

Prevalence and characterization of undiagnosed arterial hypertension in the eastern zone of Mexico

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Abstract

Arterial hypertension is considered a public health problem with severe consequences at an individual and public health levels. However, there is a lack of information regarding its characterization in Mexico. The objective of this study is to estimate the proportion of undiagnosed arterial hypertension (UAH) and the overall prevalence and clinical management of arterial hypertension within the Eastern Zone of Mexico. Additionally, we explore associated factors related with both UAH and uncontrolled arterial hypertension. We obtained information from the May Measure Month (MMM) 2019 study. People were asked for cardiovascular risk factors and blood pressure was

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measured according to the protocols of the European Society of Hypertension (ESH). Data from 5901 subjects were extracted: 76.04% from the Eastern Zone of the State of Mexico. The overall prevalence of hypertension was 32.4% (95% CI 31.2-33.6). From all subjects living with hypertension, 28.3% had UAH, 22.1% had previous diagnosis but were untreated; 29.3% were treated but had uncontrolled hypertension. Younger men adults living in the State of Michoacán had increased proportion of UAH and untreated hypertension. We observed that male sex, age, obesity, living at Michoacán were risk factors for UAH. Finally, male sex, diabetes, and living at Michoacán were related risk conditions for having uncontrolled arterial hypertension. In summary, there is a high proportion of UAH in Easter Zone of Mexico. Younger adults had higher proportion of UAH and untreated hypertension profiles. Efficient actions are required to make a timely diagnosis in the young adult population to prevent long-term complications.

KEYWORDS

blood pressure, control, hypertension, Mexico, undiagnosed arterial hypertension

1 | INTRODUCTION

Arterial hypertension continuous to be a worldwide healthcare problem as it has been estimated that approximately 626-652 millions of women and men live with the disease, respectively.¹ Overall, arterial hypertension acts as one of the main contributors to cardiovascular disease (CVD) and chronic kidney disease (CKD), which is further translated into a high impact at an individual and public health levels.^{2,3} In Mexico, according to the last National Health and Nutrition Survey (ENSANUT) there is an estimated prevalence of 30% of adult subjects living with arterial hypertension across the country, with a high proportion of untreated and uncontrolled blood pressure.⁴ Furthermore, it has been estimated that half of these adults are not aware of their condition at diagnosis.⁴ This phenomenon has been classified as undiagnosed arterial hypertension (UAH), and has been related with a high incidence of severe complications related to arterial hypertension at short and long-term.⁵ Moreover, the situation in Mexico is further complicated with the high prevalence of metabolic syndrome traits (eg, hyperglycemia, overweight, obesity, and dyslipidemias) and unhealthy lifestyle habits (eg, consumption of ultra-processed foods, smoking, and alcoholism) staged at the younger ages.^{6,7} Additionally, there is a lack of complete social security coverage and a low proportion of adults that assists to preventive and primary care services at their disposal to promptly detect and treat chronic health conditions across the country.⁸ All these factors create a challenge for healthcare providers to appropriately diagnose and treat arterial hypertension. Although there has been estimated a high prevalence of UAH in other countries, in Mexico there are few reports and still a lack of epidemiological information related to the characterization of UAH and their contributing factors. These reports could help improve healthcare policies and targeted interventions to prevent the natural course of the disease, particularly in younger adults. A recent approach to study UAH was carried

out during 2019, where a sample of Mexican adult subjects living in the Eastern Zone of Mexico participated in the May Measurement Month International Campaign (MMM-2019).⁹ The MMM-2019 provides an excellent opportunity to better characterize arterial hypertension in Mexico. Hence, the objective of this study is to estimate the proportion of undiagnosed arterial hypertension (UAH) and the overall prevalence and clinical management of arterial hypertension within the Eastern Zone of Mexico. Additionally, we explore associated factors related with both UAH and uncontrolled arterial hypertension. We hypothesize that this region is characterized by a high proportion of UAH and a poor treatment management and uncontrolled arterial hypertension related to the combination of the high burden of non-communicable diseases and a limited access of preventive services in Mexico.

