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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 10 799 individuals

Mesnad Alyabsi [ID] ,[1,2] Reham Gaid,[1,3] Ada Alqunaibet,[4] Ahmed Alaskar,[2,5] Azra Mahmud,[2,5,6] Jahad Alghamdi[2,5]

For numbered affiliations see end of article.

Correspondence to
Dr Mesnad Alyabsi;
mesnadalyabsi@unomaha.edu

ABSTRACT

Objectives To assess the effect of the 2017 American College of Cardiology and the American Heart Association (ACC/AHA) hypertension guideline on the prevalence of elevated blood pressure (BP) and hypertension and the initiation of antihypertensive treatment, as well as the level of adherence to the 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 was used.

Primary outcome Hypertension was defined using three sources: the Joint National Committee 7 Blood Pressure Guideline (JNC-7) guideline (systolic BP (SBP)≥140 or diastolic BP (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 to 14.61), and the 2017 ACC/AHA, 40.77% (95% CI 40.60 to 40.94), a difference of 26.28%. Antihypertensive medication was recommended for 24.84% (95% CI 24.69 to 24.98) based on the JNC-7 guideline and 27.67% (95% CI 27.52 to 27.82) using the 2017 ACC/AHA guideline. Lifestyle modification was recommended for 13.10% (95% CI 12.47 to 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 to 53.64) and 27.81% (95% CI 24.31 to 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, 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 BP and hypertension will increase cardiovascular disease.

Strengths and limitations of this study

► The study had a large sample size.
► We ascertained the hypertensive status using three blood pressure (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.

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 BP and hypertension has been controversial.[6–9] Based on evidence from randomised 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 mm Hg systolic

BP (SBP) or ≥90 mm Hg diastolic BP (DBP) to ≥130 mm Hg SBP or ≥80 mm Hg DBP. Elevated BP is now limited to individuals with an SBP of 120–129 mm Hg and DBP <80 mm Hg instead of 120–139 mm Hg or 80–89 mm Hg, as suggested by the Joint National Committee 7 Blood Pressure Guideline (JNC-7).[11] Although not endorsed by some organisations, 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]

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, Kibria 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 years population of China and the USA, 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 low-income and middle-income 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 BP in the Saudi population were 15.2% and 40.6%, respectively.[20] For the patients with an antihypertensive medication prescription, 55%–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 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 study had a cross-sectional design using data from the SBB. The SBB is an ongoing project to investigate the current health behaviour 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 personal and family medications use, disabilities, others, women and men health, health behaviours, 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 10 December 2017 to 29 January 2020, with three recorded BP measurements. The data related to the prescribed antihypertensive medication were extracted from the electronic medical records.

Measurement method for BP
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.

BP classification
Using the JNC-7 guideline, BP was categorised into four categories: normal (SBP<120 and DBP<80 mm Hg), elevated BP (SBP=120–139 or DBP=80–89 mm Hg), stage 1 (SBP=140–159 or DBP=90–99 mm Hg) and stage 2 (SBP≥160 or DBP≥100 mm Hg).[11] Using the ACC/AHA guideline, BP was also categorised into four categories: normal (SBP<120 and DBP<80 mm Hg), elevated (SBP=120–129 and DBP<80 mm Hg), stage 1 (SBP=130–139 or DBP=80–89 mm Hg) and stage 2 (SBP≥140 or DBP≥90 mm Hg).[10] Individuals with BP measurements

Table 1 Characteristics of Saudi Biobank by blood pressure 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)					
SBP	108.47 (7.70)	124.01 (2.81)	126.55 (9.0)	143.81 (20.88)	123.40 (18.01)
DBP	67.98 (6.68)	71.47 (5.71)	80.92 (5.88)	90.49 (13.17)	78.95 (15.45)

CVD, cardiovascular disease; DBP, diastolic blood pressure; SBP, systolic blood pressure.

