Title: Hypertension Awareness, Treatment, and Control in Mexico: An Opportunistic Medical Student-led Blood Pressure Screening Campaign – A Cross-sectional Study

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Acknowledgment: The authors would like to thank the following for their support: Sara Patricia Yee-González, Eliezer Morales-Rojas, Andrea Isabel Ochoa-Rodríguez, Jonathan Dazaeth Delgado-Sánchez, Manuel Antonio Moreno-Colorado, Edson Lezama-Cisneros, Sandra Juárez-Paredes, José Arturo Valdés-Méndez and all the Asociación Mexicana de Médicos en Formación, A.C. members who served as volunteers at screening sites.

Financing: Self-funded.

Conflict of interest statement by authors: The Authors have no conflicts of interest to disclose.

Compliance with ethical standards: Relevant ethical guidelines have been followed; details are included in the manuscript. All necessary patient/participant consent has been obtained.

Authors Contribution Statement: Conceptualization: JY, SN. Methodology: JY, SN, SR. Software: SR. Validation: JY. Formal Analysis: SR. Investigation: JY, SN, SR, JG, MM. Resources: JY, SN. Data Curation: JY. Writing – Original Draft: JY, SN, SR, JG, MM. Writing – Review & Editing: JY, SN, SR. Visualization: JY, SN, SR. Supervision: JY, SN. Project Administration: JY, SN. Funding Acquisition: JY, SN.

Manuscript word count: 3,463

Abstract word count: 238

Number of Figures and Tables: 10

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Discussion Points:

1. This is currently the only medical student-led campaign to raise hypertension awareness at a national level in Mexico
2. A significant proportion of the study population was unaware of having hypertension especially in states with a lower level of marginalization and considered to be more developed
3. A larger number of subjects within BP control targets were found in more marginalized, less developed regions
4. More than half the participants taking antihypertensive agents were on a single medication, achieving BP control in almost 8 in 10 patients

ABSTRACT.

Background: Hypertension is still a growing public health problem in Mexico. An estimated 151% increase in the number of individuals with hypertension is expected for 2050 if actions are not taken in the country. The aim of this study is to describe hypertension awareness, treatment, control and its associated factors in participants of an opportunistic medical student-led blood pressure screening campaign in Mexico.

Methods: A cross-sectional study, using convenience sampling was performed, including participants aged 18 years and older from 15 Mexican states. Each participant completed a questionnaire about risk factors and had three BP measurements taken. Hypertension was defined as ≥140/90 mmHg. Multiple imputation with linear regression was performed where data was missing.

Results: From a population of 2,545 participants, 623 (24.5%) participants had hypertension. Of those with hypertension, 81.9% had a previous diagnosis of hypertension and only 16.1% were not on medication at the time of screening; 61% were controlled, 21% were uncontrolled patients and 18% were not aware they had hypertension. High marginalization was found to have the biggest proportion of uncontrolled cases (33%), while the number of unaware hypertensives in very low marginalization states doubled the national figure. More than half the participants taking antihypertensive agents were on a single medication, achieving control in almost 8 in 10 patients.

Conclusion: A majority of uncontrolled hypertensive patients in Mexico belong to marginalized states. These results could inform state legislative policy to help bridging healthcare gaps.

Key Words: hypertension; blood pressure; screening; Mexico (Source: MeSH-NLM).

INTRODUCTION.

Hypertension is defined as a chronic, controllable disease of multifactorial etiology, characterized by a sustained increase in blood pressure (BP) levels.[1] Its importance lies in the fact that it is the most common risk factor for the development of cardiovascular disease (CVD), which is the leading cause of death worldwide, generating approximately 10.5 million deaths a year.[2,3]

In high-income countries an improvement in the awareness, treatment and control of the disease has been observed.[4] Healthcare systems in countries with better control of hypertension such as Canada, the USA, South Korea, and Germany have in common that they all have programs in health education or health check-up.[5] However, in low and middle-income countries such as Brazil, China, India, Indonesia, Mexico, and South Africa, the results of disease prevention strategies have been less favorable, revealing a need to improve health services and prevention programs.[6]

In Latin America, 40% of the adult population suffers from hypertension, having considerable variations in hypertension awareness, treatment and control depending on race/ethnicity, sex, income, occupation, education, social position, psychosocial and behavioral factors, among other social aspects.[7] For example, people with a higher socioeconomic level are more likely to be physically inactive, with physical inactivity being one of the main risk factors for hypertension.[7] On the other hand, better adherence to treatment has been observed in people with a higher educational level.[8] Small studies have shown that the majority of people living with hypertension do not know the normal BP levels and that correlation between body weight and elevated BP.[9]

Hypertension is still a growing public health problem in Mexico. The National Health and Nutrition Survey (ENSANUT) reported prevalence figures for this condition of 25.5%, of which 40.0% were not aware they had it. Among those with a previous diagnosis of hypertension, 79.3% received pharmacological treatment and, only 45.6% were properly controlled.[10] An estimated 151% increase in the number of individuals who will need care for hypertension is expected for 2050 if further actions are not taken in the country.[8]

Several global campaigns have been devised to improve awareness and early detection of hypertension, such as May Measurement Month (MMM), a global screening intervention performed on an annual basis by the International Society of Hypertension (ISH), this campaign focuses on measuring BP among the general population and identifying risk and predisposing factors for the disease.[3,6] The 2019 intervention had a response from more than 100 countries, with a final count of 1,508,130 participants around the world.[6]

As an approach to addressing such problems in Mexico, the Asociación Mexicana de Médicos en Formación (AMMEF, the Mexican Association of Physicians in Training) took the initiative to perform an opportunistic BP screening campaign inspired by the MMM methodology.[3,6] The aim of this study is to describe hypertension awareness, treatment, control and its associated factors in participants of an opportunistic medical student-led BP screening campaign in Mexico.

MATERIALS AND METHODS.

Study design and participants

This was a cross-sectional study, using convenience sampling. A detailed protocol was developed to be used for all entities in the country. The eligibility criteria for participants were an age of 18 years and older and consent to participate in the study according to local policies. Online and face-to-face trainings were provided for leaders of local screening teams distributed in 15 states of Mexico about questionnaire application and standardized methodology for BP measurements. Screening was performed in Aguascalientes, Baja California, Chihuahua, Chiapas, Coahuila, Durango, Guanajuato, México, Nayarit, Nuevo León, Puebla, San Luis Potosí, Sonora, Veracruz and Zacatecas. Sites of screening were set up in locations such as hospital waiting rooms, public outdoor or indoor areas, nursing homes, schools, homes, and workplaces.

Data was collected from the beginning of June to the end of October 2019 by volunteer medical students with the use of an automated electronic device or an aneroid sphygmomanometer with a stethoscope. Recommendations for the measurement of BP included three seated recordings taken on the left (preferably) or right arm with a one-minute gap between readings. The full protocol can be consulted in **Supplementary material 1**.