2 | METHODS

2.1 | Study design

The MMM-2019 consisted of a cross-sectional study between the period of May 1 and 31, 2019, with accordance to the international protocol established by the MMM and the European Society of Cardiology (ESC).¹⁰ The preliminary report of the MMM-2019 campaign in Mexico has been published elsewhere.⁹ Briefly, the protocol consisted of inviting the general population ≥ 18 years of age to attend the medical units that participated in the MMM-2019 modules, located in different Primary Care Units in the Eastern Zone of the State of Mexico and the State of Michoacán. The complete medical units that participated in the detection campaign are shown in [Supplementary Material](#). All health personnel involved in the campaigns received prior training according to the MMM-2019 international protocol. The Human Research Ethics Committee of the "Instituto Mexicano del Seguro Social" approved the

study. All the information of the participants was anonymized, and verbal consent was requested prior to their participation and blood pressure taking before entering the study.

2.2 | Clinical and anthropometric risk factors assessment

We carried out a brief and standardized clinical and anthropometric questionnaire focused on risk factors for developing clinical complications related to arterial hypertension. Briefly, our related factors comprised on time since last clinical visit to a health care provider, smoking and alcohol consumption, statin and aspirin use, and previous medical history of diabetes, ischemic heart disease (IHD), or stroke. For the anthropometric evaluation, subjects were weighed on calibrated scales and height was measured with flexible tapes. Wherever these anthropometric measurements were not able to obtain, we directly asked for the self-reported estimated weight and height. Body mass index (BMI) was calculated as weight in kg divided by the height squared in meters. Overweight was considered as a BMI ≥ 25 and < 30 kg/m². Obesity was defined as BMI ≥ 30 kg/m². The complete questionnaire is presented in [Supplementary Material](#). All those participants who were identified with more than one risk factor to develop complications related to arterial hypertension received standardized recommendations for diet and lifestyle changes in an information card ([Supplementary Material](#)) and medical follow-up was recommended.

2.3 | Arterial hypertension assessment

Arterial blood pressure measurement was performed using a brand digital sphygmomanometer (OMRON HEM-7720) provided to all healthcare units, according to the MMM-2019 protocol. Blood pressure was recorded on three different intervals, with a pause of one minute between each measurement. Subsequently, the result of the last two measurements was averaged and considered as our estimated blood pressure assessment. Also, we directly asked whether a health-care worker had previously made the diagnosis of arterial hypertension with the following question: "Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?". Additionally, we assessed whether a person was taking medication for arterial hypertension using the following question: "Are you currently taking any medicines, tablets, or pills for high blood pressure?". Arterial hypertension was defined as a construct of systolic BP ≥ 140 mmHg, and/or diastolic BP ≥ 90 mmHg, prior medical diagnosis or whether the subject was taking any antihypertensive medication.¹¹ Treated arterial hypertension was defined as a subject living with arterial hypertension and reported with actual treatment with any antihypertensive medication. UAH was defined as a subject living with arterial hypertension but without previous medical diagnosis. Uncontrolled arterial hypertension was defined as a previously diagnosed and treated subject but with BP $\geq 130/\geq 80$ mmHg according to "Norma Oficial Mexicana 2021."¹²

2.4 | Statistical analysis

Continuous data is shown as means (standard deviation) or medians (interquartile range) according to their distribution evaluated through the Anderson-Darling normality test. Categorical variables are presented in absolute frequency with their respective absolute percentage. We performed a multiple imputation method to estimate the mean of the second and third BP measurements that were missing. To estimate the overall prevalence of arterial hypertension, we used the *epiR* package (Version 2.0.3) using the Clopper-Pearson interval method stratified by sex and state of residency. Diagnosed and therapeutic assessment across age categories was stratified by sex and state of residency and further visualized with Sankey-Plots diagrams and built with the *networkD3* (Version 0.4) package. We fitted Logistic Regression Models to explore the role of sociodemographic (age, sex, state of residency) and clinical and anthropometric characteristics (BMI categories, medication use, time since last visit to health care provider, and self-reported comorbidities) potentially related to both UAH and uncontrolled arterial hypertension. The final models were selected according to the lowest Bayesian Information Criteria (BIC). A Variance Inflation Factor (VIF) > 5 was considered as a model with multicollinearity in its estimation. Finally, an interaction analysis was used to explore the combined effect of our explored associated factors for our previously mentioned outcomes. Odds-ratio plots were created using the *jtools* package (Version 2.1.4). All statistical analyses were performed in R Studio (Version 4.1). A value of $p < .05$ was considered as our statistical significance threshold.

