Prevalence and Trends of Metabolic Syndrome in Mexican Adults: Data of the National Health and Nutrition Surveys 2006 and 2016

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Research article

Keywords: Metabolic Syndrome, Hyperglycemia, Hypertension, Dyslipidemia, Survey, Prevalence, Trends, Mexico

DOI: https://doi.org/10.21203/rs.3.rs-72797/v1

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Abstract

Background: The metabolic syndrome (MetSx) is a group of risk factors interconnected with cardiovascular diseases and type 2 diabetes, major morbidity and mortality causes globally and in Mexico. More than a thousand million individuals in the world were found with MetSx in 2018, and the last national investigation in Mexico on this condition carried out in 2006 registered a prevalence of 49.8% in adults. This study aimed to describe the prevalence of MetSx in Mexican adults, the degree of association with risk factors, and its trends in the period 2006 to 2016.

Methods: We gathered and analyzed sociodemographic, clinical, dietary, and physical activity data from 8,626 adults aged ≥20 years who participated in the Mexican National Health and Nutrition Survey Midway 2016 (ENSANUT MC-2016). To define MetSx, we used the harmonized diagnosis criteria as the main instrument. Other classification systems were also used to complement our analysis. To identify the prevalence trends of MetSx, we compared information of ENSANUT-2006 with that of ENSANUT-2016.

Results: The prevalence of MetSx in Mexican adults was of 60.5% (57.9% in men and 63.2% in women). The proportion of subjects with at least one MetSx component was of 95.3% and with at least two components was of 21.3%. The most frequent combination of three MetSx components was the cluster of abdominal obesity, low HDL-cholesterol, and hypertriglyceridemia (16%). In comparison with the MetSx prevalence reported in ENSANUT-2006, the prevalence of this condition in ENSANUT-2016 increased 15.3%.

Conclusions: A high prevalence of MetSx was registered in Mexico in 2016, and an increased trend of this condition during the period 2006 to 2016 was observed. This study shows the necessity to improve prevention and diagnosis programs for MetSx and its components, as well as the need to adopt a healthy lifestyle in the highest risk population in order to achieve corrections and reductions in associated susceptible risk factors.

Background

The metabolic syndrome (MetSx) is a group of risk factors that are related to insulin resistance and interconnected with cardiovascular diseases (CVD) and type 2 diabetes (T2D) [1]. The components of this cluster are abdominal obesity (AO), hypertension, hyperglycemia, high levels of triglycerides, and low levels of high-density lipoprotein cholesterol (HDL-c) [2].

In 2018 more than a thousand million people were found with MetSx worldwide [3], and in Mexico during 2006, the prevalence of this conditions was of 49.8% in adults [4]. Some MetSx determinants are not modifiable, such as ageing and sex [5]. In the other hand, some lifestyle-related factors strongly associated with each MetSx component [6] are susceptible to corrections and reductions, such as sedentarism [7], diet diversity [8], sleep duration [9], smoking [10], and alcohol intake [11].
MetSx diagnosis is complex because health services require enough technical infrastructure and medical supplies to measure the five risk factors [12], and physicians should have the necessary skills and competences to perform this process. In some Mexican regions, primary care physicians have a low level of clinical ability to identify this syndrome [13], which could in part mean that the prevalence of MetSx is underestimated or that it is increasing as in other countries [3].

Each MetSx component increases diabetes and CVD incidence and mortality [14, 15], main death causes in Mexico during at least the last two decades. Not knowing which factors are associated with MetSx, its prevalence, and its epidemiological dynamics in the Mexican population could exacerbate comorbidities, complications, and attributable mortality to this condition and its associated diseases in years to come [16, 17]. Therefore, the objective of this study is to describe the prevalence of MetSx among Mexican adults, the magnitude of its association with potential risk factors, and its trends in the period 2006 to 2016 by analyzing population-based datasets.

**Methods**

**Design and study population**

Datasets from the Mexican 2016 Mid-way National Health and Nutrition Survey (ENSANUT MC-2016) were utilized to perform this study. ENSANUT MC-2016 is a probabilistic survey with national, regional, and urban and rural strata representativeness. ENSANUT MC-2016’s main objective was to describe the health and nutrition status of the Mexican population, as well as its determinants. Details of design, sampling size calculation, and methodology of this survey have been previously described elsewhere [18]. The period of data collection was between May and October 2016. For ENSANUT MC-2016, 8,626 adults aged ≥ 20 years were selected. Afterwards, a subsample with fasting ≥ 8 hours and with complete information on biomarkers associated with metabolic syndrome was analyzed (n = 3,188).

**Sociodemographic and clinical data collection**

Questionnaires were administered to gather sociodemographic information, personal history of lifestyle, and chronic diseases background. A socioeconomic status index (SSI) was generated through principal component analyses, for which household characteristics, goods, and services available were considered. Afterwards, SSI was categorized in tertiles (low, middle, high).

**Anthropometry**

Trained and standardized personnel measured weight, height, and waist circumference by using internationally accepted protocols [19]. Body mass index (BMI; weight in kilograms divided by height in square meters [kg/m^2]) was calculated and categorized considering the World Health Organization (WHO) classification: normal BMI (18.5–24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), obesity (≥ 30.0 kg/m^2) [20]. AO was defined as a waist circumference of 80 cm or greater for women and 90 cm or higher for men [2].
Blood pressure

Blood pressure (BP) was measured by using a digital sphygmomanometer Omron HEM-907 XL, following the protocol recommended by the American Heart Association [21]. Adults were classified with hypertension when they had a systolic BP ≥ 130 mmHg and/or a diastolic BP ≥ 85 mmHg and/or they were under elevated blood pressure pharmacologic treatment.