Questionnaire

The MMM questionnaire was created by the International Society of Hypertension (ISH), it consisted of 24 items with sociodemographic data; identification of risk factors; anthropometric and blood pressure measurements (it can be downloaded from: https://maymeasure.com/get-involved/downloadable-resources/)

Variables

Hypertension was defined as a systolic blood pressure (SBP) ≥140 mmHg or a diastolic blood pressure (DBP) ≥90 mmHg in at least two of the readings. Cases were classified as “unaware hypertensive” (UAH) patients for those that satisfy the hypertension definition at screening but did not have a previous diagnosis or treatment; “controlled hypertensive” (CH) population for those with normal BP values at screening but with a previous diagnosis or treatment for hypertension; “uncontrolled hypertensive” (UCH) patients were those that complied hypertension criteria at screening and had a diagnosis and/or treatment for hypertension; “non-hypertensive” (NH) population were those that did not satisfy any of the previous conditions. A control group was established including participants without hypertension, that declared taking no medication or having clinical signs of diabetes, with no history of stroke, myocardial infarction (MI), gestational hypertension (GH), pregnancy at the moment of screening, smoking and alcohol drinking. Associated factors to changes in BP were considered to be fasting, history of stroke, history of MI, diabetes, pregnancy, history of GH, tobacco smoking, alcohol consumption, BMI and heart rate. Screening locations were classified according to Social Gap Index (SGI) emitted by the National Council for the Evaluation of Social Development Policy, which ranks federal entities on five levels based on access to education, health, basic services and housing, from lowest to highest level of social inequality.[11]

According to the SGI, marginalization is very low in Aguascalientes, Coahuila and Nuevo León; low in Baja California, Chihuahua, State of Mexico, Sonora and Zacatecas; middle in Durango, Guanajuato and Nayarit; high in Puebla and San Luis Potosí and very high in Chiapas and Veracruz.[11]

Statistical analysis

Multiple imputation with linear regression was performed five times using the missing at random (MAR) assumption where data was missing for variables such as height, weight and subsequent BP readings. Geographical localization, sex, medical history, SBP and DBP measurements were used as indicators for multiple imputation. Missing values were replaced with the pooled imputed data, and the resulting dataset was tested for normality using the Kolmogorov-Smirnov test in a Monte Carlo simulation of 500 cases. For the analysis of attributable factors to changes in BP, mean SBP and DBP of the control group were calculated, and used as referent. All statistical analysis was performed using IBM SPSS Statistics for Windows (Armonk, NY) and began in June 2020.

RESULTS.

From a total of 2,549 entries, the study included 2,545 participants after eliminating 4 entries as shown in **Figure 1**. Missing data was observed in 48 (1.80%) cases for height, 52 (2.04%) for weight, 800 (31.43%) for second BP reading, and 1,320 (51.47%) for third BP reading. An estimated error <2% in data distribution was observed after multiple imputation.

Roughly half the screenings were carried out in open public areas (53.8%), followed by hospitals and clinics (26.8%), closed public areas (12.5%), homes (5.1%), workplaces (1.0%), educational institutions (0.5%) and nursing homes (0.3%). From the total number of participants included, 53.6% were women (see **Table 1**). Mean age was 41 years with a range from 18 to 91 years, with a majority of participants in the 18 to 39 years age group, accounting for 50.6% of screenees. Almost a quarter (24.1%) of participants had a history of smoking, 57.7% of screenees declared having never or almost never consumed alcohol, 26.6% consumes alcohol between one and three times per month, and 15.3% at least once a week. Regarding diabetes, 6.9% of participants did not know if they had diabetes, whereas 11.4% declared having the diagnosis. Only 1.5% and 2.7% of screenees had a history of stroke or MI, respectively. A history of GH was declared by 9.2% of women involved, and only 40 (1.6%) participants were pregnant at the time of screening.

The state with the most screenees was Chiapas (12.9%), followed by Puebla (12.8%) and Sonora (11.9%). On the other hand, states with the smallest screened samples were San Luis Potosí (1.0%), Nuevo León (1.1%) and Zacatecas (2.0%). The highest mean BP standardized for age and sex was that of Coahuila (SBP 130.13 mmHg, DBP 85.20 mmHg) and the lowest that of Aguascalientes (SBP 110.75 mmHg, DBP 70.56 mmHg), as shown in **Table 2**. Stratifying by the SGI, states with a low SGI had the most participants (33.7%), and those with very low SGI had least participation (11.2%). Mean BP standardized by age and sex was highest at high SGI (SBP 124.14 mmHg, DBP 82.29 mmHg) and lowest at low SGI (SBP 121.14 mmHg, 78.64 mmHg), as can be seen in **Table 3**. The number of identified cases of hypertension decreases 1.25% and 3.57% with the second and third readings, respectively, and falling up to 5.18% using the mean of the three readings, as shown in **Table 4**.

National mean BP, considering all three readings, was 119.56 mmHg for SBP and 77.28 for DBP. Classifying participants by type of case, as previously described, it was found that 922 (75.5%) were NH and 623 (24.5%) participants had hypertension. Of those with hypertension, 510 (81.9%) subjects had a previous diagnosis of hypertension and only 82 (16.1%) did not declare taking a pharmacological treatment at the time of screening; 397 (61%) were CH patients, 128 (21%) were UCH patients and 113 (18%) were UAH cases. The proportion of UAH patients in areas of very high SGI was only 1% above the national figure, meanwhile those areas with very low SGI doubled it (34% vs. 18%). States with a low SGI were the areas with the smallest number of cases of UAH (14%). A high SGI was found to have the highest number of UCH cases (33%), being the only group of states surpassing the national figure. On the other hand, areas with medium SGI had the biggest proportion of CH cases with 67%, whereas regions with a very low SGI has the smallest proportion of controlled patients, followed by the states with low SGI, 13% and 9% below the national figure, respectively, as shown in **Figure 2**.

The most common medications among participants were antihypertensive drugs, such as ACEI, ARB, calcium channel-blockers, diuretics, beta-blockers and alpha-agonists, with 428 (16.8%) patients taking at least one of them, which accounts for 68.7% of hypertensive patients taking medication. Of these, 225 (52.6%) took one medication with 171 (76.0%) controlled, 145 (33.87%) took two and 98 (67.6%) were controlled, 42 (9.8%) took three antihypertensive drugs with 30 (71.4%) controlled, 10 (2.3%) took four different medications with 100% control rate, and 6 (1.42%) took five or more achieving BP control in 4 (66.7%). Aspirin was the second most used drug among hypertensives (33.5%), followed by statins (25.5%).

A polynomic (two degrees) model of the association between age and mean BP from all three readings including patients not receiving pharmacological treatment (**Figure 3**) showed an ascending linear trend for SBP in women, and an inverted U shape for DBP, with the biggest increment in BP between 65 and 75 years of age. Meanwhile, both curves showed an inverted U shape for men with highest BP levels between 50 and 60 years for SBP and between 45 and 55 years for DBP. Men had a SBP higher than women up until 73 years, at which point trends get inverted. The same phenomenon is also observed for DBP at age 72.

