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Impact of the 2017 ACC/AHA guidelines on the prevalence of prehypertension and hypertension: a cross-sectional analysis of 10799 individuals.

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Impact of the 2017 ACC/AHA guidelines on the prevalence of prehypertension and hypertension: a cross-sectional analysis of 10799 individuals.

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ABSTRACT

Objectives To assess the effect of the 2017 ACC/AHA hypertension guidelines on the prevalence of prehypertension and hypertension and the eligibility for the initiation of antihypertensive treatment in the Saudi population.

Design A cross-sectional study.

Participants A total of 10,799 adults (≥18 years old) with three blood pressure readings, during 2017-2020 from the Saudi Biobank (SBB) was used.

Primary outcome Hypertension was defined using three sources: the JNC-7 guidelines (SBP≥140 or DBP≥90 mmHG), the 2017 ACC/AHA guidelines (SBP≥130 or DBP≥80 mmHg), and a self-reported hypertension diagnosis.

Results The prevalence of prehypertension, based on the JNC-7 guidelines, was 49.23% (95% CI: 49.04, 49.42), and on the 2017 ACC/AHA guidelines, 15.78% (95% CI: 15.66, 15.91), a reduction of 33.45%. The prevalence of hypertension, according to JNC-7 guidelines, was 14.49% (95% CI: 14.37, 14.61), and the ACC/AHA, 40.77% (95% CI: 40.60, 40.94), an increase of 26.28 %. Using the two definitions, the risk factors are older age, male gender, diabetes diagnosis, increased body mass index (BMI), increased waist circumference, and waist-to-hip ratios. A small proportion (16.42%) of the hypertensive individuals are currently prescribed medications based on the JNC-7, and 67.77% are on recommended treatment according to the ACC/AHA.

Conclusions Unless public health prevention efforts are adopted, the increased prevalence of prehypertension and hypertension will increase cardiovascular diseases, a leading cause of mortality globally.

Strengths and limitations of this study

- The study provide data from the Saudi Biobank on the prevalence and determinants of prehypertension and hypertension for adult females and males.
- We ascertained the hypertensive status using BP measurements, self-report, and antihypertensive use.
- The cross-sectional design limit our ability to assess the temporal relationship between our independent factors and prehypertension/hypertension.

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- There was no ambulatory BP data for the participants, which may overestimate some individuals who may have white coat hypertension; however, the prevalence of white coat hypertension is approximately 3% in a Saudi cohort, which is too small to affect the prevalence data.

Keywords: Hypertension; Guidelines; Saudi Arabia; Prevention; Biobank; Blood pressure, Cardiovascular, Antihypertensive drugs

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INTRODUCTION

Hypertension is the most prevalent risk factor for cardiovascular diseases (CVDs). It is the main contributor of CVDs related morbidity and mortality[1] and the cause of more than 9.4 million annual preventable deaths globally[2]. The global number of patients with hypertension is expected to increase by 60% between 2000 and 2025[3]. Risk factors that contribute to the increased prevalence of hypertension are increasing age, male gender, lifestyle factors such as smoking, alcohol consumption, unhealthy diet, sedentary lifestyle, and increased weight[4]. Though the burden of hypertension is substantial, detecting and controlling Blood Pressure (BP) levels at the prehypertension stage will reduce the risk and burden of CVDs[5].

Identifying the optimal BP levels for the definition of prehypertension and hypertension, has been controversial [6]. Based on evidence from Randomized Controlled Trials (RCTs) and other observational studies, the American College of Cardiology and the American Heart Association (ACC/AHA) developed the Hypertension Practice Guidelines in 2017-

"The ACC/AHA Guidelines for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults" [7]. The guidelines lowered the threshold categories of hypertension from ≥140 mmHg Systolic Blood Pressure (SBP) or ≥90 mmHg Diastolic Blood Pressure (DBP) to ≥130 mmHg SBP or ≥80 mmHg DBP. Prehypertension, or according to the guidelines "elevated BP," is now limited to individuals with a SBP of 120-129 mmHg and DBP <80 mmHg instead of 120-139 mmHg or 80-89 mmHg suggested by the Joint National Committee 7 Blood Pressure Guidelines (JNC-7)[8]. Although not endorsed by some organizations, the new lower BP categories have been assessed in a systematic review and meta-analysis and were associated with a lower risk of CVDs[9].

Recent estimates from Saudi Arabia indicate the overall prevalence of prehypertension was 40.6%-54.9%, and hypertension 15.0%-26.1% [10-12]. The current estimates indicate that men have a higher prevalence of prehypertension and hypertension than women, for instance, 48.1% of women and 66.1% of men were prehypertensive, with 6%-10.2% of men and 4.2%-12.8% of women hypertensive [11]. Although the use of ACC/AHA guidelines is expected to increase the prevalence of prehypertension and hypertension [13], the amount of the increase is unclear. It is also not known whether women will have a greater change in prevalence than men and which individuals' characteristics will have an impact on the prevalence of hypertension.

We designed the current study to measure the prevalence of hypertension and to assess the change in prevalence according to the ACC/AHA guidelines compared to the Joint National Committee 7 Blood Pressure Guidelines (JNC-7). We also aimed to evaluate the determinants of prehypertension and hypertension among the population of the Saudi Biobank (SBB). Finally, we aimed to measure the use of antihypertensive medications and

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compare the use with the recommended medication according to the ACC/AHA guidelines. The results will be useful for public health officials and health care providers to plan and implement primary, secondary and tertiary prevention interventions. These interventions reduce the burden of hypertension in addition to the morbidity and mortality associated with CVDs.

MATERIALS AND METHODS

Data sources

The Institutional Review Board of King Abdullah International Medical Research Center (IRB#139 RC19/028/R) approved the study. The study has a cross-sectional design using data from the SBB. The SBB is an ongoing project to investigate the current health behavior of the Saudi population. The project aims to investigate the fundamental mechanisms of diseases by combining bio-specimens and survey data, sociodemographic and medical history information. The current study only used the survey data available from the survey part of the SBB.

Patient and Public Involvement

No patient involved.

Survey development and administration

The SBB research team created the survey based on a previously developed and validated questionnaire. The questionnaire partly corresponds to other similar population biobank projects to allow for comparability between the Saudi population and other populations. The preliminary survey questions were pilot tested, and the questions were revised according to the findings. The questionnaire includes the following sections: Date and Location of Recruitment, Demographic Information, Family Information, Housing

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Information, General Health Status, Personal and Family Medical History, History of Personal and Family Medications Use, Disabilities, Others, Women and Men Health, Health Behaviors, Nutrition, Physical Activity, and Anthropometric Measurements.

The questionnaire items are primarily closed-ended questions with Likert scale responses. For example, to assess a person's overall health status, a 5-point Likert scale rating was used with the designation of Excellent, Very Good, Good, Not Too Bad, and Weak. To evaluate the time a person spends sitting, standing, or walking while at work, a 5-point Likert scale rating was used as Never, Few Times, Sometimes, Most Times, and All Times. The questionnaire is administered to participants by trained research coordinators. Before obtaining consent and completing the questionnaire, the coordinators describe the SBB objectives, the benefits of study participation, the security and privacy of collected information, voluntary participation, and the unconditional withdrawal from the study.

Study population and data extraction

The study population are adults (≥18 years old) who participated in the survey from December 10th, 2017 to January 29th, 2020 with three recorded BP measurements. The data related to the prescribed antihypertensive medications was extracted from the electronic medical records.

Measurement method for blood pressure

The BP was measured using a calibrated sphygmomanometer and arm cuffs (Omron 705it or Omron M3). Research coordinators are trained to measure the BP once the participants are rested, with legs uncrossed. The average of the three BP measurements was computed and used as the final BP reading.

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Blood pressure classification

Using the JNC-7 guidelines, BP was categorized into four categories: normal (SBP<120 and DBP<80 mmHg), prehypertension (SBP=120-139 or DBP=80-89 mmHg), stage 1 (SBP=140-159 or DBP=90-99 mmHg) and stage 2 (SBP≥160 or DBP≥100 mmHg) [8]. Using the ACC/AHA guidelines, BP was also categorized into four categories: normal (SBP<120 and DBP<80 mmHg), elevated (SBP=120-129 and DBP<80 mmHg), stage 1 (SBP=130-139 or DBP=80-89 mmHg) and stage 2 (SBP≥140 or DBP≥90 mmHg) [7]. Individuals with BP measurements in stage 1 or stage 2 were considered as diagnosed with hypertension.

Data collection and definitions

The participants' sociodemographic information, including age, gender, marital status, education level, occupation, and family income, was extracted from the SBB data. In addition, behavioral health factors such as physical activities, smoking status, including shisha use, dietary intake, and comorbidities, were retrieved. The waist and hip circumferences, height, and weight measurements were categorized as suggested by Lear et al. [14]. Comorbidities such as a diagnosis of diabetes mellitus or any CVD were self-reported.

Age was reported as a continuous variable and categorized into 18-29, 30-39, 40-49, 50-59, and ≥60-year. Marital status was classified into three categories; married as one category, never married and divorced as another category, and separated and widowed as a single category. Employment status included retired, unemployed-wives, and others combined into one category, never employed and ex-employed in one category, business

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owner, and currently employed as one category and student as a single category. Educational attainment was categorized into seven groups: literate and low literacy under a separate category called less than primary school (<primary school), primary, intermediate, high school, some college, bachelor's degree, and higher education. The daily consumption of tea or Arabic coffee was categorized in: none, 1-2 servings, 3-4 servings, 5-6 servings, 7-9 servings, and ≥ten servings; the daily intake of fruit and vegetables 0-1, 2, 3 and ≥4; the daily soda and black coffee consumption in none, 1-2, 3-4 and ≥5. Additionally, weekly vigorous-, moderate-, or light-exercises that lasted more than 15 minutes was categorized in never, 1, 2-3, 4-5, and > 5. Time spent sitting, standing, or walking while at work was categorized into never, a few times, sometimes, most of the time and all the time.

Prescription data

We used the medical records and pharmacy data to identify participants with an antihypertensive medication prescription. We identified patients with a diagnosis of hypertension in their medical file and at least one prescription of antihypertensive medication were also identified [15]. The antihypertensive drugs used were beta-blockers, calcium channel blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, diuretics, and centrally or peripherally acting agents found in the pharmacy files during the diagnosis year.

Data analysis

The data were analyzed using SAS statistical software version 9.4 (SAS Institute Inc. Cary, NC). Descriptive data for the sample, stratified by gender are presented as frequency and percentage for categorical variables, and continuous variables are presented as a mean and

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standard deviation (SD). Also, for each BP category the mean, SD, median, interquartile range (IQR), minimum and maximum value was calculated. Hypertension was defined as SBP ≥130 mmHg or DBP≥90 mmHg according to ACA/AHA and SBP ≥140 mmHg or DBP≥90 mmHg, based on JNC-7 guidelines [7,8]. The prevalence of hypertension was calculated by dividing the total number of hypertensive individuals by the total of the normotensive and prehypertensive individuals. The prevalence of prehypertension was measured by dividing the total number of prehypertensive by normotensive individuals. The prevalence of hypertension and prehypertension and the 95% CI were calculated using the Wald binomial method.

Missing covariates data were handled using the multiple imputation by chained equations (fully conditional method), assuming that data are missing at random (MAR). The missing data ranges from 0% to 30%, and 30 imputations were conducted. Given the arbitrary pattern of the missing data, the PROC MI procedure was used with the "FCS regpmm" statement for continuous variables and the "FCS logistic" for categorical variables[16]. Univariate and multivariate logistic regressions were conducted using the multiple imputed data to estimate the odds ratio (OR) and the adjusted odds ratio (AOR). Backward elimination was used to determine variables included at the multivariate level. Collinearity was assessed using the SAS Macro condition indices (CNIs) and variance decomposition proportions (VDPs) with CNIs of >30 and at least two VDPs ≥0.50 indicating collinearity [17]. The linearity of continuous variables with the log odds of the outcome variables was checked using the fractional polynomial method [18]. All statistical tests were 2-sided, and findings were considered statistically significant at $P < .05$. STROBE cross-sectional guidelines were used to assure that all essential elements are reported and covered [19].

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RESULTS

Descriptive statistics

A total of 11571 individuals were captured in the SBB. After excluding individuals <18 years old (n=327) and with less than three BP readings (n=445), the final sample was 10799 individuals (women=5302 and men=5497). The overall characteristics of the study sample stratified by gender are summarized in Table 1 and Table 2. The average age was 30 years, and the majority (94%) were younger than 40 years. Compared to women, men were more likely to never have been married, presently employed, and have higher incomes but lower educational status than women. A small proportion (1.24%) of the women smoked compared to 30.74% of the men, who were more likely to report being physically active and less likely to be obese. Table 3 presents the BP measurements based on JNC-7 and ACC/AHA guidelines; the mean BP of stage 1 hypertensive patients based on the JNC- 7 classification was 140.1±10.5/87.9±7.7 mmHg compared to 126.5±9/ 80.9±5.9 mmHg according to the ACC/AHA guidelines. The prevalence of hypertension increased from 14.49% (95% CI: 14.37-14.61) based on the JNC-7 guidelines to 40.77% (95% CI: 40.60-40.94) based on ACC/AHA guidelines; an increase of 26.28% (Table 4). The difference in the prevalence of prehypertensive patients was from 15.78% based on the JNC-7 guidelines to 49.23% based on the ACC/AHA guidelines (Table 5).

Hypertension in men and women from different age groups

Figure 1 demonstrates the prevalence of hypertension in males and females from different age groups using the JNC-7 and ACC/AHA guidelines. For females, using the JNC-7, the prevalence of hypertension was the highest in 50-59 year age group (33.4%); however, using the ACC/AHA, the prevalence of hypertension in the same age group increased to

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63.40% and became the second highest prevalence. In terms of the males, using the JNC-7, the 50-59 year age group, had the highest hypertension prevalence (40.46%) the same age groups had the highest prevalence for hypertension (70.99%) when using the ACC/AHA guidelines.

BP stages in different age groups using the 2017 ACC/AHA guidelines

Figure 2 illustrates the prevalence of the BP stages in different age groups. In the age group of 60 and older, 10.98% were prehypertensive, 34.92% in stage 1, and 34.15 % in stage 2 of hypertension, with only 19.96% normotensive. In contrast, in the 30-39 year age group, 13.94% were prehypertensive, 28.9% in stage 1, 14.62% at stage 2, and 42.54% normotensive.

BP stages in male and female using the 2017 ACC/AHA guidelines

Figure 3 demonstrates the prevalence of BP stages in males and females. In the females, 52.24% had a normal BP, 14.03% were prehypertensive, 23.15% in stage 1, and 10.58% at stage 2 of hypertension. For the males, however, 34.74% of the males had normal BP, 17.5% prehypertensive, 29.27% in stage 1, and 18.48% at stage 2 hypertension.

Determinants of hypertension and prehypertension/elevated BP

Hypertension determinants, according to the ACC/AHA and JNC-7 guidelines are presented in Table 4 (adjusted for all variables shown in the tables). According to the ACC/AHA guidelines, the determinants of hypertension were increasing age, male gender, being a student or unemployed, having diabetes, increasing BMI, particularly with abdominal adiposity. The odds of hypertension were significantly highest for adults who were in the 50 to 59-year age group *vs*. the 18-29- year age group (adj OR: 2.28, 95% CI: 1.72,3.03), men *vs*. women (adj OR: 2.79 95% CI: 2.51,3.11) and students *vs.* employed

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(adj OR: 1.36, 95% CI: 1.14,1.63). Notably, diabetic adults were 67% more likely to develop hypertension compared to non-diabetics (adj OR:1.67, 95% CI: 1.37,2.04), and obese (adj OR: 3.17, 95% CI: 2.52,3.99) or extremely obese (adj OR: 4.64, 95% CI: 3.31,6.52) compared to the underweight individuals. Individuals with a high waist circumference and a high waist-to-hip were 32% (adj OR: 1.32, 95% CI: 1.17, 1.50) and 27% (adj OR: 1.27, 95% CI: 1.13, 1.43) more likely to develop hypertension compared to their counterparts. Unlike the JNC-7 guidelines, per the 2017 ACC/AHA guidelines, individuals practicing vigorous weekly-exercise were consistently less likely to develop hypertension.

Determinants of hypertension based on JNC-7 guidelines were increasing age, male gender, employment status, time spent standing while at work, diabetes, and increasing BMI, mostly central obesity. For instance, the odds of hypertension were highest in the 50-59 year age group (adj OR: 3.23, 95% CI: 2.34, 4.44) compared to adults 18-29 years old, in men vs. women (adj OR: 3.10, 95% CI: 2.66, 3.60), in unemployed compared to employed (adj OR: 1.35, 95% CI: 1.03, 1.78), and for individuals standing at work most of the time compared to never (adj OR: 2.66, 95% CI: 1.48, 4.76). In addition, diabetic adults were 64% more likely to develop hypertension compared to non-diabetics (adj OR: 1.64, 95% CI: 1.34,2.00), adults who are obese (adj OR: 2.97, 95% CI: 2.04,4.34), or extremely obese (adj OR: 5.24, 95% CI: 3.35,8.19), compared to underweight and individuals with an abnormal waist circumference (adj OR: 1.53, 95% CI: 1.29,1.81), or waist-to-hip ratio (adj OR: 1.19, 95% CI: 1.02,1.38) compared to their counterparts. Contrary to the 2017 ACC/AHA guidelines, using the JNC-7 guidelines, married individuals were less likely than never-married individuals to develop hypertension.

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Finally, the predictors of prehypertension/elevated BP, adjusted for all covariates in the table, are presented in Table 5. Elevated BP determinants (according to ACC/AHA) were being male, a student or unemployed, sitting at work a few times, sometimes or most of the time, and having an increased BMI. The odds of elevated BP were significantly highest in men compared to women (adj OR: 2.86, 95% CI: 2.45, 3.33), in students vs. employed (adj OR: 1.63, 95% CI: 1.27, 2.10) and in individuals who sometimes sat at work (adj OR: 2.56, 95% CI: 1.21, 5.44) compared to never. Both obese and extremely obese individuals had increased odds of elevated BP by 3.33 fold (95% CI: 2.44, 4.54) and 4.76 fold (95% CI: 2.84, 7.98), compared to underweight individuals.

In contrast, the prehypertension determinants based on the JNC-7 guidelines were male gender, being student or unemployed, having diabetes, increased BMI, with an abnormal waist circumference or waist-to-hip ratio. Men had three times the odds of prehypertension compared to women (adj OR: 3.00, 95% CI: 2.67, 3.37). Besides, being a student increased the odds of 58% (adj OR: 1.58, 95% CI: 1.31, 1.90) compared to the employed. The odds of prehypertension were significantly higher for diabetic individuals (adj OR: 1.29, 95% CI: 1.04, 1.59), individuals with an increased BMI, and individuals with and abnormal waist circumference or waist-to-hip ratio. Finally, individuals who reported moderate weekly-exercises, and who reported to consume fruit and vegetables, were all less likely to develop prehypertension compared to their counterparts.

Medication utilization

According to the JNC-7 guidelines, the sample included 435 adults with a self-reported diagnosis of hypertension by a healthcare provider (Figure 4). The majority (n=359) did not have antihypertensive medication records, and 172 of the 359 were not hypertensive

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based on their BP measurements. Accordingly, 76 of the 1565 hypertensive patients (per JNC-7) had records of antihypertensive medication use and were hypertensive. The majority (60.5%) had uncontrolled hypertension. Most of the adults with uncontrolled hypertension were male (65.1%), with an average age of 40.8 (men: 42.5, women: 39.75), and had an average SBP of 151.03 and DBP of 97.64 mmHg. The comparisons of adults who are on the recommended antihypertensive medications (using ACC/AHA) compared to individuals actually prescribed the medications are displayed in Figure 5.

DISCUSSION

The current study assessed the impact of the 2017 ACC/AHA guidelines definitions of prehypertension and hypertension and the level of awareness and control of hypertension of Saudi adults. The implementation of the 2017 ACC/AHA guidelines will result in an increase of 26.28% in the prevalence of hypertension, which is an increase from 1.8 million hypertensive adults into 5.1 million adults according to the latest census estimates of Saudis ≥18 years old [21]. The increase is predominantly observed in men (47.72%) vs. women (33.57%), in individuals ≥60 years old (70.13%), diabetics (62.37%), and individuals who are obese (56.12%).

Prior research in Saudi Arabia reported the prevalence of hypertension ranging from 15.0%-26.1% [10-12]. The findings of the current study estimated the prevalence of hypertension as 14.49%, similar to previous studies. The findings that 40.77% of the population are considered hypertensive according to the 2017 ACC/AHA guidelines are alarming. The observation that 2 out of 5 Saudi adults could be diagnosed with hypertension heralds a sharp increase in the utilization of healthcare services, including

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more clinic visits, increase in prescription, and potential implications for insurance, which will place a significant burden on the Saudi healthcare system.

The risk factors for hypertension in the Saudi population have been investigated previously. However, in the current study, we compared these factors according to the two guidelines. With both guidelines, the predictors of hypertension were male gender, increasing age, diabetes mellitus, and obesity, particularly abdominal obesity, findings similar to prior studies except for education, which was a predictor in some studies[12]. We reported four differences in the predictors of hypertension between the two guidelines. Firstly, marital status was a protective factor of hypertension development according to the JNC-7 guidelines only. Secondly, employment status was a risk factor per 2017 ACC/AHA alone (except unemployment with the JNC-7 guidelines). Thirdly, weekly vigorous-exercise was a protective factor based on the 2017 ACC/AHA. Fourthly, time standing at work was a risk factor for hypertension, according to the JNC-7 guidelines. For the predictors of prehypertension, diagnosis of diabetes, and abnormal waist circumference and waist-to-hip ratio were significantly associated with prehypertension according to the JNC-7 guidelines.

Based on our findings, we recommend the following three public health prevention measures to be implemented at a population level. Firstly, for the average-risk normotensive individuals, primary preventions should be applied to prevent or delay the occurrence of hypertension. Examples include practicing a healthy lifestyle such as eating a healthy diet, maintaining a healthy weight, avoiding smoking, and being physically active [8]. These non-pharmacological interventions have been endorsed by the 2017 ACC/AHA guidelines based on several observational and randomized controlled trials [21]. For instance, in normotensive individuals, engaging in physical activities of 90-150 minutes/week is

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associated with a reduction of 2-4 mmHg in systolic BP [22]. Although it is unfortunate that most of our population (70.70%), especially women (84.25%), reported never being engaged in any moderate exercise, governmental efforts through the Quality of Life program are ongoing to promote physical activities. Future studies should assess the impact of these programs on the incidence of hypertension.

Secondly, high-risk individuals who are non-hypertensive but at an increased risk of CVDs (e.g., overweight, smokers) and prehypertensive individuals, should be targeted for secondary prevention strategies. The goal is to achieve even lower BP levels compared to normotensive individuals. Primary Care Physicians (PCPs) are key players and have an essential role in detecting the disease and initiating non-pharmacologic treatment, including lifestyle modifications [23].

Finally, for individuals with established hypertension, the goal of tertiary prevention is to control the hypertension and prevent the risk of CVDs. In addition to maintaining ideal body weight, consuming a healthy diet, and being physically active, the current Saudi guidelines, which are based on JNC-7, recommend pharmacological intervention in patients with stage 1 hypertension with a CVDs risk of ≥10% or stage 2 hypertension [24]. In our study, though 28% of hypertensive individuals were aware of their condition, only 58% had a prescription for antihypertensive medications and 60.50% were uncontrolled. However, it is unclear whether the uncontrolled hypertension is due to patient factors such as lack of medication adherence or the providers' inability to titrate antihypertensive treatment when the BP is suboptimal. For instance, half of the patients on a single antihypertensive agent were uncontrolled, compared to 12% uncontrolled in the group who

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received ≥ four antihypertensive medications. A multidisciplinary disease management strategy and follow-up of patients with uncontrolled BP should be emphasized.

STRENGTHS AND LIMITATION

Our study has several strengths. Firstly, we used a large sample of the Saudi population (n=10799) from diverse backgrounds (e.g., wives, professionals, students, and unemployed women). Secondly, we ascertained the hypertensive status using BP measurements, self-report, and antihypertensive use. Our study also has several limitations. Firstly, the study is limited to the capital of Saudi Arabia, Riyadh. However, given the characteristics of the participants, we believe that the geographic location is unlikely to affect the external validity of our findings. Secondly, we relied on the medical and pharmacy files to identify users of antihypertensive medications, and we may have missed some patients who were not identified with this approach. However, we only described the use of antihypertensive medications in the study and the effect estimate is not impacted. Thirdly, smoking was not a predictor of hypertension in this study, which could be because of reverse causation (i.e., patients with hypertension have changed their behavior and quit smoking). In a sensitivity analysis, after excluding stage 2 hypertension patients (the severe cases who are more likely to quit), the multivariate regression in the JNC patients showed insignificant results; OR: 0.84 (0.71, 1.00), but the effect estimates remained unchanged in the ACC/AHA patients (OR: 0.79, 0.60, 0.91). Lastly, we do not have ambulatory BP data for the participants, which may overestimate some individuals who may have white coat hypertension; however, the prevalence of white coat hypertension is approximately 3% in a Saudi cohort, which is too small to affect the prevalence data.

CONCLUSION

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The new hypertension guidelines resulted in an alarming increase in the prevalence of hypertension and prehypertension, with implications for an escalation in healthcare costs. Unless strong public health measures are adopted, including the implementation of lifestyle changes at a population level in conjunction with the aggressive management of hypertension, we are likely to see an upward trend in the prevalence of hypertension and associated cardiovascular morbidity and mortality.

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Data not available due containing sensitive information that might expose the subject's identity.

AUTHOR STATEMENT

MA designed the study, conducted the analyses, and wrote the manuscript. RG collected data, conducted analyses, and drafted manuscript. GA, ADA, AHA, and AM helped with the study design and assisted with the manuscript preparation. All authors helped with

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manuscript revisions. GA helped with data acquisition. All authors have read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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REFERENCE:

1. Zhou DP, Xi BP, Zhao MP, Wang LP, Veeranki SP. Uncontrolled hypertension increases risk of all-cause and cardiovascular disease mortality in US adults: the NHANES III Linked Mortality Study. Scientific Reports [Internet]. 2018;8(1). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6010458/.

2. A global brief on Hypertension [Internet]. World Health Organization; 2013 [cited 2020May17]. Available from: https://ish-world.com/downloads/pdf/global_brief_hypertension.pdf.

3. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. The Lancet [Internet]. 2005;365(9455):217–23. Available from: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(05)17741-1/fulltext.

4. Islam JY, Zaman MM, Haq SA, Ahmed S, Quadir ZA-. Epidemiology of hypertension among Bangladeshi adults using the 2017 ACC/AHA Hypertension Clinical Practice Guidelines and Joint National Committee 7 Guidelines. Journal of Human Hypertension [Internet]. 2018;32(10):668–80. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6207562/#CR1 .

5. Han M, Li Q, Liu L, Zhang D, Ren Y, Zhao Y, et al. Prehypertension and risk of cardiovascular diseases. Journal of Hypertension [Internet]. 2019;37(12):2325–32. Available from: https://pubmed.ncbi.nlm.nih.gov/31335511/.