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, behavioural 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 categorised 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 an SBP/DBP of ≥140/90 mm Hg, for high-risk patients (ie, DM, CVD, age ≥65), the cut-off was 130/80 mm Hg. 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 blockers, diuretics and centrally or peripherally acting agents found in the pharmacy files during the year of diagnosis.

Data analysis

The data were analysed using SAS statistical software V.9.4. Descriptive data for the sample, stratified by gender, are

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		JNC-7 guideline		2017 ACC/AHA but not JNC-7	
	Hypertension	Recommended antihypertensive medications	Hypertension	Recommended antihypertensive medications	Hypertension	Recommended antihypertensive medications
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Overall	40.77 (40.60 to 40.94)	27.67 (27.52 to 27.82)	14.49 (14.37 to 14.61)	24.84 (24.69 to 24.98)	26.28 (26.23 to 26.33)	2.83 (2.83 to 2.84)
Age, years						
18–29	34.86 (34.64 to 35.08)	21.62 (21.43 to 21.81)	10.67 (10.53 to 10.81)	19.66 (19.47 to 19.84)	24.19 (24.11 to 24.27)	1.96 (1.96 to 1.97)
30–39	43.44 (43.12 to 43.76)	29.68 (29.39 to 29.97)	14.62 (14.40 to 14.85)	26.46 (26.18 to 26.75)	28.82 (28.72 to 28.91)	3.22 (3.21 to 3.22)
40–49	55.58 (55.06 to 56.11)	44.15 (43.63 to 44.68)	27.33 (26.87 to 27.80)	39.35 (38.84 to 39.87)	28.25 (28.19 to 28.31)	4.80 (4.79 to 4.81)
50–59	66.87 (65.94 to 67.80)	54.91 (53.92 to 55.89)	36.31 (35.39 to 37.22)	48.16 (47.17 to 49.15)	30.56 (30.55 to 30.58)	6.75 (6.75 to 6.74)
≥60	70.13 (68.23 to 71.96)	64.94 (62.97 to 66.85)	34.15 (32.27 to 36.02)	54.55 (52.51 to 56.57)	35.98 (35.96 to 35.94)	10.39 (10.46 to 10.28)
Gender						
Women	33.57 (33.34 to 33.80)	32.02 (31.79 to 32.24)	10.39 (10.24 to 10.54)	19.97 (19.78 to 20.17)	23.18 (23.10 to 23.26)	12.05 (12.01 to 12.07)
Men	47.72 (47.48 to 47.96)	23.16 (22.95 to 23.37)	18.45 (18.26 to 18.63)	29.53 (29.31 to 29.75)	29.27 (29.22 to 29.33)	−6.37 (−6.36 to −6.38)
Marital status						
Never married	36.18 (35.95 to 36.40)	22.89 (22.70 to 23.09)	11.91 (11.76 to 12.06)	21.05 (20.86 to 21.24)	24.27 (24.19 to 24.34)	1.84 (1.84 to 1.85)
Married	46.39 (46.13 to 46.65)	33.37 (33.12 to 33.62)	17.76 (17.59 to 17.99)	29.39 (29.15 to 29.63)	28.63 (28.54 to 28.66)	3.98 (3.97 to 3.99)
Divorced, Sep.	44.18 (44.10 to 46.25)	34.61 (33.58 to 35.65)	17.30 (16.50 to 18.10)	29.83 (28.84 to 30.82)	26.88 (27.6 to 28.15)	4.78 (4.74 to 4.83)
Tobacco use						
No	40.93 (40.75 to 41.12)	27.81 (27.64 to 27.97)	14.47 (14.34 to 14.60)	24.94 (24.78 to 25.10)	26.46 (26.41 to 26.52)	2.87 (2.86 to 2.87)
Yes	39.98 (39.57 to 40.39)	27.00 (26.63 to 27.37)	14.60 (14.30 to 14.89)	24.32 (23.96 to 24.68)	25.38 (25.27 to 25.50)	2.68 (2.67 to 2.69)
Diabetes						
No	39.37 (39.20 to 39.54)	18.87 (18.70 to 19.04)	13.44 (13.32 to 13.56)	14.25 (14.09 to 14.40)	25.39 (25.88 to 25.98)	4.62 (4.61 to 4.64)
Yes	62.37 (61.69 to 63.04)	41.60 (41.33 to 41.88)	30.65 (30.01 to 31.30)	41.60 (41.33 to 41.88)	31.72 (31.68 to 31.74)	0
BMI, kg/m²						
Underweight	20.84 (20.28 to 21.39)	11.72 (11.28 to 12.17)	5.41 (5.10 to 5.72)	10.55 (10.13 to 10.97)	15.43 (15.18 to 15.67)	1.17 (1.15 to 1.20)
Normal weight	30.76 (30.51 to 31.02)	19.14 (18.92 to 19.36)	8.89 (8.73 to 9.04)	16.98 (16.77 to 17.19)	21.87 (21.78 to 21.98)	2.16 (2.15 to 2.17)
Overweight	44.37 (44.06 to 44.68)	30.40 (30.12 to 30.69)	14.69 (14.47 to 14.92)	27.16 (26.88 to 27.44)	29.68 (29.59 to 29.76)	3.24 (3.24 to 3.25)
Obese	56.12 (55.76 to 56.48)	40.46 (40.10 to 40.82)	23.98 (23.67 to 24.29)	36.63 (36.27 to 36.98)	32.14 (32.09 to 32.19)	3.83 (3.83 to 3.84)
Extremely obese	67.53 (66.53 to 68.54)	54.21 (53.14 to 55.28)	37.82 (36.78 to 38.87)	50.46 (49.38 to 51.53)	29.71 (29.75 to 29.67)	3.75 (3.76 to 3.75)
Waist circum., cm						
Normal	32.65 (32.44 to 32.85)	20.51 (20.34 to 20.68)	9.30 (9.17 to 9.42)	18.13 (17.96 to 18.29)	23.35 (23.27 to 23.43)	2.38 (2.38 to 2.39)
Not normal	55.54 (55.25 to 55.83)	40.68 (40.39 to 40.96)	23.94 (23.69 to 24.18)	37.03 (36.75 to 37.30)	31.60 (31.56 to 31.65)	3.65 (3.64 to 3.66)