Biomarkers values and MetSx definition

Glucose, triglycerides, and HDL-c concentrations were evaluated in subjects with a fasting period of at least 8 hours. Impaired fasting glucose was defined as a fasting glucose of ≥ 100 mg/dL and/or the presence of pharmacologic treatment to control glucose. Hypertriglyceridemia was defined as a triglycerides concentration of ≥ 150 mg/dL and hypoalphalipoproteinemia as a HDL-c level of < 50 mg/dL in men and < 40 mg/dL in women [2]. Serum creatinine level was obtained from subjects to evaluate their kidney function alteration, which was calculated through the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation [22]. Glomerular filtration rate (GFR) ml/min/1.73 m²: normal (≥ 90); mildly reduced (60–89); moderately reduced (30–59); severely reduced (15–29). All serum and blood samples were analyzed in the Nutrition Laboratory located in the Mexican National Institute of Public Health.

MetSx presence was evaluated through the International Diabetes Federation (IDF) harmonized criteria. At least three of the five components described in the harmonized definition meant MetSx presence [2]: AO (waist circumference [cm], men ≥ 90, women ≥ 80), hyperglycemia (glucose [mg/dl] ≥ 100 or drug treatment for glucose control), hypertriglyceridemia (triglycerides [mg/dL] ≥ 150), hypoalphalipoproteinemia (HDL-c [mg/dL], men < 40, women < 50), or elevated blood pressure (BP [mm Hg] ≥ 130/85 or drug treatment for hypertension control). Prevalence of MetSx was complementary estimated by using the criteria proposed by the National Cholesterol Education Program Adult Treatment Panel III (ATP III) [23] (3 or more of the following alterations: waist circumference ≥ 102 cm in men, ≥ 88 cm in women; glucose ≥ 110 mg/dL or previous diabetes diagnosis; triglycerides ≥ 150 mg/dL; BP ≥ 130/85 mm Hg or previous hypertension diagnosis; HDL-c < 40 mg/dL in men and < 50 mg/dL in women), the American Heart Association/National Heart, Lung and Blood Institute (AHA/NHLBI) [24] (3 or more of the following alterations: waist circumference ≥ 102 cm in men, ≥ 88 cm in women; glucose ≥ 100 mg/dL or previous diabetes diagnosis; triglycerides ≥ 150 mg/dL or drug treatment for triglycerides control; BP ≥ 130/85 mm Hg or previous hypertension diagnosis; HDL-c < 40 mg/dL in men and < 50 mg/dL in women), and IDF [25] (AO, waist circumference ≥ 90 cm in men or ≥ 80 cm in women plus two or more of the following alterations: triglycerides ≥ 150 mg/dL or drug treatment for triglycerides control; HDL-c < 40 mg/dL in men and < 50 mg/dL in women; BP ≥ 130/85 mm Hg or previous hypertension diagnosis; glucose ≥ 100 mg/dL or previous diabetes diagnosis).

Dietary diversity
Data on dietary intake were obtained from a Food Frequency Questionnaire (FFQ), which accounts for seven days of consumption and contains information of 140 foods and beverages. Information derived from this instrument was used to build 21 food and drinks groups [26]. Afterwards, a dietary diversity index (DDI) was generated by multiplying the number of consumed food groups by the number of days they were consumed in a week. Subsequently, the DDI score was divided into quartiles to provide it with interpretability. Additionally, DDI was categorized into quartiles according to its association with MetSx [27].

**Physical activity, screen time, and sleep duration**

The short version of the International Physical Activity Questionnaire (IPAQ) was utilized to evaluate physical activity (PA) levels of the study sample [28]. PA level performed during the last seven days was categorized by using the WHO classification: inactive < 150 minutes, moderately active 150–299, and active > 300 [29]. Regarding screen time categorization, minutes per week that individuals spent on tv watching, videogaming, and computer interaction were counted and then divided into three groups: ≤ 840, 840–1680, and > 1680 minutes/week [30]. Sleep duration per day was self-reported by participants and classified following the recommendations of the National Sleep Foundation: 7–9 hours (reference category), < 7 hours, and > 9 hours (risk categories) [31].

**Ethical considerations**

All participants received and signed an informed consent approved by the Institutional Review Board of the National Institute of Public Health in Mexico. This study is based on an analysis of databases, the original protocols have the approvals of the Ethical and Research Commissions of the National Institute of Public Health, with Commission Number 1102 AND 1401; registration with Conbioetics: 7 AND 17 CEI00120130424, and registration with COFEPRIS CEI 17 007 36.

**Statistical Analysis**

The prevalence and confidence intervals (CI 95%) of MetSx were estimated and described considering categories of sex, sociodemographic variables, anthropometric variables, personal history of lifestyle, chronic diseases background, and biomarkers. Same statistical estimators of MetSx components were estimated by sex and age. The prevalence of both MetSx and its components were reviewed, calculated, and compared between 2006 (National Health and Nutrition Survey 2006 [ENSANUT 2006]) [32] and 2016. To control the effect of the change in the population pyramid, the prevalences were adjusted through the indirect method [33] and by using the WHO standard population as reference [34]. Pearson's chi-squared tests were used to compare prevalences among strata and Bonferroni corrections were carried out for multiple comparisons. To maintain the representativeness of the sample nationwide and by strata, an expansion factor was included. A general $p < 0.05$ value was considered to set the statistical significance. All the analyses were performed by using the SVY module for survey designs in Stata version 14 (StataCorp LLC).