3 | RESULTS

3.1 | Study population

We included information of 5901 adult subjects from the Eastern Zone of the State of Mexico (76.0%) and Michoacán (23.9%), with a female predominance (62.7%) and a median age of 48 (IQR: 31–60) years in our studied population. Complete demographic, anthropometrical and clinical information of the overall population is presented in [Supplementary material](#). Adults living with arterial hypertension ($n = 1909$) trend to be men with a median age of 57 (IQR: 47–66) years. In this group, 14.5% of women had previous history of high BP during pregnancy. Regarding their clinical profile, we recorded a higher proportion of overweight (38.7%), obesity (34.7%), diabetes (29.3%), and previous history of IHD (7.7%) and stroke (2.6%) along with a higher use of aspirin (24.9%) and statin (14.1%) compared with subjects living without arterial hypertension ([Supplementary Material](#)).

3.2 | Prevalence of arterial hypertension

The overall estimated prevalence of arterial hypertension in our population was 32.4% (95% CI: 31.2–33.6). The estimated prevalence was higher in men and adults living in Michoacán. Moreover, we

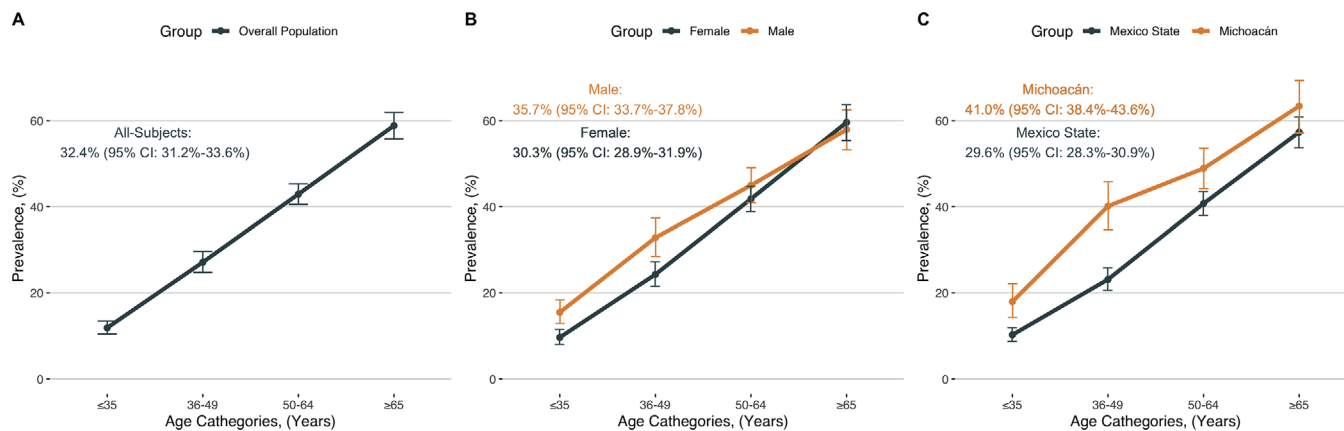


FIGURE 1 Estimated prevalence of arterial hypertension the overall population of adult subjects in the Eastern Zone of the State of Mexico and the State of Michoacán (A) stratified by sex (B) and state of residency (C). Estimated prevalence was calculated using the Clopper-Pearson based on a binomial distribution approach

observed a linear trend of arterial hypertension within age groups. Subjects < 35 years had an estimated prevalence of 11.9% (95% CI: 10.4-13.4), followed by a prevalence of 27.1% (95% CI: 24.8-29.6) in adults 36-49 years, 42.9% (95% CI: 40.6-45.3) in adults 50-64 years, and 58.9% (95% CI: 55.8-51.9) in adults ≥65 years. These trends were more accentuated in men and subjects living in Michoacán; women ≥65 years had an estimated prevalence of 59.6% (95% CI: 55.4-63.7) (Figure 1).

