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Secular trends of hypertension prevalence based on 2017 ACC/AHA and 2018 Chinese hypertension guidelines: Results from CHNS data (1991-2015)

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Abstract

This study aimed to assess the impact of the 2017 American College of Cardiology and American Heart Association (ACC/AHA) guideline and the 2018 Chinese hypertension guidelines on the different secular trends for hypertension prevalence. A total of 82 665 eligible individuals aged ≥20 years were selected from nine cross-sectional study periods (1991-2015) from the China Health and Nutrition Survey (CHNS). Over the 24-year period, the long-term trend for the prevalence of the 2017 ACC/AHA-defined age-adjusted hypertension showed an increase from 32.2% (95% confidence interval (CI): 31.0%-33.3%) in 1991 to 60.0% (95% CI: 58.6%-61.3%) in 2015 ($P_{trend} < 0.001$). According to the 2018 Chinese guideline for hypertension, the weighted hypertension prevalence increased from 10.0% (95% CI: 9.4%-10.5%) in 1991 to 28.7% (95% CI: 27.9%-29.6%) in 2015 ($P_{trend} < 0.001$). However, slopes of increasing prevalence of hypertension were significantly greater according to the 2017 ACC/AHA guideline than that based on Joint National Committee (JNC 7) report ($\beta = 1.00\%$ vs $\beta = 0.67\%$ per year, respectively, $P = 0.041$). Based on the 2017 ACC/AHA definition, the prevalence of stage 1 hypertension and elevated blood pressure significantly increase from 22.3% and 6.9% in 1991 to 31.2% and 10.1% in 2015 (all $P < 0.05$), respectively. The secular trend for the prevalence of hypertension according to the 2017 ACC/AHA guideline showed a greater rate of increase compared with the prevalence based on the 2018 Chinese hypertension guidelines. Public health initiatives should focus on the current status of hypertension in China because of the possible high prevalence of hypertension and concomitant vascular risks.

1 | INTRODUCTION

In November 2017, the American College of Cardiology and American Heart Association (ACC/AHA) released the new hypertension guideline and changed the systolic/diastolic blood pressure (SBP/DBP) related to hypertension from 140/90 mm Hg to ≥ 130/80 mm Hg,[1] which is the most notable change related to high blood pressure that differed from the seventh report of the Joint National Committee (JNC 7), which was released in 2003.[2] The direct short-term effects of the new hypertension threshold

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on the population include an increase in the hypertension prevalence.[3-5] Recently, the data of several Chinese populations also indicated that the 2017 ACC/AHA guideline substantially increased the hypertension prevalence.[6-8] After the publication of the new guidelines, the use of the new guidelines by other countries is a focus point. However, the Hypertension Committee of China Medical Association published consensus that recommended not to change the 2010 Chinese hypertension guidelines [9] and the Chinese hypertension guideline have seriously considered the current situation of hypertension management in China.[6] Hypertension affects approximately 1 billion adults worldwide and is a critically important modifiable risk factor for cardiovascular morbidity and mortality, which is the leading cause of death in China.[10-12] In addition, 44.7% of Chinese adults aged 35-75 years [13] suffer from hypertension (≥140/90 mm Hg) and the numbers of hypertensive adults is now estimated to be more than 300 million in China. Also, data from the China Health and Nutrition Survey (CHNS) indicated an increasing trend of hypertension prevalence and blood pressure (BP) among Chinese adults from 1991 to 2009 based on the Chinese hypertension guideline.[14] However, the long-term potential impact of 2017 ACC/AHA guideline on hypertension prevalence is poorly understood,[15,16] especially in China. Determining the prevalence of hypertension and disparity based on the 2017 ACC/AHA guideline and Chinese hypertension guideline would be helpful in improving our understanding of the impact of the 2017 ACC/AHA guidelines on the Chinese population. Therefore, we used CHNS data from 1991 to 2015 to evaluate the secular trends for the prevalence of hypertension and elevated BP based on 2017 ACC/AHA and 2018 Chinese hypertension guidelines.

2 | METHODS

2.1 | Data source and study population

CHNS is a subsequent follow-up survey of nutrition and food safety of the Chinese Center for Disease Control and Prevention in collaboration with the Population Center of the University of North Carolina in the United States. CHNS covered nine provinces (Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou), a multistage, random cluster process was used to draw the samples surveyed in each of the provinces. Counties in the nine provinces were stratified by income (low, middle, and high), and four counties were randomly selected in each province. In addition, a provincial capital and a lower income city were selected when feasible, except in two provinces where large cities rather than provincial capitals had to be selected. Villages and townships within the counties and urban/suburban neighborhoods within the cities were selected randomly. Details of the CHNS survey data have been described elsewhere.[17] The survey was approved by the institutional review committees of the University of North Carolina, the Chinese Institute of Nutrition and Food Safety, and the China Center for Disease Control and Prevention. The inclusion criteria of the study participants were as follows: (a) age ≥ 20 years; (b) complete recorded information on individual's sex, height, weight, and region; (3) complete information record of hypertension and antihypertensive drug usage. Finally, 8054, 7575, 8238, 9263, 8699, 8832, 8333, 12 388, and 11 283 eligible individuals aged ≥20 years were selected from the 9 study periods (1991, 1993, 1997, 2000, 2004, 2006, 2009, 2011, and 2015) for this study.