**Results**
Prevalence of MetSx in Mexican adults was of 47.4% (95% CI: 44.0-50.7) considering the ATP III criteria; 52.4% (95% CI: 48.9–55.8) according to the AHA/NHLBI criteria; 58.4% (95% CI: 55.1–61.6) under the IDF classification, and of 60.5% (95% CI: 57.1–63.9) taking into consideration the harmonized criteria (Table 1). The harmonized classification was used as a reference for the rest of results. When comparing by age group, the prevalence of MetSx was 65% higher in adults aged ≥ 60 years (76.9%; 95% CI: 71.6–81.5) than it was in adults aged 20–39 years (46.7%; 95% CI: 41.5–51.9). Regarding presence of MetSx in each BMI category, its prevalence was 3.7 times higher in adults with > 30 kg/m$^2$ (84.0%; 95% CI: 79.5–87.7) than it was in adults with < 25 kg/m$^2$ (22.4%; 95% CI: 17.8–27.7). As for the glucose metabolism status, the prevalence of MetSx was two times higher in participants with previously diagnosed diabetes (90.5%; 95% CI: 81.5–95.3) than in those who had normal glycemia (45.1%; 95% CI: 40.6–49.7). Prevalence of MetSx was significantly greater in adults with severely reduced (99.0%; 95% CI: 91.7–99.9) and mildly reduced (75.2%; 95% CI: 66.8–82.0) kidney function that in those ones with a normal glomerular filtration rate (57.7%; 95% CI: 53.9–61.4).
Table 1
Prevalence of metabolic syndrome according to sociodemographic, nutritional, and clinical characteristics. ENSANUT MC-2016