3.3 | Diagnosed and therapeutic assessment of adults living with arterial hypertension

Concerning to the diagnostic and therapeutic profiles, we observed that 28.3% lived with UAH, 22.1% had already been diagnosed but had no actual treatment, and 49.6% had been previously diagnosed and were currently treated with any antihypertensive; only 20.3% were appropriately controlled and 29.3% lived with uncontrolled arterial hypertension. After stratification by sex, we observed that men had higher proportion of UAH compared to women. Conversely, women had higher proportion of untreated and uncontrolled arterial hypertension compared with men. Stratification for state of residency revealed that subjects living in Mexico State had higher proportions of untreated arterial hypertension, while Michoacán had a higher percentage of uncontrolled blood pressure (Figure 2). As observed with the estimated prevalence, the proportions of the diagnosed and therapeutic goals changed within age groups. Adults ≤35 and 36-49 years categories trend to had higher proportions of UAH or being diagnosed but not properly treated compared with adults with 50-64 and ≥65 years. Men < 50 years categories had the highest proportion of UAH, while women at the same age categories had the highest untreated arterial hypertension percentages. Men in the 50-64 and ≥65 age categories had the highest proportion of uncontrolled blood pressure (Figure 2). Finally, evaluating the antihypertensive regime in treated adults, 59.2% were under single-antihypertensive regime, 31.3% with double-antihypertensive and 9.5% were prescribed with three or more antihypertensives.

3.4 | Characterization of undiagnosed arterial hypertension

Adults living with UAH trend to be younger (median age: 53 [IQR: 40-65] years) compared with subjects with previously diagnosed arterial hypertension. In this group, we observed a higher proportion with ≥12 months since last BP measurement (29.1%). Regarding their clinical profile, there was a lower proportion of obesity (31.1%), diabetes (19.8%), women with high BP during pregnancy (8.3%), previous IHD (4.6%), stroke (0.93%), along with use of statins (3.7%) and aspirins (8.9%) but a higher percentage of active smoking (18.5%) compared with adults previously diagnosed. Both systolic (Median: 136, IQR: 122-145 mmHg) and diastolic (Median: 91, IQR: 83-96 mmHg) arterial BP measurements were increased compared with previously diagnosed subjects (Table 1). Compared with adults without arterial hypertension, male subjects (OR: 1.86, 95% CI: 1.54-2.24, $p < .001$), increased age (OR: 1.79, 95% CI: 1.62-1.97, $p < .001$), living in Michoacán (OR: 1.58, 95% CI: 1.29-1.95, $p < .001$), previously diagnosed diabetes (OR: 1.39, 95% CI: 1.08-1.79, $p = .01$), and living with obesity (OR: 1.92, 95% CI: 1.52-2.44, $p < .001$) were associated risk factors for having UAH (Figure 3).

3.5 | Characterization of uncontrolled arterial hypertension

Subjects with uncontrolled arterial hypertension trend to be men (45%) living at Michoacán (32.9%) and with a higher proportion of diabetes (46.4%), alcohol consumption (15%) and women with high blood pressure during pregnancy (19.8%) compared with subjects with controlled blood pressure (Supplementary Material). Regarding associated factors for uncontrolled hypertension, we observed that men (OR: 1.59, 95% CI: 1.20-2.12, $p < .001$), living with diabetes (OR: 1.34, 95% CI: 1.01-1.79, $p = .04$), and subjects from Michoacán (OR: 1.56, 95% CI: 1.15-2.11) had increased odds for having uncontrolled arterial hypertension compared with adults with controlled arterial