Continued

Table 2 Continued

Characteristics	2017 ACC/AHA guideline		JNC-7 guideline		2017 ACC/AHA but not JNC-7	
	Hypertension	Recommended antihypertensive medications	Hypertension	Recommended antihypertensive medications	Hypertension	Recommended antihypertensive medications
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Waist–hip ratio						
Normal	37.55 (37.37 to 37.74)	24.68 (24.51 to 24.84)	12.38 (12.26 to 12.51)	22.11 (21.95 to 22.27)	25.17 (25.11 to 25.23)	2.57 (2.56 to 2.57)
Not normal	54.57 (54.18 to 54.97)	40.50 (40.11 to 40.88)	23.53 (23.19 to 23.86)	36.51 (36.13 to 36.89)	31.04 (30.99 to 31.11)	3.99 (3.98 to 3.99)

ACC/AHA, American College of Cardiology and the American Heart Association; BMI, body mass index; JNC-7, Joint National Committee 7 Blood Pressure Guideline; SAR, Saudi Arabian Riyals.

presented as frequency and percentage for categorical variables, and for continuous variables, as a mean and SD. In addition, for each BP category, the mean, SD, median, 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 BP was measured by dividing the total number of the group with elevated BP by the total number of the study population. The prevalence of hypertension and elevated BP 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. The missing data ranges from 0% to 30%, and 30 imputations were conducted. Given the arbitrary pattern of the missing data, the procedure multiple imputation (PROC MI) procedure was used with the 'fully conditional specifications (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 OR and the adjusted OR. Backward elimination was used to determine variables included at the multivariate level. All statistical tests were two-sided, and findings were considered statistically significant at p<0.05. The Strengthening the Reporting of Observational Studies in Epidemiology cross-sectional guideline was used to assure that all essential elements are reported and covered.[26]

RESULTS

Descriptive statistics

A total of 11 571 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 10 799 individuals. The overall characteristics of the sample, stratified by antihypertensive prescription, are summarised 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 mm Hg, 120–129/<80 mm Hg, 130–139/80–89 mm Hg and ≥140/90 mm Hg, respectively. Participants with an increased BP were likely to be men, of older age and with a history of DM or CVD.