For peer review only

6. Bolli P, Hemmelgarn B, Myers MG, Mckay D, Tremblay G, Tobe SW. High normal blood pressure and prehypertension: The debate continues. Canadian Journal of Cardiology [Internet]. 2007;23(7):581–3. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2650764/.

7. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Himmelfarb CD, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension [Internet]. 2018;71(6):1269–324. Available from: https://pubmed.ncbi.nlm.nih.gov/29133354/.

8. National High Blood Pressure Education Program. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure [Internet]. National Center for Biotechnology Information. US National Library of Medicine; [cited 2020May14]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK9630/.

9. Reboussin DM, Allen NB, Griswold ME, Guallar E, Hong Y, Lackland DT, et al. Systematic Review for the 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association

For peer review only

Task Force on Clinical Practice Guidelines. Hypertension [Internet]. 2018;71(6). Available from: https://pubmed.ncbi.nlm.nih.gov/29133355/.

10. El Bcheraoui, C., Memish, Z. A., Tuffaha, M., Daoud, F., Robinson, M., Jaber, S., ... & Al Rabeeah, A. A. (2014). Hypertension and its associated risk factors in the Kingdom of Saudi Arabia, 2013: a national survey. International journal of hypertension, 2014. Available from: https://pubmed.ncbi.nlm.nih.gov/25170423/

11. Aldiab A, Shubair MM, Al-Zahrani JM, Aldossari KK, Al-Ghamdi S, Househ M, et al. Prevalence of hypertension and prehypertension and its associated cardioembolic risk factors; a population based cross-sectional study in Alkharj, Saudi Arabia. BMC Public Health [Internet]. 2018;18(1). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6267095/.

12. Saeed AA, Al-Hamdan NA, Bahnassy AA, Abdalla AM, Abbas MAF, Abuzaid LZ. Prevalence, Awareness, Treatment, and Control of Hypertension among Saudi Adult Population: A National Survey. International Journal of Hypertension [Internet]. 2011;2011:1–8. Available from: https://pubmed.ncbi.nlm.nih.gov/21912737/.

13. Kibria GMA, Swasey K, Kc A, Mirbolouk M, Sakib MN, Sharmeen A, et al. Estimated Change in Prevalence of Hypertension in Nepal Following Application of the 2017 ACC/AHA Guideline. JAMA Network Open [Internet]. 2018;1(3). Available from: https://pubmed.ncbi.nlm.nih.gov/30646022/.

For peer review only

14. Lear SA, James PT, Ko GT, Kumanyika S. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. European Journal of Clinical Nutrition [Internet]. 2009Dec;64(1):42–61. Available from: https://www.nature.com/articles/ejcn200970 .

15. Bullano MF, Kamat S, Willey VJ, Barlas S, Watson DJ, Brenneman SK. Agreement between administrative claims and the medical record in identifying patients with a diagnosis of hypertension. Agreement between administrative claims and the medical record in identifying patients with a diagnosis of hypertension [Internet]. 2006May [cited 2020May17];44(5):486–90. Available from: https://journals.lww.com/lww-medicalcare/Abstract/2006/05000/Agreement_Between_Administrative_Claims_and_the.14.aspx.

16. Smith C, Kosten S. Multiple Imputation: A Statistical Programming Story.PharmaSUG.[Internet]. 2017[cited 2020May17]. Available from: https://www.pharmasug.org/proceedings/2017/SP/PharmaSUG-2017-SP01.pdf.

17. Kleinbaum DG, Klein M. Logistic Regression a Self-Learning Text. New York, NY: Springer New York; 2010.

18. Hosmer DW, Lemeshow S, Sturdivant RX. Applied logistic regression. Hoboken, NJ: Wiley; 2013.

For peer review only

19. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

20. General Authority for statistics. Family Health Survey [Internet]. Household Health Survey 2017. General Authority of Statistics Kingdom of Saudi Arabia; 2017 [cited 2020Apr30]. Available from: https://www.stats.gov.sa/sites/default/files/household_health_survey_2017_1.pdf.

21. Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, et al. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation [Internet]. 2019Oct;140(11). Available from: https://pubmed.ncbi.nlm.nih.gov/30879355/.

22. Stefani L, Mascherini G, Tosi B, Galanti G. Hypertension Today: Role of Sports and Exercise Medicine. Journal Of Hypertension And Cardiology [Internet]. 2019;2(4):20–7. Available from: https://openaccesspub.org/jhc/article/1078.

23. Weltermann B, Kersting C, Viehmann A. Hypertension Management in Primary Care: A Cluster Randomized Trial of a Physician-focused Educational Intervention. Deutsches Aerzteblatt Online [Internet]. 2016Nov; Available from: https://pubmed.ncbi.nlm.nih.gov/27010951/.

24. Saudi Hypertension Management Society. Saudi Hypertension Guidelines. 2018.

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Table 1. Sociodemographic characteristics of the Saudi National Biobank, 2017-2020

Characteristics	Total (n=10799)		Men (n=5497)		Women (n=5302)	
	n	%	n	%	n	%
Age mean (SD)	30.05	8.85	29.78	8.52	30.34	9.18
18-29	6110	56.58	3189	58.01	2921	55.09
30-39	3140	29.08	1612	29.33	1528	28.82
40-49	1146	10.61	517	9.41	629	11.86
50-59	326	3.02	138	2.51	188	3.55
≥60	77	0.71	41	0.75	36	0.68
Marital status						
Never married	5874	54.39	3118	56.72	2756	51.98
Married	4587	42.48	2293	41.71	2294	43.27
Divorced	270	2.50	49	0.89	221	4.17
Missing	68	0.63	37	0.67	31	0.58
Employment						
Employed	5453	50.50	3852	70.07	1601	30.20
Unemployed	960	8.89	184	3.35	776	14.64
Student	2950	27.32	1201	21.85	1749	32.99
Retired/others	1307	12.10	155	2.82	1152	21.73
Missing	129	1.19	105	1.91	24	0.45
Family income						
≤5000	3487	32.29	1231	22.39	2256	42.55
5001 - 10,000	2371	21.96	1849	33.64	522	9.85
1,0001 - 15,000	1006	9.32	675	12.28	331	6.24
15,001 – 20,000	413	3.82	276	5.02	137	2.58
>20,000	221	2.05	176	3.20	45	0.85
Missing	3301	30.57	1290	23.47	2011	37.93
Education level						
< Primary school	119	1.10	23	0.42	96	1.81
Primary school	235	2.18	55	1.00	180	3.39
Intermediate school	372	3.44	154	2.80	218	4.11
High school	4557	42.20	2752	50.06	1805	34.04
Some college	759	7.03	591	10.75	168	3.17
Bachelor's degree	4346	40.24	1738	31.62	2608	49.19
Higher education	345	3.19	137	2.49	208	3.92
Missing	66	0.61	47	0.86	19	0.36
BMI (kg/m^2)						
Underweight	683	6.32	343	6.24	340	6.41

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Normal weight	4206	38.99	2108	38.35	2098	39.57
Overweight	3235	29.99	1741	31.67	1494	28.18
Obese	2386	22.12	1165	21.19	1221	23.03
Extremely obese	277	2.57	132	2.40	145	2.73
Missing	12	0.11	4	0.08	8	0.15
Waist circum., mean (SD)	82.39	(16.09)	88.52	(15.12)	76.01	(14.51)
Missing	105	0.97	43	0.78	62	1.17
Waist to hip ratio	0.81	(0.10)	0.87	(0.08)	0.75	(0.09)
Missing	112	1.04	45	0.82	67	1.26
Diabetes History						
No	10140	93.90	5161	93.89	4979	93.91
Yes	659	6.10	336	6.11	323	6.09
Blood pressure						
Systolic blood pressure	120.73	15.01	123.97	15.24	117.37	14.01
Diastolic blood pressure	75.24	10.70	76.46	10.70	73.97	10.56

Table 2. Selected lifestyle characteristics of the Saudi National Biobank, 2017-2020

Characteristics	**Total (n=10799)**		**Men (n=5497)**		**Women (n=5302)**	
	n	%	n	%	n	%
Tobacco use						
No	8811	81.59	3625	65.95	5186	97.81
Yes	1756	16.26	1690	30.74	66	1.24
Missing	232	2.15	182	3.31	50	0.94
Vigorous exercise (week)						
Never	7635	70.70	3168	57.63	4467	84.25
Once	744	6.89	571	10.39	173	3.26
2-3	944	8.74	615	11.19	329	6.21
4-5	740	6.85	556	10.11	184	3.47
>5	541	5.01	423	7.70	118	2.23
Missing	195	1.81	164	2.98	31	0.58
Time spent sitting						
Never	113	1.05	102	1.86	11	0.21
A few times	2259	20.92	1279	23.27	980	18.48
Sometimes	3058	28.32	1421	25.85	1637	30.88

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Most of the times	4841	44.83	2269	41.28	2572	48.51
All the times	304	2.82	242	4.40	62	1.17
Missing	224	2.07	184	3.35	40	0.75
Time spent standing						
Never	198	1.83	138	2.51	60	1.13
A few times	4098	37.95	1998	36.35	2100	39.61
Sometimes	4261	39.46	1997	36.33	2264	42.70
Most of the times	1864	17.26	1045	19.01	819	15.45
All the times	131	1.21	114	2.07	17	0.32
Missing	247	2.29	205	3.73	42	0.79
Time spent walking						
Never	204	1.89	150	2.73	54	1.02
A few times	3423	31.70	1741	31.67	1682	31.72
Sometimes	3847	35.62	1752	31.87	2095	39.51
Most of the times	2730	25.28	1332	24.23	1398	26.37
All the times	359	3.32	326	5.93	33	0.62
Missing	236	2.19	196	3.57	40	0.75
Cup of tea per day						
None	4233	39.20	1376	25.03	2857	53.89
1-2	4188	38.78	2282	41.51	1906	35.95
3-4	1309	12.12	954	17.35	355	6.70
5-6	432	4.00	332	6.04	100	1.89
7-9	147	1.36	130	2.36	17	0.32
≥10	303	2.81	275	5.00	28	0.53
Missing	187	1.73	148	2.69	39	0.74
Black coffee per day						
None	6524	60.41	3040	55.30	3484	65.71
1-2	3152	29.19	1711	31.13	1441	27.18
3-4	721	6.68	430	7.82	291	5.49
≥5	181	1.68	126	2.29	55	1.04
Missing	221	2.05	190	3.46	31	0.58
Arabic coffee per day						
None	3232	29.93	1476	26.85	1756	33.12
1-2	2174	20.13	1256	22.85	918	17.31

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3-4	1912	17.71	1049	19.08	863	16.28
5-6	1232	11.41	619	11.26	613	11.56
7-9	556	5.15	267	4.86	289	5.45
≥10	1462	13.54	665	12.10	797	15.03
Missing	231	2.14	165	3.00	66	1.24
Soda per day						
None	6300	58.34	2396	43.59	3904	73.63
1-2	3365	31.16	2172	39.51	1193	22.50
3-4	708	6.56	570	10.37	138	2.60
≥5	201	1.86	180	3.27	21	0.40
Missing	225	2.08	179	3.26	46	0.87
Fruit per day						
0-1	8203	75.96	3803	69.18	4400	82.99
2	1550	14.35	952	17.32	598	11.28
3	362	3.35	189	3.44	173	3.26
≥4	156	1.44	99	1.80	57	1.08
Missing	528	4.89	454	8.26	74	1.40
Vegetable per day						
0-1	7685	71.16	3633	66.09	4052	76.42
2	1890	17.50	1032	18.77	858	16.18
3	562	5.20	297	5.40	265	5.00
≥4	156	1.44	96	1.75	60	1.13
Missing	506	4.69	439	7.99	67	1.26

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Table 3. Measures of blood pressure based on different guidelines, Saudi Biobank 2017-2020

		JNC-7				ACC/AHA			
				Hypertension				Hypertension	
	Measures	**Normal**	**Pre-HTN**	**Stage 1**	**Stage 2**	**Normal**	**Elevated**	**Stage 1**	**Stage 2**
Definition (mm Hg)		<120 *And* <80	120-139 *Or* 80-89	140-159 Or 90-99	≥160 Or ≥100	<120 *And* <80	120-129 *And* <80	130-139 *Or* 80-89	≥140 Or ≥90
SBP	Mean	108.50	125.57	140.06	157.32	108.50	124.0	126.51	143.33
	SD	7.70	7.49	10.55	16.58	7.70	2.81	9.10	13.71
	Median	110.0	126.0	142.0	160.0	110.0	124.0	129.0	143.0
	IQR	11.0	10.0	12.0	21.0	11.0	4.0	12.0	14.0
	Min	70	71	65	109	70	120	71	65
	Max	119	139	159	211	119	129	139	211
DBP	Mean	68.02	77.43	87.94	101.42	68.02	71.50	80.99	90.50
	SD	6.67	7.40	7.71	10.0	6.67	5.70	5.86	9.75
	Median	69.0	79.0	90.0	102.0	69.0	73.0	82.0	91.0
	IQR	10.0	10.0	9.0	8.0	10.0	8.0	5.0	11.0
	Min	37	42	58	71	37	42	44	58
	Max	79	89	99	134	79	79	89	134

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Table 4. Determinants of hypertension according to guidelines among Saudi National Biobank, 2017-2020 (n = 10799)

	JNC-7			ACC/AHA		
Characteristics	**HTN (%)**	**OR (95% CI)**	**AOR (95% CI)**	**HTN (%)**	**OR (95% CI)**	**AOR (95% CI)**
Overall	14.49 (14.37,14.61)	-	-	40.77 (40.60,40.94)	-	-
Gender						
Women	10.39 (10.24,10.54)	1.0	1.0	33.57 (33.34,33.80)	1.0	1.0
Men	18.45 (18.26,18.63)	1.95 (1.74,2.18)	3.10 (2.66,3.60)	47.72 (47.48,47.96)	1.80 (1.67,1.95)	2.79 (2.51,3.11)
Age (years)						
18-29	10.67 (10.53,10.81)	1.0	1.0	34.86 (34.64,35.08)	1.0	1.0
30-39	14.62 (14.40,14.85)	1.42 (1.25,1.62)	1.39 (1.16,1.67)	43.44 (43.12,43.76)	1.43 (1.31,1.57)	1.27 (1.13,1.44)
40-49	27.33 (26.87,27.80)	3.14 (2.69,3.66)	2.55 (2.03,3.19)	55.58 (55.06,56.11)	2.34 (2.06,2.66)	1.70 (1.44,2.02)
50-59	36.31 (35.39,37.22)	4.82 (3.79,6.13)	3.23 (2.34,4.44)	66.87 (65.94,67.80)	3.77 (2.98,3.78)	2.28 (1.72,3.03)
≥60	34.15 (32.27,36.02)	4.53 (2.81,7.28)	2.21 (1.26,3.87)	70.13 (68.23,71.96)	4.39 (2.68,7.17)	2.09 (1.20,3.63)
Marital status						
Never married	11.91 (11.76,12.06)	1.0	1.0	36.18 (35.95,36.40)	1.0	1.0
Married	17.76 (17.59,17.99)	1.60 (1.43,1.78)	0.73 (0.61,0.87)	46.39 (46.13,46.65)	1.53 (1.41,1.65)	0.91 (0.81,1.02)
Divorced, separated	17.30 (16.50,18.10)	1.64 (1.19,2.26)	0.95 (0.66,1.38)	44.18 (44.10,46.25)	1.45 (1.14,1.85)	1.07 (0.81,1.41)
Education						
< Primary school	28.44 (26.97,29.92)	1.0	1.0	58.75 (57.13,60.35)	1.0	1.0
Primary school	30.07 (29.01,31.14)	1.08 (0.66,1.75)	1.18 (0.70,1.98)	59.72 (58.58,60.86)	1.04 (0.66,1.63)	1.11 (0.69,1.79)
Intermediate school	22.52 (21.75,23.29)	0.73 (0.46,1.16)	0.84 (0.51,1.39)	50.43 (49.50,51.35)	0.71 (0.47,1.08)	0.82 (0.52,1.28)
High school	13.45 (13.27,13.63)	0.39 (0.26,0.59)	0.78 (0.49,1.23)	38.04 (37.79,38.30)	0.43 (0.30,0.62)	0.75 (0.49,1.12)
Some college	18.68 (18.18,19.19)	0.58 (0.37,0.89)	1.00 (0.61,1.65)	48.19 (47.54,48.84)	0.65 (0.44,0.97)	1.01 (0.65,1.56)
Bachelor's degree	12.90 (12.71,13.08)	0.37 (0.25,0.56)	0.78 (0.49,1.25)	40.05 (39.78,40.31)	0.47 (0.32,0.68)	0.86 (0.57,1.31)
Higher education	15.02 (14.33,15.72)	0.44 (0.27,0.73)	0.79 (0.45,1.41)	40.08 (39.14,41.02)	0.47 (0.31,0.72)	0.80 (0.49,1.29)
Employment status						
Employed	15.02 (14.84,15.19)	1.0	1.0	41.70 (41.46,41.94)	1.0	1.0
Unemployed	13.54 (13.14,13.93)	0.89 (0.72,1.08)	1.35 (1.03,1.78)	38.36 (37.80,38.92)	0.87 (0.75,1.00)	1.27 (1.04,1.55)
Student	11.72 (11.50,11.93)	0.75 (0.65,0.86)	1.60 (0.90, 1.50)	37.33 (37.01,37.65)	0.83 (0.76,0.91)	1.36 (1.14,1.63)
Retired/others	19.26 (18.87,19.65)	1.35 (1.15,1.58)	1.24 (0.96,1.59)	46.44 (45.94,46.93)	1.21 (1.07,1.37)	1.21 (1.00,1.45)
Income						
≤5000	13.43 (13.26,13.59)	1.0	1.0	38.86 (38.62,39.10)	1.0	1.0
5001 - 10,000	12.87 (12.66,13.08)	0.95 (0.83,1.09)	0.76 (0.60,0.97)	38.46 (38.15,38.76)	0.98 (0.89,1.08)	0.86 (0.72,1.03)
1,0001 - 15,000	18.40 (18.02,18.97)	1.45 (1.22,1.72)	0.94 (0.71,1.25)	47.95 (47.45,48.44)	1.45 (1.27,1.65)	1.03 (0.83,1.27)
15,001 – 20,000	20.68 (20.06,21.30)	1.68 (1.31,2.15)	0.98 (0.69,1.39)	50.89 (50.12,51.66)	1.63 (1.34,1.99)	1.08 (0.82,1.43)
>20,000	22.77 (21.90,23.64)	1.90 (1.40,2.58)	0.89 (0.58,1.37)	50.26 (49.22,51.30)	1.59 (1.22,2.06)	0.85 (0.61,1.20)
Vigorous exercise						
Never	15.79 (15.64,15.94)	1.0	1.0	42.84 (42.63,43.04)	1.0	1.0
1	13.67 (13.23,14.12)	0.84 (0.68,1.05)	1.17 (0.93,1.48)	38.95 (38.31,39.58)	0.85 (0.73,0.99)	0.79 (0.67,0.94)
2-3	11.15 (10.79,11.52)	0.67 (0.54,0.83)	0.87 (0.64,1.18)	35.29 (34.74,35.84)	0.73 (0.63,0.84)	0.75 (0.65,0.88)
4-5	10.01 (9.62,10.40)	0.59 (0.46,0.76)	0.75 (0.54,1.04)	33.65 (33.04,34.26)	0.68 (0.58,0.79)	0.68 (0.57,0.81)
>5	9.64 (9.19,10.08)	0.57 (0.43,0.76)	0.76 (0.53,1.10)	34.00 (33.29,34.72)	0.69 (0.57,0.82)	0.72 (0.59,0.87)

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Time standing at work						
Never	7.07 (6.43,7.72)	1.0	1.0	38.80 (37.57,40.02)	1.0	1.0
A few times	15.02 (14.82,15.22)	2.32 (1.34,4.02)	2.60 (1.47,4.62)	40.90 (40.62,41.17)	1.09 (0.81,1.46)	1.09 (0.80,1.50)
Sometimes	14.76 (14.56,14.95)	2.27 (1.31,3.94)	2.60 (1.47,4.62)	42.30 (42.04,42.57)	1.16 (0.86,1.55)	1.18 (0.86,1.62)
Most of the times	13.80 (13.51,14.08)	2.10 (1.20,3.67)	2.66 (1.48,4.76)	37.60 (37.20,38.00)	0.95 (0.70,1.28)	1.03 (0.74,1.42)
All the times	10.60 (9.65,11.55)	1.56 (0.71,3.39)	1.92 (0.85,4.34)	35.54 (34.07,37.02)	0.87 (0.55,1.37)	0.95 (0.58,1.55)
Current smoker						
No	14.47 (14.34,14.60)	1.0	1.0	40.93 (40.75,41.12)	1.0	1.0
Yes	14.60 (14.30,14.89)	1.01 (0.87,1.17)	0.79 (0.67,0.93)	39.98 (39.57,40.39)	0.96 (0.87,1.07)	0.75 (0.66,0.85)
Diabetes						
No	13.44 (13.32,13.56)	1.0	1.0	39.37 (39.20,39.54)	1.0	1.0
Yes	30.65 (30.01,31.30)	2.48 (2.39,3.39)	1.64 (1.34,2.00)	62.37 (61.69,63.04)	2.55 (2.17,3.00)	1.67 (1.40,1.99)
BMI (kg/m^2)						
Underweight	5.41 (5.10,5.72)	1.0	1.0	20.84 (20.28,21.39)	1.0	1.0
Normal weight	8.89 (8.73,9.04)	1.70 (1.20,2.41)	1.67 (1.17,2.38)	30.76 (30.51,31.02)	1.69 (1.39,2.05)	1.67 (1.37,2.04)
Overweight	14.69 (14.47,14.92)	3.01 (2.13,4.24)	2.15 (1.50,3.08)	44.37 (44.06,44.68)	3.03 (2.49,3.69)	2.43 (1.97,3.00)
Obese	23.98 (23.67,24.29)	5.51 (3.90,7.77)	2.97 (2.04,4.34)	56.12 (55.76,56.48)	4.86 (3.97,5.94)	3.17 (2.52,3.99)
Extremely Obese	37.82 (36.78,38.87)	10.62 (7.04,16.01)	5.24 (3.35,8.19)	67.53 (66.53,68.54)	7.90 (5.78,10.79)	4.64 (3.31,6.52)
Waist Circum.						
Normal	9.30 (9.17,9.42)	1.0	1.0	32.65 (32.44,32.85)	1.0	1.0
Not Normal	23.94 (23.69,24.18)	3.07 (2.75,3.43)	1.53 (1.29,1.81)	55.54 (55.25,55.83)	2.58 (2.38,2.79)	1.32 (1.17,1.50)
Waist to hip ratio						
Normal	12.38 (12.26,12.51)	1.0	1.0	37.55 (37.37,37.74)	1.0	1.0
Not Normal	23.53 (23.19,23.86)	2.18 (1.93,2.45)	1.19 (1.02,1.38)	54.57 (54.18,54.97)	1.99 (1.81,2.20)	1.27 (1.13,1.43)

Waist Circumference: (men<94, women <80), Waist to hip ratio: (men<0.95, women <0.80), AOR: Adjusted OR.