|                                | Total (95% CI) | Men (95% CI) | Women (95% CI) |
|--------------------------------|---------------|--------------|---------------|
| **Metabolic syndrome, (ATP III criteria) n = 3183** | 47.4 (44.0, 50.7) | 39.9 (35.1, 44.8) | 55.2b (50.9, 59.4) |
| **Metabolic syndrome, (AHA/NHLBI criteria) n = 3183** | 52.4 (48.9, 55.8) | 45.3 (40.0, 50.8) | 59.7b (55.4, 63.9) |
| **Metabolic syndrome, (IDF criteria) n = 3183** | 58.4 (55.1, 61.6) | 53.3 (48.1, 58.5) | 63.7b (59.7, 67.6) |
| **Metabolic syndrome, (harmonized criteria) n = 3188** | 60.5 (57.1, 63.9) | 57.9 (52.5, 63.1) | 63.2 (58.8, 67.4) |
| **Age, years, n = 3188** |               |              |               |
| 20–39                          | 46.7 (41.5,51.9) | 47.4 (39.1,55.8) | 45.8 (39.9,51.9) |
| 40–59                          | 70.6a (66.1,74.8) | 67.0a (59.4,73.8) | 73.8 (67.2,79.5) |
| ≥ 60                           | 76.9a (71.6,81.5) | 70.5a (62.0,77.8) | 83.9b (78.2,88.4) |
| **Locality, n = 3188**         |               |              |               |
| Rural                          | 57.0 (53.1,60.9) | 53.2 (46.8,59.5) | 60.8 (55.7,65.7) |
| Urban                          | 64.8a (58.2,70.9) | 63.2 (51.7,73.5) | 66.4 (57.6,74.2) |
| Metropolitan                   | 60.7 (55.5,65.6) | 58.2 (50.2,65.8) | 63.3 (56.7,69.5) |
| **Region, n = 3188**           |               |              |               |
| North                          | 60.3 (52.7,67.4) | 57.1 (46.2,67.3) | 63.5 (52.5,73.3) |
| Center                         | 59.1 (53.1,64.8) | 56.5 (45.7,66.8) | 62.2 (56.6,67.4) |
| Mexico City and the State of Mexico | 62.7 (52.8,71.6) | 62.8 (46.8,76.5) | 62.5 (51.2,72.6) |
| South                          | 60.9 (55.4,66.1) | 57.1 (50.0,63.9) | 64.6 (56.3,72.1) |
| **Socioeconomic status, n = 3188** |               |              |               |
| Low                            | 56.1 (51.1,61.0) | 48.4 (40.4,56.4) | 64.4b (57.8,70.6) |
| Medium                         | 60.6 (55.3,65.7) | 54.6 (47.0,62.1) | 67.4b (60.6,73.6) |
| High                           | 62.5 (56.5,68.0) | 64.7a (55.5,73.0) | 60.2 (52.7,67.3) |
| **Smoking, n = 3167**          |               |              |               |
| Total               | Men            | Women           |
|---------------------|----------------|-----------------|
|                     | % (95% CI)     | % (95% CI)      | % (95% CI)     |
| Never smoker        | 61.9, 57.2, 66.5 | 60.8, 50.9, 69.9 | 62.5, 57.1, 67.6 |
| Current smokers     | 57.2, 48.6, 65.5 | 52.9, 42.3, 63.2 | 68.9, 53.9, 80.8 |
| Ex-smokers          | 61.0, 56.0, 65.8 | 59.5, 52.6, 66.1 | 63.2, 56.3, 69.6 |
| **Sleep (hours/day), n = 3161** |                 |                 |                 |
| 7 to 9              | 59.3, 55.3, 63.2 | 56.9, 50.7, 63.0 | 61.6, 56.5, 66.6 |
| < 7                 | 62.2, 54.9, 69.0 | 58.7, 48.4, 68.3 | 66.6, 56.3, 75.6 |
| > 9                 | 60.8, 49.5, 71.1 | 49.5, 31.6, 67.6 | 68.0, 55.6, 78.4 |
| **Body mass index (kg/m^2), n = 3177** |                 |                 |                 |
| < 25                | 22.4, 17.8, 27.7 | 17.1, 11.9, 23.8 | 29.7, 22.6, 37.8 |
| 25–30               | 62.7, 56.7, 68.4 | 61.4, 52.4, 69.7 | 64.3, 56.7, 71.3 |
| > 30                | 84.0, 79.5, 87.7 | 90.9, 86.0, 94.2 | 79.1, 72.4, 84.4 |
| **Weight changes in the past year, n = 3024** |                 |                 |                 |
| Kept his/her weight | 59.8, 55.1, 64.4 | 57.2, 50.3, 63.8 | 63.8, 57.5, 69.6 |
| She/he has lost weight | 57.8, 51.3, 63.9 | 54.7, 44.3, 64.6 | 61.3, 53.5, 68.5 |
| She/he has gained weight | 64.7, 58.0, 70.8 | 64.3, 53.6, 73.8 | 64.9, 56.8, 72.2 |
| **Physical activity (WHO classification), n = 2836** |                 |                 |                 |
| Inactive            | 67.0, 58.2, 74.8 | 76.7, 61.7, 87.1 | 59.1, 48.7, 68.8 |
| Moderately active   | 58.1, 46.6, 68.9 | 57.1, 34.3, 77.2 | 58.8, 46.6, 70  |
| Active              | 58.4, 54.2, 62.4 | 53.6, 47.2, 59.9 | 63.8, 58.2, 68.9 |
| **Time in front of a screen (minutes/week), n = 2836** |                 |                 |                 |
| < 840               | 60.8, 56.4, 65.0 | 51.9, 44.4, 59.3 | 67.6, 62.3, 72.5 |
| 840–1680            | 59.9, 53.6, 65.9 | 60.0, 50.8, 68.5 | 59.7, 51.8, 67.1 |
| > 1680              | 55.0, 45.6, 64.1 | 59.1, 45.3, 71.6 | 49.1, 36.3, 61.9 |
|                          | Total       | Men         | Women        |
|--------------------------|-------------|-------------|--------------|
|                          | %           | (95% CI)    | %            | (95% CI)    | %           | (95% CI)    |
| **Diet diversity, n = 3142** |             |             |              |             |             |             |
| Quartile 1               | 61.8        | 56.5,66.8   | 59.0         | 48.5,68.8   | 63.8        | 56.6,70.4   |
| Quartile 2               | 61.9        | 55.5,67.9   | 59.1         | 48.7,68.8   | 64.7        | 57.0,71.6   |
| Quartile 3               | 62.4        | 56.3,68.1   | 60.0         | 50.8,68.6   | 64.8        | 56.0,72.7   |
| Quartile 4               | 62.0        | 55.5,68.0   | 59.5         | 49.6,68.7   | 65.2        | 58.1,71.6   |
| **Diabetes, n = 3062**   |             |             |              |             |             |             |
| No diabetes              | 45.1        | 40.6,49.7   | 43.6         | 36.5,51.0   | 46.9        | 41.6,52.2   |
| Prediabetes              | 81.8a       | 76.0,86.4   | 78.7a        | 70.0,85.4   | 84.7        | 76.9,90.2   |
| Previous diagnosis       | 89.9a       | 80.8,94.9   | 97.0a        | 91.1,99.0   | 85.5b       | 72.0,93.1   |
| Survey finding           | 90.5a       | 81.5,95.3   | 90.4a        | 76.1,96.6   | 90.5        | 74.5,96.9   |
| Diabetes by previous diagnosis or survey finding | 90.0a | 83.4, 94.2 | 94.5a | 89.1, 97.3 | 86.7a | 75.8, 93.1 |
| **Impaired kidney function (CKD-EPI), (GFR, ml/min/1.73 m²), n = 3182** | | | | | | |
| Normal (≥ 90)            | 57.7        | 53.9,61.4   | 53.4         | 47.5,59.1   | 62.0b       | 57.4,66.4   |
| Slightly reduced (60–89) | 73.3a       | 65.2,80.0   | 75.6a        | 63.2,84.8   | 70.0        | 59.1,79.1   |
| Moderately reduced (30–59)| 58.3       | 41.7,73.2   | 53.7         | 26.2,79.1   | 61.6        | 29.5,86.0   |
| Severely reduced (15–29) | 99.0a       | 91.7,99.9   | 97.8a        | 73.1,99.9   | 100.0       | -           |
| **Diagnosis of cerebrovascular event, n = 3134** | | | | | | |
| Negative                 | 60.5        | 57.0,63.9   | 57.8         | 52.3,63.1   | 63.2        | 58.8,67.5   |
| Positive                 | 80.4a       | 60.0,91.8   | 83.2a        | 54.6,95.3   | 77.7        | 46.9,93.2   |
| **Diagnosis of acute myocardial infarction, n = 3174** | | | | | | |
| Negative                 | 60.6        | 57.1,64.1   | 58.2         | 52.6,63.6   | 63.2        | 58.7,67.4   |
| Positive                 | 59.8        | 39.6,77.2   | 51.9         | 24.7,78.1   | 71.2        | 50.7,85.6   |
| **Health system affiliation, n = 2077** | | | | | | |
| IMSS                     | 65.4        | 57.5,72.5   | 63.9         | 54.4,72.4   | 67.9        | 55.4,78.2   |
|                | Total           |               | Men            | (95% CI)      | Women          | (95% CI)      |       |
|----------------|-----------------|---------------|----------------|---------------|----------------|---------------|-------|
|                | %               | (95% CI)      | %              | (95% CI)      | %              | (95% CI)      |       |
| ISSSTE         | 80.2            | 59.7,91.8     | 73.2           | 46.6,89.5     | 94.3<sup>a</sup> | 83.7,98.1     |       |
| Private and others | 51.3            | 23.4,78.4     | 57.6           | 22.2,86.7     | 43.6           | 11.1,82.7     |       |
| Seguro popular | 62.7            | 56.9,68.1     | 57.8           | 49.7,65.4     | 71.5<sup>b</sup> | 64.8,77.4     |       |
| None           | 63.9            | 52.4,74.1     | 65.8           | 51.8,77.5     | 60.1           | 40.6,76.8     |       |

