

Percentage of the population according to the presentation of metabolic syndrome, its components and the high risk of developing DM * in 10 years, based on FINDRISC. Mexico, Ensanut 2012 and 2018

	2012			2018		
	Low to moderate risk <15% % (95%CI)	High risk >15% % (95%CI)	OR (95%CI)‡	Low to moderate risk <15% % (95%CI)	High risk >15% % (95%CI)	OR (95%CI)‡
Total	96.83 (95.97,97.52)	3.17 (2.48,4.03)		95.14 (94.24,95.91)	4.86 (4.09,5.76)	
Metabolic syndrome						
No	99.16 (98.51,99.53)	0.84 (0.47,1.49)		98.13 (96.84,98.90)	1.87 (1.10,3.16)	
Yes	94.8 (93.23,96.03)	5.2 (3.97,6.77)	3.9 (2.0,7.8)	92.38 (90.97,93.59)	7.62 (6.41,9.03)	2.8 (1.6,5.0)
Abdominal obesity W>=80, M>=90						
No	100	0		100	0	
Yes	95.58 (94.39,96.52)	4.42 (3.48,5.61)	1	93.98 (92.88,94.93)	6.02 (5.07,7.12)	1
Triglycerides >=150mg/dl						
No	97.76 (96.73,98.47)	2.24 (1.53,3.27)		96.14 (94.37,97.37)	3.86 (2.63,5.63)	
Yes	95.82 (94.29,96.95)	4.18 (3.05,5.71)	1.6 (0.9,2.7)	94.45 (93.39,95.35)	5.55 (4.65,6.61)	1.3 (0.8,2.1)
HDL M<40mg/dl W<50mg/dl						
No	97.42 (95.95,98.37)	2.58 (1.63,4.05)		96.14 (94.67,97.22)	3.86 (2.78,5.33)	
Yes	96.63 (95.51,97.48)	3.37 (2.52,4.49)	1.7 (0.9,3.4)	94.35 (93.14,95.37)	5.65 (4.63,6.86)	1.6 (1.0,2.5)
Glucose >100 mg/dl						
No	98 (97.27,98.54)	2 (1.46,2.73)		96.37 (95.35,97.18)	3.63 (2.82,4.65)	
Yes	93.71 (90.99,95.65)	6.29 (4.35,9.01)	2.1 (1.2,3.6)	90.89 (88.73,92.67)	9.11 (7.33,11.27)	1.8 (1.2,2.7)
Blood pressure >130/85						
No	98.63 (97.60,99.22)	1.37 (0.78,2.40)		97.97 (97.33,98.45)	2.03 (1.55,2.67)	
Yes	93.16 (91.20,94.70)	6.84 (5.30,8.80)	2.5 (1.2,5.2)	88.53 (85.90,90.73)	11.47 (9.27,14.10)	2.9 (1.9,4.4)

* Diagnosed diabetes cases excluded
‡ Adjusted for sex and age
DM: biabetes mellitus; FINDRISC: Finnish Diabetes Risk Score; HDL: high-density lipoprotein cholesterol
Ensanut: *Encuesta Nacional de Salud y Nutrición*

Table IV

Percentage of the population according to the presentation of metabolic syndrome, its components and the high risk of developing some cardiovascular disease* in 10 years, based on the tables for Mexico of the Globorisk. Mexico, Ensanut 2012 and 2018

	2012			2018		
	Globorisk			Globorisk		
	Low to moderate risk <15% % (95%CI)	High risk >15% % (95%CI)	OR (95%CI)‡	Low to moderate risk <15% % (95%CI)	High risk >15% % (95%CI)	OR (95%CI)‡
Total	92.62 (91.30,93.76)	7.38 (6.24,8.70)		91.48 (90.21,92.60)	8.52 (7.40,9.79)	
Metabolic syndrome						
No	96.92 (95.45,97.92)	3.08 (2.08,4.55)		97.69 (96.58,98.44)	2.31 (1.56,3.42)	
Yes	91.13 (89.35,92.63)	8.87 (7.37,10.65)	5.7 (3.5,9.5)	88.37 (86.56,89.96)	11.63 (10.04,13.44)	5.5 (3.4,8.9)
Abdominal obesity W>=80, M>=90						
No	93.82 (91.18,95.71)	6.18 (4.29,8.82)		92.75 (89.71,94.94)	7.25 (5.06,10.29)	
Yes	92.39 (90.87,93.68)	7.61 (6.32,9.13)	2.2 (1.3,3.7)	91.32 (89.94,92.53)	8.68 (7.47,10.06)	2.2[1.3,3.6]
Triglycerides >=150mg/dl						
No	94.57 (92.96,95.83)	5.43 (4.17,7.04)		95.07 (93.56,96.24)	4.93 (3.76,6.44)	
Yes	91.2 (89.19,92.86)	8.8 (7.14,10.81)	2.4 (1.5,3.9)	89.67 (87.91,91.19)	10.33 (8.81,12.09)	2.5 (1.5,3.9)
HDL M<40mg/dl W<50mg/dl						
No	91.66 (88.90,93.78)	8.34 (6.22,11.10)		92.03 (90.16,93.57)	7.97 (6.43,9.84)	
Yes	92.94 (91.37,94.25)	7.06 (5.75,8.63)	1.5 (0.9,2.3)	91.06 (89.25,92.58)	8.94 (7.42,10.75)	1.5 (0.9,2.2)
Glucose >100 mg/dl						
No	97.48 (96.57,98.15)	2.52 (1.85,3.43)		96.98 (95.82,97.82)	3.02 (2.18,4.18)	
Yes	87.52 (84.91,89.73)	12.48 (10.27,15.09)	9.3 (5.6,15.2)	83.53 (80.87,85.89)	16.47 (14.11,19.13)	8.9 (5.6,14.3)
Blood pressure >130/85						
No	98.42 (97.36,99.06)	1.58 (0.94,2.64)		97.61 (96.63,98.32)	2.39 (1.68,3.37)	
Yes	87.17 (84.77,89.24)	12.83 (10.76,15.23)	5.9 (3.1,11.3)	84.28 (81.77,86.51)	15.72 (13.49,18.23)	5.8 (3.1,10.9)