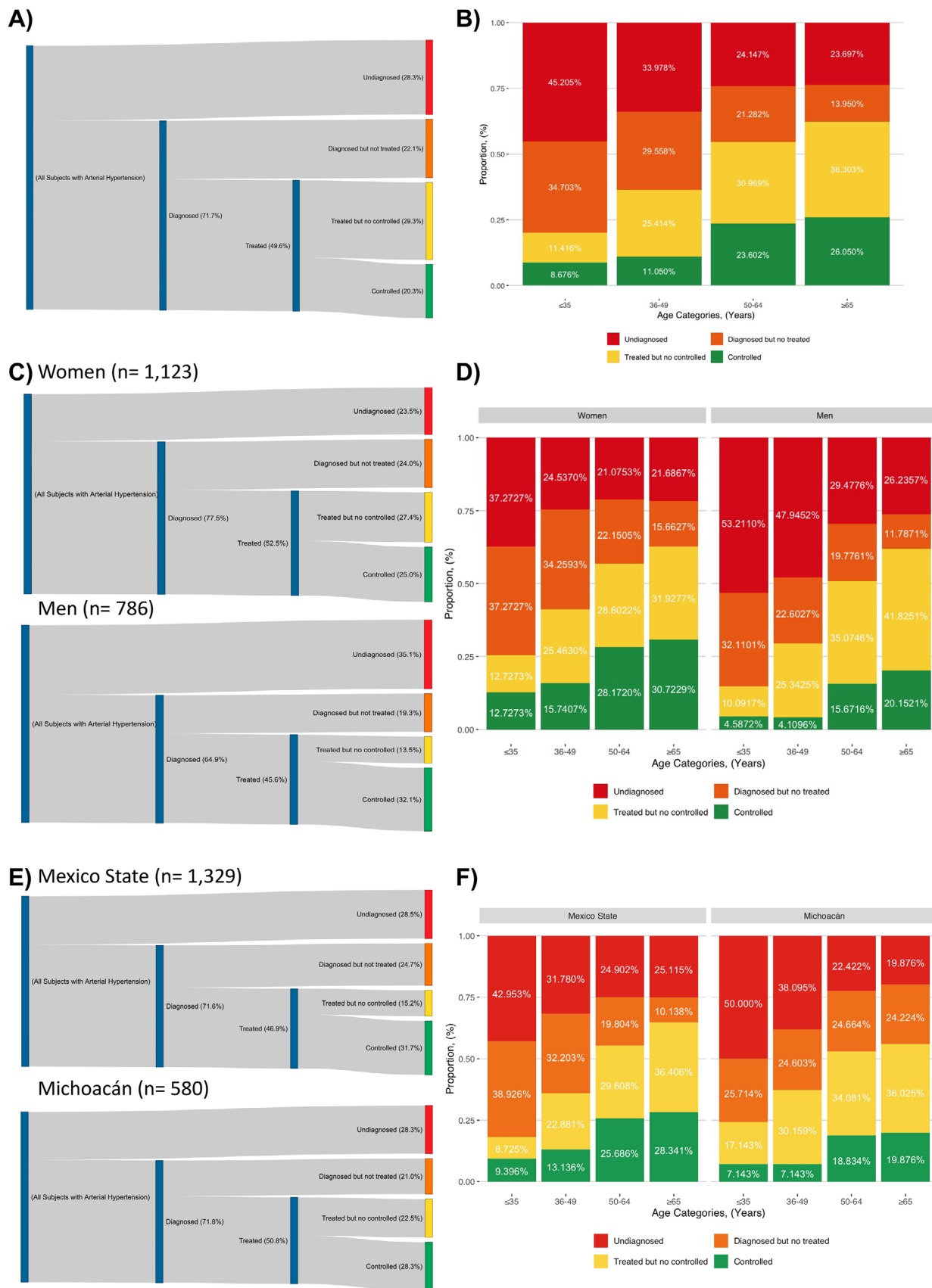


FIGURE 2 Sankey-plot of the proportion of diagnosed and treatment cascade (A), stratified by sex (C), and state of residency (E). Bar plots for the distribution of diagnosed and treatment cascade across age categories in subjects living with arterial hypertension (B), stratified by sex (D), and state of residency (F)

TABLE 1 Demographic, anthropometric, and clinical characteristics of subjects living with arterial hypertension stratified by undiagnosed and diagnosed hypertension status