Estimates were adjusted for the complex survey design.

- <sup>a</sup> Statistically significant differences between the reference category and other categories.
- <sup>b</sup> Statistically significant differences between sex categories.
- <sup>c</sup> Classification of diabetes: prediabetes (fasting glucose ≥ 100 and < 126 mg/dL/HbA1c ≥ 5.7 and < 6.5%); survey finding (fasting glucose ≥ 126 mg/dL/HbA1c ≥ 6.5% without previous diagnosis).

ENSANUT MC-2016: Mexican 2016 Mid-way National Health and Nutrition Survey 2016; ATP III: National Cholesterol Education Program Adult Treatment Panel III.

AHA/NHLBI: American Heart Association/National Heart, Lung and Blood Institute; IDF: International Diabetes Federation; WHO: World Health Organization.

CKD-EPI: Chronic Kidney Disease Epidemiology Collaboration; GFR: glomerular filtration rate.

IMSS: The Mexican Social Security Institute (Spanish acronym: IMSS); ISSSTE: The Institute for Social Security and Services for State Workers (Spanish acronym: ISSSTE).

The national prevalence of AO was 77.0%, which was 34% higher in women (88.5%; 95% CI: 86.0–90.7) than in men (65.9%; 95% CI: 60.7–70.7) (Table 2). The prevalence of elevated blood pressure was 34.4% and 3.8 times higher in adults aged ≥ 60 years (68.3%; 95% CI: 61.7–74.2) than in those aged 20–39 years (18.0%; 95% CI: 13.8–23.0). The prevalence of impaired fasting glucose was 33.3% nationwide, and 296% higher in adults aged ≥ 60 years (54.2%; 95% CI: 47.9–60.4) than in those aged 20–39 years (18.3%; 95% CI: 14.8–22.5). Prevalence of hypertriglyceridemia and hypoalphalipoproteinemia in the total population was of 57.4% and 75.2% respectively. Particularly, the proportion of high triglycerides concentration was significantly higher in the youngest (59.9%; 95% CI: 52.4–66.9) and oldest (47.9%; 95% CI: 37.8–58.3) men than in their women counterparts (42.6%; 95% CI: 36.8–48.7 and 62.0%; 95% CI: 53.9–69.4). Regarding data on low HDL-c level, the prevalence of this condition was higher in women (79.8%; 95% CI: 76.2–83.0) than in men (70.9%; 95% CI: 65.6–75.7).
Table 2
Prevalence of metabolic syndrome components in the sex and age categories. ENSANUT MC-2016

|                          | Total       | Men          | Women        |
|--------------------------|-------------|--------------|--------------|
|                          | %           | (95% CI)     | %            | (95% CI)     | %            | (95% CI)     |
| Abdominal obesity        |             |              |              |              |
| Total                    | 77.0        | 74.1, 79.6   | 65.9         | 60.7,70.7    | 88.5<sup>b</sup> | 86.0,90.7   |
| 20–39                    | 69.3        | 64.1,74.1    | 58.1         | 49.4,66.4    | 82.6<sup>b</sup> | 77.8,86.5   |
| 40–59                    | 83.8<sup>a</sup> | 79.7,87.2   | 72.5<sup>a</sup> | 65.3,78.6   | 93.6<sup>a,b</sup> | 89.1,96.3   |
| ≥ 60                     | 83.4<sup>a</sup> | 78.2,87.5   | 75.3<sup>a</sup> | 66.6,82.4   | 92.2<sup>a,b</sup> | 87.3,95.3   |
| High blood pressure      |             |              |              |              |
| Total                    | 34.4        | 31.2, 37.8   | 38.5         | 33.5,43.8    | 30.1<sup>b</sup> | 26.6,33.9   |
| 20–39                    | 18.0        | 13.8,23.0    | 25.7         | 18.8,34.0    | 8.9<sup>b</sup>  | 5.3,14.5    |
| 40–59                    | 39.5<sup>a</sup> | 34.4,44.8   | 43.1<sup>a</sup> | 34.7,51.8   | 36.3<sup>a</sup> | 30.5,42.6   |
| ≥ 60                     | 68.3<sup>a</sup> | 61.7,74.2   | 65.9<sup>a</sup> | 56.3,74.4   | 70.8<sup>a</sup> | 63.3,77.4   |
| Impaired fasting glucose |             |              |              |              |
| Total                    | 33.3        | 30.4, 36.3   | 31.7         | 27.1,36.7    | 34.9         | 31.1,38.8   |
| 20–39                    | 18.3        | 14.8,22.5    | 16.7         | 11.7,23.2    | 20.3         | 15.5,26.2   |
| 40–59                    | 42.6<sup>a</sup> | 37.4,48.0   | 44.2<sup>a</sup> | 35.5,53.3   | 41.2<sup>a</sup> | 35.5,47.2   |
| ≥ 60                     | 54.2<sup>a</sup> | 47.9,60.4   | 50.8<sup>a</sup> | 41.9,59.7   | 57.9<sup>a</sup> | 48.9,66.5   |
| Hypertriglyceridemia     |             |              |              |              |
| Total                    | 57.4        | 54.1, 60.6   | 60.7         | 55.7,65.6    | 53.9<sup>b</sup> | 49.9,57.8   |
| 20–39                    | 52.0        | 47.0,57.0    | 59.9         | 52.4,66.9    | 42.6<sup>b</sup> | 36.8,48.7   |
| 40–59                    | 65.8<sup>a</sup> | 60.6,70.6   | 69.0         | 61.5,75.7    | 63.0<sup>a</sup> | 56.7,68.9   |
| ≥ 60                     | 54.6        | 48.0,61.1    | 47.9         | 37.8,58.3    | 62.0<sup>a,b</sup> | 53.9,69.4   |
| Low HDL-c                |             |              |              |              |