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Table 5. Determinants of prehypertension/elevated BP according to guidelines among Saudi National Biobank, 2017-2020 (n = 10799)

	JNC-7			ACC/AHA		
Characteristics	**Pre-HTN (%)**	**OR (95% CI)**	**AOR (95% CI)**	**Elevated BP (%)**	**OR (95% CI)**	**AOR (95% CI)**
Overall	49.23 (49.04,49.42)	-	-	15.78 (15.66,15.91)	-	-
Gender						
Women	41.57 (41.31,41.83)	1.0	1.0	21.18 (20.93,21.43)	1.0	1.0
Men	57.35 (57.09,57.61)	1.89 (1.74,2.05)	3.00 (2.67,3.37)	33.47 (331.6,33.79)	1.87 (1.67,2.09)	2.86 (2.45,3.33)
Age (years)						
18-29	46.84 (46.60,47.08)	1.0	1.0	27.09 (26.83,27.34)	1.0	1.0
30-39	50.15 (49.80,50.49)	1.14 (1.04,1.25)	0.95 (0.85,1.07)	24.66 (24.30,25.03)	0.88 (0.77,1.00)	0.76 (0.64,0.89)
40-49	56.59 (55.98,57.21)	1.48 (1.28,1.71)	1.05 (0.88,1.26)	28.88 (28.16,29.60)	1.09 (0.89,1.34)	0.80 (0.62,1.02)
50-59	65.70 (64.52,66.88)	2.17 (1.62,2.91)	1.33 (0.96,1.86)	34.26 (32.63,35.89)	1.40 (0.94,2.10)	0.93 (0.59,1.47)
≥60	70.00 (67.63,72.27)	2.64 (1.44,4.86)	1.42 (0.73,2.77)	34.78 (31.23,38.34)	1.43 (0.61,3.40)	0.79 (0.31,2.01)
Education						
< Primary school	59.94 (58.04,61.83)	1.0	1.0	30.50 (28.16,32.84)	1.0	1.0
Primary school	59.45 (58.09,60.82)	0.98 (0.57,1.67)	0.96 (0.55,1.68)	29.61 (27.93,31.28)	0.96 (0.45,2.03)	0.89 (0.41,1.92)
Intermediate school	53.35 (52.30,54.39)	0.76 (0.47,1.25)	0.74 (0.44,1.25)	27.08 (25.92,28.25)	0.85 (0.42,1.69)	0.74 (0.36,1.50)
High school	47.51 (47.23,47.80)	0.60 (0.39,0.94)	0.68 (0.43,1.10)	26.68 (26.39,26.98)	0.83 (0.45,1.53)	0.70 (0.37,1.34)
Some college	54.90 (54.18,55.61)	0.81 (0.51,1.29)	0.84 (0.51,1.38)	29.21 (28.39,30.03)	0.94 (0.49,1.79)	0.77 (0.39,1.51)
Bachelor's degree	49.23 (48.94,49.52)	0.65 (0.42,1.00)	0.79 (0.49,1.27)	26.24 (25.93,26.55)	0.81 (0.44,1.50)	0.74 (0.39,1.41)
Higher education	47.49 (46.45,48.53)	0.60 (0.37,0.99)	0.74 (0.43,1.27)	25.53 (24.45,26.61)	0.78 (0.39,1.54)	0.74 (0.36,1.54)
Employment status						
Employed	49.66 (49.40,49.94)	1.0	1.0	26.62 (26.34,26.90)	1.0	1.0
Unemployed	47.27 (46.66,47.89)	0.91 (0.78,1.05)	1.38 (1.12,1.69)	26.04 (25.40,26.69)	0.97 (0.79,1.18)	1.50 (1.13,1.99)
Student	48.97 (48.62,49.32)	0.97 (0.88,1.07)	1.58 (1.31,1.90)	28.11 (27.74,28.49)	1.08 (0.95,1.22)	1.63 (1.27,2.10)
Retired/others	49.53 (48.98,50.08)	0.99 (0.87,1.14)	1.22 (1.00,1.49)	23.92 (23.35,24.50)	0.87 (0.72,1.05)	1.24 (0.97,1.67)
Income						
≤5000	47.75 (47.48,48.01)	1.0	1.0	26.01 (25.73,26.28)	1.0	1.0
5001 - 10,000	47.19 (46.85,47.53)	0.98 (0.88,1.08)	0.97 (0.81,1.15)	25.23 (24.88,25.58)	0.96 (0.83,1.10)	1.01 (0.79,1.30)
1,0001 - 15,000	55.16 (54.62,55.70)	1.35 (1.16,1.57)	1.20 (0.94,1.51)	29.71 (29.09,30.33)	1.20 (0.98,1.47)	1.31 (0.97,1.78)
15,001 – 20,000	59.03 (58.18,59.87)	1.58 (1.27,1.97)	1.34 (0.99,1.80)	33.82 (32.78,34.86)	1.45 (1.08,1.95)	1.58 (1.07,2.34)
>20,000	58.28 (57.12,59.45)	1.53 (1.14,2.04)	1.07 (0.75,1.53)	35.23 (33.82,36.63)	1.55 (1.07,2.23)	1.38 (0.91,2.20)
Moderate exercise						
Never	51.12 (50.88,51.36)	1.0	1.0	27.75 (27.49,28.01)	1.0	1.0
1	47.78 (47.12,48.45)	0.87 (0.75,1.02)	0.80 (0.67,0.94)	23.32 (22.64,23.99)	1.26 (1.01,1.57)	0.70 (0.55,0.88)
2-3	45.27 (44.77,45.78)	0.79 (0.70,0.90)	0.78 (0.68,0.89)	25.31 (24.79,25.82)	1.11 (0.86,1.44)	0.83 (0.69,0.99)
4-5	45.73 (45.10,46.36)	0.80 (0.69,0.94)	0.77 (0.65,0.90)	25.17 (24.53,25.82)	1.11 (0.83,1.47)	0.80 (0.65,0.99)
>5	46.18 (45.51,46.86)	0.82 (0.70,0.96)	0.83 (0.70,0.99)	26.24 (25.55,26.94)	1.17 (0.88,1.56)	0.88 (0.70,1.11)
Soda per day						
None	49.60 (49.36,49.85)	1.0	1.0	26.40 (26.14,26.66)	1.0	1.0
1-2	49.81 (49.49,50.14)	1.01 (0.92,1.10)	0.93 (0.84,1.03)	27.56 (27.21,27.91)	0.94 (0.83,1.06)	0.94 (0.82,1.07)
3-4	45.60 (44.90,46.30)	0.85 (0.72,1.00)	0.79 (0.65,0.94)	25.49 (24.78,26.21)	0.90 (0.71,1.13)	0.81 (0.63,1.03)
≥5	41.84 (40.55,43.14)	0.73 (0.54,0.99)	0.78 (0.56,1.08)	26.32 (25.02,27.62)	0.94 (0.64,1.38)	0.95 (0.63,1.44)
Time walking at work						
Never	47.22 (45.91,48.53)	1.0	1.0	23.60 (22.26,24.90)	1.0	1.0

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A few times	51.04 (50.71,51.37)	1.16 (0.86,1.57)	1.15 (0.77,1.71)	28.47 (28.11,28.83)	1.29 (0.84,1.96)	1.01 (0.60,1.71)
Sometimes	50.29 (49.98,50.60)	1.13 (0.84,1.52)	1.18 (0.79,1.77)	26.85 (26.51,27.18)	1.19 (0.78,1.81)	0.95 (0.56,1.61)
Most of the times	46.54 (46.17,46.90)	0.97 (0.72,1.31)	1.10 (0.73,1.65)	25.63 (25.26,26.01)	1.11 (0.73,1.70)	0.93 (0.55,1.59)
All the times	43.66 (42.69,44.63)	0.87 (0.60,1.25)	0.84 (0.52,1.33)	19.99 (19.06,20.92)	0.81 (0.48,1.36)	0.59 (0.31,1.10)
Time standing at work						
Never	48.12 (46.82,49.43)	1.0	1.0	21.23 (19.92,22.54)	1.0	1.0
A few times	49.48 (49.18,49.78)	1.05 (0.78,1.42)	0.94 (0.64,1.40)	27.36 (27.04,27.68)	0.71 (0.46,1.11)	1.31 (0.76,2.25)
Sometimes	50.86 (50.57,51.15)	1.11 (0.83,1.50)	1.05 (0.71,1.56)	27.40 (27.08,27.72)	1.00 (0.88,1.13)	1.43 (0.83,2.47)
Most of the times	45.68 (45.24,46.12)	0.91 (0.67,1.23)	0.89 (0.59,1.33)	24.96 (24.51,25.41)	0.88 (0.75,1.04)	1.23 (0.70,2.15)
All the times	42.29 (40.69,43.90)	0.79 (0.49,1.26)	0.90 (0.52,1.58)	19.96 (18.43,21.49)	0.66 (0.38,1.14)	1.19 (0.54,2.61)
Time sitting at work						
Never	40.71 (38.96,42.46)	1.0	1.0	13.44 (11.97,14.91)	1.0	1.0
A few times	48.82 (48.42,49.22)	1.39 (0.92,2.10)	1.41 (0.89,2.25)	26.37 (25.95,26.79)	2.31 (1.13,4.72)	2.45 (1.15,5.20)
Sometimes	48.30 (47.95,48.64)	1.36 (0.90,2.05)	1.35 (0.85,2.15)	27.20 (26.84,27.57)	2.41 (1.18,4.91)	2.56 (1.21,5.44)
Most of the times	49.87 (49.60,50.15)	1.45 (0.96,2.18)	1.37 (0.86,2.17)	26.70 (26.41,27.00)	2.35 (1.15,4.77)	2.25 (1.06,4.78)
All the times	54.94 (53.82,56.06)	1.78 (1.10,2.86)	1.32 (0.79,2.22)	29.45 (28.16,30.73)	2.69 (1.23,5.88)	2.03 (0.90,4.61)
Fruits per day						
0-1	50.07 (49.86,50.28)	1.0	1.0	27.27 (27.05,27.50)	1.0	1.0
2	47.00 (46.52,47.48)	0.88 (0.78,0.99)	0.87 (0.76,1.00)	25.50 (25.01,26.00)	0.91 (0.78,1.07)	0.92 (0.76,1.11)
3	41.56 (40.59,42.52)	0.71 (0.56,0.89)	0.74 (0.57,0.97)	20.29 (19.38,21.21)	0.68 (0.49,0.94)	0.72 (0.50,1.04)
≥4	45.78 (44.33,47.24)	0.84 (0.60,1.18)	0.94 (0.64,1.40)	25.56 (24.07,27.05)	0.91 (0.58,1.44)	1.04 (0.62,1.74)
Vegetables per day						
0-1	50.38 (50.17,50.60)	1.0	1.0	27.66 (27.42,27.89)	1.0	1.0
2	45.94 (45.50,46.37)	0.84 (0.75,0.93)	0.85 (0.75,0.96)	24.41 (23.97,24.86)	0.84 (0.73,0.98)	0.85 (0.72,1.00)
3	44.97 (44.18,45.75)	0.80 (0.67,0.97)	0.93 (0.75,1.15)	22.97 (22.18,23.75)	0.78 (0.60,1.01)	0.89 (0.67,1.20)
≥4	48.15 (46.71,49.59)	0.91 (0.66,1.27)	1.11 (0.75,1.63)	23.35 (21.87,24.84)	0.80 (0.50,1.27)	0.90 (0.53,1.53)
Current smoker						
No	49.20 (48.99,49.40)	1.0	1.0	26.43 (26.22,26.65)	1.0	1.0
Yes	49.40 (48.95,49.86)	1.01 (0.90,1.13)	0.77 (0.67,0.88)	28.01 (27.53,28.50)	1.08 (0.93,1.25)	0.82 (0.69,0.97)
Diabetes						
No	48.57 (48.38,48.76)	1.0	1.0	26.58 (26.38,26.78)	1.0	1.0
Yes	61.93 (61.11,62.74)	1.72 (1.42,2.09)	1.29 (1.04,1.59)	29.84 (28.81,30.88)	1.17 (8964,1.55)	0.93 (0.69,1.26)
BMI (kg/m^2)						
Underweight	29.15 (28.51,29.79)	1.0	1.0	15.34 (14.79,15.89)	1.0	1.0
Normal weight	41.90 (41.61,42.18)	1.75 (1.46,2.10)	1.83 (1.52,2.21)	23.54 (23.26,23.82)	1.70 (1.32,2.18)	1.84 (1.45,2.42)
Overweight	54.09 (53.75,54.43)	2.86 (2.38,3.45)	2.79 (2.29,3.40)	29.60 (29.22,29.99)	2.32 (1.80,2.99)	2.51 (1.92,3.29)
Obese	62.40 (61.99,62.81)	4.03 (3.32,4.90)	3.63 (2.89,4.56)	34.86 (34.34,35.39)	2.95 (2.26,3.85)	3.33 (2.44,4.54)
Extremely Obese	70.95 (69.72,72.19)	5.93 (4.09,8.59)	4.80 (3.23,7.19)	44.38 (42.51,46.25)	4.40 (2.73,7.09)	4.76 (2.84,7.98)
Waist Circumference						
Normal	43.78 (43.55,44.00)	1.0	1.0	24.29 (24.06,24.51)	1.0	1.0
Not Normal	61.05 (60.72,61.37)	2.01 (1.84,2.20)	1.18 (1.03,1.35)	33.36 (32.95,33.77)	1.56 (1.38,1.76)	1.11 (0.92,1.33)
Waist to hip ratio						
Normal	47.28 (47.08,47.49)	1.0	1.0	26.04 (25.83,26.25)	1.0	1.0
Not Normal	58.78 (58.34,59.23)	1.59 (1.42,1.77)	1.26 (1.10,1.44)	30.62(30.08,31.16)	1.25 (1.07,1.46)	1.15 (0.96,1.38)

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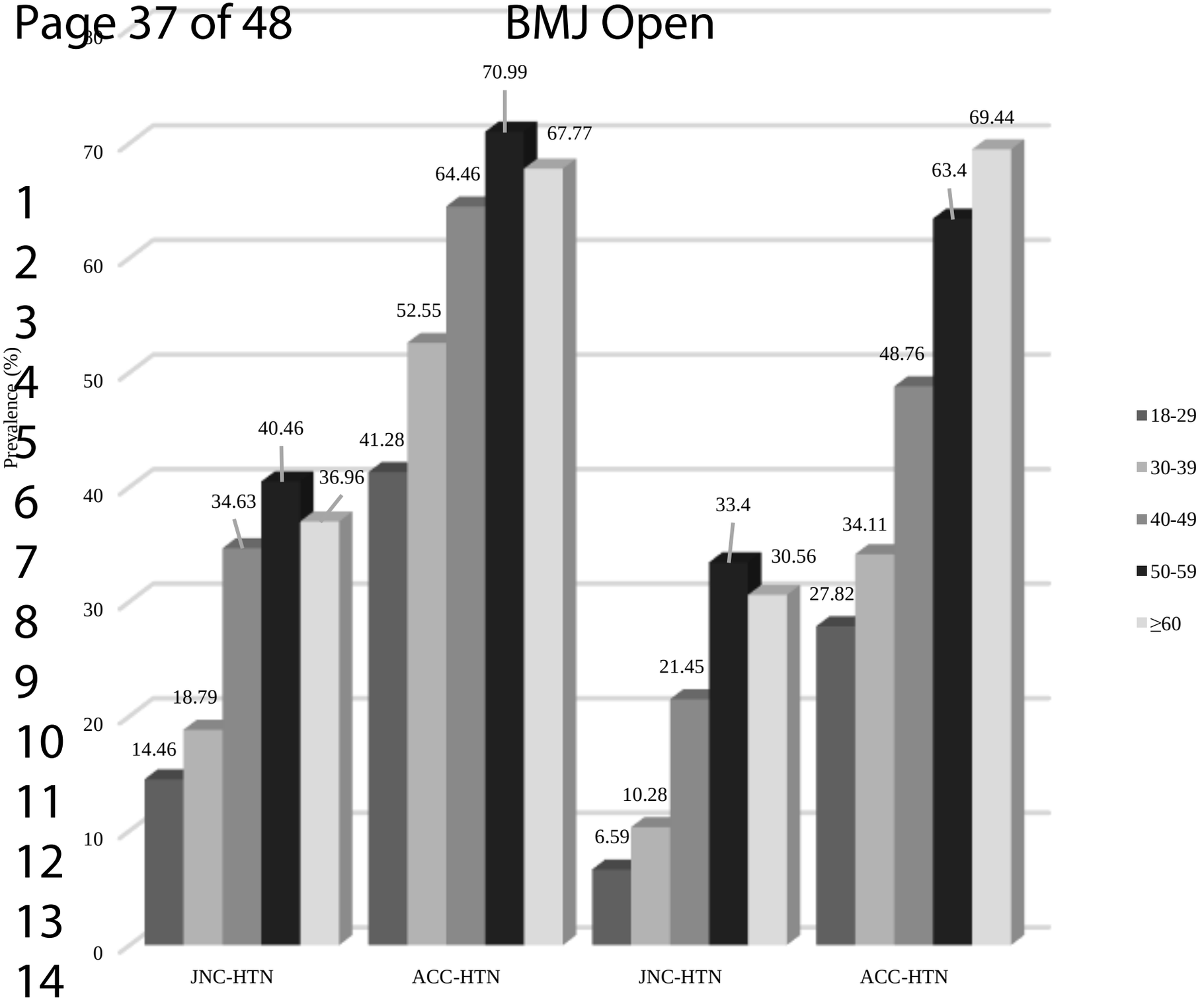

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Figure 1. Prevalence of hypertension based on JNC-7 and 2017 ACC/AHA guidelines among Saudi Biobank males and females (2017-2020) stratified by age (n= 10799)

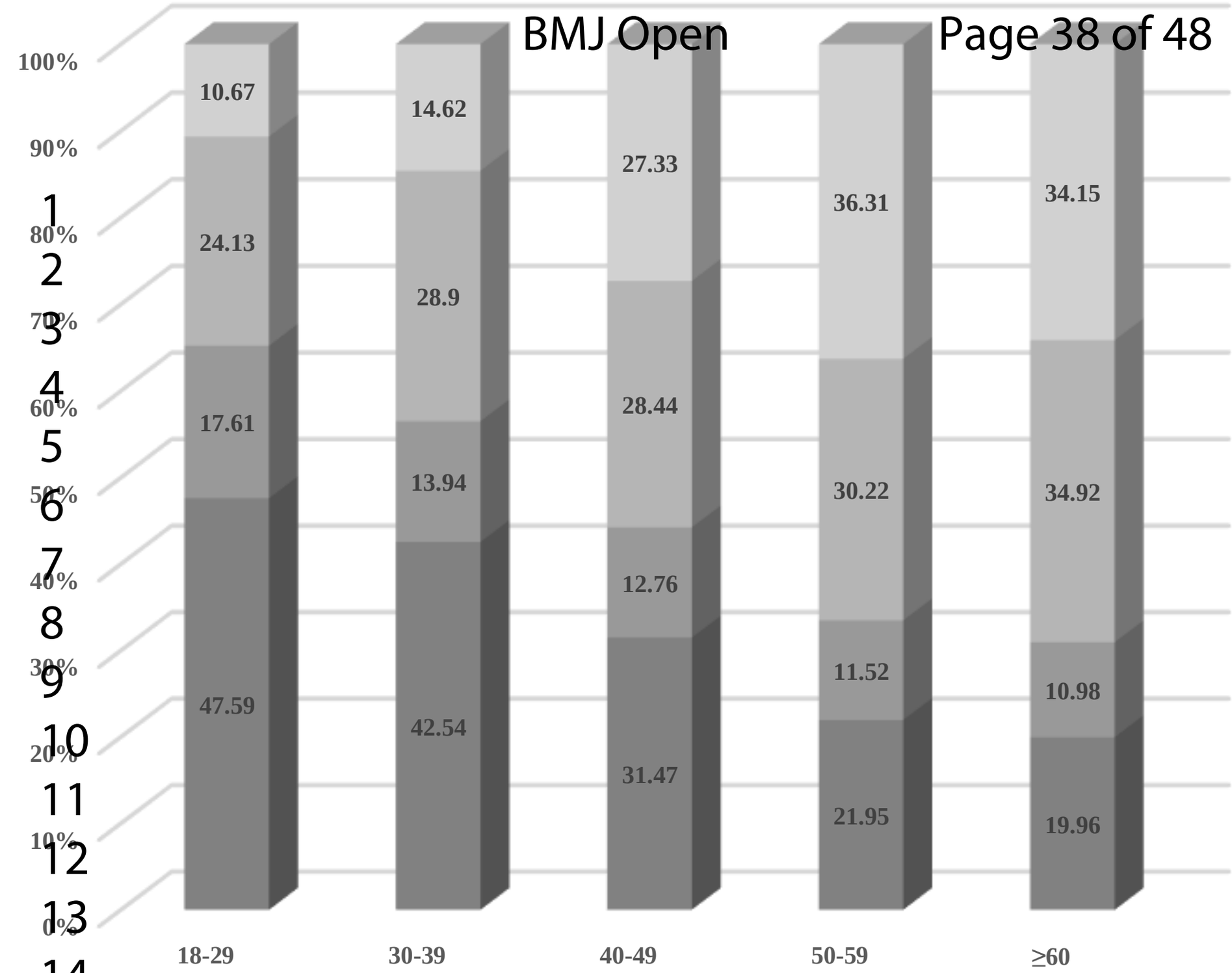

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Figure 2. Prevalence of BP stages defined by ACC/AHA guideline among Saudi Biobank population stratified by age (n=10799)

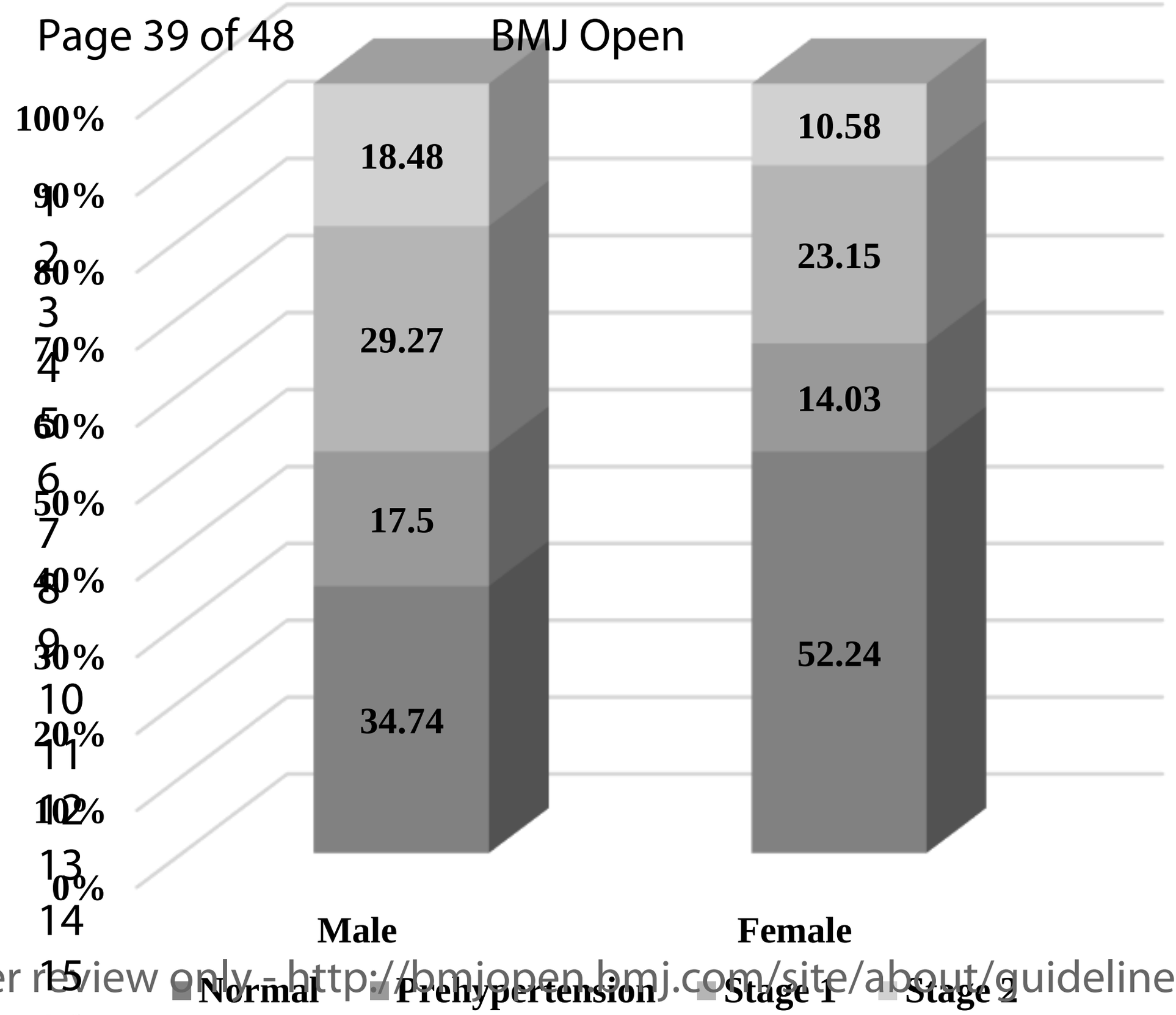

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Figure 3. Prevalence of BP stages defined by 2017 ACC/AHA guideline in males compared to females of the SBB population (n=10799)

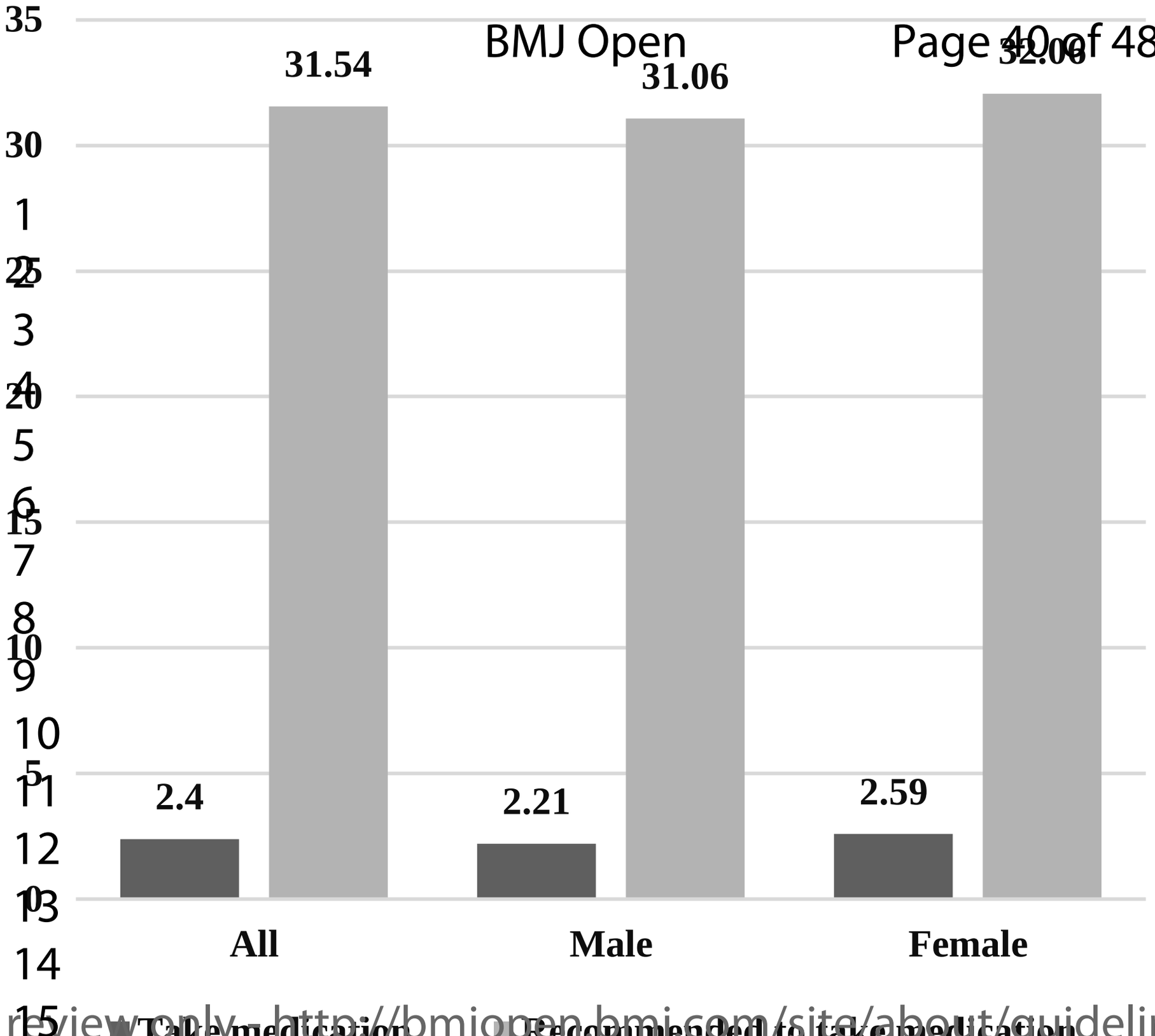

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Figure 4. Prevalence of hypertension according to self-report, SBB 2017-2020

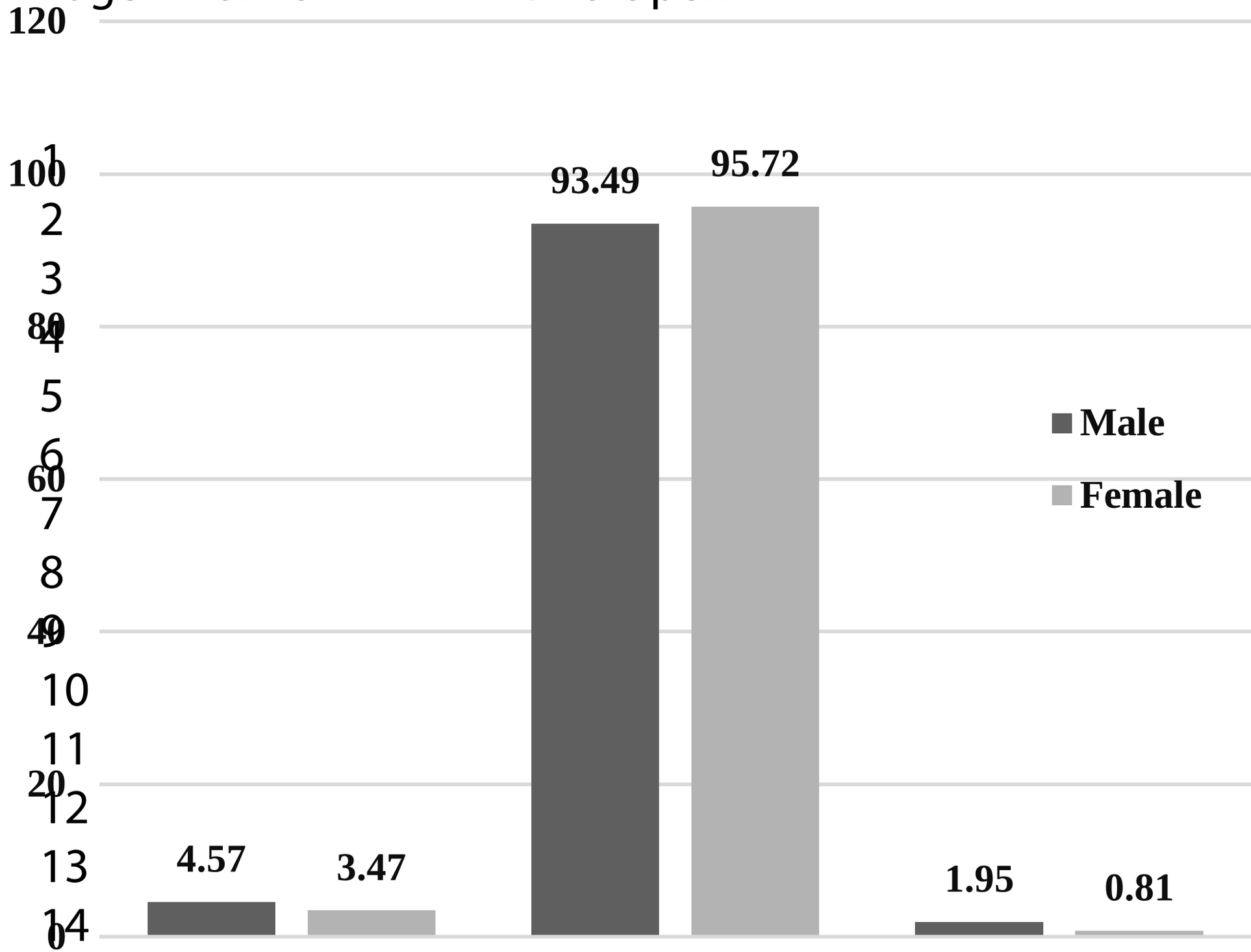

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Figure 5. Prevalence of adults diagnosed with hypertension according to 2017 ACA/AHA and recommended taking antihypertensives vs adults already taking antihypertensives, SBB2017-2020

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1

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Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3,4
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5,6,7,8,9

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Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	9
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5,6,7,8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5,6,7,8
Bias	#9	Describe any efforts to address potential sources of bias	5,6,7,8,9
Study size	#10	Explain how the study size was arrived at	9

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Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8,9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	8,9
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	8,9
Statistical methods	#12c	Explain how missing data were addressed	9
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
Statistical methods	#12e	Describe any sensitivity analyses	9
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible,	9

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		examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	9
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9,10,11,12,13,25,26,27,28,29,30,31,32,33
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	25,26,27,28
Outcome data	#15	Report numbers of outcome events or summary	30,31,32,33

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		measures. Give information separately for exposed and unexposed groups if applicable.	
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11,12
Main results	#16b	Report category boundaries when continuous variables were categorized	10,11,29
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9,10,11,13,17,30,31,32,33

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Discussion			
Key results	#18	Summarise key results with reference to study objectives	14,15,16
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	17
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14,15,16
Generalisability	#21	Discuss the generalisability (external validity) of the study results	17
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if	18

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	applicable, for the original study on which the present article is based

Notes:

- 14a: 9,10,11,12,13,25,26,27,28,29,30,31,32,33
- 14b: 25,26,27,28
- 15: 30,31,32,33
- 17: 9,10,11,13,17,30,31,32,33 The STROBE checklist is distributed under the terms of the Creative Commons Attribution License CC-BY. This checklist was completed on 19. June 2020 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai

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Impact of the 2017 ACC/AHA guideline on the prevalence of elevated blood pressure and hypertension: a cross-sectional analysis of 10799 individuals.