2.2 | BP measurements

BP was measured by trained examiners using a mercury sphygmomanometer with a suitable cuff size according to a standard protocol.[18] Triplicate measurements were taken 10 minutes after rest, and the average of those three measurements was documented as the individual's BP. According to the 2017 ACC/AHA guideline, hypertension was defined as BP ≥ 130/80 mm Hg or use of antihypertensive medications within the previous 2 weeks. Stage 1 hypertension was defined by SBP of 130-139 mm Hg or DBP of 80-89 mm Hg; and stage 2 hypertension was defined as SBP ≥ 140 or DBP ≥ 90 mm Hg or the use of antihypertensive medications, which is identical to 2018 Chinese hypertension guideline.[19] Elevated BP was defined by SBP of 120-129 mm Hg and DBP < 80 mm Hg according to the 2017 ACC/AHA guideline.

2.3 | Statistical analysis

Continuous variables are presented as means and standard deviation, and categorical variables are expressed as percentages. The secular trend for the key characteristics across survey years was calculated using multiple linear (continuous variable) or logistic regression (categorical variable) models with adjustments for age, sex, region, and body mass index (BMI). Since the age distribution among the nine survey visits varied, the age-adjusted prevalence of hypertension and elevated BP was weighted using the 2000 China Census data. We calculated the weighted prevalence from 1991 to 2015 overall and by sex (men and women), age (<60 years and ≥60 years), and region type (urban and rural). The linear regression models were used to evaluate the secular trends for the prevalence of hypertension over the years, with the survey year as the independent variable and the weighted prevalence as the dependent variable. The slope across survey years was used as a surrogate indicator of the average increase velocity, and we detected significant increasing trends across the nine survey years. The difference between slopes was examined using t test, which is recommended by Kleinbaum.[20] All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc, Cary, NC) and SPSS statistical software version 22.0 (IBM Corp). A 2-sided P value < 0.05 was considered to be statistically significant.

TABLE 1 Characteristics of study Chinese participants aged ≥ 20 years from 1991 to 2015 (CHNS)

Variables	1991	1993	1997	2000	2004	2006	2009	2011	2015	*P* trend*
Number	8054	7575	8238	9263	8699	8832	8333	12 388	11 283	
Age (y)	42.0 ± 15.3	42.7 ± 15.3	44.1 ± 15.4	45.6 ± 15.1	48.5 ± 15.0	49.7 ± 14.8	50.8 ± 15.3	51.3 ± 15.0	53.7 ± 14.7	<0.001
Women, n (%)	4232 (52.5)	3988 (52.6)	4276 (51.9)	4863 (52.5)	4585 (52.7)	4705 (53.3)	4397 (52.8)	6614 (53.4)	6125 (54.3)	0.002
BMI (kg/m^2)	21.7 ± 2.9	21.9 ± 2.9	22.4 ± 3.1	22.9 ± 3.3	23.1 ± 3.4	23.2 ± 3.6	23.4 ± 3.5	24.0 ± 4.6	24.3 ± 4.1	<0.001
SBP (mm Hg)	115.3 ± 18.6	116.0 ± 17.6	119.1 ± 18.1	120.1 ± 18.0	122.5 ± 18.7	121.8 ± 17.9	124.8 ± 18.9	124.6 ± 17.7	129.2 ± 18.9	<0.001
DBP (mm Hg)	74.6 ± 11.4	75.9 ± 10.9	77.3 ± 11.0	77.9 ± 11.1	78.9 ± 11.2	78.9 ± 10.8	80.2 ± 11.1	79.4 ± 10.6	81.6 ± 11.0	<0.001
Rural, n (%)	5344 (66.4)	5239 (69.2)	5439 (66.0)	6109 (66.0)	5674 (65.2)	5826 (66.0)	5631 (67.6)	7360 (59.4)	6878 (61.0)	<0.001
Antihypertensive medications, n (%)	196 (2.43)	207 (2.73)	239 (2.90)	457 (4.93)	590 (6.78)	695 (7.87)	903 (10.84)	1662 (13.42)	1664 (14.75)	<0.001

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure.

**P* for trend was calculated using multiple linear (continuous variable) or logistic regression (categorical variable) model adjustment for age, sex, region, and BMI.