<sup>a</sup> p<0.05, <sup>b</sup> p<0.01
|         | Total | Men       | Women      |
|---------|-------|-----------|------------|
|         | %     | (95% CI)  | %          | (95% CI)  | %          | (95% CI)  |
| Total   | 75.2  | 72.1,78.2 | 70.9       | 65.6,75.7 | 79.8\(^b\) | 76.2,83.0 |
| 20–39   | 74.4  | 68.7,79.4 | 69.5       | 61.2,76.7 | 80.2\(^b\) | 73.5,85.5 |
| 40–59   | 77.0  | 72.8,80.8 | 73.5       | 66.1,79.7 | 80.2       | 74.4,84.9 |
| ≥ 60    | 73.8  | 67.8,79.1 | 70.1       | 60.3,78.4 | 77.9       | 70.1,84.2 |

Estimates were adjusted for the complex survey design.

- \(^a\) Statistically significant differences between the reference category and other age categories (\(p < 0.05\)).
- \(^b\) Statistically significant differences between sex categories (\(p < 0.05\)).

ENSANUT MC-2016: Mexican 2016 Mid-way National Health and Nutrition Survey 2016.

Table 3 shows that 95.3% of the adults had at least a MetSx component, a prevalence that is higher in women than in men. and 21.3% had two components. When estimating prevalences of possible combinations of three MetSx components, the AO plus low HDL-c, and hypertriglyceridemia was the most frequent combination (16.7%; 95% CI: 14.4–19.2). In the classification by four or more MetSx components analyses, the combination of AO plus high blood pressure, impaired fasting glucose, low HDL-c, and hypertriglyceridemia had the highest prevalence (8.8%; 95% CI: 7.4–10.6).
|                                | Total                  | Men                     | Women                    |
|--------------------------------|------------------------|-------------------------|--------------------------|
|                                | % (95% CI)             | % (95% CI)              | % (95% CI)               |
| **One component**              |                        |                         |                          |
| AO or Low HDL-c or HT or HBP or IG | 95.3 (93.8, 96.5)     | 93.4 (90.5, 95.4)      | 97.39\(^a\) (95.7, 98.4)|
| **Two components**             |                        |                         |                          |
| Any combination with 2 components | 21.3 (18.6, 24.3)     | 20.0 (16.3, 24.3)      | 22.6 (19.0, 26.7)        |
| **Three components**           |                        |                         |                          |
| AO + Low HDL-c + HT            | 16.7 (14.4, 19.2)     | 14.3 (10.8, 18.7)      | 19.2 (16.3, 22.4)        |
| AO + IG + Low HDL-c            | 3.1 (2.3, 4.0)        | 1.4 (0.8, 2.6)         | 4.8\(^a\) (3.5, 6.4)     |
| AO + HBP + Low HDL-c           | 2.9 (2.1, 4.0)        | 2.4 (1.3, 4.4)         | 3.5 (2.5, 4.9)           |
| AO + HBP + HT                  | 2.1 (1.2, 3.8)        | 3.3 (1.7, 6.5)         | 0.9\(^a\) (0.4, 2.0)     |
| AO + HBP + IG                  | 1.6 (1.1, 2.4)        | 1.1 (0.7, 1.8)         | 2.2 (1.2, 3.7)           |
| AO + IG + HT                   | 1.2 (0.6, 2.5)        | 1.7 (0.7, 4.4)         | 0.6 (0.3, 1.1)           |
| HBP + Low HDL-c + HT           | 0.8 (0.5, 1.4)        | 1.4 (0.8, 2.5)         | 0.3\(^a\) (0.1, 0.7)     |
| IG + Low HDL-c + HT            | 0.7 (0.4, 1.1)        | 0.9 (0.5, 1.6)         | 0.4 (0.1, 1.2)           |
| HBP + IG + Low HDL-c           | 0.4 (0.2, 0.9)        | 0.6 (0.2, 1.7)         | 0.3 (0.1, 0.8)           |
| HBP + IG + HT                  | 0.2 (0.1, 0.6)        | 0.3 (0.1, 1.2)         | 0.0 (0.0, 0.2)           |
| **Four or more components**    |                        |                         |                          |
| AO + HBP + IG + Low HDL-c + HT | 8.8 (7.4, 10.6)       | 8.1 (5.8, 11.2)        | 9.6 (7.9, 11.6)          |
| AO + IG + Low HDL-c + HT       | 8.7 (7.2, 10.5)       | 7.4 (5.4, 10.2)        | 10.1 (7.9, 12.8)         |
| AO + HBP + Low HDL-c + HT      | 7.8 (6.1, 9.8)        | 8.3 (5.8, 11.8)        | 7.2 (5.2, 9.9)           |
| AO + HBP + IG + Low HDL-c      | 2.7 (1.9, 3.9)        | 3.1 (1.8, 5.5)         | 2.3 (1.5, 3.4)           |
| AO + HBP + IG + HT             | 1.8 (1.1, 3.1)        | 1.9 (1.0, 3.3)         | 1.8 (0.7, 4.5)           |
| HBP + IG + Low HDL-c + HT      | 0.9 (0.4, 2.1)        | 1.6 (0.7, 4.0)         | 0.1\(^a\) (0.0, 0.3)     |
## Components according to glycemic status