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Impact of the 2017 ACC/AHA guideline on the prevalence of elevated blood pressure and hypertension: a cross-sectional analysis of 10799 individuals.

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ABSTRACT

Objectives To assess the effect of the 2017 ACC/AHA hypertension guideline on the prevalence of elevated blood pressure and hypertension and the initiation of antihypertensive treatment and the blood pressure (BP) target goal in the Saudi population.

Design A cross-sectional study.

Participants A total of 10,799 adults (≥18 years old) with three blood pressure readings during 2017-2020 from the Saudi Biobank (SBB) was used.

Primary outcome Hypertension was defined using three sources: the JNC-7 guideline (SBP≥140 or DBP≥90 mm Hg), the 2017 ACC/AHA guideline (SBP≥130 or DBP≥80 mm Hg), and a self-reported hypertension diagnosis.

Results The prevalence of hypertension, according to the JNC-7 guideline, was 14.49% (95% CI: 14.37, 14.61), and the 2017 ACC/AHA, 40.77% (95% CI: 40.60, 40.94), a difference of 26.28 %. Antihypertensive medication was recommended for 24.84% (95% CI: 24.69,24.98) based on the JNC-7 guideline and for 27.67% (95% CI: 27.52,27.82) using the 2017 ACC/AHA guideline. Lifestyle modification is recommended for 13.10% (95% CI:12.47,13.74) of patients with hypertension who are not recommended pharmacological intervention based on the 2017 ACA/AHA guideline. In patients prescribed antihypertensive, 49.56% (95% CI: 45.50, 53.64) and 27.81% (95% CI: 24.31,31.59) presented with BP above treatment goal based on the 2017 ACA/AHA and JNC-7 guidelines, respectively. Using the two definitions, the risk factors are older age, male gender, diabetes diagnosis, increased body mass index (BMI), increased waist circumference, and waist-to-hip ratios.

Conclusions According to the 2017 ACC/AHA, the prevalence of hypertension has increased significantly, but a small increase in the percentage of patients recommended for antihypertensive treatment. A large percentage of patients with antihypertensive have BP above the targeted goal. Unless public health prevention efforts are adopted, the increased prevalence of elevated blood pressure and hypertension will increase cardiovascular diseases, a leading cause of mortality globally.

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Strengths and limitations of this study

- The study has a large sample size.
- We ascertained the hypertensive status using three BP measurements.
- The cross-sectional design limits our ability to assess the temporal relationship between our independent factors and hypertension.
- There was no ambulatory BP data for the participants.
- The study has limited geographic variation among study participants.

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Keywords: Hypertension; guideline; Saudi Arabia; Prevention; Biobank; Blood pressure, Cardiovascular, Antihypertensive drugs

INTRODUCTION

Hypertension is the most prevalent risk factor for cardiovascular diseases (CVDs) and the cause of more than 9.4 million annual preventable deaths globally[1 2]. The global number of patients with hypertension is expected to increase by 319.7 million between 2015 and 2050[3]. Risk factors that contribute to the increased prevalence of hypertension are increasing age, male gender, lifestyle factors such as smoking, alcohol consumption, unhealthy diet, sedentary lifestyle, and increased weight[4]. Though the burden of hypertension is substantial, detecting and controlling Blood Pressure (BP) levels at the elevated blood pressure stage will reduce the risk and burden of CVDs[5].

Identifying the optimal BP levels for the definition of elevated blood pressure and hypertension has been controversial[6-9]. Based on evidence from Randomized Controlled Trials (RCTs) and other observational studies, the American College of Cardiology and the American Heart Association (ACC/AHA) developed the Hypertension Practice Guideline in 2017- "The ACC/AHA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults"[10]. The guideline lowered the threshold categories of hypertension from ≥140 mmHg Systolic Blood Pressure (SBP) or ≥90 mmHg Diastolic Blood Pressure (DBP) to ≥130 mmHg SBP or ≥80 mmHg DBP. Elevated blood pressure is now limited to individuals with an SBP of 120-129 mmHg and DBP <80 mmHg instead of 120-139 mmHg or 80-89 mmHg suggested by the Joint National Committee 7 Blood Pressure Guideline (JNC-7)[11]. Although not endorsed by some organizations, the new lower BP categories have been assessed in a systematic review and meta-analysis and were associated with a lower risk of CVDs[12].

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Prior studies from various countries have investigated the prevalence of hypertension according to the 2017 ACC/AHA guideline [13-18]. Muntner and colleagues[13] evaluated the effects of the 2017 ACC/AHA guideline on the prevalence of hypertension, and they found an increase of 13.7% in their adult population. Likewise, Alkibria et al[14] [18] assessed the changes in the prevalence of hypertension among the population of Nepal (ages ≥15) and Bangladesh (ages ≥35) and found an increase of 23% and 22.3%, respectively. Moreover, Khera et al[15] found an increase of 26.8% and 45.1% among the 45-75 years old population of China and the U.S., respectively. The estimation of hypertension would essentially update the burden of CVDs and shed light on the proportion of hypertensive patients recommended for lifestyle modifications or antihypertensive medication.

According to the latest survey in 2016, Saudi Arabia is a developing country with a total population of 31 million [19]. Half of the population are younger than 25, 35% between the ages of 20 and 39, and only 3.2% are over 64 years old [19]. Based on the JNC-7 guideline, the prevalences of hypertension and elevated blood pressure among the Saudi population were 15.2% and 40.6%, respectively [20]. Among patients on antihypertensive medication, between 55% and 73% reported BP above the targeted level by the JNC-7 guideline [21] [22].

We designed the current study to investigate the impact of the 2017 ACC/AHA guideline on the prevalence of hypertension and to assess the percentage of hypertensive patients recommended for lifestyle modification or antihypertensive medication according to the 2017 ACC/AHA guideline. We also aim to estimate the rate of patients prescribed antihypertensive medication with BP above the goal recommended by the 2017 ACC/AHA guideline. As a secondary analysis, we also aim to evaluate the determinants of elevated blood pressure and hypertension among the Saudi Biobank (SBB). The results will be

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useful for public health officials and health care providers to plan and implement primary, secondary, and tertiary prevention interventions. These interventions reduce the burden of hypertension in addition to the morbidity and mortality associated with CVDs.

MATERIALS AND METHODS

Data sources

The Institutional Review Board of King Abdullah International Medical Research Center (IRB#139 RC19/028/R) approved the study. The study has a cross-sectional design using data from the SBB. SBB is an ongoing project to investigate the current health behavior of the Saudi population. The project explores the fundamental mechanisms of diseases by combining bio-specimens and survey data, sociodemographic, and medical history information. The current study only used the survey data available from the survey part of the SBB.

Patient and Public Involvement

No patient involved.

Survey development and administration

The SBB research team created a survey based on a previously developed and validated questionnaire. The questionnaire partly corresponds to other similar population biobank projects to allow comparability between the Saudi population and other populations. The preliminary survey questions were pilot tested, and the items were revised according to the findings. The questionnaire includes the following sections: Date and Location of Recruitment, Demographic Information, Family Information, Housing Information, General Health Status, Personal and Family Medical History, History of Personal and

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Family Medications Use, Disabilities, Others, Women and Men Health, Health Behaviors, Nutrition, Physical Activity, and Anthropometric Measurements.

The questionnaire items are primarily closed-ended questions with Likert scale responses. The questionnaire is administered to participants by trained research coordinators. Before obtaining consent and completing the questionnaire, the coordinators describe the SBB objectives, the benefits of study participation, the security and privacy of collected information, voluntary participation, and the unconditional withdrawal from the study.

Study population and data extraction

The study population is adults (≥18 years old) who participated in the survey from December 10th, 2017 to January 29th, 2020, with three recorded BP measurements. The data related to the prescribed antihypertensive medications were extracted from the electronic medical records.

Measurement method for blood pressure

The BP was measured using a calibrated sphygmomanometer and arm cuffs (Omron 705it or Omron M3). Research coordinators are trained to measure BP once the participants are rested, with legs uncrossed. The average of the three BP measurements was computed and used as the final BP reading.

Blood pressure classification

Using the JNC-7 guideline, BP was categorized into four categories: normal (SBP<120 and DBP<80 mmHg), elevated blood pressure (SBP=120-139, or DBP=80-89 mmHg), stage 1 (SBP=140-159 or DBP=90-99 mmHg) and stage 2 (SBP≥160 or DBP≥100 mmHg)[11]. Using the ACC/AHA guideline, BP was also categorized into four categories: normal

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(SBP<120 and DBP<80 mmHg), elevated (SBP=120-129 and DBP<80 mmHg), stage 1 (SBP=130-139 or DBP=80-89 mmHg) and stage 2 (SBP≥140 or DBP≥90 mmHg)[10]. Individuals with BP measurements in stage 1 or stage 2 were considered as diagnosed with hypertension.

Data collection and definitions

The participants' sociodemographic information, including age, gender, marital status, education level, occupation, and family income, was extracted from the SBB data. Also, behavioral health factors such as physical activities, smoking status, including shisha use, dietary intake, and comorbidities, were retrieved. The waist and hip circumferences, height, and weight measurements were categorized as suggested by Lear et al. .[23]. Comorbidities such as a diagnosis of diabetes mellitus or any CVD were self-reported.

Prescription data

We used medical records and pharmacy data to identify participants with an antihypertensive medication prescription. Based on the 2017 ACC/AHA guideline, we defined guideline-recommended antihypertensive medication use as patients with SBP/DBP of ≥140/90 mm Hg; for high-risk patients (i.e., DM, CVD, age ≥ 65), the cut off was 130/80 mm Hg. The same applied to the JNC-7 guideline except that DM was the only designation of high risk. We identified patients with a diagnosis of hypertension in their medical file, self-reported hypertension, and at least one prescription of antihypertensive medication were also identified[24]. The antihypertensive drugs used were beta-blockers, calcium channel blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor

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blockers, diuretics, and centrally or peripherally acting agents found in the pharmacy files during the diagnosis year.

Data analysis

The data were analyzed using SAS statistical software version 9.4 (SAS Institute Inc. Cary, NC). Descriptive data for the sample, stratified by gender, are presented as frequency and percentage for categorical variables, and continuous variables are presented as a mean and standard deviation (SD). Also, for each BP category, the mean, SD, median, interquartile range (IQR), minimum, and maximum value was calculated. The prevalence of hypertension was calculated by dividing the total number of hypertensive individuals by the total number of the study population. The prevalence of elevated blood pressure was measured by dividing the total number of prehypertensive by the total number of the study population. The prevalence of hypertension and elevated blood pressure and the 95% CI were calculated using the Wald binomial method.

Missing covariates data were handled using the multiple imputations by chained equations (fully conditional method), assuming that data are missing at random (MAR). The missing data ranges from 0% to 30%, and 30 imputations were conducted. Given the arbitrary pattern of the missing data, the PROC MI procedure was used with the "FCS regpmm" statement for continuous variables and the "FCS logistic" for categorical variables[25]. Univariate and multivariate logistic regressions were conducted using the multiple imputed data to estimate the odds ratio (OR) and the adjusted odds ratio (AOR). Backward elimination was used to determine variables included at the multivariate level. All statistical tests were 2-sided, and findings were considered statistically significant at P <

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.05. STROBE cross-sectional guideline was used to assure that all essential elements are reported and covered[26].

RESULTS

Descriptive statistics

A total of 11571 individuals were captured in the SBB. After excluding individuals <18 years old (n=327) and with less than three BP readings (n=445), the final sample was 10799 individuals. The overall characteristics of the study sample stratified by antihypertensive prescriptions are summarized in Table 1 (and Table S3 in the supplementary material). Between the years 2017 and 2020, 41.22%, 15.26%, 24.84%, and 13.32% of the SBB participants not prescribed antihypertensive medication presented with SBP/DBP readings of <120/80 mm Hg, 120-129/<80 mm Hg, 130-139/80-89 mm Hg, and ≥140/90 mm Hg, respectively. Participants with increased BP tend to be male, of older age, with a history of diabetes or CVD.

The prevalence of hypertension and the recommended interventions according to the 2017 ACC/AHA and JNC-7 Guidelines.

As shown in Table 2, the prevalence of HTN based on the 2017 ACC/AHA was 40.77% and on JNC-7 was 27.57%. The overall prevalence of HTN and across all patients' characteristics were both higher using the 2017 ACC/AHA guidelines compared with the JNC-7 guidelines, and the difference in the prevalence was highest among the oldest age group. While only 24.84% of patients were recommended antihypertensive medication based on the JNC-7 guideline, 27.67% were recommended medication according to the 2017 ACC/AHA guideline. Except for males, there was an increase in the suggested use of antihypertensive medication across all patients' characteristics using the 2017 ACC/AHA

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guideline. About 13.10% of hypertensive patients were recommended lifestyle modifications based on the 2017 ACC/AHA guideline. Finally, an additional 2.83% of hypertensive patients were recommended antihypertensive intervention based on the 2017 ACC/AHA guideline.

Hypertensive patients based on the 2017 ACC/AHA guideline and not the JNC-7 guideline, compared with those meeting the definition of hypertension based on the JNC-7 guideline, were younger, have lower BMI, better waist circumference profile, lower SBP, and DBP. (Table 3). When compared with individuals recommended treatment by JNC-7 guideline, individuals recommended for antihypertensive medication according to the 2017 ACC/AHA guideline but not JNC-7 guideline were younger, less likely to be diabetic, had lower SBP and DBP, but more likely to have CVD history.

BP levels above the targeted goals by the 2017 ACC/AHA and JNC-7 Guidelines.

The percentage of patients prescribed antihypertensive medication and presented with above-goal BP according to the 2017 ACC/AHA, and JNC-7 guidelines were 49.57% and 27.80%, respectively (Table 4). Overall, patients with BP above goal according to the 2017 ACC/AHA guideline but not JNC-7 guideline were younger, less likely to be diabetic, with lower SBP and DBP, and 52.31% were taking one class antihypertensive medication.

Determinants of hypertension and elevated blood pressure

Hypertension determinants, according to the ACC/AHA and JNC-7 guidelines, are presented in Table S1 in the supplementary material (adjusted for all variables shown in the tables). According to the ACC/AHA guideline, the determinants of hypertension were increasing age, male gender, being a student or unemployed, having diabetes, increasing BMI, particularly with abdominal adiposity. Moreover, determinants of hypertension based

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on the JNC-7 guideline were increasing age, male gender, employment status, time spent standing while at work, diabetes, and increasing BMI, mostly central obesity.

The predictors of elevated blood pressure, adjusted for all covariates in the table, are presented in Table S2 (supplementary material). Elevated BP determinants were being male, younger age, sitting at work a few times, sometimes or most of the time, and increased BMI.

DISCUSSION

The current study assessed the impact of the 2017 ACC/AHA guideline definition of hypertension, the recommendation for initiation of lifestyle modifications and antihypertensive medication, and the BP goals of antihypertensive use among Saudi adults. While there will be a substantial increase in the prevalence of hypertension (26.28%), a small increase in the percentage of adults recommended antihypertensive medication (2.83%) according to the 2017 ACC/AHA guideline. The increase in the prevalence of hypertension translates into an increase from 1.8 million hypertensive adults into 5.1 million adults according to the latest census estimates of Saudis ≥18 years old[19]. The increase is predominantly observed in men (47.72%) vs. women (33.57%), in individuals ≥60 years old (70.13%), diabetics (62.37%), and individuals who are obese (56.12%).

Our findings of the prevalence of hypertension appear to complement other research from Bangladesh[16 27], Nepal [14], and to a lesser extent, the U.S.[13 17], which assessed the impact of the 2017 ACC/AHA guidelines on the prevalence of hypertension. In the U.S. study, Muntner et al[13] used the National Health and Nutrition Examination Survey and found an increase of 13.7% in the prevalence of hypertension. On the other hand, the findings from Nepal and Bangladesh, an increase in the prevalence of hypertension of 23% and 22%

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respectively, were comparable to our results; 26.28%. The findings might reflect the younger population of Nepal, Bangladesh, and Saudi Arabia compared to the U.S. population [19 28 29].

According to the 2017 ACC/AHA guideline, we also found that 13.10% of the Saudi hypertensive patients will require lifestyle modifications without antihypertensive intervention, a finding similar to the U.S. study by Muntner[13]. Examples of recommended lifestyle modifications include practicing a healthy lifestyle such as eating a healthy diet, maintaining a healthy weight, avoiding smoking, and being physically active. These non-pharmacological interventions have been endorsed by the 2017 ACC/AHA guideline based on several observational and randomized controlled trials[30]. For instance, in normotensive individuals, engaging in physical activities of 90-150 minutes/week is associated with a reduction of 2-4 mmHg in systolic BP[31]. Although it is unfortunate that most of our population (70.70%), especially women (84.25%), reported never being engaged in any moderate exercise, governmental efforts through the Quality of Life program are ongoing to promote physical activities. Future studies should assess the impact of these programs on the incidence of hypertension.

Moreover, we found 46.56% of patients taking antihypertensive medication presented with a BP above the target goal suggested by the 2017 ACC/AHA guideline. Our result is congruent with studies from the U.S. and Bangladesh, where the percentages of patients with BP above the target goal were 53.4% and 61%, respectively[13 16]. It is also similar to a study from Saudi Arabia, which found that 55% had BP above target [21]. Nonetheless, it is unclear whether uncontrolled hypertension is due to patient factors such as lack of medication adherence or the providers' inability to titrate antihypertensive treatment when

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the BP is suboptimal. A multidisciplinary disease management strategy and follow-up of patients with uncontrolled BP should be emphasized. To achieve the targeted BP goal among patients with uncontrolled BP, intensive antihypertensive treatment is also needed.

STRENGTHS AND LIMITATION

Our study has several strengths. Firstly, we used a large sample of the Saudi population (n=10799) from diverse backgrounds (e.g., wives, professionals, students, and unemployed women). Secondly, we ascertained the hypertensive status using BP measurements according to a standardized procedure. Our study also has several limitations. Firstly, the study is limited to the capital of Saudi Arabia, Riyadh. However, given the characteristics of the participants, we believe that the geographic location is unlikely to affect the external validity of our findings. Secondly, although BP was measured using three readings, the measurement was performed during a single visit. Thirdly, we relied on the medical and pharmacy files to identify users of antihypertensive medications, and we may have missed some patients who were not identified with this approach. Fourthly, we do not have ambulatory BP data for the participants, which may overestimate some individuals who may have white coat hypertension; however, the prevalence of white coat hypertension is approximately 3% in a Saudi cohort, which is too small to affect the prevalence data.

CONCLUSION

The 2017 ACC/AHA guideline resulted in an alarming increase in the prevalence of hypertension and elevated blood pressure, with implications for escalating healthcare costs. There is, however, a small increase in the percentage of patients recommended antihypertensive medication. About 49.56% of patients prescribed antihypertensive medication have BP above the target goal set by the 2017 ACC/AHA guideline. Unless

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strong public health measures are adopted, including implementing lifestyle changes at a population level in conjunction with the aggressive management of hypertension, we are likely to see an upward trend in the prevalence of hypertension and associated cardiovascular morbidity and mortality.

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DATA ACCESS STATEMENT

Data not available due containing sensitive information that might expose the subject's identity.

CONTRIBUTION STATEMENT

MA designed the study, conducted the analyses, and wrote the manuscript. RG collected data, conducted analyses, and drafted manuscript. Jahad A., Ada A., Ahmed A., and AM helped with the study design and assisted with the manuscript preparation. All authors helped with manuscript revisions and ensured its intellectual content. Jahad A. helped with data acquisition. All authors have read and approved the final manuscript. All authors agreed to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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REFERENCE:

1. Zhou D, Xi B, Zhao M, et al. Uncontrolled hypertension increases risk of all-cause and cardiovascular disease mortality in US adults: the NHANES III Linked Mortality Study. *Scientific reports* 2018;8(1):1-7.
2. Chan M. A global brief on Hypertension. *World Health Organization Switzerland* 2013
3. Sudharsanan N, Geldsetzer P. Impact of Coming Demographic Changes on the Number of Adults in Need of Care for Hypertension in Brazil, China, India, Indonesia, Mexico, and South Africa: A Modeling Study. *Hypertension* 2019;73(4):770-76.
4. Lackland DT, Weber MA. Global burden of cardiovascular disease and stroke: hypertension at the core. *Canadian Journal of Cardiology* 2015;31(5):569-71.
5. Han M, Li Q, Liu L, et al. Prehypertension and risk of cardiovascular diseases: a meta-analysis of 47 cohort studies. *Journal of Hypertension* 2019;37(12):2325-32.
6. Bolli P, Hemmelgarn B, Myers MG, et al. High normal blood pressure and prehypertension: The debate continues. *Canadian Journal of Cardiology* 2007;23(7):581-83.
7. Banach M, Michalska M, Kjeldsen SE, et al. What should be the optimal levels of blood pressure: does the J-curve phenomenon really exist? *Expert opinion on pharmacotherapy* 2011;12(12):1835-44.
8. Fan F, Yuan Z, Qin X, et al. Optimal systolic blood pressure levels for primary prevention of stroke in general hypertensive adults: findings from the CSPPT (China Stroke Primary Prevention Trial). *Hypertension* 2017;69(4):697-704.
9. Deedwania P. The ongoing saga of optimal blood pressure level in patients with diabetes mellitus and coronary artery disease: Am Heart Assoc, 2018.
10. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology* 2018;71(19):e127-e248.
11. Chobanian AV. National High blood pressure education program committee: seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension* 2003;42:1206-52.
12. Reboussin DM, Allen NB, Griswold ME, et al. Systematic review for the 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology* 2018;71(19):2176-98.
13. Muntner P, Carey RM, Gidding S, et al. Potential US population impact of the 2017 ACC/AHA high blood pressure guideline. *Journal of the American College of Cardiology* 2018;71(2):109-18.
14. Al Kibria GM, Swasey K, Angela K, et al. Estimated change in prevalence of hypertension in Nepal following application of the 2017 ACC/AHA guideline. *JAMA Network Open* 2018;1(3):e180606-e06.
15. Khera R, Lu Y, Saxena A, et al. The impact of 2017 ACC/AHA guidelines on the prevalence of hypertension and eligibility for anti-hypertensive therapy in the United States and China. *bioRxiv* 2017:218859.