Parameter	Living with Arterial Hypertension (no. = 1909)	Undiagnosed Arterial Hypertension (no. = 540)	Diagnosed Arterial Hypertension (no. = 1369)	p
Women (%)	1123 (58.83)	264 (48.89)	859 (62.75)	<.001
Age (years)	57 (47-66)	53 (40-65)	59 (49-67)	<.001
State of Mexico (%)	1329 (69.62)	375 (69.44)	954 (69.69)	.961
Michoacán (%)	580 (30.38)	165 (30.56)	415 (30.31)	.941
<12 Months (%)	1444 (75.64)	371 (68.7)	1073 (78.38)	<.001
≥12 Months (%)	436 (22.84)	157 (29.07)	279 (20.38)	<.001
Never (%)	29 (1.52)	12 (2.22)	17 (1.24)	.170
Pregnant Women (%)	19 (1.69)	3 (1.14)	16 (1.86)	.234
High Arterial Blood Pressure During Pregnancy (%)	163 (14.51)	22 (8.33)	141 (16.41)	<.001
Body Mass Index (kg/m ²)	28.25 (25.37-31.83)	28.03 (25-31.57)	28.31 (25.47-31.96)	.118
Overweight (%)	738 (38.66)	199 (36.85)	539 (39.37)	.334
Obesity (%)	663 (34.73)	168 (31.11)	495 (36.16)	.042
Statin Use (%)	270 (14.14)	20 (3.7)	250 (18.26)	<.001
Aspirin Use (%)	476 (24.93)	48 (8.89)	428 (31.26)	<.001
Smoking (%)	295 (15.45)	100 (18.52)	195 (14.24)	.025
Alcohol Consumption (%)	234 (12.26)	77 (14.26)	157 (11.47)	.110
Diabetes (%)	559 (29.28)	107 (19.81)	452 (33.02)	<.001
Previous IHD (%)	146 (7.65)	25 (4.63)	121 (8.84)	.008
Previous Stroke (%)	49 (2.57)	5 (0.93)	44 (3.21)	.0146
Diagnosed But Not Treated (%)	422 (22.1)	-	422 (30.83)	-
Treated But No Controlled (%)	653 (34.2)	-	560 (29.33)	-
Controlled Arterial Hypertension (%)	294 (15.4)	-	387 (20.27)	-
Systolic Blood Pressure (mmHg)	126 (113-140)	136 (122-145)	123 (111-136)	<.001
Diastolic Blood Pressure (mmHg)	82 (72-91)	91 (83-96)	79 (70-87)	<.001
Heart Rate (bpm) (lpm)	74 (67-83)	75 (67.75-84)	74 (67-82)	.065

Abbreviations: BP, Blood pressure; BPM, Blood pressure measurement; BMI, Body mass index; IHD, ischemic heart disease; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; mmHg, millimeters of mercury; bpm, beats per minute.

Continuous data is presented in mean (standard deviation) or median (interquartile range) and was compared between groups using unpaired t test or Mann-Whitney U test where appropriate. Categorical data is presented in frequency and absolute proportion and was compared with chi-squared test.

hypertension (Figure 3). Finally, as an exploratory analysis, we performed an interaction model that revealed that adults younger than 50 years living in the state of Michoacán and women older than 50 years had increased odds for having UAH and uncontrolled arterial hypertension compared with healthy subjects and controlled arterial hypertension, respectively after adjustment for diabetes and BMI categories (Supplementary Material).

4 | DISCUSSION

In this study, we report the estimated prevalence of arterial hypertension and the characterization of UAH using data from the MMM-2019 in the Eastern Zone of Mexico. We observed that up to one-third of our studied population lived with arterial hypertension. The characteriza-

tion of the diagnosed and treated subjects revealed that a high proportion of adults with the disease live without knowing their diagnosis, along with a high proportion of untreated and uncontrolled subjects. Additionally, to these findings, we report that age modifies the overall prevalence, diagnostic and therapeutic profiles observed in our results. Older male adults living at Michoacán with diabetes and obesity had higher odds of having UAH than non-hypertensive subjects. Whirls male adults from Michoacán with diabetes had increased odds of having an uncontrolled disease. Overall, our results yield the high burden of arterial hypertension in our country, with a dynamic presentation across age categories.