| Components according to glycemic status | PDD | Hyperglycemia<sup>b</sup> | Normoglycemia<sup>c</sup> |
|----------------------------------------|-----|---------------------------|---------------------------|
| AO                                     | 87.1 (79.6, 92.1) | 87.2 (83.0 90.8) | 72.0<sup>a</sup> (68.1, 75.5) |
| Low HDL-c                               | 76.1 (68.3, 82.5) | 77.8 (72.3, 82.6) | 74.2 (69.9, 78.0) |
| HT                                     | 71.7 (63.0, 79.1) | 66.9 (60.3, 72.9) | 52.1<sup>a</sup> (48.0, 56.1) |
| HBP                                    | 60.0 (51.3, 68.1) | 46.2 (39.8, 52.8) | 26.4<sup>a</sup> (22.7, 30.4) |

Estimates were adjusted for the complex survey design.

<sup>a</sup> Statistically significant differences between categories of sex or blood glucose status.

<sup>b</sup> Hyperglycemia: blood glucose ≥ 100 mg/dL in subjects with previous diabetes diagnosis.

<sup>c</sup> Normoglycemia: blood glucose < 100 mg/dL in subjects with previous diabetes diagnosis.

**ENSANUT MC-2016: Mexican 2016 Mid-way National Health and Nutrition Survey 2016; AO: abdominal obesity; HDL-c: high-density lipoprotein cholesterol; HT: hypertriglyceridemia; HBP: high blood pressure; IG: impaired glucose; PDD: previous diabetes diagnosis.**

In the trend analysis for the 2006–2016 period (Fig. 1), the prevalence of MetSx (+ 15.3%) and hypertriglyceridemia (+ 78.3%) in the total population was higher in 2016 than in 2006. In this comparison, the prevalence of MetSx in women and men increased by 16.0% and 15.2%, respectively in 2016. The prevalence of hypertriglyceridemia increased by 89.1% in women and 65.6% in men.

**Discussion**

According to the present study, six out of ten Mexican adults had MetSx. Among its components, AO, hypoalphalipoproteinemia and hypertriglyceridemia were the most frequent ones. These figures are more than twice than those reported worldwide in 2006 (prevalence of MetSx of ≈ 25.0%) [35]. Since both separately and combined AO and dyslipidemias are the most prevalent MetSx components in Mexican adults, which places this population at a high risk of diabetes [36, 37] and CVD [38], strengthening its preventive and control strategies is a priority. The information here presented highlights once again the necessity of implementing rigorous plans of action to enhance dietary choices, promote and increase physical activity, and secure access to pharmacological therapies able to counteract weight excess and lipid abnormalities in Mexico.
Implementation of the above-mentioned strategies is crucial especially considering the lifestyle-related epidemiological scenario in the country. According to National Health and Nutrition Survey 2012, some of the most consumed foods such as processed meats and sugary drinks are those that have a high content of saturated fat and/or sugar [26]. In relation to this, it has been described that in Mexican adults the highest contribution to total energy intake came from products high in saturated fat and/or added sugar (16%), and sugar sweetened beverages (9.8%). These products are casually linked to obesity, diabetes, and hypertension, which besides, hypertriglyceridemia, low HDL-c levels, and insulin resistance, are risk factors for MetSx [39]. On the other hand, in the Mexican population the consumption of vegetables is low since only 40% include them in their diet [40]. This fact is associated with an increased risk of having MetSx [41].

There is enough evidence in literature demonstrating that physical inactivity is one of the main risk factors of MetSx [42]. In relation to this behavior, it has been described that 11.4% of Mexican adults reported not performing enough PA in 2006 and this percentage rose to 14.4% in 2016 [43].