The control group was composed of 704 participants, their mean BP including all three readings was 114.52 mmHg for SBP and 75.14 mmHg for DBP. Analyzing for possible factors attributable for changes in BP, all variables but pregnancy, which decreased DBP in 1.5 mmHg, were associated with an increased mean difference (MD) in BP as can be seen in **Figure 4**. Factors with the most influence over SBP were history of MI (13.41 mmHg), diabetes (12.80 mmHg) and stroke (12.11 mmHg). Highest increase in DBP was observed with a history of stroke (6.64 mmHg), diabetes (4.59 mmHg) and MI (3.47 mmHg). Tobacco smoking was shown to increase SBP in 7.25 mmHg and DBP 3.37 mmHg, whereas alcohol drinking increased 4.06 and 7.06 mmHg for SBP and, 2.21 and 2.50 mmHg for DBP in those who drank one to three times per month and at least once a week, respectively. Aside from medical history, fasting at the time of screening was the condition associated with highest increase in SBP (10.36 mmHg), DBP only increased 3.01 mmHg.

A proportional increase in BP and BMI was observed, with participants considered to have obesity having an additional 13.54 mmHg in SBP and 8.11 mmHg in DBP. On the contrary, those considered underweight had a decrease of 0.43 mmHg in SBP and 4.92 mmHg in DBP compared with those in the control group, as shown in **Figure 5**.

Comparing mean heart rates from all three BP readings, a similar phenomenon from that observed with BMI emerges, where the greater the heart rate the highest the increase in BP. An increase of 16.68 mmHg in SBP and of 10.79 mmHg in DBP is seen with heart rates ≥100 bpm. Meanwhile, when heart rate <60 bpm, DDB descends 0.73 mmHg (see **Figure 6**), compared to the control group.

DISCUSSION.

In this study of a population of over 2,500 adults in Mexico, it was observed that 24.5% were hypertensive, similar to the 25.5% reported by the ENSANUT 2016 and lower compared to 73.0% reported by the MMM 2019 study for the Americas region[6,10]. Of those with hypertension, 18.0% were unaware they might have it, 21.0% were uncontrolled hypertensives and 61.0% had BP values <140/90 mmHg, therefore were considered to be well-controlled patients for this study. These numbers are far more optimistic than those reported by previous studies with only 45.6% and 37.1% of controlled subjects and, 40.0% and 53.5% of unaware patients in national and global surveys, respectively.[10,12] This could be explained by the opportunistic nature of this study. Also, through this campaign hypertension awareness was raised in only 113 individuals across Mexico.

According to Ríos-Blancas, et al.[13] low and very low SGI states have a higher probability of receiving a pharmacological treatment than states with a high and very high SGI, which accounts for three in four cases receiving a treatment but less than a third of these achieving BP control. This is consistent with the findings in this study, which showcased that states with a high marginalized states were found to be the biggest contributor to the pool of uncontrolled cases (33%). On the other hand, a biggest proportion of hypertension unawareness was observed at very low SGI states (34%), almost doubling the national figure, whereas states with medium (67%), low and very high SGI (66%) had the biggest proportion of controlled hypertensives. A possible explanation for this could be that a limited access to medications adds to the perceived value of these among populations that are not accustomed to receive medical treatment, which improves compliance in these groups.

More than half the participants taking antihypertensive agents were on a single medication, achieving blood pressure control in almost 8 in 10 patients, the biggest proportion compared with the usage of additional medication in this study, which contrasts with the findings of the MMM 2019[6] where almost 4 in 10 patients on a single agent were uncontrolled. However, these findings are not at odds with recommendations to initiate pharmacological treatment with two agents[14,15] as a 67.6% controlled rate was observed with this regimen. The questionnaire used in this study did not allow to collect data about specific types of antihypertensive drugs used by participants, only the number of pharmacologic agents they used. On the other hand, aspirin was taken by a large proportion of participants, 33.5% of hypertensives and 12.8% of non-hypertensives, which goes against the latest recommendations about minimizing the routine usage of aspirin for the primary prevention of CVD because of lack of net benefit.[16]

A strong association consistent with previous publications was observed between BP and several known risk factors such as smoking and alcohol intake,[17,18] the latter showing a dose-response effect with a greater increase in BP in heavy drinkers similar to what has been describe by other authors.[19] A higher BMI was consistently related to a higher BP, although participants considered to have obesity in this study had a much higher increase in BP (SBP 13 mmgHg and DBP 8 mmHg) compared to that reported by previous studies.[6,19,20] This is a serious concern because Mexico occupies the second place in obesity worldwide, and rates are projected to continue growing,[21] therefore a similar trend in hypertension could be expected if no further actions are taken.

On the other hand, subjects with a history of stroke and MI showcased a surplus in BP compared to the control group with an increase of 12 and 13 mmHg in SBP, respectively. A similar phenomenon was also observed in people with diabetes. These findings could suggest that patients with a history of stroke and MI in this population were not adequately controlled, even though hypertension is the most important factors for stroke recurrence.[22] However, a J-curve phenomenon has been described[23] in which a permissible BP target should be achieved to prevent that controlling such factor becomes inversely related to risk. On the contrary, evidence suggests that prompt, long-term BP control is imperative to improve secondary prevention of MI.[24] Thus, further studies are needed to explore this topic specifically in the Mexican population.

Risk of ascertainment and selection bias are inherent to the design because participants presented voluntarily at screening sites, therefore people worried about their BP were more likely to participate. Thus, prevalence should not be inferred. It is worth noting that standardized by age and sex mean BP was within normal range in all states. Coahuila had the highest mean BP with 130/85 mmHg, whereas Aguascalientes had the lowest with 110/70 mmHg. As an opportunistic campaign and cross-sectional study using convenience sampling, it could be expected that a higher proportion of health-conscious individuals (either well-controlled hypertensive patients or otherwise healthy people) took part as screenees, which could explain atypical results. Any generalization about these results should be made cautiously.

Also, despite the efforts to provide training on standardized BP readings to volunteers, differences in screening locations and the usage of different equipment account for some degree of error in measurements. Although data about the devices used to measure BP was collected, the heterogeneity in reporting and the very vast array of brands and models did not facilitate further analysis. However, as reported by Varshney et al.[25] there is no significant difference in BP readings using automated and auscultatory methods to determine SBP in the in the context of a community-based screening program, but DBP might differ between methods. Likewise, the main researchers did not have control over the number of students working at screening sites, which further limits the accuracy of measurements.

Most current guidelines recommend using ambulatory or home BP measurements,[14,15] this approach was not cost-effective for this study, and diagnosis of hypertension was based on a single set of readings. While this might not be ideal, spaced serial measurements including three BP readings provided a means to mitigate the impact of atypical values, errors in measurement or factors related to the patient such as white coat syndrome. On the other hand, at least one BP reading was missing for 31.4% of participants, which could significantly affect the statistical analysis and led to an over-diagnosis of hypertension. Using multiple imputation, it was possible to mitigate that error by estimating mean second and third BP readings from a single measurement with minimal error in data distribution models. Nevertheless, interpretation of results from this imputed data should be taken carefully.

A questionnaire was used to obtain the medical history of screenees. This limits our ability to explore other comorbidities not included in the original questionnaire, but it does not mean that other associations with hypertension (apart from diabetes, MI and stroke) could not be found. Also, this questionnaire asked screenes

about the usage of pharmacological agents prescribed by a physician for BP control, differences in the accuracy of recollection could have led to a recall bias involving the number of drugs taken by participants.