3 | RESULTS

The key characteristics of the study participants across all survey visits are described in Table 1. The trend in mean SBP and DBP values increased significantly after the age, sex, region, and BMI (all $P_{trend} < 0.001$) adjustment. In addition, the use of antihypertensive medications increased from 2.43% in 1991 to 14.75% in 2015 and an increased secular trend was observed ($P < 0.001$).

As shown in Figure 1, in 2015, the age-adjusted prevalence of hypertension was 60.0% (95% CI: 58.6% to 61.3%) based on the 2017 ACC/AHA guideline, which is 32.1% higher than the estimated prevalence (28.7%, 95% CI: 27.9% to 29.6%) according to the 2018 Chinese guideline. Over the last 24-year period, the long-term trend of the 2017 ACC/AHA-defined age-adjusted hypertension prevalence among Chinese adults increased from 32.2% (95% CI: 31.0% to 33.3%) in 1991 to 60.0% (95% CI: 58.6% to 61.3%) in 2015 ($P_{trend} < 0.001$). Similarly, according to the 2018 Chinese definition, the weighted prevalence of hypertension also increased from 10.0% (95% CI: 9.4% to 10.5%) in 1991 to 28.7% (95% CI: 27.9% to 29.6%) in 2015 ($P_{trend} < 0.001$). However, slopes of increasing prevalence of hypertension during the last 24 years, measured as regression coefficients (β), were significantly greater according to the definition of 2017 ACC/AHA guideline than that based on JNC 7 (β = 1.00% per year versus β = 0.67% per year, P = 0.041) (Figure 1).

Consequently, a similar secular trend of increased hypertension based on the 2017 ACC/AHA criteria and 2018 Chinese guideline for predefined subgroups such as sex, age, and region type were observed (all $P_{trend} < 0.05$) (Figure 2). Meanwhile, there was a similar greater slope of increasing age-adjusted prevalence of hypertension based on ACC/AHA criteria than that according to Chinese guideline, except for the subgroups older than 60 years (β = 0.48% per year versus β = 0.38% per year, P = 0.724) (Figure 2C) and urban regions (β = 0.72% per year vs β = 0.48% per year, P = 0.280) (Figure 2E). In addition, stage 1 hypertension and elevated BP based on 2017 ACC/AHA definition also significantly increased from 22.3% (95% CI: 21.3% to 23.3%) and 6.9% (95% CI: 6.3% to 7.4%) in 1991 to 31.2% (95% CI: 30.2% to 32.3%) and 10.1% (95% CI: 9.5% to 10.7%) in 2015 (all $P < 0.05$), respectively (Figure 3).

In addition, there was a significant difference in slopes between urban region and rural region based on ACC/AHA criteria (β = 0.72% per year vs β = 1.15% per year, P = 0.023) (Supplementary Table S1).

4 | DISCUSSION

In the present study, we observed that when applying the 2017 ACC/AHA guideline in comparison to the 2018 Chinese guideline, the prevalence of hypertension among Chinese adults significantly increased. Moreover, the present study demonstrated an increased secular trend of hypertension and elevated BP among Chinese adults based on 2017 ACC/AHA guideline over the past 24 years. Furthermore, the increased rate of hypertension prevalence based