* Cardiovascular diseases cases excluded
‡ Adjusted for sex and age
HDL: high-density lipoprotein cholesterol
Ensanut: *Encuesta Nacional de Salud y Nutrición*

Hyperglycemia was another component that increased during this period, from 10.3% in 2003-2004 to 13.2% in 2013-2014. The lack of change in the number of subjects with the metabolic syndrome demonstrates that public polices can modify, in the short term, the environmental determinants of the disease.

In Mexico, no matter which definition is used, the frequency and prevalence of the MS is high and rising. Based on the 2020 National Census numbers for Mexican adults aged 20 years or older (approximately 70 million), the population with metabolic syndrome is estimated to be 15.8 million men and 20.7 million women. Some groups are selectively affected. This is the case in younger adults, subjects in the Q1 socioeconomic tertile (the poorest) and urban populations. Also notable is the remarkable increment observed in the indigenous population. This information is useful to focus preventive actions in the most badly affected groups.

Another feature to be highlighted is the growing percentage of patients with T2DM that fulfilled the metabolic syndrome definition. Mozumdar and Ligouri,[16] in a comparative study between NHANES III and NHANES 1999-2006, obtained an increase of metabolic syndrome prevalence, mainly because the abdominal obesity prevalence in women. After that, they expected, an increase in diabetes prevalence and its comorbidities. T2DM care implies the attainment of several treatment targets. The coexistence of the metabolic syndrome and type 2 diabetes increases the number of patients who may need one or more drugs to reach blood pressure and lipid targets. As a result, this finding has economic and medical implications.

The main limitation of this study is that due to the cross-sectional nature of national surveys, causality cannot be established; reverse causality may explain the association between the studied variables. The ideal scenario is to measure the prevalence of the metabolic syndrome in a prospectively followed population. None of the adult questionnaires from the four surveys has information about daily fruit or vegetable consumption, FINDRISC was calculated without this information. In addition, the Ensanut 2006 questionnaire does not contain information about parents' history of diabetes, another of the FINDRISC questions; we have only included Ensanut 2012 and Ensanut 2018 data in tables III and IV for comparison purposes. Certain results may have been influenced by possible measurement bias due to the use of self-reported questionnaires and the bias of wanting to answer the questionnaires. However, the large sample size, the nation-wide coverage and the population-based sampling approach ensure that this is a representative sample of the Mexican adult population.

The metabolic syndrome is a group of interrelated metabolic risk factors useful for identifying subjects with an increased risk for developing T2DM and CVD. A weakness of the metabolic syndrome concept is the heterogeneous profile of the patients. The cases identified with the current metabolic syndrome definitions may have a diverse risk for T2DM and/or CVD, depending on the number and severity of the metabolic traits.[31] Based on this, we included a complementary analysis for measuring the percentage of cases with metabolic syndrome that also had a high 10-year risk for developing T2DM (using the threshold 15% of the FINDRISC score)[27] and/or a high 10-year risk for developing a major cardiovascular event (using 15% from the Mexican tables of the Globorisk score as threshold).[29] In 2018, 7.62% of the metabolic syndrome cases had a significant risk for incident T2DM. The corresponding rate for CVD was 11.6%. It is estimated, according to the obtained prevalence, that there are 36.5 million adults living with the metabolic syndrome in Mexico; of these two million have a high risk of developing T2DM and 2.5 million a high risk for cardiovascular diseases, over the next 10 years.

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

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