To our knowledge, this is currently the only medical student-led campaign to raise hypertension awareness at a national level in Mexico. It was observed that a significant proportion of the study population was unaware of having hypertension especially in states with a lower level of marginalization and considered to be more developed. In contrast, a larger number of subjects within BP control targets were found in more marginalized, less developed regions.

A majority of uncontrolled hypertensive patients in Mexico belong to marginalized states. These results could inform state legislative policy to help bridging these healthcare gaps by improving hypertension detection, especially among those who do not partake in regular health checkups or have limited access to healthcare.

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1 **FIGURES AND TABLES.**

2

3 **Figure 1.** Study flowchart

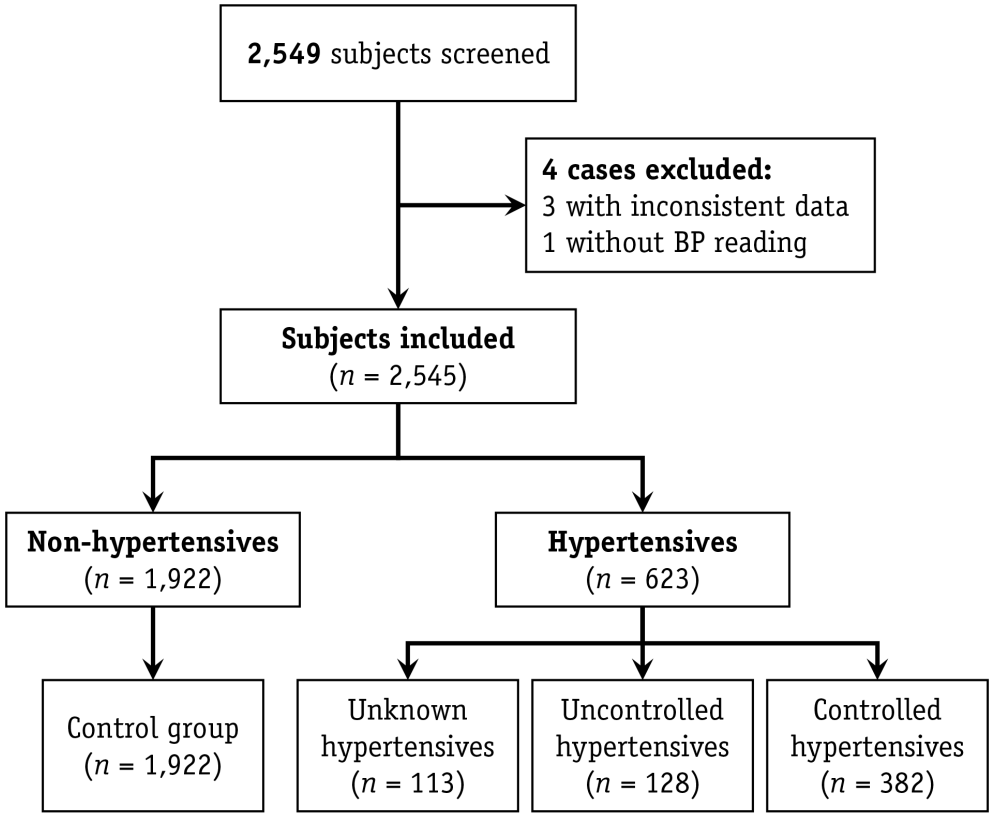

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Table 1. Demographic characteristics of participants

Variables	Hypertensive patients *n* = 623 (24.5%)	Non-hypertensive patients *n* = 1,922 (75.5%)	Total *n* = 2,545
Sex, n (%)			
Male	303 (48.6%)	878 (45.7%)	1,181 (46.4%)
Female	320 (51.4%)	1,044 (54.3%)	1,364 (53.6%)
Age, year (standard deviation)			
Mean	56 (15)	36 (16)	41 (73)
Range	18-90	18-91	18-91
Age group, n (%)			
18 to 39 years	94 (15.1%)	1,195 (62.2%)	1,289 (50.6%)
40 to 59 years	262 (42.1%)	531 (27.6%)	793 (31.2%)
>60 years	267 (42.9%)	196 (10.2%)	463 (18.2%)
History of diabetes, n (%)			
Yes	173 (27.8%)	117 (6.1%)	290 (11.4%)
No	399 (64%)	1,674 (87.1%)	2,073 (81.5%)
Does not know	51 (8.2%)	131 (6.9%)	133 (6.9%)
History of smoking, n (%)			
Yes	163 (26.3%)	447 (23.4%)	610 (24.1%)
No	456 (73.7%)	1,460 (76.6%)	1,916 (75.9%)
Alcohol consumption, n (%)			
1 to 3 times per month	132 (21.2%)	546 (28.4%)	678 (26.6%)
At least once a week	89 (14.3%)	301 (15.7%)	390 (15.3%)
Never	401 (64.4%)	1,067 (55.5%)	1,468 (57.7%)
Not declared	1 (0.2%)	8 (0.4%)	9 (0.4%)
History of stroke, n (%)			
Yes	31 (5.1%)	6 (0.3%)	37 (1.5%)
No	571 (94.9%)	1,886 (99.7%)	2,457 (98.5%)
History of myocardial infarction, n (%)			
Yes	55 (9.2%)	13 (0.7%)	68 (2.7%)
No	543 (90.8%)	1,884 (99.3%)	2,427 (97.3%)
History of gestational pregnancy, n (%)			
Yes	73 (21.8%)	65 (5.6%)	138 (9.2%)
No	262 (78.2%)	1,104 (94.4%)	1,366 (90.8%)
Antihypertensive drugs usage, n (%)			
Yes	428 (68.7%)	0 (0.0%)	428 (68.7%)
No	195 (31.7%)	0 (0.0%)	195 (31.7%)
Aspirin usage, n (%)			
Yes	208 (33.5%)	244 (12.8%)	452 (17.9%)
No	412 (66.5%)	1,666 (87.2%)	2,078 (82.1%)
Statin usage, n (%)			
Yes	158 (25.5%)	38 (2%)	196 (7.8%)
No	462 (74.5%)	1,866 (98%)	2,328 (92.2%)

Table 2. Mean Blood Pressure by State, before and after standardization by age and sex