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 with the JNC-7 guidelines. The difference in the prevalence was highest in the oldest age group. Based on the JNC-7 guideline,

Table 3 Characteristics of the Saudi Biobank population not taking antihypertensive medications meeting the definition of Hypertension and recommended antihypertensive according to 2017 ACC/AHA guideline and JNC-7 guideline, 2017–2020

	Hypertension 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
Waist–hip ratio						
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)

ACC/AHA, American College of Cardiology and the American Heart Association; BMI, body mass index; CVD, cardiovascular disease; JNC-7, Joint National Committee 7 Blood Pressure Guideline.

only 24.84% of the patients were recommended to receive antihypertensive medication, compared with 27.67%, according to the 2017 ACC/AHA guideline. With the exception of men, 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 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 body mass index (BMI), better waist circumference profile, lower SBP and DBP (table 3). When compared with 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 BP

The determinants of hypertension, according to the ACC/AHA and JNC-7 guidelines, are presented in online supplemental table 1 (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 and increasing BMI, particularly with abdominal

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/m^2			
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
Waist–hip ratio			
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

ACC/AHA, American College of Cardiology and the American Heart Association; BMI, body mass index; BP, blood pressure; CVD, cardiovascular disease; JNC-7, Joint National Committee 7 Blood Pressure Guideline.

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 BP, adjusted for all covariates in the table, are presented in online supplemental table 2. Elevated BP determinants were being men, 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 men (47.72%) compared with women (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 USA,[13 17] which assessed the impact of the 2017 ACC/AHA guidelines on the prevalence of hypertension. In the US 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 Bangladesh (22%) were comparable to our results (26.28%). The difference may reflect the younger population of Nepal, Bangladesh and Saudi Arabia compared with the US 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 US 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 RCTs.[30] For instance, in normotensive individuals, engaging in physical activities of 90–150 min/week is associated with a reduction of 2–4 mm Hg 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 programme are ongoing to promote physical activities. Future studies should assess the impact of these programmes 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 USA 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 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 recognise the current BP targets. A multidisciplinary disease management strategy and follow-up of patients with uncontrolled BP should be emphasised. To achieve the target BP in patients with an uncontrolled BP, intensive antihypertensive treatment is required.

Strengths and limitation

Our study has several strengths. First, we used a large sample of the Saudi population (n=10 799) from diverse backgrounds (eg, wives, professionals, students and unemployed women). Second, we ascertained the hypertensive status using BP measurements according to a standardised procedure. Our study also has several limitations. First, 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. Second, although the BP was measured using three readings, the measurement was performed during a single visit. Third, 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. Fourth, 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 BP, with implications for escalating healthcare costs. There was, however, only a small increase in the proportion of patients recommended to 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.

Author affiliations
[1]Population Health Research Section, King Abdullah International Medical Research Center, Riyadh, Saudi Arabia
[2]King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia
[3]Princess Noura Bint Abdul Rahman University, Health, and Rehabilitation Sciences college, Riyadh, Saudi Arabia
[4]Saudi Center for Disease Prevention and Control, Riyadh, Saudi Arabia
[5]The Saudi Biobank, King Abdullah International Medical Research Center, Riyadh, Saudi Arabia
[6]King Abdulaziz Cardiac Center, Riyadh, Saudi Arabia

ORCID iD
Mesnad Alyabsi http://orcid.org/0000-0001-7763-9572

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