Our results are supported by the epidemiological situation of arterial hypertension in our country.^{4,13,14} In Mexico, there is an heterogenous prevalence across each region in the country. According to ENSANUT-2018, it has been estimated that approximately

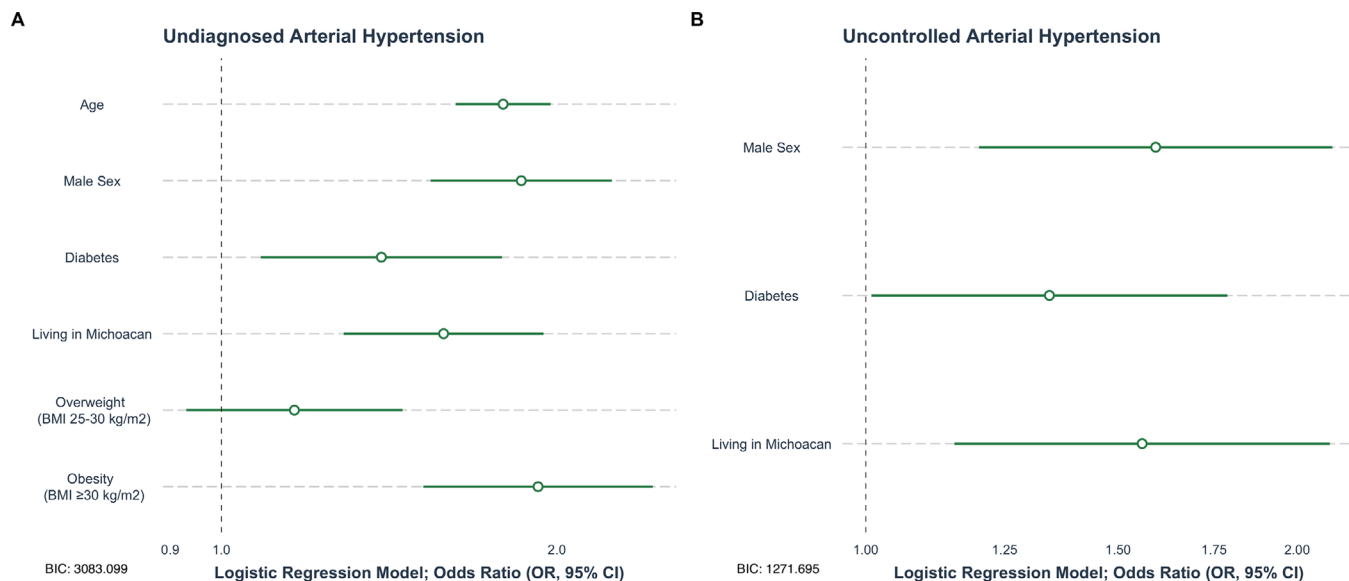


FIGURE 3 Odds-ratio plots to estimate associated factors for undiagnosed (A) and uncontrolled (B) arterial hypertension compared with compared with healthy subjects and controlled arterial hypertension, respectively

one-third of all adults across the country live with arterial hypertension, with a sharp increase in its prevalence and its associated mortality in the last two decades.¹⁵ Furthermore, in the Northern and the Gulf Region of Mexico, it has been reported the highest prevalence of arterial hypertension in all the country. Other regions such as the Central and Metropolitan Areas of Mexico had a lower prevalence, with approximately a 13–16% of its adult population living with the disease. Our findings revealed a higher proportion in our studied population compared with the national estimations. This epidemiological status has been linked to several individuals and public health care determinants.¹⁶ From an individual perspective, it has been reported that a high proportion of Mexican adults had unhealthy lifestyle habits such as high-calory diets consumption, sedentarism, and active smoking that predispose them to develop chronic health diseases related to metabolic syndrome spectrum, particularly overweight and obesity.¹⁶ From a public care perspective, a lack of full social security coverage across the country challenges a prompt diagnosis, treatment, and follow-up complications related to chronic healthcare diseases, including arterial hypertension.^{8,17}