						Standardized by age and sex			
		SBP (mmHg)		DBP (mmHg)		SBP (mmHg)		DBP (mmHg)	
State	*n* (%)	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Aguascalientes	154 (6.1)	114.66	12.13	73.08	9.48	110.75	12.13	70.56	9.48
Baja California	160 (6.3)	121.64	14.07	75.64	11.06	119.57	14.07	74.67	11.06
Chihuahua	176 (6.9)	120.41	11.95	79.89	10.72	118.99	11.95	78.79	10.72
Chiapas	328 (12.9)	119.89	11.58	76.91	8.26	118.78	11.58	76.97	8.26
Coahuila	104 (4.1)	129.93	20.42	84.92	11.98	130.13	20.42	85.20	11.98
Durango	152 (6.0)	122.16	14.82	82.09	22.54	118.62	14.82	80.88	22.54
Guanajuato	151 (5.9)	114.71	7.99	75.44	5.06	114.21	7.99	75.34	5.06
México	167 (6.6)	119.65	14.58	78.52	10.71	118.27	14.58	77.99	10.71
Nayarit	178 (7.0)	120.04	11.91	79.55	9.33	118.64	11.91	78.88	9.33
Nuevo León	28 (1.1)	122.75	6.94	77.14	3.20	122.04	6.94	76.95	3.20
Puebla	327 (12.8)	124.43	14.36	76.64	8.05	123.13	14.36	76.33	8.05
San Luis Potosí	25 (1.0)	123.47	15.37	80.51	11.28	114.85	15.37	76.58	11.28
Sonora	304 (11.9)	122.71	14.60	80.93	12.02	120.82	14.60	79.73	12.02
Veracruz	240 (9.4)	121.85	15.54	76.13	11.42	120.81	15.54	76.04	11.42
Zacatecas	51 (2.0)	123.15	14.82	81.46	9.73	122.52	14.82	80.86	9.73

Table 3. Mean Blood Pressure by Social Gap Index, before and after standardization by age and sex

						Standardized by age and sex			
		SBP (mmHg)		DBP (mmHg)		SBP (mmHg)		DBP (mmHg)	
Social Gap Index	***n* (%)**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Very low[a]	286 (11.2)	118.90	17.81	76.51	12.16	122.84	17.81	79.01	12.16
Low[b]	858 (33.7)	119.82	14.02	78.32	11.34	121.14	14.02	78.64	11.34
Medium[c]	481 (18.9)	117.24	12.07	78.40	14.31	120.07	12.07	80.98	14.31
High[d]	352 (13.8)	122.55	14.57	76.34	8.30	124.14	14.57	82.29	8.30
Very high[e]	568 (22.3)	119.63	13.42	76.58	9.73	120.89	13.42	80.64	9.73

[a] Includes Aguascalientes, Coahuila and Nuevo León
[b] Includes Baja California, Chihuahua, México, Sonora and Zacatecas
[c] Includes Durango, Guanajuato and Nayarit
[d] Includes Puebla and San Luis Potosí
[e] Includes Chiapas and Veracruz

1 **Table 4**. Mean Blood Pressure, number and percentage with hypertension across all three readings
2

	SBP (mmHg)		DBP (mmHg)			
Reading	**Mean**	**SD**	**Mean**	**SD**	**Number with hypertension**	**Proportion of hypertension (%)**
1	120.43	15.29	77.50	11.23	546	21.45
2	119.21	14.67	77.37	18.24	514	20.20
3	119.05	14.15	77.26	11.37	455	17.88
Mean of 1 and 2	119.82	14.50	77.43	12.74	450	17.68
Mean of 2 and 3	119.13	14.12	77.31	12.73	422	16.58
Mean of 1, 2 and 3	119.56	14.18	77.38	11.40	414	16.27

3
4

Figure 2. Proportion of Unaware, Uncontrolled and Controlled Hypertensives by Social Gap Index