For peer review only

16. Islam JY, Zaman MM, Haq SA, et al. Epidemiology of hypertension among Bangladeshi adults using the 2017 ACC/AHA hypertension clinical practice guidelines and joint National Committee 7 guidelines. *Journal of human hypertension* 2018;32(10):668-80.
17. Wang D, Hatahet M, Wang Y, et al. Multivariate analysis of hypertension in general US adults based on the 2017 ACC/AHA guideline: data from the national health and nutrition examination survey 1999 to 2016. *Blood pressure* 2019;28(3):191-98.
18. Al Kibria GM, Swasey K, Choudhury A, et al. The new 2017 ACC/AHA guideline for classification of hypertension: changes in prevalence of hypertension among adults in Bangladesh. *Journal of human hypertension* 2018;32(8):608-16.
19. General Authority for Statistics. Demographic Survey 2016 [cited 2020. Available from: https://www.stats.gov.sa/sites/default/files/en-demographic-research-2016_2.pdf2020.
20. El Bcheraoui C, Basulaiman M, Wilson S, et al. Breast cancer screening in Saudi Arabia: free but almost no takers. *Plos one* 2015;10(3):e0119051.
21. El Bcheraoui C, Memish ZA, Tuffaha M, et al. Hypertension and its associated risk factors in the Kingdom of Saudi Arabia, 2013: a national survey. *International journal of hypertension* 2014;2014
22. Yusufali AM, Khatib R, Islam S, et al. Prevalence, awareness, treatment and control of hypertension in four Middle East countries. *Journal of hypertension* 2017;35(7):1457-64.
23. Lear S, James P, Ko G, et al. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. *European journal of clinical nutrition* 2010;64(1):42-61.
24. Bullano MF, Kamat S, Willey VJ, et al. Agreement between administrative claims and the medical record in identifying patients with a diagnosis of hypertension. *Medical care* 2006:486-90.
25. Smith C, Kosten S. Multiple Imputation: A Statistical Programming Story 2017 [Available from: https://www.pharmasug.org/proceedings/2017/SP/PharmaSUG-2017-SP01.pdf.
26. Von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Annals of internal medicine* 2007;147(8):573-77.
27. Khanam R, Ahmed S, Rahman S, et al. Prevalence and factors associated with hypertension among adults in rural Sylhet district of Bangladesh: a cross-sectional study. *BMJ open* 2019;9(10)
28. Samir K. An age distribution story: Reading into the population pyramid of Nepal. *Asian Population Studies* 2014;10(2):121-24.
29. Kabir R, Khan HT, Kabir M, et al. Population ageing in Bangladesh and its implication on health care. *European Scientific Journal* 2013;9(33):34-47.
30. Arnett DK, Blumenthal RS, Albert MA, et al. 2019 ACC/AHA guideline on the primary prevention of cardiovascular disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology* 2019;74(10):e177-e232.
31. Stefani L, Mascherini G, Tosi B, et al. Hypertension today: Role of sports and exercise medicine. *Journal of Hypertension and Cardiology* 2019;2(4):20.

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Table 1. Characteristics of Saudi Biobank by BP levels and antihypertensive use, 2017-2020

	SBP/DBP categories among those not taking antihypertensive medications (mm Hg)				Antihypertensive recorded (n=579)
	<120/80 (n=4451)	120-129/<80 (n=1648)	130-139/80-89 (n=2683)	≥140/90 (n=1438)	
Age, years Mean (SD)	28.50 (7.44)	28.72 (8.25)	30.58 (9.06)	33.27 (10.73)	35.38 (9.92)
Age, years N (%)					
18-29	2806 (63.04)	1053 (63.90)	1432 (53.37)	631 (43.88)	188 (32.47)
30-39	1257 (28.24)	417 (25.30)	851 (31.72)	418 (29.07)	197 (34.02)
40-49	318 (7.14)	136 (8.25)	288 (10.73)	263 (18.29)	141 (24.35)
50-59	61 (1.37)	36 (2.18)	86 (3.21)	101 (7.02)	42 (7.25)
≥60	9 (0.20)	6 (0.36)	26 (0.97)	25 (1.74)	11 (1.90)
Gender, N (%)					
Female	2587 (58.12)	706 (42.84)	1127 (42.01)	485 (33.73)	397 (68.57)
Male	1864 (41.88)	942 (57.16)	1556 (57.99)	953 (66.27)	182 (31.43)
Tobacco use, N (%)					
No	3604 (83.19)	1331 (81.96)	2192 (83.35)	1158 (82.07)	526 (92.28)
Yes	728 (16.81)	293 (18.04)	438 (16.65)	253 (17.93)	44 (7.72)
Diabetes history, N (%)					
No	2777 (62.39)	1010 (61.28)	1622 (60.45)	861 (59.87)	349 (60.28)
Yes	1674 (37.61)	638 (38.71)	1061 (39.55)	577 (40.13)	230 (39.72)
CVD history, N (%)					
No	3657 (82.16)	1347 (81.74)	2145 (79.95)	1120 (77.89)	439 (75.82)
Yes	794 (17.84)	301 (18.26)	538 (20.05)	318 (22.11)	140 (24.18)
Blood pressure, Mean (SD)					
Systolic blood pressure	108.47 (7.70)	124.01 (2.81)	126.55 (9.0)	143.81 (20.88)	123.40 (18.01)
Diastolic blood pressure	67.98 (6.68)	71.47 (5.71)	80.92 (5.88)	90.49 (13.17)	78.95 (15.45)

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Table 2. The percentage of hypertension and the recommended antihypertensive medications in the Saudi Biobank according to the 2017 ACC/AHA Guideline and the JNC 7 Guideline

Characteristics	2017 ACC/AHA Guideline		JNC7 Guideline		2017 ACC/AHA but not JNC-7	
	HTN	Recommended Antihypertensive Medications	HTN	Recommended Antihypertensive Medications	HTN	Recommended Antihypertensive Medications
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Overall	40.77 (40.60,40.94)	27.67 (27.52,27.82)	14.49 (14.37,14.61)	24.84 (24.69,24.98)	26.28 (26.23,26.33)	2.83 (2.83,2.84)
Gender						
Women	33.57 (33.34,33.80)	32.02 (31.79,32.24)	10.39 (10.24,10.54)	19.97 (19.78,20.17)	23.18 (23.10,23.26)	12.05 (12.01,12.07)
Men	47.72 (47.48,47.96)	23.16 (22.95,23.37)	18.45 (18.26,18.63)	29.53 (29.31,29.75)	29.27 (29.22,29.33)	-6.37 (-6.36,-6.38)
Age, years						
18-29	34.86 (34.64,35.08)	21.62 (21.43,21.81)	10.67 (10.53,10.81)	19.66 (19.47,19.84)	24.19 (24.11,24.27)	1.96 (1.96,1.97)
30-39	43.44 (43.12,43.76)	29.68 (29.39,29.97)	14.62 (14.40,14.85)	26.46 (26.18,26.75)	28.82 (28.72,28.91)	3.22 (3.21,3.22)
40-49	55.58 (55.06,56.11)	44.15 (43.63,44.68)	27.33 (26.87,27.80)	39.35 (38.84,39.87)	28.25 (28.19,28.31)	4.80 (4.79,4.81)
50-59	66.87 (65.94,67.80)	54.91 (53.92,55.89)	36.31 (35.39,37.22)	48.16 (47.17,49.15)	30.56 (30.55,30.58)	6.75 (6.75,6.74)
≥60	70.13 (68.23,71.96)	64.94 (62.97,66.85)	34.15 (32.27,36.02)	54.55 (52.51,56.57)	35.98 (35.96,35.94)	10.39 (10.46,10.28)
Marital status						
Never married	36.18 (35.95,36.40)	22.89 (22.70,23.09)	11.91 (11.76,12.06)	21.05 (20.86,21.24)	24.27 (24.19,24.34)	1.84 (1.84,1.85)
Married	46.39 (46.13,46.65)	33.37 (33.12,33.62)	17.76 (17.59,17.99)	29.39 (29.15,29.63)	28.63 (28.54,28.66)	3.98 (3.97,3.99)
Divorced, Sep.	44.18 (44.10,46.25)	34.61 (33.58,35.65)	17.30 (16.50,18.10)	29.83 (28.84,30.82)	26.88 (27.6,28.15)	4.78 (4.74,4.83)
Education						
< Primary school	58.75 (57.13,60.35)	44.36 (42.74,45.98)	28.44 (26.97,29.92)	40.19 (38.59,41.80)	30.31 (30.16,30.43)	4.17 (4.15,4.18)
Intermediate school	50.43 (49.50,51.35)	37.17 (36.28,38.07)	22.52 (21.75,23.29)	33.97 (33.10,34.85)	27.91 (27.75,28.06)	3.20 (3.18, 3.22)
Primary school	59.72 (58.58,60.86)	45.35 (44.19,46.51)	30.07 (29.01,31.14)	40.69 (39.55,41.84)	29.65 (29.57,29.72)	4.66 (4.64,4.67)
High school	38.04 (37.79,38.30)	25.30 (25.07,25.53)	13.45 (13.27,13.63)	22.86 (22.64,23.08)	24.59 (24.52,24.67)	2.44 (2.43,2.45)
Some college	48.19 (47.54,48.84)	34.43 (33.82,35.05)	18.68 (18.18,19.19)	31.16 (30.56,31.76)	29.51 (29.36,29.65)	3.27 (3.26,3.29)
Bachelor	40.05 (39.78,40.31)	26.52 (26.28,26.76)	12.90 (12.71,13.08)	23.59 (23.36,23.82)	27.15 (27.07,27.23)	2.93 (2.92,2.94)
Higher education	40.08 (39.14,41.02)	30.44 (29.55,31.32)	15.02 (14.33,15.72)	26.67 (25.82,27.52)	25.06 (24.81,25.3)	3.77 (3.73,3.8)
Employment						
Employed	41.70 (41.46,41.94)	28.55 (28.33,28.76)	15.02 (14.84,15.19)	25.56 (25.35,25.77)	26.68 (26.62,26.75)	1.65 (2.98,2.99)
Unemployed	38.36 (37.80,38.92)	27.51 (27.00,28.03)	13.54 (13.14,13.93)	24.52 (24.03,25.02)	24.82 (24.66,24.99)	2.99 (2.97,3.01)
Student	37.33 (37.01,37.65)	22.95 (22.67,23.23)	11.72 (11.50,11.93)	20.92 (20.66,21.19)	25.61 (25.51,25.72)	2.03 (2.01,2.04)
Retired/others	46.44 (45.94,46.93)	34.75 (34.28,35.23)	19.26 (18.87,19.65)	30.87 (30.41,31.33)	27.18 (27.07,27.28)	3.88 (3.87,3.90)
Income, SAR						
≤5000	38.86 (38.62,39.10)	25.85 (25.63,26.06)	13.43 (13.26,13.59)	23.32 (23.12,23.53)	25.43 (25.36,25.51)	2.53 (2.51,2.53)
5001 - 10,000	38.46 (38.15,38.76)	25.20 (24.92,25.47)	12.87 (12.66,13.08)	22.67 (22.41,22.94)	25.59 (25.49,25.68)	2.53 (2.51,2.53)
1,0001 - 15,000	47.95 (47.45,48.44)	34.82 (34.35,35.28)	18.40 (18.02,18.97)	30.63 (30.18,31.09)	29.55 (29.43,29.47)	4.19 (4.17,4.19)
15,001 – 20,000	50.89 (50.12,51.66)	37.79 (37.04,38.53)	20.68 (20.06,21.30)	34.22 (33.49,34.95)	30.21 (30.06,30.36)	3.57 (3.55,3.58)

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>20,000	50.26 (49.22,51.30)	37.19 (36.19,38.19)	22.77 (21.90,23.64)	32.12 (31.76,33.69)	27.49 (27.32,27.66)	5.07 (4.43,4.50)
Vigorous exercise						
Never	42.84 (42.63,43.04)	30.08 (29.90,30.27)	15.79 (15.64,15.94)	26.89 (26.71,27.07)	27.05 (26.99,27.10)	3.19 (3.19,3.20)
1	38.95 (38.31,39.58)	23.34 (22.80,23.89)	13.67 (13.23,14.12)	20.53 (20.01,21.06)	25.28 (25.08,25.46)	2.81 (2.79,2.83)
2-3	35.29 (34.74,35.84)	21.08 (20.62,21.55)	11.15 (10.79,11.52)	19.62 (19.16,20.08)	24.14 (23.95,24.32)	1.46 (1.46,1.47)
4-5	33.65 (33.04,34.26)	20.98 (20.45,21.51)	10.01 (9.62,10.40)	19.64 (19.13,20.16)	23.64 (23.42,23.86)	1.34 (1.32,1.35)
>5	34.00 (33.29,34.72)	20.73 (20.12,21.34)	9.64 (9.19,10.08)	18.40 (17.81,18.98)	24.36 (24.10,24.64)	2.33 (2.31,2.36)
Current smoker						
No	40.93 (40.75,41.12)	27.81 (27.64,27.97)	14.47 (14.34,14.60)	24.94 (24.78,25.10)	26.46 (26.41,26.52)	2.87 (2.86,2.87)
Yes	39.98 (39.57,40.39)	27.00 (26.63,27.37)	14.60 (14.30,14.89)	24.32 (23.96,24.68)	25.38 (25.27,25.50)	2.68 (2.67,2.69)
Diabetes						
No	39.37 (39.20,39.54)	18.87 (18.70,19.04)	13.44 (13.32,13.56)	14.25 (14.09,14.40)	25.39 (25.88,25.98)	4.62 (4.61,4.64)
Yes	62.37 (61.69,63.04)	41.60 (41.33,41.88)	30.65 (30.01,31.30)	41.60 (41.33,41.88)	31.72 (31.68,31.74)	0
BMI, kg/m^2						
Underweight	20.84 (20.28,21.39)	11.72 (11.28,12.17)	5.41 (5.10,5.72)	10.55 (10.13,10.97)	15.43 (15.18,15.67)	1.17 (1.15,1.20)
Normal weight	30.76 (30.51,31.02)	19.14 (18.92,19.36)	8.89 (8.73,9.04)	16.98 (16.77,17.19)	21.87 (21.78,21.98)	2.16 (2.15,2.17)
Overweight	44.37 (44.06,44.68)	30.40 (30.12,30.69)	14.69 (14.47,14.92)	27.16 (26.88,27.44)	29.68 (29.59,29.76)	3.24 (3.24,3.25)
Obese	56.12 (55.76,56.48)	40.46 (40.10,40.82)	23.98 (23.67,24.29)	36.63 (36.27,36.98)	32.14 (32.09,32.19)	3.83 (3.83,3.84)
Extremely Obese	67.53 (66.53,68.54)	54.21 (53.14,55.28)	37.82 (36.78,38.87)	50.46 (49.38,51.53)	29.71 (29.75,29.67)	3.75 (3.76,3.75)
Waist Circum., cm						
Normal	32.65 (32.44,32.85)	20.51 (20.34,20.68)	9.30 (9.17,9.42)	18.13 (17.96,18.29)	23.35 (23.27,23.43)	2.38 (2.38,2.39)
Not Normal	55.54 (55.25,55.83)	40.68 (40.39,40.96)	23.94 (23.69,24.18)	37.03 (36.75,37.30)	31.60 (31.56,31.65)	3.65 (3.64,3.66)
Waist-hip ratio						
Normal	37.55 (37.37,37.74)	24.68 (24.51,24.84)	12.38 (12.26,12.51)	22.11 (21.95,22.27)	25.17 (25.11,25.23)	2.57 (2.56,2.57)
Not Normal	54.57 (54.18,54.97)	40.50 (40.11,40.88)	23.53 (23.19,23.86)	36.51 (36.13,36.89)	31.04 (30.99,31.11)	3.99 (3.98,3.99)

SD: Standard Deviation, SAR: Saudi Arabian Riyals

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Table 3: Characteristics of the Saudi Biobank population not taking antihypertensive medications meeting the definition of HTN and recommended antihypertensive according to 2017 ACC/AHA Guideline and JNC-7 Guideline, 2017-2020.

	HTN according to			Recommended treatment by		
	ACC (n=4121)	JNC 7 (n=1438)	ACC but not JNC-7 (n=2683)	ACC (n= 2783)	JNC 7 (n=743)	ACC but not JNC-7 (n=2040)
Age, Mean (SD)	31.52 (9.76)	33.27 (10.73)	30.58 (9.06)	32.53 (10.23)	34.06 (10.61)	31.97 (10.04)
Male gender, %	60.88	66.27	57.99	60.15	65.28	58.28
Smoking, %	17.10	17.93	16.65	17.06	17.93	16.73
DM, %	39.75	40.13	39.55	58.86	77.66	52.01
CVD, (%)	20.77	22.11	20.05	30.76	25.30	32.75
BMI, kg/m^2						
Underweight	3.09	2.29	3.51	2.66	1.75	2.99
Normal weight	29.50	23.64	32.65	26.94	22.07	28.72
Overweight	32.64	30.39	33.84	33.02	30.55	33.92
Obese	30.30	36.72	26.86	32.16	38.63	29.80
Extremely Obese	4.47	6.95	3.14	5.22	7.0	4.57
Waist Circum. (cm)						
Not Normal,%	47.25	57.37	41.82	50.99	58.55	48.24
WtHR						
Not Normal,%	23.88	28.93	21.17	26.05	29.21	24.90
Systolic blood pressure, Mean (SD)	132.57 (16.51)	143.81 (20.88)	126.55 (9.00)	135.59 (18.30)	147.43 (26.75)	131.28 (11.26)
Diastolic blood pressure, Mean (SD)	84.26 (10.19)	90.49 (13.17)	80.92 (5.88)	86.00 (11.28)	93.48 (16.06)	83.27 (7.20)

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Table 4: Characteristics of the Saudi Biobank population taking antihypertensive medications with BP above treatment goals according to 2017 ACC/AHA Guideline and JNC-7 Guideline, 2017-2020.

	BP above goal according to		
	ACC (n=287)	JNC 7 (n=161)	ACC but not JNC-7 (n=126)
Age, Mean (SD)	37.26 (9.94)	39.71 (9.72)	34.13 (9.35)
Male gender, %	40.07	45.34	33.33
Smoking, %	7.80	6.96	8.87
DM, %	35.89	46.58	22.22
CVD, (%)	25.09	24.84	25.40
BMI, kg/m²			
Underweight	4.18	2.48	6.35
Normal weight	28.92	26.71	31.75
Overweight	32.06	29.19	35.71
Obese	30.66	34.78	25.40
Extremely Obese	4.18	6.83	0.79
Waist Circum. (cm)			
Not Normal, %	56.45	63.98	46.83
WtHR			
Not Normal, %	42.16	44.72	38.89
Systolic blood pressure, Mean (SD)	135.11 (17.21)	144.07 (15.99)	123.65 (10.71)
Diastolic blood pressure, Mean (SD)	88.65 (15.91)	93.42 (19.45)	82.56 (5.34)
Number of antihypertensive medications			
1	45.51	41.59	52.31
2	29.78	31.86	26.15
3	7.87	7.96	7.69
4	8.99	8.85	9.23
≥5	7.87	9.73	4.62

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Supp. 1. Determinants of hypertension according to guidelines among Saudi Biobank, 2017-2020 (n = 10799)

	ACC/AHA			JNC-7		
Characteristics	**OR (95% CI)**	**AOR (95% CI)**	**P**	**OR (95% CI)**	**AOR (95% CI)**	**P**
Gender						
Women	1.0	1.0		1.0	1.0	
Men	1.80 (1.67,1.95)	2.79 (2.51,3.11)	<0.01	1.95 (1.74,2.18)	3.10 (2.66,3.60)	<0.01
Age (years)						
18-29	1.0	1.0		1.0	1.0	
30-39	1.43 (1.31,1.57)	1.27 (1.13,1.44)	<0.01	1.42 (1.25,1.62)	1.39 (1.16,1.67)	<0.01
40-49	2.34 (2.06,2.66)	1.70 (1.44,2.02)	<0.01	3.14 (2.69,3.66)	2.55 (2.03,3.19)	<0.01
50-59	3.77 (2.98,3.78)	2.28 (1.72,3.03)	<0.01	4.82 (3.79,6.13)	3.23 (2.34,4.44)	<0.01
≥60	4.39 (2.68,7.17)	2.09 (1.20,3.63)	0.009	4.53 (2.81,7.28)	2.21 (1.26,3.87)	<0.01
Marital status						
Never married	1.0	1.0		1.0	1.0	
Married	1.53 (1.41,1.65)	0.91 (0.81,1.02)	0.12	1.60 (1.43,1.78)	0.73 (0.61,0.87)	<0.01
Divorced, separated	1.45 (1.14,1.85)	1.07 (0.81,1.41)	0.67	1.64 (1.19,2.26)	0.95 (0.66,1.38)	0.66
Employment status						
Employed	1.0	1.0		1.0	1.0	
Unemployed	0.87 (0.75,1.00)	1.27 (1.04,1.55)	0.01	0.89 (0.72,1.08)	1.35 (1.03,1.78)	0.02
Student	0.83 (0.76,0.91)	1.36 (1.14,1.63)	<0.01	0.75 (0.65,0.86)	1.60 (0.90, 1.50)	0.21
Retired/others	1.21 (1.07,1.37)	1.21 (1.00,1.45)	0.03	1.35 (1.15,1.58)	1.24 (0.96,1.59)	0.07
Income						
≤5000	1.0	1.0		1.0	1.0	
5001 - 10,000	0.98 (0.89,1.08)	0.86 (0.72,1.03)	0.12	0.95 (0.83,1.09)	0.76 (0.60,0.97)	0.04
1,0001 - 15,000	1.45 (1.27,1.65)	1.03 (0.83,1.27)	0.66	1.45 (1.22,1.72)	0.94 (0.71,1.25)	0.80
15,001 – 20,000	1.63 (1.34,1.99)	1.08 (0.82,1.43)	0.45	1.68 (1.31,2.15)	0.98 (0.69,1.39)	0.92
>20,000	1.59 (1.22,2.06)	0.85 (0.61,1.20)	0.45	1.90 (1.40,2.58)	0.89 (0.58,1.37)	0.83
Vigorous exercise						
Never	1.0	1.0		1.0	1.0	
1	0.85 (0.73,0.99)	0.79 (0.67,0.94)	<0.01	0.84 (0.68,1.05)	1.17 (0.93,1.48)	0.18
2-3	0.73 (0.63,0.84)	0.75 (0.65,0.88)	<0.01	0.67 (0.54,0.83)	0.87 (0.64,1.18)	0.36
4-5	0.68 (0.58,0.79)	0.68 (0.57,0.81)	<0.01	0.59 (0.46,0.76)	0.75 (0.54,1.04)	0.08
>5	0.69 (0.57,0.82)	0.72 (0.59,0.87)	<0.01	0.57 (0.43,0.76)	0.76 (0.53,1.10)	0.14
Time standing at work						

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Never	1.0	1.0		1.0	1.0	
A few times	1.09 (0.81,1.46)	1.09 (0.80,1.50)	0.56	2.32 (1.34,4.02)	2.60 (1.47,4.62)	<0.01
Sometimes	1.16 (0.86,1.55)	1.18 (0.86,1.62)	0.28	2.27 (1.31,3.94)	2.60 (1.47,4.62)	<0.01
Most of the times	0.95 (0.70,1.28)	1.03 (0.74,1.42)	0.84	2.10 (1.20,3.67)	2.66 (1.48,4.76)	<0.01
All the times	0.87 (0.55,1.37)	0.95 (0.58,1.55)	0.86	1.56 (0.71,3.39)	1.92 (0.85,4.34)	0.11
Current smoker						
No	1.0	1.0		1.0	1.0	
Yes	0.96 (0.87,1.07)	0.75 (0.66,0.85)	<0.01	1.01 (0.87,1.17)	0.79 (0.67,0.93)	<0.01
Diabetes						
No	1.0	1.0		1.0	1.0	
Yes	2.55 (2.17,3.00)	1.67 (1.40,1.99)	<0.01	2.48 (2.39,3.39)	1.64 (1.34,2.00)	<0.01
BMI (kg/m^2)						
Underweight	1.0	1.0		1.0	1.0	
Normal weight	1.69 (1.39,2.05)	1.67 (1.37,2.04)	<0.01	1.70 (1.20,2.41)	1.67 (1.17,2.38)	<0.01
Overweight	3.03 (2.49,3.69)	2.43 (1.97,3.00)	<0.01	3.01 (2.13,4.24)	2.15 (1.50,3.08)	<0.01
Obese	4.86 (3.97,5.94)	3.17 (2.52,3.99)	<0.01	5.51 (3.90,7.77)	2.97 (2.04,4.34)	<0.01
Extremely Obese	7.90 (5.78,10.79)	4.64 (3.31,6.52)	<0.01	10.62 (7.04,16.01)	5.24 (3.35,8.19)	<0.01
Waist Circum.						
Normal	1.0	1.0		1.0	1.0	
Not Normal	2.58 (2.38,2.79)	1.32 (1.17,1.50)	<0.01	3.07 (2.75,3.43)	1.53 (1.29,1.81)	<0.01
Waist to hip ratio						
Normal	1.0	1.0		1.0	1.0	
Not Normal	1.99 (1.81,2.20)	1.27 (1.13,1.43)	<0.01	2.18 (1.93,2.45)	1.19 (1.02,1.38)	0.02

Waist Circumference: (men<94, women <80), Waist to hip ratio: (men<0.95, women <0.80), AOR: Adjusted OR.

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Supp. 2. The percentage and determinants of elevated BP according to 2017 ACC/AHA Guideline among Saudi Biobank, 2017-2020 (n = 10799)

Characteristics	Elevated BP according to 2017 ACC/AHA Guideline			
	Percentage (95% CI)	OR (95% CI)	AOR (95% CI)	P-value
Overall	15.82 (15.69,15.94)	-	-	-
Gender				
Women	14.07 (13.90,14.24)	1.0	1.0	
Men	17.50 (17.32,17.68)	1.29 (1.17,1.44)	1.35 (1.19,1.54)	<0.01
Age, years				
18-29	17.64 (17.47,17.82)	1.0	1.0	
30-39	13.95 (13.73,14.17)	0.76 (0.67,0.85)	0.76 (0.66,0.88)	<0.01
40-49	12.83 (12.47,13.18)	0.69 (0.57,0.83)	0.71 (0.58,0.87)	<0.01
50-59	11.35 (10.73,11.98)	0.60 (0.42,0.85)	0.62 (0.43,0.89)	<0.01
≥60	10.39 (9.15,11.63)	0.54 (0.26,1.13)	0.54 (0.26,1.15)	0.08
Time sitting at work				
Never	8.02 (7.12,8.92)	1.0	1.0	
A few times	15.80 (15.53,16.07)	2.15 (1.08,4.30)	2.39 (1.19,4.77)	0.02
Sometimes	16.41 (16.17,16.65)	2.25 (1.13,4.48)	2.59 (1.30,5.17)	0.01
Most of the times	15.66(15.47,15.84)	2.13 (1.07,4.23)	2.34 (1.17,4.66)	0.03
All the times	15.44 (14.70,16.17)	2.10 (0.99,4.42)	2.10 (0.99,4.44)	0.08
Current smoker				
No	15.62 (15.48,15.75)	1.0	1.0	
Yes	16.80 (16.49,17.12)	1.09 (0.95,1.25)	0.97 (0.83,112)	0.72
Diabetes				
No	15.76 (15.60,15.92)	1.0	1.0	
Yes	15.91 (15.71,16.11)	0.99 (0.89,1.10)	1.03 (0.93,1.15)	0.61
BMI, kg/m^2				
Underweight	12.14 (11.69,12.59)	1.0	1.0	
Normal weight	16.30 (16.10,16.50)	1.41 (1.10,1.80)	1.48 (1.16,1.89)	<0.01
Overweight	16.47 (16.23,16.70)	1.43 (1.11,1.83)	1.64 (1.27,2.12)	<0.01
Obese	15.30 (15.04,15.56)	1.31 (1.01,1.69)	1.68 (1.26,2.24)	<0.01
Extremely Obese	14.41 (13.65,15.16)	1.22 (0.81,1.83)	1.54 (1.00,2.37)	0.04
Waist Circum. (cm)				
Normal	16.36 (16.20,16.52)	1.0	1.0	
Not Normal	14.83 (14.62,15.03)	0.89 (0.80,0.99)	0.91 (0.77,1.07)	0.21
WtHR				
Normal	16.27 (16.12,16.41)	1.0	1.0	
Not Normal	13.89 (13.62,14.17)	0.83 (0.72,0.95)	0.99 (0.84,1.16)	0.93

Waist Circumference: (men<94, women <80), WtHR (Waist to hip ratio): (men<0.95, women <0.80), AOR: Adjusted OR, SR: Saudi Riyals.