Our finding revealed a differential impact of diagnosis, treatment, and blood pressure control rates across age categories, which are further exacerbated by sex and state of residency. We observed that UAH has its higher proportion in younger male adults, living with obesity, diabetes and at Michoacán. Moreover, women had the highest proportion of untreated and uncontrolled arterial hypertension. Comparing our results with a recent study spanning two decades in trends of arterial hypertension worldwide, the authors stated that men living in Latin-America had one of the highest proportions of untreated arterial hypertension, while women had a higher proportion of uncontrolled arterial hypertension compared with other regions of the world.¹ Our results revealed that both conditions are increased within the Eastern Zone of Mexico. Mexico has dwelled with several conditions that

could explain these rates of untreated and uncontrolled disease. A lack of efficient anti-hypertensive treatment coverage and the implementation of old anti-hypertensive regimes across the country, are combined with the low proportion of adults that receive preventive and primary care strategies to prevent complications related to arterial hypertension. As a whole, these factors create a whole challenge to appropriately treat and control arterial hypertension at a community level in our country.^{8,18,19}

At an individual daily clinical practice, there is a need to improve the awareness of modifiable health-style habits and contributors to arterial hypertension in younger adult ages, especially in men to increase the rate of detection of the disease. At a public healthcare perspective, there is a need to implement community-based programs based on regular visits to healthcare providers, with standardized protocols of measurements for a prompt treatment and diagnosis of arterial hypertension. The clinical relevance of a promptly diagnosis and treatment of the disease relies primarily on the fact that arterial hypertension represents the main contributor to CVD, such as heart failure, IHD, and arrhythmia, which continues to be a mayor burden of mortality in Latin-America countries.²⁰ Overall, this is a call to action to reframe the current public healthcare strategies to treat and close gaps of access to healthcare services to treat arterial hypertension. It is imperative to stop the current trends in prevalence, untreated and uncontrolled hypertension, to eventually diminish their impact on the burden of other chronic healthcare related conditions and within the health care expenditure at long-term in Mexico.

This study highlights the current situation of arterial hypertension within the Eastern Zone of Mexico studied through two urban populations. Nevertheless, some limitations must be acknowledged. The MMM-2019 represents a sample of a particular zone of interest in the Eastern Zone of Mexico and may be not fully representative of the whole country. Moreover, the people voluntarily assisted to the

medical units that were included, which could represent a potential selection bias. However, according to recent reports from ENSANUT-2018, there has been estimated that no more than 19% of the subjects living in Eastern Zone of Mexico use preventive and primary care services at their disposal, which makes a challenge to design representative clinical-based surveys datasets in our country.²¹ Additionally, we reported our results using a cross-sectional design that makes difficult to assess complications associated with arterial hypertension at long-term follow-up which could be assessed in future studies.

5 | CONCLUSIONS

In summary, we report a high proportion of UAH in Easter Zone of Mexico. Age acted as a modifier of the proportion of undiagnosed and untreated hypertension profiles, adults at younger ages had an increased rate for these conditions. Moreover, the related factors associated with UAH are male sex, obesity, diabetes, and living at Michoacán. Only male sex, with diabetes, and living at Michoacán were associated factor with uncontrolled hypertension. Our work could serve as evidence to the current knowledge of arterial hypertension in Mexico and Latin America and yields for urgent actions at individual and public health level to stop the burden and complications of the disease.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

AUTHOR CONTRIBUTIONS

Research Idea and Study Design: SPP, NEAV; Data Acquisition: LRGC, CAA, EGP, OMBM, MEFS, FVH, IGHO, JECT, MACA, BSM, GMC, CJMM; Data Analysis/Interpretation: SPP, NEAV; Statistical Analysis: NEAV; Manuscript Drafting: SPP, NEAV; Supervision and Mentorship: SPP. Each author contributed important intellectual content during manuscript drafting or revision and accepted accountability for the overall work by ensuring that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved.

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SUPPORTING INFORMATION

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