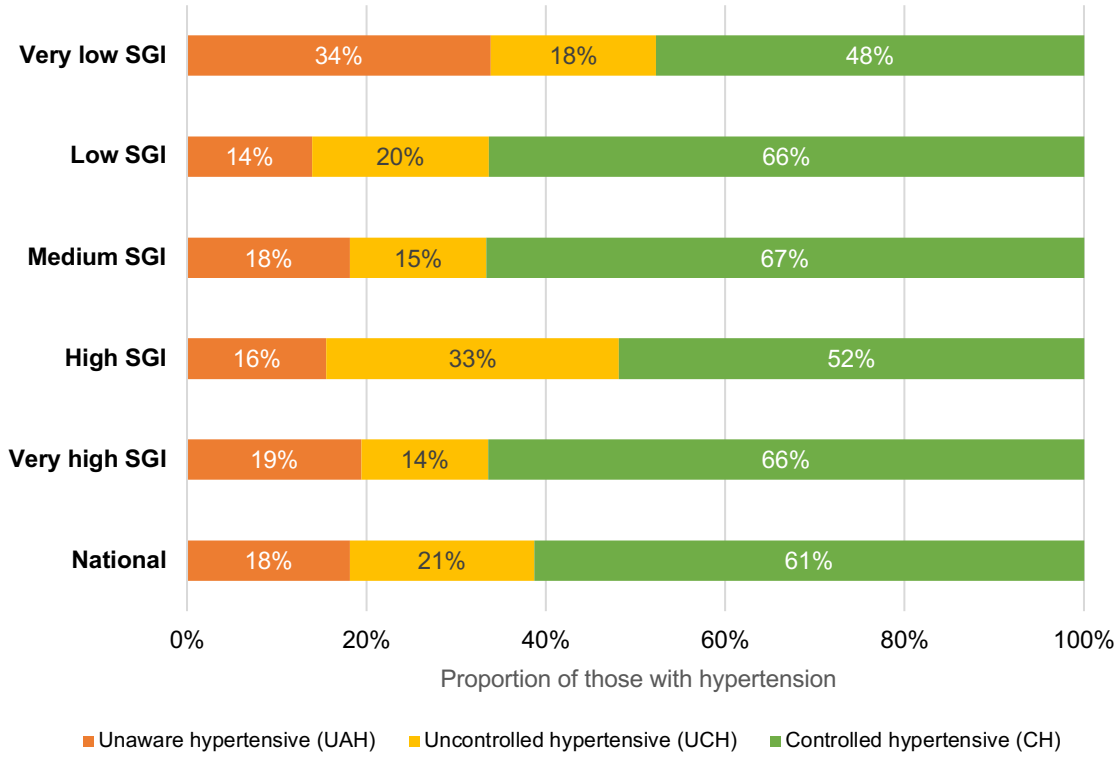


Figure 3. Change in Blood Pressure with Age and Sex from linear polynomic model

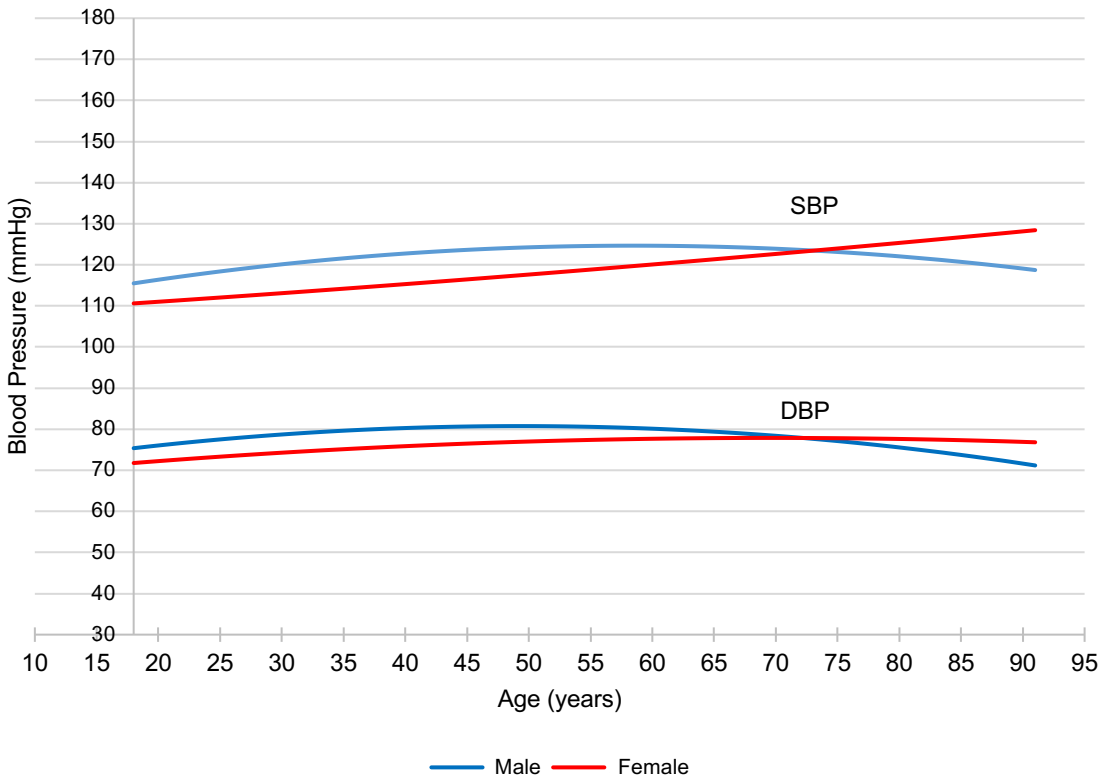


Figure 4. Change in mean Systolic and Diastolic Blood Pressure compared to control group, for associated factors to changes in BP

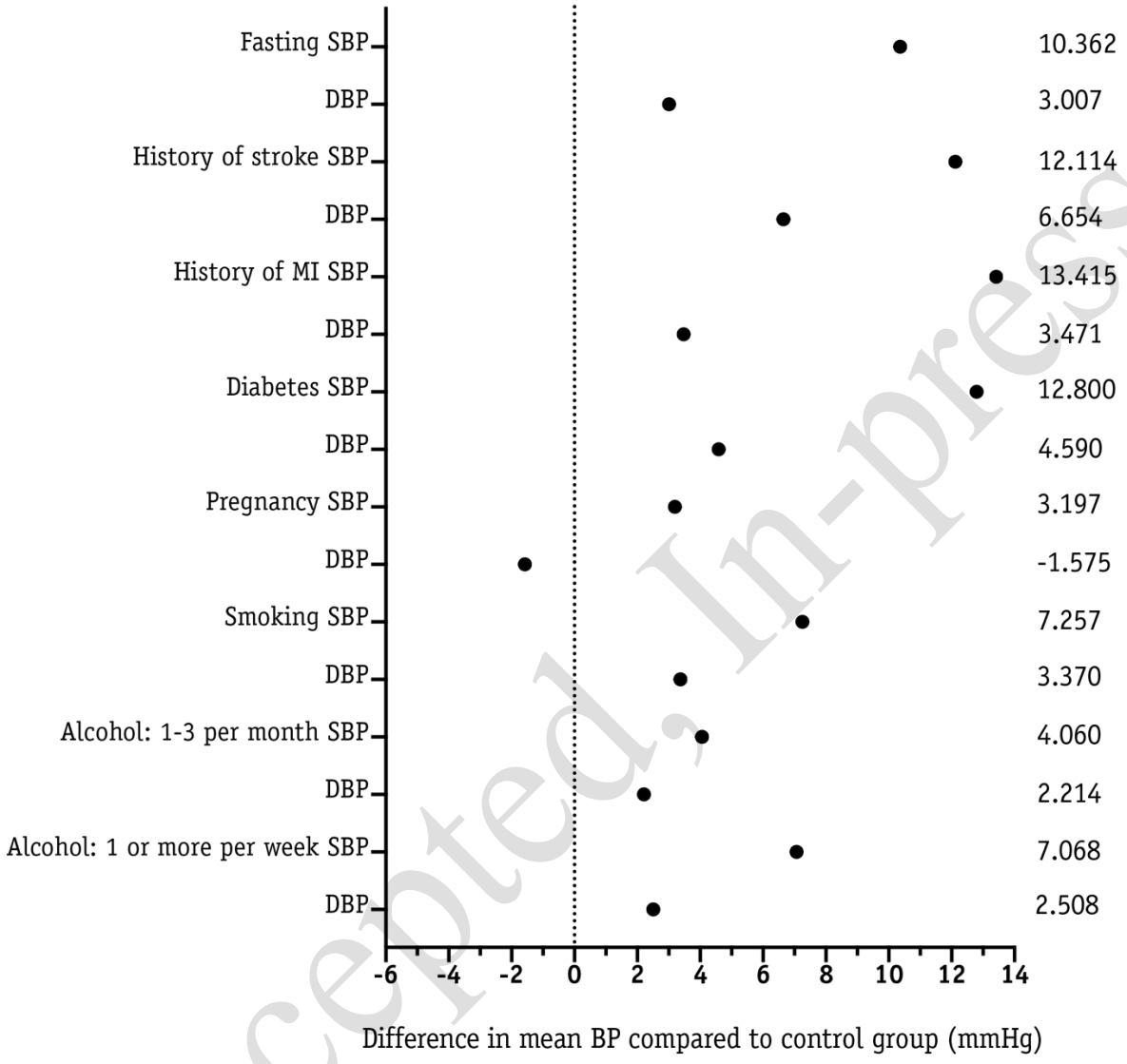


Figure 5. Change in mean Systolic and Diastolic Blood Pressure compared to control group, for Body Mass Index category