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Supp. 3. Sociodemographic and lifestyle characteristics of the Saudi Biobank, 2017-2020

Characteristics	Total (n=10799)		Men (n=5497)		Women (n=5302)	
	n	%	n	%	n	%
Age, years						
Mean (SD)	30.05	(8.85)	29.78	(8.52)	30.34	(9.18)
18-29	6110	56.58	3189	58.01	2921	55.09
30-39	3140	29.08	1612	29.33	1528	28.82
40-49	1146	10.61	517	9.41	629	11.86
50-59	326	3.02	138	2.51	188	3.55
≥60	77	0.71	41	0.75	36	0.68
Marital status						
Never married	5874	54.39	3118	56.72	2756	51.98
Married	4587	42.48	2293	41.71	2294	43.27
Divorced	270	2.50	49	0.89	221	4.17
Missing	68	0.63	37	0.67	31	0.58
Employment						
Employed	5453	50.50	3852	70.07	1601	30.20
Unemployed	960	8.89	184	3.35	776	14.64
Student	2950	27.32	1201	21.85	1749	32.99
Retired/others	1307	12.10	155	2.82	1152	21.73
Missing	129	1.19	105	1.91	24	0.45
Family income, SAR						
≤5000	3487	32.29	1231	22.39	2256	42.55
5001 - 10,000	2371	21.96	1849	33.64	522	9.85
1,0001 - 15,000	1006	9.32	675	12.28	331	6.24
15,001 – 20,000	413	3.82	276	5.02	137	2.58
>20,000	221	2.05	176	3.20	45	0.85
Missing	3301	30.57	1290	23.47	2011	37.93
Education level						
< Primary school	119	1.10	23	0.42	96	1.81
Primary school	235	2.18	55	1.00	180	3.39
Intermediate school	372	3.44	154	2.80	218	4.11
High school	4557	42.20	2752	50.06	1805	34.04
Some college	759	7.03	591	10.75	168	3.17
Bachelor’s degree	4346	40.24	1738	31.62	2608	49.19
Higher education	345	3.19	137	2.49	208	3.92
Missing	66	0.61	47	0.86	19	0.36
BMI, kg/m^2						

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Underweight	683	6.32	343	6.24	340	6.41
Normal weight	4206	38.99	2108	38.35	2098	39.57
Overweight	3235	29.99	1741	31.67	1494	28.18
Obese	2386	22.12	1165	21.19	1221	23.03
Extremely obese	277	2.57	132	2.40	145	2.73
Missing	12	0.11	4	0.08	8	0.15
Tobacco use						
Yes	1756	16.26	1690	30.74	66	1.24
Missing	232	2.15	182	3.31	50	0.94
Vigorous exercise, week						
Never	7635	70.70	3168	57.63	4467	84.25
Once	744	6.89	571	10.39	173	3.26
2-3	944	8.74	615	11.19	329	6.21
4-5	740	6.85	556	10.11	184	3.47
>5	541	5.01	423	7.70	118	2.23
Missing	195	1.81	164	2.98	31	0.58
Time spent standing, week						
Never	198	1.83	138	2.51	60	1.13
A few times	4098	37.95	1998	36.35	2100	39.61
Sometimes	4261	39.46	1997	36.33	2264	42.70
Most of the times	1864	17.26	1045	19.01	819	15.45
All the times	131	1.21	114	2.07	17	0.32
Missing	247	2.29	205	3.73	42	0.79
Waist circum., cm mean (SD)	82.39	(16.09)	88.52	(15.12)	76.01	(14.51)
Missing	105	0.97	43	0.78	62	1.17
Waist to hip ratio mean (SD)	0.81	(0.10)	0.87	(0.08)	0.75	(0.09)
Missing	112	1.04	45	0.82	67	1.26
Diabetes History						
Yes	659	6.10	336	6.11	323	6.09
Blood pressure, mmHg						
Systolic blood pressure	120.73	15.01	123.97	15.24	117.37	14.01
Diastolic blood pressure	75.24	10.70	76.46	10.70	73.97	10.56

SD: Standard Deviation, SAR: Saudi Arabian Riyals

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Supp. 1. Determinants of hypertension according to guidelines among Saudi Biobank, 2017-2020 (n = 10799)

	ACC/AHA			JNC-7		
Characteristics	**OR (95% CI)**	**AOR (95% CI)**	**P**	**OR (95% CI)**	**AOR (95% CI)**	**P**
Gender						
Women	1.0	1.0		1.0	1.0	
Men	1.80 (1.67,1.95)	2.79 (2.51,3.11)	<0.01	1.95 (1.74,2.18)	3.10 (2.66,3.60)	<0.01
Age (years)						
18-29	1.0	1.0		1.0	1.0	
30-39	1.43 (1.31,1.57)	1.27 (1.13,1.44)	<0.01	1.42 (1.25,1.62)	1.39 (1.16,1.67)	<0.01
40-49	2.34 (2.06,2.66)	1.70 (1.44,2.02)	<0.01	3.14 (2.69,3.66)	2.55 (2.03,3.19)	<0.01
50-59	3.77 (2.98,3.78)	2.28 (1.72,3.03)	<0.01	4.82 (3.79,6.13)	3.23 (2.34,4.44)	<0.01
≥60	4.39 (2.68,7.17)	2.09 (1.20,3.63)	0.009	4.53 (2.81,7.28)	2.21 (1.26,3.87)	<0.01
Marital status						
Never married	1.0	1.0		1.0	1.0	
Married	1.53 (1.41,1.65)	0.91 (0.81,1.02)	0.12	1.60 (1.43,1.78)	0.73 (0.61,0.87)	<0.01
Divorced, separated	1.45 (1.14,1.85)	1.07 (0.81,1.41)	0.67	1.64 (1.19,2.26)	0.95 (0.66,1.38)	0.66
Employment status						
Employed	1.0	1.0		1.0	1.0	
Unemployed	0.87 (0.75,1.00)	1.27 (1.04,1.55)	0.01	0.89 (0.72,1.08)	1.35 (1.03,1.78)	0.02
Student	0.83 (0.76,0.91)	1.36 (1.14,1.63)	<0.01	0.75 (0.65,0.86)	1.60 (0.90, 1.50)	0.21
Retired/others	1.21 (1.07,1.37)	1.21 (1.00,1.45)	0.03	1.35 (1.15,1.58)	1.24 (0.96,1.59)	0.07
Income						
≤5000	1.0	1.0		1.0	1.0	
5001 - 10,000	0.98 (0.89,1.08)	0.86 (0.72,1.03)	0.12	0.95 (0.83,1.09)	0.76 (0.60,0.97)	0.04
1,0001 - 15,000	1.45 (1.27,1.65)	1.03 (0.83,1.27)	0.66	1.45 (1.22,1.72)	0.94 (0.71,1.25)	0.80
15,001 – 20,000	1.63 (1.34,1.99)	1.08 (0.82,1.43)	0.45	1.68 (1.31,2.15)	0.98 (0.69,1.39)	0.92
>20,000	1.59 (1.22,2.06)	0.85 (0.61,1.20)	0.45	1.90 (1.40,2.58)	0.89 (0.58,1.37)	0.83
Vigorous exercise						
Never	1.0	1.0		1.0	1.0	
1	0.85 (0.73,0.99)	0.79 (0.67,0.94)	<0.01	0.84 (0.68,1.05)	1.17 (0.93,1.48)	0.18
2-3	0.73 (0.63,0.84)	0.75 (0.65,0.88)	<0.01	0.67 (0.54,0.83)	0.87 (0.64,1.18)	0.36
4-5	0.68 (0.58,0.79)	0.68 (0.57,0.81)	<0.01	0.59 (0.46,0.76)	0.75 (0.54,1.04)	0.08
>5	0.69 (0.57,0.82)	0.72 (0.59,0.87)	<0.01	0.57 (0.43,0.76)	0.76 (0.53,1.10)	0.14
Time standing at work						

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Never	1.0	1.0		1.0	1.0	
A few times	1.09 (0.81,1.46)	1.09 (0.80,1.50)	0.56	2.32 (1.34,4.02)	2.60 (1.47,4.62)	<0.01
Sometimes	1.16 (0.86,1.55)	1.18 (0.86,1.62)	0.28	2.27 (1.31,3.94)	2.60 (1.47,4.62)	<0.01
Most of the times	0.95 (0.70,1.28)	1.03 (0.74,1.42)	0.84	2.10 (1.20,3.67)	2.66 (1.48,4.76)	<0.01
All the times	0.87 (0.55,1.37)	0.95 (0.58,1.55)	0.86	1.56 (0.71,3.39)	1.92 (0.85,4.34)	0.11
Current smoker						
No	1.0	1.0		1.0	1.0	
Yes	0.96 (0.87,1.07)	0.75 (0.66,0.85)	<0.01	1.01 (0.87,1.17)	0.79 (0.67,0.93)	<0.01
Diabetes						
No	1.0	1.0		1.0	1.0	
Yes	2.55 (2.17,3.00)	1.67 (1.40,1.99)	<0.01	2.48 (2.39,3.39)	1.64 (1.34,2.00)	<0.01
BMI (kg/m^2)						
Underweight	1.0	1.0		1.0	1.0	
Normal weight	1.69 (1.39,2.05)	1.67 (1.37,2.04)	<0.01	1.70 (1.20,2.41)	1.67 (1.17,2.38)	<0.01
Overweight	3.03 (2.49,3.69)	2.43 (1.97,3.00)	<0.01	3.01 (2.13,4.24)	2.15 (1.50,3.08)	<0.01
Obese	4.86 (3.97,5.94)	3.17 (2.52,3.99)	<0.01	5.51 (3.90,7.77)	2.97 (2.04,4.34)	<0.01
Extremely Obese	7.90 (5.78,10.79)	4.64 (3.31,6.52)	<0.01	10.62 (7.04,16.01)	5.24 (3.35,8.19)	<0.01
Waist Circum.						
Normal	1.0	1.0		1.0	1.0	
Not Normal	2.58 (2.38,2.79)	1.32 (1.17,1.50)	<0.01	3.07 (2.75,3.43)	1.53 (1.29,1.81)	<0.01
Waist to hip ratio						
Normal	1.0	1.0		1.0	1.0	
Not Normal	1.99 (1.81,2.20)	1.27 (1.13,1.43)	<0.01	2.18 (1.93,2.45)	1.19 (1.02,1.38)	0.02

Waist Circumference: (men<94, women <80), Waist to hip ratio: (men<0.95, women <0.80), AOR: Adjusted OR.

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Supp. 2. The percentage and determinants of elevated BP according to 2017 ACC/AHA Guideline among Saudi Biobank, 2017-2020 (n = 10799)

Characteristics	Elevated BP according to 2017 ACC/AHA Guideline			
	Percentage (95% CI)	OR (95% CI)	AOR (95% CI)	P-value
Overall	15.82 (15.69,15.94)	-	-	-
Gender				
Women	14.07 (13.90,14.24)	1.0	1.0	
Men	17.50 (17.32,17.68)	1.29 (1.17,1.44)	1.35 (1.19,1.54)	<0.01
Age, years				
18-29	17.64 (17.47,17.82)	1.0	1.0	
30-39	13.95 (13.73,14.17)	0.76 (0.67,0.85)	0.76 (0.66,0.88)	<0.01
40-49	12.83 (12.47,13.18)	0.69 (0.57,0.83)	0.71 (0.58,0.87)	<0.01
50-59	11.35 (10.73,11.98)	0.60 (0.42,0.85)	0.62 (0.43,0.89)	<0.01
≥60	10.39 (9.15,11.63)	0.54 (0.26,1.13)	0.54 (0.26,1.15)	0.08
Time sitting at work				
Never	8.02 (7.12,8.92)	1.0	1.0	
A few times	15.80 (15.53,16.07)	2.15 (1.08,4.30)	2.39 (1.19,4.77)	0.02
Sometimes	16.41 (16.17,16.65)	2.25 (1.13,4.48)	2.59 (1.30,5.17)	0.01
Most of the times	15.66(15.47,15.84)	2.13 (1.07,4.23)	2.34 (1.17,4.66)	0.03
All the times	15.44 (14.70,16.17)	2.10 (0.99,4.42)	2.10 (0.99,4.44)	0.08
Current smoker				
No	15.62 (15.48,15.75)	1.0	1.0	
Yes	16.80 (16.49,17.12)	1.09 (0.95,1.25)	0.97 (0.83,112)	0.72
Diabetes				
No	15.76 (15.60,15.92)	1.0	1.0	
Yes	15.91 (15.71,16.11)	0.99 (0.89,1.10)	1.03 (0.93,1.15)	0.61
BMI, kg/m^2				
Underweight	12.14 (11.69,12.59)	1.0	1.0	
Normal weight	16.30 (16.10,16.50)	1.41 (1.10,1.80)	1.48 (1.16,1.89)	<0.01
Overweight	16.47 (16.23,16.70)	1.43 (1.11,1.83)	1.64 (1.27,2.12)	<0.01
Obese	15.30 (15.04,15.56)	1.31 (1.01,1.69)	1.68 (1.26,2.24)	<0.01
Extremely Obese	14.41 (13.65,15.16)	1.22 (0.81,1.83)	1.54 (1.00,2.37)	0.04
Waist Circum. (cm)				
Normal	16.36 (16.20,16.52)	1.0	1.0	
Not Normal	14.83 (14.62,15.03)	0.89 (0.80,0.99)	0.91 (0.77,1.07)	0.21
WtHR				
Normal	16.27 (16.12,16.41)	1.0	1.0	
Not Normal	13.89 (13.62,14.17)	0.83 (0.72,0.95)	0.99 (0.84,1.16)	0.93

Waist Circumference: (men<94, women <80), WtHR (Waist to hip ratio): (men<0.95, women <0.80), AOR: Adjusted OR, SR: Saudi Riyals.

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Supp. 3. Sociodemographic and lifestyle characteristics of the Saudi Biobank, 2017-2020

Characteristics	Total (n=10799)		Men (n=5497)		Women (n=5302)	
	n	%	n	%	n	%
Age, years						
Mean (SD)	30.05	(8.85)	29.78	(8.52)	30.34	(9.18)
18-29	6110	56.58	3189	58.01	2921	55.09
30-39	3140	29.08	1612	29.33	1528	28.82
40-49	1146	10.61	517	9.41	629	11.86
50-59	326	3.02	138	2.51	188	3.55
≥60	77	0.71	41	0.75	36	0.68
Marital status						
Never married	5874	54.39	3118	56.72	2756	51.98
Married	4587	42.48	2293	41.71	2294	43.27
Divorced	270	2.50	49	0.89	221	4.17
Missing	68	0.63	37	0.67	31	0.58
Employment						
Employed	5453	50.50	3852	70.07	1601	30.20
Unemployed	960	8.89	184	3.35	776	14.64
Student	2950	27.32	1201	21.85	1749	32.99
Retired/others	1307	12.10	155	2.82	1152	21.73
Missing	129	1.19	105	1.91	24	0.45
Family income, SAR						
≤5000	3487	32.29	1231	22.39	2256	42.55
5001 - 10,000	2371	21.96	1849	33.64	522	9.85
1,0001 - 15,000	1006	9.32	675	12.28	331	6.24
15,001 – 20,000	413	3.82	276	5.02	137	2.58
>20,000	221	2.05	176	3.20	45	0.85
Missing	3301	30.57	1290	23.47	2011	37.93
Education level						
< Primary school	119	1.10	23	0.42	96	1.81
Primary school	235	2.18	55	1.00	180	3.39
Intermediate school	372	3.44	154	2.80	218	4.11
High school	4557	42.20	2752	50.06	1805	34.04
Some college	759	7.03	591	10.75	168	3.17
Bachelor’s degree	4346	40.24	1738	31.62	2608	49.19
Higher education	345	3.19	137	2.49	208	3.92
Missing	66	0.61	47	0.86	19	0.36
BMI, kg/m^2						

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Underweight	683	6.32	343	6.24	340	6.41
Normal weight	4206	38.99	2108	38.35	2098	39.57
Overweight	3235	29.99	1741	31.67	1494	28.18
Obese	2386	22.12	1165	21.19	1221	23.03
Extremely obese	277	2.57	132	2.40	145	2.73
Missing	12	0.11	4	0.08	8	0.15
Tobacco use						
Yes	1756	16.26	1690	30.74	66	1.24
Missing	232	2.15	182	3.31	50	0.94
Vigorous exercise, week						
Never	7635	70.70	3168	57.63	4467	84.25
Once	744	6.89	571	10.39	173	3.26
2-3	944	8.74	615	11.19	329	6.21
4-5	740	6.85	556	10.11	184	3.47
>5	541	5.01	423	7.70	118	2.23
Missing	195	1.81	164	2.98	31	0.58
Time spent standing, week						
Never	198	1.83	138	2.51	60	1.13
A few times	4098	37.95	1998	36.35	2100	39.61
Sometimes	4261	39.46	1997	36.33	2264	42.70
Most of the times	1864	17.26	1045	19.01	819	15.45
All the times	131	1.21	114	2.07	17	0.32
Missing	247	2.29	205	3.73	42	0.79
Waist circum., cm mean (SD)	82.39	(16.09)	88.52	(15.12)	76.01	(14.51)
Missing	105	0.97	43	0.78	62	1.17
Waist to hip ratio mean (SD)	0.81	(0.10)	0.87	(0.08)	0.75	(0.09)
Missing	112	1.04	45	0.82	67	1.26
Diabetes History						
Yes	659	6.10	336	6.11	323	6.09
Blood pressure, mmHg						
Systolic blood pressure	120.73	15.01	123.97	15.24	117.37	14.01
Diastolic blood pressure	75.24	10.70	76.46	10.70	73.97	10.56

SD: Standard Deviation, SAR: Saudi Arabian Riyals

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Supp. 1. Determinants of hypertension according to guidelines among Saudi Biobank, 2017-2020 (n = 10799)

	ACC/AHA			JNC-7		
Characteristics	**OR (95% CI)**	**AOR (95% CI)**	**P**	**OR (95% CI)**	**AOR (95% CI)**	**P**
Gender						
Women	1.0	1.0		1.0	1.0	
Men	1.80 (1.67,1.95)	2.79 (2.51,3.11)	<0.01	1.95 (1.74,2.18)	3.10 (2.66,3.60)	<0.01
Age (years)						
18-29	1.0	1.0		1.0	1.0	
30-39	1.43 (1.31,1.57)	1.27 (1.13,1.44)	<0.01	1.42 (1.25,1.62)	1.39 (1.16,1.67)	<0.01
40-49	2.34 (2.06,2.66)	1.70 (1.44,2.02)	<0.01	3.14 (2.69,3.66)	2.55 (2.03,3.19)	<0.01
50-59	3.77 (2.98,3.78)	2.28 (1.72,3.03)	<0.01	4.82 (3.79,6.13)	3.23 (2.34,4.44)	<0.01
≥60	4.39 (2.68,7.17)	2.09 (1.20,3.63)	0.009	4.53 (2.81,7.28)	2.21 (1.26,3.87)	<0.01
Marital status						
Never married	1.0	1.0		1.0	1.0	
Married	1.53 (1.41,1.65)	0.91 (0.81,1.02)	0.12	1.60 (1.43,1.78)	0.73 (0.61,0.87)	<0.01
Divorced, separated	1.45 (1.14,1.85)	1.07 (0.81,1.41)	0.67	1.64 (1.19,2.26)	0.95 (0.66,1.38)	0.66
Employment status						
Employed	1.0	1.0		1.0	1.0	
Unemployed	0.87 (0.75,1.00)	1.27 (1.04,1.55)	0.01	0.89 (0.72,1.08)	1.35 (1.03,1.78)	0.02
Student	0.83 (0.76,0.91)	1.36 (1.14,1.63)	<0.01	0.75 (0.65,0.86)	1.60 (0.90, 1.50)	0.21
Retired/others	1.21 (1.07,1.37)	1.21 (1.00,1.45)	0.03	1.35 (1.15,1.58)	1.24 (0.96,1.59)	0.07
Income						
≤5000	1.0	1.0		1.0	1.0	
5001 - 10,000	0.98 (0.89,1.08)	0.86 (0.72,1.03)	0.12	0.95 (0.83,1.09)	0.76 (0.60,0.97)	0.04
1,0001 - 15,000	1.45 (1.27,1.65)	1.03 (0.83,1.27)	0.66	1.45 (1.22,1.72)	0.94 (0.71,1.25)	0.80
15,001 – 20,000	1.63 (1.34,1.99)	1.08 (0.82,1.43)	0.45	1.68 (1.31,2.15)	0.98 (0.69,1.39)	0.92
>20,000	1.59 (1.22,2.06)	0.85 (0.61,1.20)	0.45	1.90 (1.40,2.58)	0.89 (0.58,1.37)	0.83
Vigorous exercise						
Never	1.0	1.0		1.0	1.0	
1	0.85 (0.73,0.99)	0.79 (0.67,0.94)	<0.01	0.84 (0.68,1.05)	1.17 (0.93,1.48)	0.18
2-3	0.73 (0.63,0.84)	0.75 (0.65,0.88)	<0.01	0.67 (0.54,0.83)	0.87 (0.64,1.18)	0.36
4-5	0.68 (0.58,0.79)	0.68 (0.57,0.81)	<0.01	0.59 (0.46,0.76)	0.75 (0.54,1.04)	0.08
>5	0.69 (0.57,0.82)	0.72 (0.59,0.87)	<0.01	0.57 (0.43,0.76)	0.76 (0.53,1.10)	0.14
Time standing at work						

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Never	1.0	1.0		1.0	1.0	
A few times	1.09 (0.81,1.46)	1.09 (0.80,1.50)	0.56	2.32 (1.34,4.02)	2.60 (1.47,4.62)	<0.01
Sometimes	1.16 (0.86,1.55)	1.18 (0.86,1.62)	0.28	2.27 (1.31,3.94)	2.60 (1.47,4.62)	<0.01
Most of the times	0.95 (0.70,1.28)	1.03 (0.74,1.42)	0.84	2.10 (1.20,3.67)	2.66 (1.48,4.76)	<0.01
All the times	0.87 (0.55,1.37)	0.95 (0.58,1.55)	0.86	1.56 (0.71,3.39)	1.92 (0.85,4.34)	0.11
Current smoker						
No	1.0	1.0		1.0	1.0	
Yes	0.96 (0.87,1.07)	0.75 (0.66,0.85)	<0.01	1.01 (0.87,1.17)	0.79 (0.67,0.93)	<0.01
Diabetes						
No	1.0	1.0		1.0	1.0	
Yes	2.55 (2.17,3.00)	1.67 (1.40,1.99)	<0.01	2.48 (2.39,3.39)	1.64 (1.34,2.00)	<0.01
BMI (kg/m^2)						
Underweight	1.0	1.0		1.0	1.0	
Normal weight	1.69 (1.39,2.05)	1.67 (1.37,2.04)	<0.01	1.70 (1.20,2.41)	1.67 (1.17,2.38)	<0.01
Overweight	3.03 (2.49,3.69)	2.43 (1.97,3.00)	<0.01	3.01 (2.13,4.24)	2.15 (1.50,3.08)	<0.01
Obese	4.86 (3.97,5.94)	3.17 (2.52,3.99)	<0.01	5.51 (3.90,7.77)	2.97 (2.04,4.34)	<0.01
Extremely Obese	7.90 (5.78,10.79)	4.64 (3.31,6.52)	<0.01	10.62 (7.04,16.01)	5.24 (3.35,8.19)	<0.01
Waist Circum.						
Normal	1.0	1.0		1.0	1.0	
Not Normal	2.58 (2.38,2.79)	1.32 (1.17,1.50)	<0.01	3.07 (2.75,3.43)	1.53 (1.29,1.81)	<0.01
Waist to hip ratio						
Normal	1.0	1.0		1.0	1.0	
Not Normal	1.99 (1.81,2.20)	1.27 (1.13,1.43)	<0.01	2.18 (1.93,2.45)	1.19 (1.02,1.38)	0.02

Waist Circumference: (men<94, women <80), Waist to hip ratio: (men<0.95, women <0.80), AOR: Adjusted OR.

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Supp. 2. The percentage and determinants of elevated BP according to 2017 ACC/AHA Guideline among Saudi Biobank, 2017-2020 (n = 10799)

Characteristics	Elevated BP according to 2017 ACC/AHA Guideline			
	Percentage (95% CI)	OR (95% CI)	AOR (95% CI)	P-value
Overall	15.82 (15.69,15.94)	-	-	-
Gender				
Women	14.07 (13.90,14.24)	1.0	1.0	
Men	17.50 (17.32,17.68)	1.29 (1.17,1.44)	1.35 (1.19,1.54)	<0.01
Age, years				
18-29	17.64 (17.47,17.82)	1.0	1.0	
30-39	13.95 (13.73,14.17)	0.76 (0.67,0.85)	0.76 (0.66,0.88)	<0.01
40-49	12.83 (12.47,13.18)	0.69 (0.57,0.83)	0.71 (0.58,0.87)	<0.01
50-59	11.35 (10.73,11.98)	0.60 (0.42,0.85)	0.62 (0.43,0.89)	<0.01
≥60	10.39 (9.15,11.63)	0.54 (0.26,1.13)	0.54 (0.26,1.15)	0.08
Time sitting at work				
Never	8.02 (7.12,8.92)	1.0	1.0	
A few times	15.80 (15.53,16.07)	2.15 (1.08,4.30)	2.39 (1.19,4.77)	0.02
Sometimes	16.41 (16.17,16.65)	2.25 (1.13,4.48)	2.59 (1.30,5.17)	0.01
Most of the times	15.66(15.47,15.84)	2.13 (1.07,4.23)	2.34 (1.17,4.66)	0.03
All the times	15.44 (14.70,16.17)	2.10 (0.99,4.42)	2.10 (0.99,4.44)	0.08
Current smoker				
No	15.62 (15.48,15.75)	1.0	1.0	
Yes	16.80 (16.49,17.12)	1.09 (0.95,1.25)	0.97 (0.83,112)	0.72
Diabetes				
No	15.76 (15.60,15.92)	1.0	1.0	
Yes	15.91 (15.71,16.11)	0.99 (0.89,1.10)	1.03 (0.93,1.15)	0.61
BMI, kg/m^2				
Underweight	12.14 (11.69,12.59)	1.0	1.0	
Normal weight	16.30 (16.10,16.50)	1.41 (1.10,1.80)	1.48 (1.16,1.89)	<0.01
Overweight	16.47 (16.23,16.70)	1.43 (1.11,1.83)	1.64 (1.27,2.12)	<0.01
Obese	15.30 (15.04,15.56)	1.31 (1.01,1.69)	1.68 (1.26,2.24)	<0.01
Extremely Obese	14.41 (13.65,15.16)	1.22 (0.81,1.83)	1.54 (1.00,2.37)	0.04
Waist Circum. (cm)				
Normal	16.36 (16.20,16.52)	1.0	1.0	
Not Normal	14.83 (14.62,15.03)	0.89 (0.80,0.99)	0.91 (0.77,1.07)	0.21
WtHR				
Normal	16.27 (16.12,16.41)	1.0	1.0	
Not Normal	13.89 (13.62,14.17)	0.83 (0.72,0.95)	0.99 (0.84,1.16)	0.93

Waist Circumference: (men<94, women <80), WtHR (Waist to hip ratio): (men<0.95, women <0.80), AOR: Adjusted OR, SR: Saudi Riyals.