The prevalence of MetSx registered and increment of 21% in the 2006–2016 period [44]. This increase could be in part due to the Western lifestyle diffusion, which entails an unhealthy diet [45] and sedentary behaviors [46], but also to other factors such as population ageing. According to the National Institute of Statistics and Geography in Mexico, the median population age ranged from 24 in 2005 to 28 in 2015 [47]. Given that an increasing trend in the prevalence of MetSx is observed as age increases, it is possible that part of this increment in the prevalence is due to the existence of a larger proportion of adults aged > 40 years in 2016 compared to 2006. However, the prevalence of MetSx in each age group was higher in 2016 compared with 2006. For example, in 2006 [4], 67.9% of adults aged ≥ 60 years had MetSx, whereas in 2016 the prevalence was 76.9%. As it was expected, as age increases, the prevalence of its components also increases, except for low HDL-c. For this reason, execution of actions to tackle MetSx must be directed to every age group, but especially it must start at young ages, since one out of two 20 to 49-year-old adults had this syndrome.

Altogether, MetSx elements are associated with a higher risk of diabetes and CVD [48]. Equally important, its components have been separately associated with these diseases [49]. According to the trend analysis carried out in this study, the prevalence of AO, impaired fasting glucose, low HDL-c, and hypertension relatively remained stable between 2006 and 2016. In contrast, the proportion of Mexican subjects who suffered from hypertriglyceridemia increased by 74%, being this the component that explains to a greater extent the observed increase in the general prevalence of MetSx in this period. Further, the prevalence of hypertriglyceridemia in Mexico is higher than in other developing and developed countries, such as India, Nigeria, China, Japan, and the United States [50]. This scenario exposes the need to continue reinforcing health and nutrition policies able to decrease population's triglycerides concentration, such as soda tax since sweetened-sugar beverages consumption is strongly associated with hypertriglyceridemia [51], and an adequate front-of-pack food labeling system that would allow consumers to take more informed dietary choices and diminish purchases and consumption of high-sugar products. Undoubtedly, early diagnosis and treatment through mass health promotion and screening campaigns, enhancements in the
health system infrastructure, an improved medical personnel training, and greater accessibility to pharmacological treatments and nutrition counseling are also crucial strategies to diminish the burden of hypertriglyceridemia and the rest of MetSx components.

The main limitation of this study is its cross-sectional design, which did not allow us to establish causal associations. However, the population-based information generated in this investigation is highly essential to continue designing, evaluating, and reformulating strategies to reduce the burden of MetSx in Mexico.

Conclusions

In conclusion, our results confirm that there is a high prevalence of MetSx in Mexico and the trend in the period 2006–2016 increased. Our findings show the necessity to improve prevention and diagnosis programs for MetSx and its components. The health system in Mexico should emphasize the importance of adopting a healthy lifestyle in the most susceptible population to avoid the early occurrence of MetSx and its components. There are some risk factors of this condition that cannot be changed, such as age, sex, and genes. Nevertheless, all MetSx components are modifiable and can be reduced and corrected.

Abbreviations

MetSx
metabolic syndrome.
CVD
cardiovascular diseases.
T2D
type 2 diabetes.
AO
abdominal obesity.
HDL-c
high-density lipoprotein cholesterol.
ENSANUT MC-2016
Mexican 2016 Mid-way National Health and Nutrition Survey.
SSI
socioeconomic status index.
BMI
body mass index.
WHO
World Health Organization.
kg
kilograms.
m²
square meters.
BP
Blood pressure
CKD-EPI
Chronic Kidney Disease Epidemiology Collaboration.
GFR
glomerular filtration rate.
IDF
International Diabetes Federation.
ATP III
National Cholesterol Education Program Adult Treatment Panel III.
AHA/NHLBI
American Heart Association/National Heart, Lung and Blood Institute.
FFQ
food frequency questionnaire.
DDI
dietary diversity index.
IPAQ
International Physical Activity Questionnaire.
PA
physical activity.
ENSANUT 2006
National Health and Nutrition Survey 2006.
SVY
survey.

**Declarations**

*Ethics approval and consent to participate*

All participants received and signed an informed consent approved by the Institutional Review Board of the National Institute of Public Health in Mexico. This study is based on an analysis of databases of ENSANUT-2006 and ENSANUT-MC 2016, the original protocols have the approvals of the Ethical and Research Commissions of the National Institute of Public Health, with Commission Number 1102 AND 1401; registration with Conbioetics: 7 AND 17 CEI00120130424, and registration with COFEPRIS CEI 17 007 36.

*Consent for publication*

Not applicable.

*Availability of data and material*
Datasets from ENSANUT are available from the corresponding author on reasonable request.

**Competing interests**

The authors have declared that they have no competing interests.

**Funding**

Development of research in this article was supported by the financing provided to the Mexican National Institute of Public Health (Spanish acronym: INSP) by the Mexican Ministry of Health under registration number CEI00120130424 (Shamah T., Rivera J., Hernández M, ENSANUT-2006) and number CEI 17 007 36 (Shamah T., Rivera J., Cuevas L., Rosas M. ENSANUT-MC 2016). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

**Authors’ contributions**

Conceptualization: ICN, CAAS, KMH, APT, RR, and SB. Formal Analysis: KMH and APT. Funding Acquisition: Not applicable. Project Administration: ICN. Writing – original draft: ICN and KMH. Writing – review & editing: ICN, CAAS, KMH, APT, RR. All authors read and approved the final manuscript.

**Acknowledgements**

Not applicable.

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**Figures**

![Figure 1](image)

**Figure 1**

Estimates were adjusted for the complex survey design. Prevalences were adjusted through the indirect method and by using the World Health Organization's standard population as reference. ENSANUT 2006: Mexican National Health and Nutrition Survey 2006; ENSANUT MC-2016: Mexican 2016 Mid-way National Health and Nutrition Survey 2016.