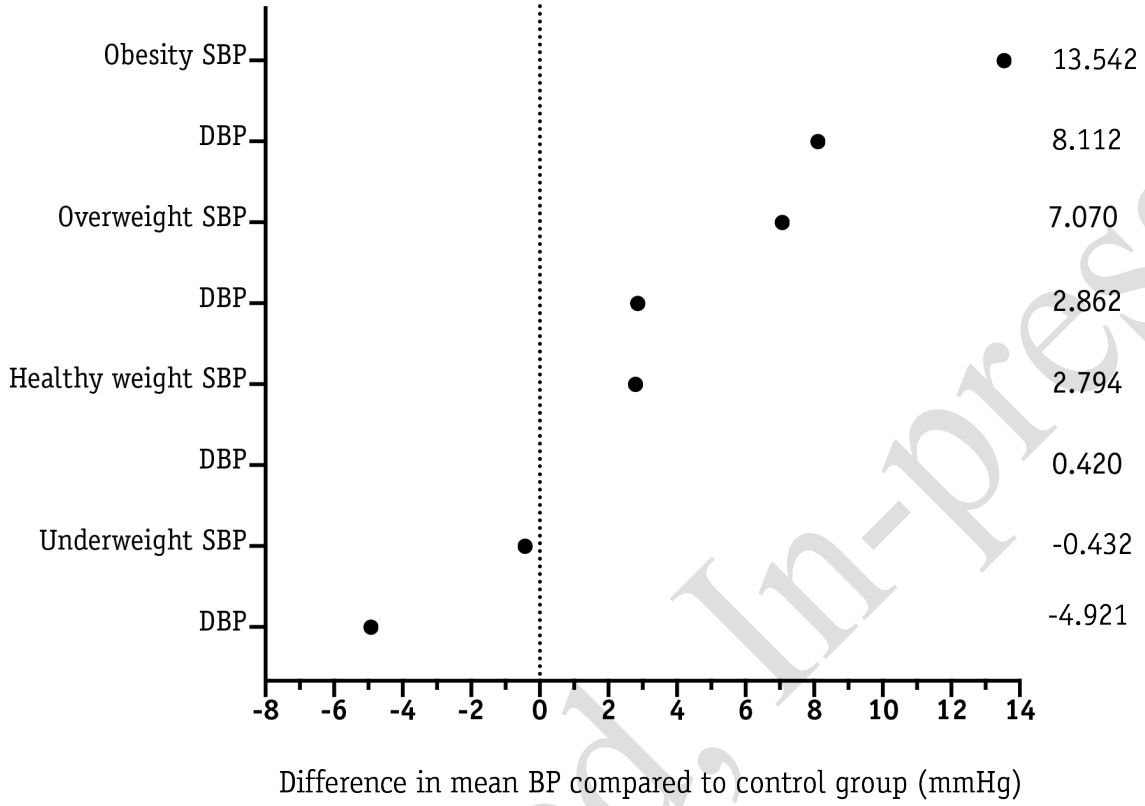
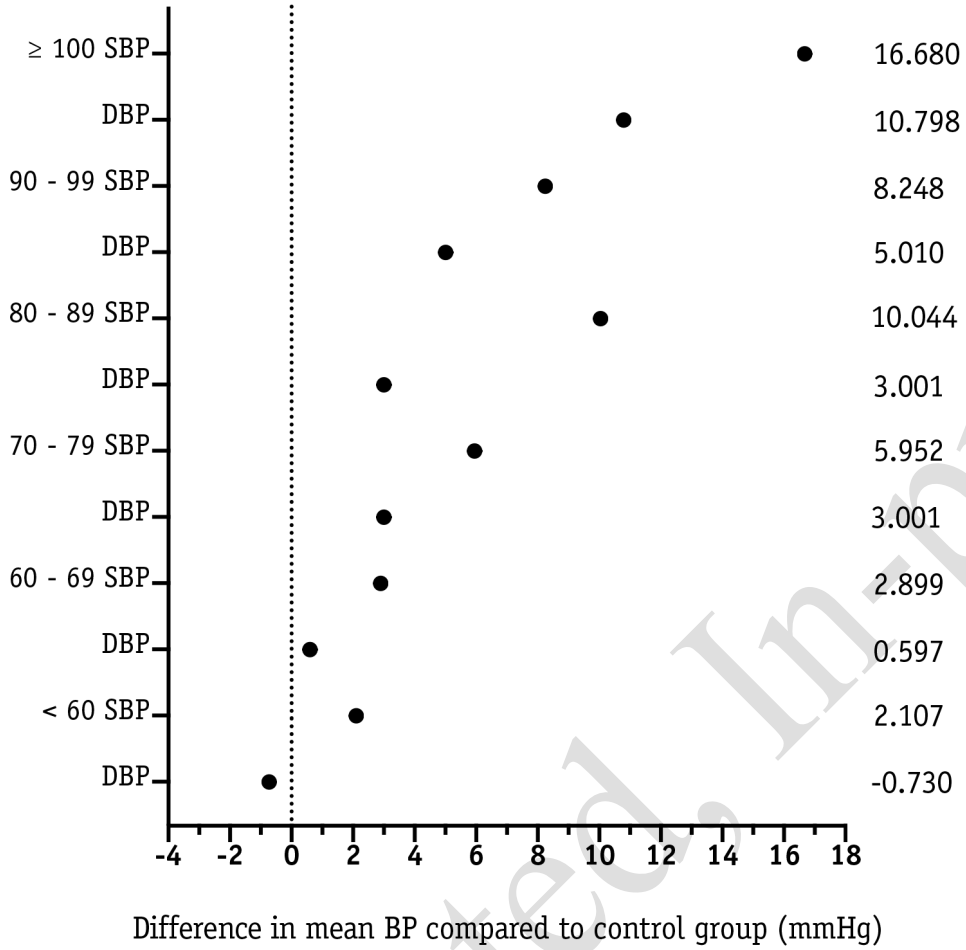


Figure 6. Change of Systolic and Diastolic Blood Pressure compared to control group, for heart rate range



Supplementary material 1. Study protocol

La Medición AMMEF [Mexican Association of Medical Students]
(The AMMEF BP Reading)
2019 Protocol

Executive summary

In May 2017 and 2018, the International Society of Hypertension (ISH) performed a global BP awareness campaign including more than 2.7 million people from more than 100 countries to raise hypertension awareness.[1,2]

Hypertension is defined as the sustained elevation of the pressure within the blood vessels. In Mexico, the cutoff values to diagnose hypertension are 140/90 mmHg and above.[3]

The aim of this protocol is to conduct a national opportunistic blood pressure (BP) detection campaign in Mexico, to raise awareness and estimate control of those screened who were detected as hypertensive.

Background

Hypertension is the modifiable risk factor to which more deaths are attributed around the world. In Mexico, the National Health and Nutrition Survey (ENSANUT) 2016 showcased that around 30% of the population above 20 years of age lives with hypertension, and roughly half of these people do not know about their condition. Another worrying figure is that 65% of people with hypertension do not adhere to anti-hypertensive treatment.[3]

Several strategies have been implemented globally and nationally to fight hypertension, one of the most recent and ambitious ones is the May Measurement Month (MMM), created by the ISH.[1,2] The MMM is a cross sectional study which aim is the raise awareness and determine prevalence, control and associations related to elevated BP.[1,2] In 2018, our national medical students' association (AMMEF) performed a longitudinal pilot study across Mexico about knowledge and control of hypertension. However, the methodological complexity of that project has deterred its analysis and publication.

Justification

Social and economic consequences derived from hypertension have been devastating to health systems around the world.[4] There is a gap in hypertension awareness and control in our country.[5] And more information is needed about the characteristics of people who live with uncontrolled hypertension in Mexico.

As previously mentioned, our association has tried to contribute in increasing the knowledge about this phenomenon. However, study designs previously selected for this purpose were too ambitious to be carried nationally by medical students and no background information was obtained prior its implementation to justify the need of such type of study.

This is the reason why a cross-sectional design is best suited to explore issues that could later be studied through a longitudinal methodology.

General objective

To perform an opportunistic blood pressure reading campaign in the Mexican population to raise awareness and study control of hypertension.

Specific objectives

- To measure BP in a population obtained by convenience sampling around Mexico
- Apply the ISH MMM Questionnaire to determine associated factors
- Raise awareness of hypertension
- Raise awareness of the importance of knowing one's BP numbers through printed materials and talks at screening sites
- Estimate the prevalence of hypertension, the proportion of controlled and uncontrolled individuals within the study population
- Compare hypertension prevalence, awareness and control of participants between states of Mexico

Methodology

Study design

A cross-sectional study, based off an opportunistic screening campaign.