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Supp. 3. Sociodemographic and lifestyle characteristics of the Saudi Biobank, 2017-2020

Characteristics	Total (n=10799)		Men (n=5497)		Women (n=5302)	
	n	%	n	%	n	%
Age, years						
Mean (SD)	30.05	(8.85)	29.78	(8.52)	30.34	(9.18)
18-29	6110	56.58	3189	58.01	2921	55.09
30-39	3140	29.08	1612	29.33	1528	28.82
40-49	1146	10.61	517	9.41	629	11.86
50-59	326	3.02	138	2.51	188	3.55
≥60	77	0.71	41	0.75	36	0.68
Marital status						
Never married	5874	54.39	3118	56.72	2756	51.98
Married	4587	42.48	2293	41.71	2294	43.27
Divorced	270	2.50	49	0.89	221	4.17
Missing	68	0.63	37	0.67	31	0.58
Employment						
Employed	5453	50.50	3852	70.07	1601	30.20
Unemployed	960	8.89	184	3.35	776	14.64
Student	2950	27.32	1201	21.85	1749	32.99
Retired/others	1307	12.10	155	2.82	1152	21.73
Missing	129	1.19	105	1.91	24	0.45
Family income, SAR						
≤5000	3487	32.29	1231	22.39	2256	42.55
5001 - 10,000	2371	21.96	1849	33.64	522	9.85
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15,001 – 20,000	413	3.82	276	5.02	137	2.58
>20,000	221	2.05	176	3.20	45	0.85
Missing	3301	30.57	1290	23.47	2011	37.93
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Primary school	235	2.18	55	1.00	180	3.39
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Higher education	345	3.19	137	2.49	208	3.92
Missing	66	0.61	47	0.86	19	0.36
BMI, kg/m^2						

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Waist to hip ratio mean (SD)	0.81	(0.10)	0.87	(0.08)	0.75	(0.09)
Missing	112	1.04	45	0.82	67	1.26
Diabetes History						
Yes	659	6.10	336	6.11	323	6.09
Blood pressure, mmHg						
Systolic blood pressure	120.73	15.01	123.97	15.24	117.37	14.01
Diastolic blood pressure	75.24	10.70	76.46	10.70	73.97	10.56

SD: Standard Deviation, SAR: Saudi Arabian Riyals

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Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1

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Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3,4
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5,6,7,8,9

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Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	9
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5,6,7,8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5,6,7,8
Bias	#9	Describe any efforts to address potential sources of bias	5,6,7,8,9
Study size	#10	Explain how the study size was arrived at	9

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Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8,9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	8,9
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	8,9
Statistical methods	#12c	Explain how missing data were addressed	9
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
Statistical methods	#12e	Describe any sensitivity analyses	9
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible,	9

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		examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.		
Participants	#13b	Give reasons for non-participation at each stage		9
Participants	#13c	Consider use of a flow diagram		n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9,10,11,12,13,25,26,27,28,29,30,31,32,33	
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest		25,26,27,28
Outcome data	#15	Report numbers of outcome events or summary		30,31,32,33

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		measures. Give information separately for exposed and unexposed groups if applicable.	
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11,12
Main results	#16b	Report category boundaries when continuous variables were categorized	10,11,29
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9,10,11,13,17,30,31,32,33

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Discussion			
Key results	#18	Summarise key results with reference to study objectives	14,15,16
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	17
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14,15,16
Generalisability	#21	Discuss the generalisability (external validity) of the study results	17
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if	18

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	applicable, for the original study on which the present article is based

Notes:

- 14a: 9,10,11,12,13,25,26,27,28,29,30,31,32,33
- 14b: 25,26,27,28
- 15: 30,31,32,33
- 17: 9,10,11,13,17,30,31,32,33 The STROBE checklist is distributed under the terms of the Creative Commons Attribution License CC-BY. This checklist was completed on 19. June 2020 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai

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BMJ Open

The impact of the 2017 ACC/AHA guideline on the prevalence of elevated blood pressure and hypertension: a cross-sectional analysis of 10799 individuals.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-041973.R2
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Complete List of Authors:	Alyabsi, Mesnad; King Abdullah International Medical Research Center, Population Health Research Section; King Saud bin Abdulaziz University for Health Sciences, Gaid, Reham; Princess Noura Bint AbdulRahman University Alqunaibet, Ada; King Abdullah International Medical Research Center Alaskar, Ahmed; King Abdullah International Medical Research Center; King Saud bin Abdulaziz University for Health Sciences Mahmud, Azra; King Abdulaziz Cardiac Center; King Abdullah International Medical Research Center Alghamdi, Jahad; King Abdullah International Medical Research Center; King Saud bin Abdulaziz University for Health Sciences
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The impact of the 2017 ACC/AHA guideline on the prevalence of elevated blood pressure and hypertension: a cross-sectional analysis of 10799 individuals

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ABSTRACT

Objectives To assess the effect of the 2017 ACC/AHA hypertension guideline on the prevalence of elevated blood pressure and hypertension and the initiation of antihypertensive treatment, as well as the level of adherence to the blood pressure (BP) target in the Saudi population.

Design A cross-sectional study.

Participants A total of 10,799 adults (≥18 years old), with three BP readings during 2017-2020 from the Saudi Biobank (SBB) was used.

Primary outcome Hypertension was defined using three sources: the JNC-7 guideline (SBP≥140 or DBP≥90 mmHg), the 2017 ACC/AHA guideline (SBP≥130 or DBP≥80 mmHg), and a self-reported hypertension diagnosis.

Results The prevalence of hypertension, according to the JNC-7 guideline, was 14.49% (95% CI: 14.37, 14.61), and the 2017 ACC/AHA, 40.77% (95% CI: 40.60, 40.94), a difference of 26.28 %. Antihypertensive medication was recommended for 24.84% (95% CI: 24.69,24.98) based on the JNC-7 guideline and 27.67% (95% CI: 27.52,27.82) using the 2017 ACC/AHA guideline. Lifestyle modification was recommended for 13.10% (95% CI:12.47,13.74) of patients with hypertension who were not eligible for a pharmacological intervention, based on the 2017 ACA/AHA guideline. For patients with prescribed antihypertensive medication, 49.56% (95% CI: 45.50, 53.64) and 27.81% (95% CI: 24.31,31.59) presented with a BP reading above the treatment goal, based on the 2017 ACA/AHA and JNC-7 guidelines, respectively. Using the two definitions, the risk factors were older age, male gender, diabetes diagnosis, increased body mass index (BMI), waist circumference, and waist-to-hip ratio.

Conclusions According to the 2017 ACC/AHA guideline, the prevalence of hypertension has increased significantly, but there was only a small increase in the proportion of patients recommended for antihypertensive treatment. A large proportion of patients with prescribed antihypertensive medication, had a BP above the target. Unless public health prevention efforts are adopted, the increased prevalence of elevated blood pressure and hypertension will increase cardiovascular disease.

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Strengths and limitations of this study

- The study had a large sample size.
- We ascertained the hypertensive status using three BP measurements.
- The cross-sectional design limits our ability to assess the temporal relationship between the independent factors and hypertension.
- There was no ambulatory BP data available for the participants.
- The study had a limited geographic variation in terms of the study participants.

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Keywords: Hypertension; guideline; Saudi Arabia; Prevention; Biobank; Blood pressure, Cardiovascular, Antihypertensive drugs

INTRODUCTION

Hypertension is the most prevalent risk factor for cardiovascular diseases (CVDs) and the cause of 9.4 million annual preventable deaths globally[1 2]. The global number of patients with hypertension is expected to increase by 319.7 million from 2015 and 2050[3]. The risk factors contributing to the increased prevalence of hypertension are increasing age, male gender, lifestyle factors such as smoking, alcohol consumption, unhealthy diet, sedentary lifestyle, and increased weight[4]. Though the burden of hypertension is substantial, detecting and controlling blood pressure (BP) levels at the elevated BP stage, will reduce the risk and burden of CVDs[5].

Identifying the optimal BP levels for the definition of elevated blood pressure and hypertension has been controversial[6-9]. Based on evidence from randomized controlled trials (RCTs) and other observational studies, the American College of Cardiology and the American Heart Association (ACC/AHA) developed the Hypertension Practice Guideline in 2017- "The ACC/AHA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults"[10]. The guideline lowered the threshold categories of hypertension from ≥140 mmHg systolic blood pressure (SBP) or ≥90 mmHg diastolic blood pressure (DBP) to ≥130 mmHg SBP or ≥80 mmHg DBP. Elevated blood pressure is now limited to individuals with an SBP of 120-129 mmHg and DBP <80 mmHg instead of 120-139 mmHg or 80-89 mmHg, as suggested by the Joint National Committee 7 Blood Pressure Guideline (JNC-7)[11]. Although not endorsed by some organizations, the new lower BP categories have been assessed in a systematic review and meta-analysis and were associated with a lower risk of CVDs[12].

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Literature from various countries reported the prevalence of hypertension according to the 2017 ACC/AHA guideline [13-18]. Muntner et al.[13] evaluated the effect of the 2017 ACC/AHA guideline on the prevalence of hypertension, and reported an increase of 13.7% in their adult population. Similarly, Alkibria et al.[14 18] assessed the changes in the prevalence of hypertension in the population of Nepal (aged ≥15 years) and Bangladesh (aged ≥35 years) and reported an increase of 23% and 22.3%, respectively. Moreover, Khera et al.[15] found an increase of 26.8% and 45.1% in the 45-75 year population of China and the U.S., respectively. The estimation of hypertension would essentially update the burden of CVDs and identify the proportion of hypertensive patients recommended for lifestyle modifications or antihypertensive medication.

According to the latest survey in 2016, Saudi Arabia is a developing country with a total population of 31 million [19]. Half of the population are younger than 25 years, 35% from 20 to 39 years, and only 3.2% are over 64 years old [19]. Based on the JNC-7 guideline, the prevalence of hypertension and elevated blood pressure in the Saudi population were 15.2% and 40.6%, respectively [20]. For the patients with an antihypertensive medication prescription, 55% to 73% had a BP above the JNC-7 guideline targeted level [21 22].

We designed the current study to investigate the effect of the 2017 ACC/AHA guideline on the prevalence of hypertension and to assess the proportion of hypertensive patients recommended for lifestyle modification or antihypertensive medication, according to the 2017 ACC/AHA guideline. We also aimed to determine the proportion of patients with prescribed antihypertensive medication who have a BP above the target recommended by the 2017 ACC/AHA guideline. As a secondary analysis, we aimed to evaluate the determinants of elevated BP and hypertension in the Saudi Biobank (SBB) data. The results

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will be useful for public health officials and healthcare providers to plan and implement primary, secondary, and tertiary prevention interventions. The objectives of these interventions are to reduce the burden of hypertension, in addition to the morbidity and mortality associated with CVDs.

MATERIALS AND METHODS

Data sources

The Institutional Review Board of King Abdullah International Medical Research Center (IRB#139 RC19/028/R) approved the study. The study had a cross-sectional design using data from the SBB. The SBB is an ongoing project to investigate the current health behavior of the Saudi population. The project explores the fundamental mechanisms of diseases by combining bio-specimens and survey data, sociodemographic and medical history information. The current study used only the survey data available from the SBB.

Patient and Public Involvement

No patients involved.

Survey development and administration

The SBB research team created a questionnaire based on a previously developed and validated questionnaire. The questionnaire partly corresponds to projects of other similar population biobanks to allow comparability between the Saudi population and other populations. The preliminary questionnaire was pilot tested, and the items revised according to the findings. The questionnaire includes the following sections: Date and Location of Recruitment, Demographic Information, Family Information, Housing Information, General Health Status, Personal and Family Medical History, History of

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Personal and Family Medications Use, Disabilities, Others, Women and Men Health, Health Behaviors, Nutrition, Physical Activity, and Anthropometric Measurements.

The questionnaire items are primarily closed-ended questions with Likert scale responses. The questionnaire is administered to participants by trained research coordinators. Before obtaining consent and completing the questionnaire, the coordinators describe the SBB objectives, the benefits of study participation, the security and privacy of collected information, voluntary participation, and unconditional withdrawal from the study.

Study population and data extraction

The study population was adults (≥18 years old) who participated in the survey from December 10th, 2017 to January 29th, 2020, with three recorded BP measurements. The data related to the prescribed antihypertensive medication were extracted from the electronic medical records.

Measurement method for blood pressure

The BP was measured using a calibrated sphygmomanometer and arm cuffs (Omron 705it or Omron M3). Research coordinators are trained to measure BP once the participants are rested, with legs uncrossed. The average of the three BP measurements was computed and used as the final BP reading.

Blood pressure classification

Using the JNC-7 guideline, BP was categorized into four categories: normal (SBP<120 and DBP<80 mmHg), elevated blood pressure (SBP=120-139, or DBP=80-89 mmHg), stage 1 (SBP=140-159 or DBP=90-99 mmHg) and stage 2 (SBP≥160 or DBP≥100 mmHg)[11]. Using the ACC/AHA guideline, BP was also categorized into four categories: normal

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(SBP<120 and DBP<80 mmHg), elevated (SBP=120-129 and DBP<80 mmHg), stage 1 (SBP=130-139 or DBP=80-89 mmHg) and stage 2 (SBP≥140 or DBP≥90 mmHg)[10]. Individuals with BP measurements in stage 1 or stage 2 were considered as diagnosed with hypertension.

Data collection and definitions

The participants' sociodemographic information, including age, gender, marital status, education level, occupation, and family income, was extracted from the SBB data. In addition, behavioral health factors such as physical activities, smoking status, including shisha use, dietary intake, and comorbidities, were retrieved. The waist and hip circumference, height, and weight measurements were categorized as suggested by Lear et al.[23] Comorbidities, such as a diagnosis of diabetes mellitus (DM) or any CVD, were self-reported.

Prescription data

We used the medical records and pharmacy data to identify participants with an antihypertensive medication prescription. Based on the 2017 ACC/AHA guideline, we defined guideline-recommended antihypertensive medication use as patients with a SBP/DBP of ≥140/90 mmHg, for high-risk patients (i.e., DM, CVD, age ≥ 65), the cutoff was 130/80 mmHg. The same applied to the JNC-7 guideline, with the exception that DM was the only designation of high risk. We identified patients with a diagnosis of hypertension in their medical file, self-reported hypertension, and at least one prescription of antihypertensive medication[24]. The antihypertensive drugs used were beta-blockers, calcium channel blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor

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blockers, diuretics, and centrally or peripherally acting agents found in the pharmacy files during the year of diagnosis.

Data analysis

The data were analyzed using SAS statistical software version 9.4 (SAS Institute Inc. Cary, NC). Descriptive data for the sample, stratified by gender, are presented as frequency and percentage for categorical variables, and for continuous variables, as a mean and standard deviation (SD). In addition, for each BP category, the mean, SD, median, interquartile range (IQR), minimum, and maximum value was calculated. The prevalence of hypertension was calculated by dividing the total number of hypertensive individuals by the total number of the study population. The prevalence of elevated blood pressure was measured by dividing the total number of the group with elevated blood pressure by the total number of the study population. The prevalence of hypertension and elevated blood pressure and the 95% CI was calculated using the Wald binomial method.

Missing covariate data were manage by using the multiple imputations by chained equations (fully conditional method), assuming that data are missing at random (MAR). The missing data ranges from 0% to 30%, and 30 imputations were conducted. Given the arbitrary pattern of the missing data, the PROC MI procedure was used with the "FCS regpmm" statement for continuous variables and the "FCS logistic" for categorical variables[25]. Univariate and multivariate logistic regressions were conducted using the multiple imputed data to estimate the odds ratio (OR) and the adjusted odds ratio (AOR). Backward elimination was used to determine variables included at the multivariate level. All statistical tests were 2-sided, and findings were considered statistically significant at P

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< .05. The STROBE cross-sectional guideline was used to assure that all essential elements are reported and covered[26].

RESULTS

Descriptive statistics

A total of 11571 individuals were captured in the SBB. After excluding individuals <18 years old (n=327) and with less than three BP readings (n=445), the final sample was 10799 individuals. The overall characteristics of the sample, stratified by antihypertensive prescription, are summarized in Table 1. From 2017 to 2020, 41.22%, 15.26%, 24.84%, and 13.32% of the SBB participants who did not have a prescription for antihypertensive medication, presented with SBP/DBP readings of <120/80 mmHg, 120-129/<80 mmHg, 130-139/80-89 mmHg, and ≥140/90 mmHg, respectively. Participants with an increased BP were likely to be male, of older age, and with a history of DM or CVD.

The prevalence of hypertension and the recommended interventions according to the 2017 ACC/AHA and JNC-7 Guidelines

As shown in Table 2, the prevalence of hypertension, based on the 2017 ACC/AHA, was 40.77%, and the JNC-7, 27.57%. The overall prevalence of hypertension, and in terms of all patient characteristics, were higher using the 2017 ACC/AHA guidelines compared to the JNC-7 guidelines. The difference in the prevalence was highest in the oldest age group. Based on the JNC-7 guideline, only 24.84% of the patients were recommended to receive antihypertensive medication, compared to 27.67%, according to the 2017 ACC/AHA guideline. With the exception of males, there was an increase in the suggested use of antihypertensive medication for all patient characteristics using the 2017 ACC/AHA guideline. A small proportion, 13.10% of the hypertensive patients were recommended

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lifestyle modification, based on the 2017 ACC/AHA guideline. Finally, an additional 2.83% of the hypertensive patients were recommended for an antihypertensive intervention, based on the 2017 ACC/AHA guideline.

Hypertensive patients, based on the 2017 ACC/AHA guideline and not the JNC-7 guideline, compared with patients complying with the definition of hypertension based on the JNC-7 guideline, were younger, have a lower BMI, better waist circumference profile, lower SBP, and DBP (Table 3). When compared to individuals recommended to receive treatment treatment using the JNC-7 guideline, individuals recommended for antihypertensive medication according to the 2017 ACC/AHA guideline, but not JNC-7 guideline, were younger, less likely to be diabetic, had lower SBP and DBP, but more likely to have a CVD history.

BP levels above the targeted goals by the 2017 ACC/AHA and JNC-7 Guidelines.

The proportions of patients prescribed antihypertensive medication and presenting with above-target BP, according to the 2017 ACC/AHA and JNC-7 guidelines, were 49.57% and 27.80%, respectively (Table 4). Overall, the patients with an above-target BP, according to the 2017 ACC/AHA guideline, but not the JNC-7 guideline, were younger, less likely to be diabetic, with a lower SBP and DBP, and 52.31% were taking one class of antihypertensive medication.

Determinants of hypertension and elevated blood pressure

The determinants of hypertension, according to the ACC/AHA and JNC-7 guidelines, are presented in Supplementary Table 1 in the supplementary material (adjusted for all variables shown in the tables). According to the ACC/AHA guideline, the determinants of hypertension were increasing age, male gender, being a student or unemployed, having

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diabetes, and increasing BMI, particularly with abdominal adiposity. The determinants of hypertension based on the JNC-7 guideline, were increasing age, male gender, employment status, time spent standing while at work, diabetes, and increasing BMI, mostly central obesity. The predictors of elevated blood pressure, adjusted for all covariates in the table, are presented in Supplementary Table 2. Elevated BP determinants were being male, younger age, sitting at work a few times, sometimes or most of the time, and an increased BMI.

DISCUSSION

The current study assessed the impact of the 2017 ACC/AHA guideline definition of hypertension, the recommendation for the initiation of lifestyle modifications and antihypertensive medication, and the BP target of antihypertensive medication use in Saudi adults. Based on the 2017 ACC/AHA guideline, there was a substantial increase in the prevalence of hypertension (26.28%), but only a small increase (2.83%) in the proportion of adults who were recommended for antihypertensive medication. The increase in the prevalence of hypertension translates in an increase of 1.8 million hypertensive adults in the 5.1 million adults which, according to the latest census, are ≥18 years old[19]. The increase is predominantly observed in males (47.72%) compared to females (33.57%), individuals ≥60 years old (70.13%), diabetic patients (62.37%), and individuals who are obese (56.12%).

Our findings of the prevalence of hypertension complement research from Bangladesh[16 27], Nepal [14], and to a lesser extent, the U.S.[13 17], which assessed the impact of the 2017 ACC/AHA guidelines on the prevalence of hypertension. In the U.S. study, Muntner et al.[13] used the National Health and Nutrition Examination Survey and found a 13.7% increase in the prevalence of hypertension. However, the increase in Nepal (23%) and

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Bangladesh (22%) were comparable to our results (26.28%). The difference may reflect the younger population of Nepal, Bangladesh, and Saudi Arabia compared to the U.S. population [19 28 29].

According to the 2017 ACC/AHA guideline, 13.10% of the Saudi hypertensive patients will require lifestyle modifications without an antihypertensive medication intervention, a finding similar to the U.S. study by Muntner et al.[13]. Examples of the recommended lifestyle modifications include practicing a healthy lifestyle, such as eating a healthy diet, maintaining a healthy weight, avoiding smoking, and being physically active. These non-pharmacological interventions have been endorsed by the 2017 ACC/AHA guideline based on several observational and randomized controlled trials[30]. For instance, in normotensive individuals, engaging in physical activities of 90-150 minutes/week is associated with a reduction of 2-4 mmHg in systolic BP[31]. Although it is unfortunate that most of our population (70.70%), especially women (84.25%), reported never engaging in any moderate exercise, governmental efforts through the Quality of Life program are ongoing to promote physical activities. Future studies should assess the impact of these programs on the incidence of hypertension.

In the current study, 46.56% of the patients taking antihypertensive medication presented with a BP above the target suggested by the 2017 ACC/AHA guideline. Our result is congruent with studies from the U.S. and Bangladesh, where the proportions of patients with a BP above the target were 53.4% and 61%, respectively[13 16]. It is also similar to a study from Saudi Arabia, reporting that 55% of the sample had a BP above the target [21]. It is unclear whether the uncontrolled hypertension is due to patient factors, such as lack of medication adherence or the providers' inability to titrate antihypertensive treatment when

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the BP is suboptimal. It is also possible that the providers' lack of information or acceptance of the current BP guidelines contributed to the failure to recognize the current BP targets. A multidisciplinary disease management strategy and follow-up of patients with uncontrolled BP should be emphasized. To achieve the target BP in patients with an uncontrolled BP, intensive antihypertensive treatment is required.

STRENGTHS AND LIMITATION

Our study has several strengths. Firstly, we used a large sample of the Saudi population (n=10799) from diverse backgrounds (e.g., wives, professionals, students, and unemployed women). Secondly, we ascertained the hypertensive status using BP measurements according to a standardized procedure. Our study also has several limitations. Firstly, the study is limited to the capital of Saudi Arabia, Riyadh. However, given the characteristics of the participants, we believe that the geographic location is unlikely to affect the external validity of our findings. Secondly, although the BP was measured using three readings, the measurement was performed during a single visit. Thirdly, we relied on the medical and pharmacy files to identify users of antihypertensive medication, and we may have missed some patients who were not identified with this approach. Fourthly, we do not have ambulatory BP data for the participants, which may overestimate some individuals who may have white coat hypertension. However, the prevalence of white coat hypertension is approximately 3% in a Saudi cohort, which is too small to affect the prevalence data.

CONCLUSION

The 2017 ACC/AHA guideline resulted in a concerning increase in the prevalence of hypertension and elevated blood pressure, with implications for escalating healthcare costs. There was, however, only a small increase in the proportion of patients recommended to

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receive antihypertensive medication. Almost half (49.56%) of the patients prescribed antihypertensive medication, had a BP above the target set by the 2017 ACC/AHA guideline. Unless strong public health measures are adopted, including implementing lifestyle changes at a population level, with aggressive management of hypertension, we are likely to experience an upward trend in the prevalence of hypertension and associated cardiovascular morbidity and mortality.

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DATA ACCESS STATEMENT

Data not available due containing sensitive information that might expose the subject's identity.

CONTRIBUTION STATEMENT

MA designed the study, conducted the analyses, and wrote the manuscript. RG collected data, conducted analyses, and drafted the manuscript. Jahad A., Ada A., Ahmed A., and AM assisted with the study design and assisted with manuscript preparation. All authors revised the manuscript and ensured its intellectual content. Jahad A. assisted with data

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acquisition. All the authors have read and approved the final manuscript. All authors agreed to be accountable for all aspects of the work.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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REFERENCE:

1. Zhou D, Xi B, Zhao M, et al. Uncontrolled hypertension increases risk of all-cause and cardiovascular disease mortality in US adults: the NHANES III Linked Mortality Study. *Scientific reports* 2018;8(1):1-7.
2. Chan M. A global brief on Hypertension. *World Health Organization Switzerland* 2013
3. Sudharsanan N, Geldsetzer P. Impact of Coming Demographic Changes on the Number of Adults in Need of Care for Hypertension in Brazil, China, India, Indonesia, Mexico, and South Africa: A Modeling Study. *Hypertension* 2019;73(4):770-76.
4. Lackland DT, Weber MA. Global burden of cardiovascular disease and stroke: hypertension at the core. *Canadian Journal of Cardiology* 2015;31(5):569-71.
5. Han M, Li Q, Liu L, et al. Prehypertension and risk of cardiovascular diseases: a meta-analysis of 47 cohort studies. *Journal of Hypertension* 2019;37(12):2325-32.
6. Bolli P, Hemmelgarn B, Myers MG, et al. High normal blood pressure and prehypertension: The debate continues. *Canadian Journal of Cardiology* 2007;23(7):581-83.
7. Banach M, Michalska M, Kjeldsen SE, et al. What should be the optimal levels of blood pressure: does the J-curve phenomenon really exist? *Expert opinion on pharmacotherapy* 2011;12(12):1835-44.
8. Fan F, Yuan Z, Qin X, et al. Optimal systolic blood pressure levels for primary prevention of stroke in general hypertensive adults: findings from the CSPPT (China Stroke Primary Prevention Trial). *Hypertension* 2017;69(4):697-704.
9. Deedwania P. The ongoing saga of optimal blood pressure level in patients with diabetes mellitus and coronary artery disease: Am Heart Assoc, 2018.
10. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology* 2018;71(19):e127-e248.
11. Chobanian AV. National High blood pressure education program committee: seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension* 2003;42:1206-52.
12. Reboussin DM, Allen NB, Griswold ME, et al. Systematic review for the 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology* 2018;71(19):2176-98.
13. Muntner P, Carey RM, Gidding S, et al. Potential US population impact of the 2017 ACC/AHA high blood pressure guideline. *Journal of the American College of Cardiology* 2018;71(2):109-18.
14. Al Kibria GM, Swasey K, Angela K, et al. Estimated change in prevalence of hypertension in Nepal following application of the 2017 ACC/AHA guideline. *JAMA Network Open* 2018;1(3):e180606-e06.
15. Khera R, Lu Y, Saxena A, et al. The impact of 2017 ACC/AHA guidelines on the prevalence of hypertension and eligibility for anti-hypertensive therapy in the United States and China. *bioRxiv* 2017:218859.