Sampling

Convenience sampling will be the method to include participants in the study given the characteristics of an opportunistic screening campaign. We have not calculated a sample size to reach statistical power.

Temporality

All training about BP measurement and questionnaire application should be carried out before June 10 2019. A first phase of screening at hospitals and clinics waiting rooms and entrance will be performed from June 10 to August 9, 2019. A second phase of screening in public spaces will be carried out from Septembter 23 to October 21, 2019 in the same cities as the hospital/clinic screenings were performed.

Territory

This is protocol is applicable throughout Mexico.

Inclusion criteria

- People older than 18 yeas of age
- Informed consent by participants conforming to local dispositions (an informed consent form will be provided as a document and digital to local screening teams)

Proceedings

- Students should give ample information about the study to participants as well as obtain informed consent to participate. All information (including written material) should be given in a clear and easy to understand language.
- Data collection about the screening site and basic demographic information
    - All data must be collected and registered before BP readings.
    - If using the digital format (see Questionnare below), data will not be changed and therefore should be registered only one time
    - Indispensable information includes: City and state, address of screening site, date, participant's age, sex, at least 1 BP reading of systolic blood pressure and diastolic blood pressure, and heart rate.
- Other variables that should be registered when available:
    - Screening site identification and/or e-mail from the center at which is screening took place
    - Type of screening site: hospital/clinic, pharmacy, workplace, open public space, closed public space, home, other
- Students must apply the questionnaire to all screenees according to training, and after completion perform the BP reading.

May Measurement Month by the International Society of Hypertension Questionnaire

- The Questionnaire should be fill into the digital format or using the official printed version
    - When was the last time you had your blood pressure read? Never / >12 months ago / <12 months ago
    - Have you been diagnosed with hypertension/high blood pressure by a health professional? Yes / No
    - Currently, are you taking any medication/prescription for hypertension/high blood pressure? Yes / No / Does not know, if YES:
        - How many drugs are you taking for your blood pressure? 1 / 2 / 3 / 4 / 5 or more
    - Are you taking a statin (give examples)? Yes / No
    - Are you taking aspirin (give alternative names)? Yes / No
    - If WOMAN: Are you pregnant? Yes / No
        - Has your blood pressure increased in this or a previous pregnancy? Yes / No
    - Self-declared ethnic origin
    - Right now, are you fasting? Yes / No

    - Do you have diabetes or have been diagnosed with diabetes by a doctor? Yes / No / Does not know
    - Do you smoke or use any tobacco product? Yes / No
    - Do you consume alcohol? Never or almost never / 1-3 times per month / at least 1 time per week
    - Have you had a heart attack? Yes / No / Does not know
    - Have you had a stroke? Yes / No / Does not know
    - Height (measured at screening site [preferably] or declared if not possible to measure, approximate if necessary)
    - Weight (measured at screening site [preferably] or declared if not possible to measure, approximate if necessary)
- Systolic blood pressure (1-3 readings)
- Diastolic blood pressure (1-3 readings)
- Heart rate (1-3 readings)
- Name of the brand and model of the device(s) used to perform BP reading

Blood pressure readings

- All students must use the method described in: https://youtu.be/9kesU_3_7As to perform BP readings.
- BP should preferably be measured by an automated electronic device or, if this is not available, a conventional sphygmomanometer using a stethoscope can be used.
    - If a sphygmomanometer is used, the first and fifth Korotkoff sounds (the appearance and disappearance of sounds) will be recorded as the systolic and diastolic BP.
- BP should be measured on the upper-arm
- Ensure that the correct size of arm cuff is used
    - For arms with circumference < 32 cm, use regular cuff
    - For arms with circumference 32-42 cm, use large cuff
    - For arms with circumference >42 cm, use extra-large cuff
    - For arms with circumference <20cm use paediatric cuff
    - The cuff should be placed at the heart level
- The screenees' arm being used for the measurement should rest comfortably on a table
- BP should be measured on one arm only, preferably left
- Prior to measurement:
    - The participant should be seated with their backs supported, legs uncrossed and feet flat on the ground for 5 min (during which time the Questionnaire should be applied)
    - Participants should not have smoked immediately before or during the measurement and should not talk during and between BP measurements.
- Three (3) BP readings should be taken with 1 min between readings and recorded
- For each BP reading, the automated BP devices also provide data on heart rate, and this information should also be captured
- If the auscultatory method/sphygmomanometer is used, the heart rate should be established during the 1 minute after each BP reading, and also recorded

Definitions

- Hypertension
    - Hypertension was defined as a systolic blood pressure (SBP) ≥140 mmHg or a diastolic blood pressure (DBP) ≥90 mmHg in at least two of the readings, OR
    - Taking at least one anti-hypertensive agent.
- Unaware hypertensive
    - Those that satisfy the hypertension definition at screening but did not have a previous diagnosis or treatment.
- Controlled hypertensive
    - Those with normal BP values at screening but with a previous diagnosis or treatment for hypertension.
- Uncontrolled hypertensive
    - Those that complied hypertension criteria at screening and had a diagnosis and/or treatment for hypertension.

Addressing bias

- As a cross-sectional study using a convenience sample, selection bias is inherent to the study design.
- To minimize detection bias, multiple BP readings will be performed by students to each participant.
- All students at screenings sties MUST have taken part of standardized BP reading trainings facilitated by local screening teams.
- There is a great risk for recall bias in this study, given that a questionnaire is going to be applied as a measurement tool.
- Training MUST be provided to all students at screening sites to correctly apply our questionnaire according to the approved script, avoiding asking the same questions multiple times or in multiple ways to get a specific answer and creating a new source of recall bias apart from the participant memory.

Materials to be used at screening site

- Mobile devices with Internet access to the digital Questionnaire or printed copies of the Questionnaire (MMM_Cuestionario.pdf)
- Stethoscope
- Sphygmomanometer (aneroid)
- Digital BP reading devices
- Calibrated body weight scales
- Calibrated stadiometer
- Printed copies of informed consent (InformedConsent_Example.docx)
- Tables, chairs and tents as necessary

Recommendations that could be made to screenees

- Reducing salt consumption
- Moderate ingest of alcohol
- Stop smoking

- Reducing caffeine consumption
- Reducing sugar and fat consumption
- Regular physical activity at least 30 minutes a day, almost every day
- Consumption of fruits and vegetables every day
- Maintaining a normal body weight
- Avoiding stress as possible and having relaxation momments

Statistical analysis

- Sample size was not calculated, in aims to include the largest number of participants as attainable by the local screening teams.
- Analysis will include, but not be limited to:
    - Hypertension prevalence in study population
    - Proportion of unaware patients
    - Proportion of controlled patients
    - Proportion of uncontrolled patients
    - Relationship between associated factors and change in BP compared to non-hypertensive patients

Ethical issues

- Conforming to local dispositions. All participants should give their informed consent to be included, which will be recorded in the digital and/or printed forms.
- All participants must receive a verbal and/or written explanation of the study.

References

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