For peer review only

16. Islam JY, Zaman MM, Haq SA, et al. Epidemiology of hypertension among Bangladeshi adults using the 2017 ACC/AHA hypertension clinical practice guidelines and joint National Committee 7 guidelines. *Journal of human hypertension* 2018;32(10):668-80.
17. Wang D, Hatahet M, Wang Y, et al. Multivariate analysis of hypertension in general US adults based on the 2017 ACC/AHA guideline: data from the national health and nutrition examination survey 1999 to 2016. *Blood pressure* 2019;28(3):191-98.
18. Al Kibria GM, Swasey K, Choudhury A, et al. The new 2017 ACC/AHA guideline for classification of hypertension: changes in prevalence of hypertension among adults in Bangladesh. *Journal of human hypertension* 2018;32(8):608-16.
19. General Authority for Statistics. Demographic Survey 2016 [cited 2020. Available from: https://www.stats.gov.sa/sites/default/files/en-demographic-research-2016_2.pdf2020.
20. El Bcheraoui C, Basulaiman M, Wilson S, et al. Breast cancer screening in Saudi Arabia: free but almost no takers. *Plos one* 2015;10(3):e0119051.
21. El Bcheraoui C, Memish ZA, Tuffaha M, et al. Hypertension and its associated risk factors in the Kingdom of Saudi Arabia, 2013: a national survey. *International journal of hypertension* 2014;2014
22. Yusufali AM, Khatib R, Islam S, et al. Prevalence, awareness, treatment and control of hypertension in four Middle East countries. *Journal of hypertension* 2017;35(7):1457-64.
23. Lear S, James P, Ko G, et al. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. *European journal of clinical nutrition* 2010;64(1):42-61.
24. Bullano MF, Kamat S, Willey VJ, et al. Agreement between administrative claims and the medical record in identifying patients with a diagnosis of hypertension. *Medical care* 2006:486-90.
25. Smith C, Kosten S. Multiple Imputation: A Statistical Programming Story 2017 [Available from: https://www.pharmasug.org/proceedings/2017/SP/PharmaSUG-2017-SP01.pdf.
26. Von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Annals of internal medicine* 2007;147(8):573-77.
27. Khanam R, Ahmed S, Rahman S, et al. Prevalence and factors associated with hypertension among adults in rural Sylhet district of Bangladesh: a cross-sectional study. *BMJ open* 2019;9(10)
28. Samir K. An age distribution story: Reading into the population pyramid of Nepal. *Asian Population Studies* 2014;10(2):121-24.
29. Kabir R, Khan HT, Kabir M, et al. Population ageing in Bangladesh and its implication on health care. *European Scientific Journal* 2013;9(33):34-47.
30. Arnett DK, Blumenthal RS, Albert MA, et al. 2019 ACC/AHA guideline on the primary prevention of cardiovascular disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology* 2019;74(10):e177-e232.
31. Stefani L, Mascherini G, Tosi B, et al. Hypertension today: Role of sports and exercise medicine. *Journal of Hypertension and Cardiology* 2019;2(4):20.

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Table 1. Characteristics of Saudi Biobank by BP levels and antihypertensive use, 2017-2020

	SBP/DBP categories among those not taking antihypertensive medications (mmHg)				Antihypertensive recorded (n=579)
	<120/80 (n=4451)	120-129/<80 (n=1648)	130-139/80-89 (n=2683)	≥140/90 (n=1438)	
Age, years Mean (SD)	28.50 (7.44)	28.72 (8.25)	30.58 (9.06)	33.27 (10.73)	35.38 (9.92)
Age, years N (%)					
18-29	2806 (63.04)	1053 (63.90)	1432 (53.37)	631 (43.88)	188 (32.47)
30-39	1257 (28.24)	417 (25.30)	851 (31.72)	418 (29.07)	197 (34.02)
40-49	318 (7.14)	136 (8.25)	288 (10.73)	263 (18.29)	141 (24.35)
50-59	61 (1.37)	36 (2.18)	86 (3.21)	101 (7.02)	42 (7.25)
≥60	9 (0.20)	6 (0.36)	26 (0.97)	25 (1.74)	11 (1.90)
Gender, N (%)					
Female	2587 (58.12)	706 (42.84)	1127 (42.01)	485 (33.73)	397 (68.57)
Male	1864 (41.88)	942 (57.16)	1556 (57.99)	953 (66.27)	182 (31.43)
Tobacco use, N (%)					
No	3604 (83.19)	1331 (81.96)	2192 (83.35)	1158 (82.07)	526 (92.28)
Yes	728 (16.81)	293 (18.04)	438 (16.65)	253 (17.93)	44 (7.72)
Diabetes history, N (%)					
No	2777 (62.39)	1010 (61.28)	1622 (60.45)	861 (59.87)	349 (60.28)
Yes	1674 (37.61)	638 (38.71)	1061 (39.55)	577 (40.13)	230 (39.72)
CVD history, N (%)					
No	3657 (82.16)	1347 (81.74)	2145 (79.95)	1120 (77.89)	439 (75.82)
Yes	794 (17.84)	301 (18.26)	538 (20.05)	318 (22.11)	140 (24.18)
Blood pressure, Mean (SD)					
Systolic blood pressure	108.47 (7.70)	124.01 (2.81)	126.55 (9.0)	143.81 (20.88)	123.40 (18.01)
Diastolic blood pressure	67.98 (6.68)	71.47 (5.71)	80.92 (5.88)	90.49 (13.17)	78.95 (15.45)

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Table 2. The percentage of hypertension and the recommended antihypertensive medications in the Saudi Biobank according to the 2017 ACC/AHA Guideline and the JNC 7 Guideline

Characteristics	2017 ACC/AHA Guideline		JNC7 Guideline		2017 ACC/AHA but not JNC-7	
	HTN	Recommended Antihypertensive Medications	HTN	Recommended Antihypertensive Medications	HTN	Recommended Antihypertensive Medications
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Overall	40.77 (40.60,40.94)	27.67 (27.52,27.82)	14.49 (14.37,14.61)	24.84 (24.69,24.98)	26.28 (26.23,26.33)	2.83 (2.83,2.84)
Age, years						
18-29	34.86 (34.64,35.08)	21.62 (21.43,21.81)	10.67 (10.53,10.81)	19.66 (19.47,19.84)	24.19 (24.11,24.27)	1.96 (1.96,1.97)
30-39	43.44 (43.12,43.76)	29.68 (29.39,29.97)	14.62 (14.40,14.85)	26.46 (26.18,26.75)	28.82 (28.72,28.91)	3.22 (3.21,3.22)
40-49	55.58 (55.06,56.11)	44.15 (43.63,44.68)	27.33 (26.87,27.80)	39.35 (38.84,39.87)	28.25 (28.19,28.31)	4.80 (4.79,4.81)
50-59	66.87 (65.94,67.80)	54.91 (53.92,55.89)	36.31 (35.39,37.22)	48.16 (47.17,49.15)	30.56 (30.55,30.58)	6.75 (6.75,6.74)
≥60	70.13 (68.23,71.96)	64.94 (62.97,66.85)	34.15 (32.27,36.02)	54.55 (52.51,56.57)	35.98 (35.96,35.94)	10.39 (10.46,10.28)
Gender						
Women	33.57 (33.34,33.80)	32.02 (31.79,32.24)	10.39 (10.24,10.54)	19.97 (19.78,20.17)	23.18 (23.10,23.26)	12.05 (12.01,12.07)
Men	47.72 (47.48,47.96)	23.16 (22.95,23.37)	18.45 (18.26,18.63)	29.53 (29.31,29.75)	29.27 (29.22,29.33)	-6.37 (-6.36,-6.38)
Marital status						
Never married	36.18 (35.95,36.40)	22.89 (22.70,23.09)	11.91 (11.76,12.06)	21.05 (20.86,21.24)	24.27 (24.19,24.34)	1.84 (1.84,1.85)
Married	46.39 (46.13,46.65)	33.37 (33.12,33.62)	17.76 (17.59,17.99)	29.39 (29.15,29.63)	28.63 (28.54,28.66)	3.98 (3.97,3.99)
Divorced, Sep.	44.18 (44.10,46.25)	34.61 (33.58,35.65)	17.30 (16.50,18.10)	29.83 (28.84,30.82)	26.88 (27.6,28.15)	4.78 (4.74,4.83)
Tobacco use						
No	40.93 (40.75,41.12)	27.81 (27.64,27.97)	14.47 (14.34,14.60)	24.94 (24.78,25.10)	26.46 (26.41,26.52)	2.87 (2.86,2.87)
Yes	39.98 (39.57,40.39)	27.00 (26.63,27.37)	14.60 (14.30,14.89)	24.32 (23.96,24.68)	25.38 (25.27,25.50)	2.68 (2.67,2.69)
Diabetes						
No	39.37 (39.20,39.54)	18.87 (18.70,19.04)	13.44 (13.32,13.56)	14.25 (14.09,14.40)	25.39 (25.88,25.98)	4.62 (4.61,4.64)
Yes	62.37 (61.69,63.04)	41.60 (41.33,41.88)	30.65 (30.01,31.30)	41.60 (41.33,41.88)	31.72 (31.68,31.74)	0
BMI, kg/m^2						
Underweight	20.84 (20.28,21.39)	11.72 (11.28,12.17)	5.41 (5.10,5.72)	10.55 (10.13,10.97)	15.43 (15.18,15.67)	1.17 (1.15,1.20)
Normal weight	30.76 (30.51,31.02)	19.14 (18.92,19.36)	8.89 (8.73,9.04)	16.98 (16.77,17.19)	21.87 (21.78,21.98)	2.16 (2.15,2.17)
Overweight	44.37 (44.06,44.68)	30.40 (30.12,30.69)	14.69 (14.47,14.92)	27.16 (26.88,27.44)	29.68 (29.59,29.76)	3.24 (3.24,3.25)
Obese	56.12 (55.76,56.48)	40.46 (40.10,40.82)	23.98 (23.67,24.29)	36.63 (36.27,36.98)	32.14 (32.09,32.19)	3.83 (3.83,3.84)
Extremely Obese	67.53 (66.53,68.54)	54.21 (53.14,55.28)	37.82 (36.78,38.87)	50.46 (49.38,51.53)	29.71 (29.75,29.67)	3.75 (3.76,3.75)
Waist Circum., cm						
Normal	32.65 (32.44,32.85)	20.51 (20.34,20.68)	9.30 (9.17,9.42)	18.13 (17.96,18.29)	23.35 (23.27,23.43)	2.38 (2.38,2.39)
Not Normal	55.54 (55.25,55.83)	40.68 (40.39,40.96)	23.94 (23.69,24.18)	37.03 (36.75,37.30)	31.60 (31.56,31.65)	3.65 (3.64,3.66)
Waist-hip ratio						
Normal	37.55 (37.37,37.74)	24.68 (24.51,24.84)	12.38 (12.26,12.51)	22.11 (21.95,22.27)	25.17 (25.11,25.23)	2.57 (2.56,2.57)
Not Normal	54.57 (54.18,54.97)	40.50 (40.11,40.88)	23.53 (23.19,23.86)	36.51 (36.13,36.89)	31.04 (30.99,31.11)	3.99 (3.98,3.99)

SD: Standard Deviation, SAR: Saudi Arabian Riyals

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Table 3: Characteristics of the Saudi Biobank population not taking antihypertensive medications meeting the definition of HTN and recommended antihypertensive according to 2017 ACC/AHA Guideline and JNC-7 Guideline, 2017-2020.

	HTN according to			Recommended treatment by		
	ACC (n=4121)	JNC 7 (n=1438)	ACC but not JNC-7 (n=2683)	ACC (n= 2783)	JNC 7 (n=743)	ACC but not JNC-7 (n=2040)
Age, Mean (SD)	31.52 (9.76)	33.27 (10.73)	30.58 (9.06)	32.53 (10.23)	34.06 (10.61)	31.97 (10.04)
Male gender, %	60.88	66.27	57.99	60.15	65.28	58.28
Tobacco use, %	17.10	17.93	16.65	17.06	17.93	16.73
Diabetes, %	39.75	40.13	39.55	58.86	77.66	52.01
CVD, (%)	20.77	22.11	20.05	30.76	25.30	32.75
BMI, kg/m^2						
Underweight	3.09	2.29	3.51	2.66	1.75	2.99
Normal weight	29.50	23.64	32.65	26.94	22.07	28.72
Overweight	32.64	30.39	33.84	33.02	30.55	33.92
Obese	30.30	36.72	26.86	32.16	38.63	29.80
Extremely Obese	4.47	6.95	3.14	5.22	7.0	4.57
Waist Circum. (cm)						
Not Normal,%	47.25	57.37	41.82	50.99	58.55	48.24
WtHR						
Not Normal,%	23.88	28.93	21.17	26.05	29.21	24.90
Systolic blood pressure, Mean (SD)	132.57 (16.51)	143.81 (20.88)	126.55 (9.00)	135.59 (18.30)	147.43 (26.75)	131.28 (11.26)
Diastolic blood pressure, Mean (SD)	84.26 (10.19)	90.49 (13.17)	80.92 (5.88)	86.00 (11.28)	93.48 (16.06)	83.27 (7.20)

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Table 4: Characteristics of the Saudi Biobank population taking antihypertensive medications with BP above treatment goals according to 2017 ACC/AHA Guideline and JNC-7 Guideline, 2017-2020.

	BP above goal according to		
	ACC (n=287)	JNC 7 (n=161)	ACC but not JNC-7 (n=126)
Age, Mean (SD)	37.26 (9.94)	39.71 (9.72)	34.13 (9.35)
Male gender, %	40.07	45.34	33.33
Tobacco use, %	7.80	6.96	8.87
Diabetes, %	35.89	46.58	22.22
CVD, (%)	25.09	24.84	25.40
BMI, kg/m²			
Underweight	4.18	2.48	6.35
Normal weight	28.92	26.71	31.75
Overweight	32.06	29.19	35.71
Obese	30.66	34.78	25.40
Extremely Obese	4.18	6.83	0.79
Waist Circum. (cm)			
Not Normal, %	56.45	63.98	46.83
WtHR			
Not Normal, %	42.16	44.72	38.89
Systolic blood pressure, Mean (SD)	135.11 (17.21)	144.07 (15.99)	123.65 (10.71)
Diastolic blood pressure, Mean (SD)	88.65 (15.91)	93.42 (19.45)	82.56 (5.34)
Number of antihypertensive medications			
1	45.51	41.59	52.31
2	29.78	31.86	26.15
3	7.87	7.96	7.69
4	8.99	8.85	9.23
≥5	7.87	9.73	4.62

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Supplementary table 1. Determinants of hypertension according to guidelines among Saudi Biobank, 2017-2020 (n = 10799)

	ACC/AHA			JNC-7		
Characteristics	**OR (95% CI)**	**AOR (95% CI)**	**P**	**OR (95% CI)**	**AOR (95% CI)**	**P**
Gender						
Women	1.0	1.0		1.0	1.0	
Men	1.80 (1.67,1.95)	2.79 (2.51,3.11)	<0.01	1.95 (1.74,2.18)	3.10 (2.66,3.60)	<0.01
Age (years)						
18-29	1.0	1.0		1.0	1.0	
30-39	1.43 (1.31,1.57)	1.27 (1.13,1.44)	<0.01	1.42 (1.25,1.62)	1.39 (1.16,1.67)	<0.01
40-49	2.34 (2.06,2.66)	1.70 (1.44,2.02)	<0.01	3.14 (2.69,3.66)	2.55 (2.03,3.19)	<0.01
50-59	3.77 (2.98,3.78)	2.28 (1.72,3.03)	<0.01	4.82 (3.79,6.13)	3.23 (2.34,4.44)	<0.01
≥60	4.39 (2.68,7.17)	2.09 (1.20,3.63)	0.009	4.53 (2.81,7.28)	2.21 (1.26,3.87)	<0.01
Marital status						
Never married	1.0	1.0		1.0	1.0	
Married	1.53 (1.41,1.65)	0.91 (0.81,1.02)	0.12	1.60 (1.43,1.78)	0.73 (0.61,0.87)	<0.01
Divorced, separated	1.45 (1.14,1.85)	1.07 (0.81,1.41)	0.67	1.64 (1.19,2.26)	0.95 (0.66,1.38)	0.66
Education						
< Primary school	1.0	1.0		1.0	1.0	
Primary school	1.04 (0.66,1.63)	1.11 (0.69,1.79)	0.65	1.08 (0.66,1.75)	1.18 (0.70,1.98)	0.53
Intermediate school	0.71 (0.47,1.08)	0.82 (0.52,1.28)	0.37	0.73 (0.46,1.16)	0.84 (0.51,1.39)	0.47
High school	0.43 (0.30,0.62)	0.75 (0.49,1.12)	0.15	0.39 (0.26,0.59)	0.78 (0.49,1.23)	0.26
Some college	0.65 (0.44,0.97)	1.01 (0.65,1.56)	0.98	0.58 (0.37,0.89)	1.00 (0.61,1.65)	0.95
Bachelor's degree	0.47 (0.32,0.68)	0.86 (0.57,1.31)	0.47	0.37 (0.25,0.56)	0.78 (0.49,1.25)	0.27
Higher education	0.47 (0.31,0.72)	0.80 (0.49,1.29)	0.34	0.44 (0.27,0.73)	0.79 (0.45,1.41)	0.37
Employment status						
Employed	1.0	1.0		1.0	1.0	
Unemployed	0.87 (0.75,1.00)	1.27 (1.04,1.55)	0.01	0.89 (0.72,1.08)	1.35 (1.03,1.78)	0.02
Student	0.83 (0.76,0.91)	1.36 (1.14,1.63)	<0.01	0.75 (0.65,0.86)	1.60 (0.90, 1.50)	0.21
Retired/others	1.21 (1.07,1.37)	1.21 (1.00,1.45)	0.03	1.35 (1.15,1.58)	1.24 (0.96,1.59)	0.07
Income						
≤5000	1.0	1.0		1.0	1.0	
5001 - 10,000	0.98 (0.89,1.08)	0.86 (0.72,1.03)	0.12	0.95 (0.83,1.09)	0.76 (0.60,0.97)	0.04
1,0001 - 15,000	1.45 (1.27,1.65)	1.03 (0.83,1.27)	0.66	1.45 (1.22,1.72)	0.94 (0.71,1.25)	0.80
15,001 – 20,000	1.63 (1.34,1.99)	1.08 (0.82,1.43)	0.45	1.68 (1.31,2.15)	0.98 (0.69,1.39)	0.92
>20,000	1.59 (1.22,2.06)	0.85 (0.61,1.20)	0.45	1.90 (1.40,2.58)	0.89 (0.58,1.37)	0.83
Vigorous exercise						
Never	1.0	1.0		1.0	1.0	
1	0.85 (0.73,0.99)	0.79 (0.67,0.94)	<0.01	0.84 (0.68,1.05)	1.17 (0.93,1.48)	0.18

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2-3	0.73 (0.63,0.84)	0.75 (0.65,0.88)	<0.01	0.67 (0.54,0.83)	0.87 (0.64,1.18)	0.36
4-5	0.68 (0.58,0.79)	0.68 (0.57,0.81)	<0.01	0.59 (0.46,0.76)	0.75 (0.54,1.04)	0.08
>5	0.69 (0.57,0.82)	0.72 (0.59,0.87)	<0.01	0.57 (0.43,0.76)	0.76 (0.53,1.10)	0.14
Time standing at work						
Never	1.0	1.0		1.0	1.0	
A few times	1.09 (0.81,1.46)	1.09 (0.80,1.50)	0.56	2.32 (1.34,4.02)	2.60 (1.47,4.62)	<0.01
Sometimes	1.16 (0.86,1.55)	1.18 (0.86,1.62)	0.28	2.27 (1.31,3.94)	2.60 (1.47,4.62)	<0.01
Most of the times	0.95 (0.70,1.28)	1.03 (0.74,1.42)	0.84	2.10 (1.20,3.67)	2.66 (1.48,4.76)	<0.01
All the times	0.87 (0.55,1.37)	0.95 (0.58,1.55)	0.86	1.56 (0.71,3.39)	1.92 (0.85,4.34)	0.11
Tobacco use						
No	1.0	1.0		1.0	1.0	
Yes	0.96 (0.87,1.07)	0.75 (0.66,0.85)	<0.01	1.01 (0.87,1.17)	0.79 (0.67,0.93)	<0.01
Diabetes						
No	1.0	1.0		1.0	1.0	
Yes	2.55 (2.17,3.00)	1.67 (1.40,1.99)	<0.01	2.48 (2.39,3.39)	1.64 (1.34,2.00)	<0.01
BMI (kg/m^2)						
Underweight	1.0	1.0		1.0	1.0	
Normal weight	1.69 (1.39,2.05)	1.67 (1.37,2.04)	<0.01	1.70 (1.20,2.41)	1.67 (1.17,2.38)	<0.01
Overweight	3.03 (2.49,3.69)	2.43 (1.97,3.00)	<0.01	3.01 (2.13,4.24)	2.15 (1.50,3.08)	<0.01
Obese	4.86 (3.97,5.94)	3.17 (2.52,3.99)	<0.01	5.51 (3.90,7.77)	2.97 (2.04,4.34)	<0.01
Extremely Obese	7.90 (5.78,10.79)	4.64 (3.31,6.52)	<0.01	10.62(7.04,16.01)	5.24 (3.35,8.19)	<0.01
Waist Circum.						
Normal	1.0	1.0		1.0	1.0	
Not Normal	2.58 (2.38,2.79)	1.32 (1.17,1.50)	<0.01	3.07 (2.75,3.43)	1.53 (1.29,1.81)	<0.01
Waist to hip ratio						
Normal	1.0	1.0		1.0	1.0	
Not Normal	1.99 (1.81,2.20)	1.27 (1.13,1.43)	<0.01	2.18 (1.93,2.45)	1.19 (1.02,1.38)	0.02

Waist Circumference: (men<94, women <80), Waist to hip ratio: (men<0.95, women <0.80), AOR: Adjusted OR.

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Supplementary table 2. The percentage and determinants of elevated BP according to 2017 ACC/AHA Guideline among Saudi Biobank, 2017-2020 (n = 10799)

Characteristics	Elevated BP according to 2017 ACC/AHA Guideline			
	Percentage (95% CI)	OR (95% CI)	AOR (95% CI)	P-value
Overall	15.82 (15.69,15.94)	-	-	-
Gender				
Women	14.07 (13.90,14.24)	1.0	1.0	
Men	17.50 (17.32,17.68)	1.29 (1.17,1.44)	1.35 (1.19,1.54)	<0.01
Age, years				
18-29	17.64 (17.47,17.82)	1.0	1.0	
30-39	13.95 (13.73,14.17)	0.76 (0.67,0.85)	0.76 (0.66,0.88)	<0.01
40-49	12.83 (12.47,13.18)	0.69 (0.57,0.83)	0.71 (0.58,0.87)	<0.01
50-59	11.35 (10.73,11.98)	0.60 (0.42,0.85)	0.62 (0.43,0.89)	<0.01
≥60	10.39 (9.15,11.63)	0.54 (0.26,1.13)	0.54 (0.26,1.15)	0.08
Employment				
Employed	15.51 (15.34,15.69)	1.0	1.0	
Unemployed	16.10 (15.68,16.52)	1.04 (0.87,1.26)	1.15 (0.94,1.41)	0.11
Student	17.62 (17.37,17.87)	1.16 (1.03,1.31)	1.11 (0.96,1.29)	0.10
Retired/others	12.81 (12.48,13.14)	0.80 (0.67,0.96)	1.01 (0.83,1.24)	0.52
Time sitting at work				
Never	8.02 (7.12,8.92)	1.0	1.0	
A few times	15.80 (15.53,16.07)	2.15 (1.08,4.30)	2.39 (1.19,4.77)	0.02
Sometimes	16.41 (16.17,16.65)	2.25 (1.13,4.48)	2.59 (1.30,5.17)	0.01
Most of the times	15.66(15.47,15.84)	2.13 (1.07,4.23)	2.34 (1.17,4.66)	0.03
All the times	15.44 (14.70,16.17)	2.10 (0.99,4.42)	2.10 (0.99,4.44)	0.08
Current smoker				
No	15.62 (15.48,15.75)	1.0	1.0	
Yes	16.80 (16.49,17.12)	1.09 (0.95,1.25)	0.97 (0.83,112)	0.72
Diabetes				
No	15.76 (15.60,15.92)	1.0	1.0	
Yes	15.91 (15.71,16.11)	0.99 (0.89,1.10)	1.03 (0.93,1.15)	0.61
BMI, kg/m^2				
Underweight	12.14 (11.69,12.59)	1.0	1.0	
Normal weight	16.30 (16.10,16.50)	1.41 (1.10,1.80)	1.48 (1.16,1.89)	<0.01
Overweight	16.47 (16.23,16.70)	1.43 (1.11,1.83)	1.64 (1.27,2.12)	<0.01
Obese	15.30 (15.04,15.56)	1.31 (1.01,1.69)	1.68 (1.26,2.24)	<0.01
Extremely Obese	14.41 (13.65,15.16)	1.22 (0.81,1.83)	1.54 (1.00,2.37)	0.04
Waist Circum. (cm)				
Normal	16.36 (16.20,16.52)	1.0	1.0	
Not Normal	14.83 (14.62,15.03)	0.89 (0.80,0.99)	0.91 (0.77,1.07)	0.21
WtHR				
Normal	16.27 (16.12,16.41)	1.0	1.0	
Not Normal	13.89 (13.62,14.17)	0.83 (0.72,0.95)	0.99 (0.84,1.16)	0.93

Waist Circumference: (men<94, women <80), WtHR (Waist to hip ratio): (men<0.95, women <0.80), AOR: Adjusted OR, SR: Saudi Riyals.

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Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1

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Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3,4
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5,6,7,8,9

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Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	9
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5,6,7,8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5,6,7,8
Bias	#9	Describe any efforts to address potential sources of bias	5,6,7,8,9
Study size	#10	Explain how the study size was arrived at	9

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Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8,9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	8,9
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	8,9
Statistical methods	#12c	Explain how missing data were addressed	9
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
Statistical methods	#12e	Describe any sensitivity analyses	9
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible,	9

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		examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	9
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9,10,11,12,13,25,26,27,28,29,30,31,32,33
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	25,26,27,28
Outcome data	#15	Report numbers of outcome events or summary	30,31,32,33

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		measures. Give information separately for exposed and unexposed groups if applicable.	
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11,12
Main results	#16b	Report category boundaries when continuous variables were categorized	10,11,29
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9,10,11,13,17,30,31,32,33

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Discussion			
Key results	#18	Summarise key results with reference to study objectives	14,15,16
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	17
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14,15,16
Generalisability	#21	Discuss the generalisability (external validity) of the study results	17
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if	18

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	applicable, for the original study on which the present article is based

Notes:

- 14a: 9,10,11,12,13,25,26,27,28,29,30,31,32,33
- 14b: 25,26,27,28
- 15: 30,31,32,33
- 17: 9,10,11,13,17,30,31,32,33 The STROBE checklist is distributed under the terms of the Creative Commons Attribution License CC-BY. This checklist was completed on 19. June 2020 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai

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