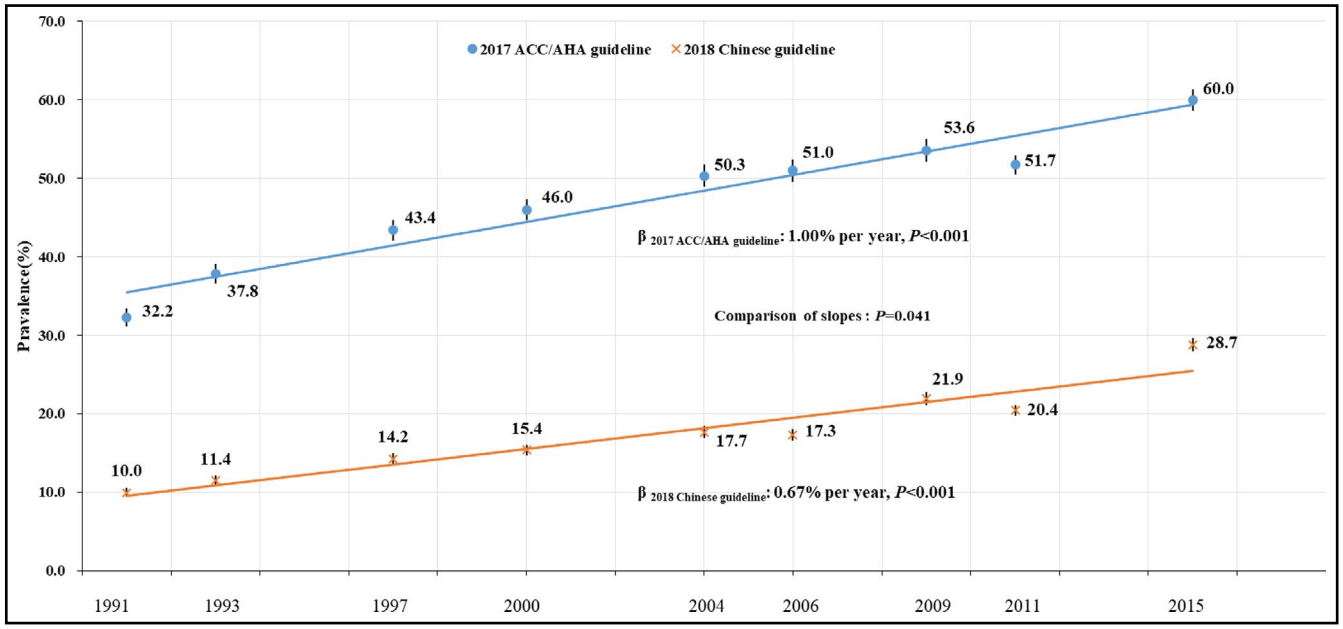

FIGURE 1 Secular trends of age-adjusted prevalence of hypertension defined by 2017 ACC/AHA guideline and 2018 Chinese criteria among Chinese adults, 1991 to 2015. ACC = American College of Cardiology; AHA = American Heart Association [Color figure can be viewed at wileyonlinelibrary.com]

on the 2017 ACC/AHA guideline was significantly steeper than that estimated based on the 2018 Chinese guideline.

In the past decades, the prevalence of hypertension among adults and children in China has increased dramatically and has become an important public health issue.[14,21] Muntner et al analyzed the National Health and Nutrition Examination Survey (NHANES) data and showed that applying the 2017 ACC/AHA criteria increased the prevalence of hypertension in the United States from 31.9% to 45.6%, with a relative increase of 43.0%.[3] Wang et al [6] demonstrated that if a SBP/DBP of 130/80 mmHg is applied to the most recent data in China, the prevalence of hypertension would increase from approximately 25% to 50%. Using NHANES data from the most recent two periods (2013-14, 2015-16) and the China Health and Retirement Longitudinal Study (CHARLS) (2011-12), Khera et al [7] indicated that the application of the 2017 ACC/AHA guideline would result in an increased hypertension prevalence of 26.8% (95%CI: 23.2% to 30.9%) and 45.1% (95%CI: 41.3% to 48.9%) in United States and China among adults aged 45-75 years, respectively. Using longitudinal CHNS data, the present study protracted the previous prevalence of hypertension from several cross-sectional studies in China [6-8] and demonstrated an increasing secular trend of hypertension prevalence based on 2017 ACC/AHA guideline, which is different from the long-term trend among US adults.[16,17]

In addition, we observed that the rate of increase in the prevalence of hypertension based on 2017 ACC/AHA guideline is significantly steeper than that estimated by the 2018 Chinese guideline (β = 1.00% per year versus β = 0.67% per year, $P = 0.041$). With the new definition of 2017 ACC/AHA hypertension guideline, more individuals with BP ≥ 130-139/80-89 mmHg will be newly diagnosed as hypertension and the prevalence of hypertension in populations will increase significantly. Our analysis also indicated that stage 1 hypertension defined as BP ≥ 130-139/80-89 mmHg according to the 2017 ACC/AHA guideline gradually increased in the last 24 years (β = 1.00% per year, $P = 0.014$). These findings have potential implications for the category of prehypertension defined by JNC 7 and stage 1 hypertension over the past two decades and the implications for patient outcomes. Based on the 2017 ACC/AHA guideline, elevated BP also increased significantly across the nine survey visits (β = 0.12% per year, $P = 0.002$). These results indicated that a more intensive BP management should be encouraged in China.

The advantages of lowering the definition of hypertension to 130/80 mm Hg provide an opportunity for healthcare providers and patients to discuss the value of nonpharmacological treatments in lowering BP, that is, to implement recommended lifestyle changes and to emphasize that BP has a potential hazard that can be controlled. The new definition of hypertension based on the 2017 ACC/AHA guideline may have a potential impact on Chinese adults. In China, most cardiovascular specialists have suggested that the threshold BP of the 2017 ACC/AHA hypertension guideline may not be adaptable currently in China.[6] Although prospective cohort studies from China and other countries have shown a positive association of 130-139/80-89 mm Hg with the onset of subsequent cardiovascular diseases,[22-24] whether or not the new definition of hypertension will improve the control of hypertension and reduce the risk of cardiovascular disease without a substantial increase of cost is still controversial.[25,26]

Limitations should be considered in light of these results. Firstly, the BP measurements in CHNS were obtained from a single visit which

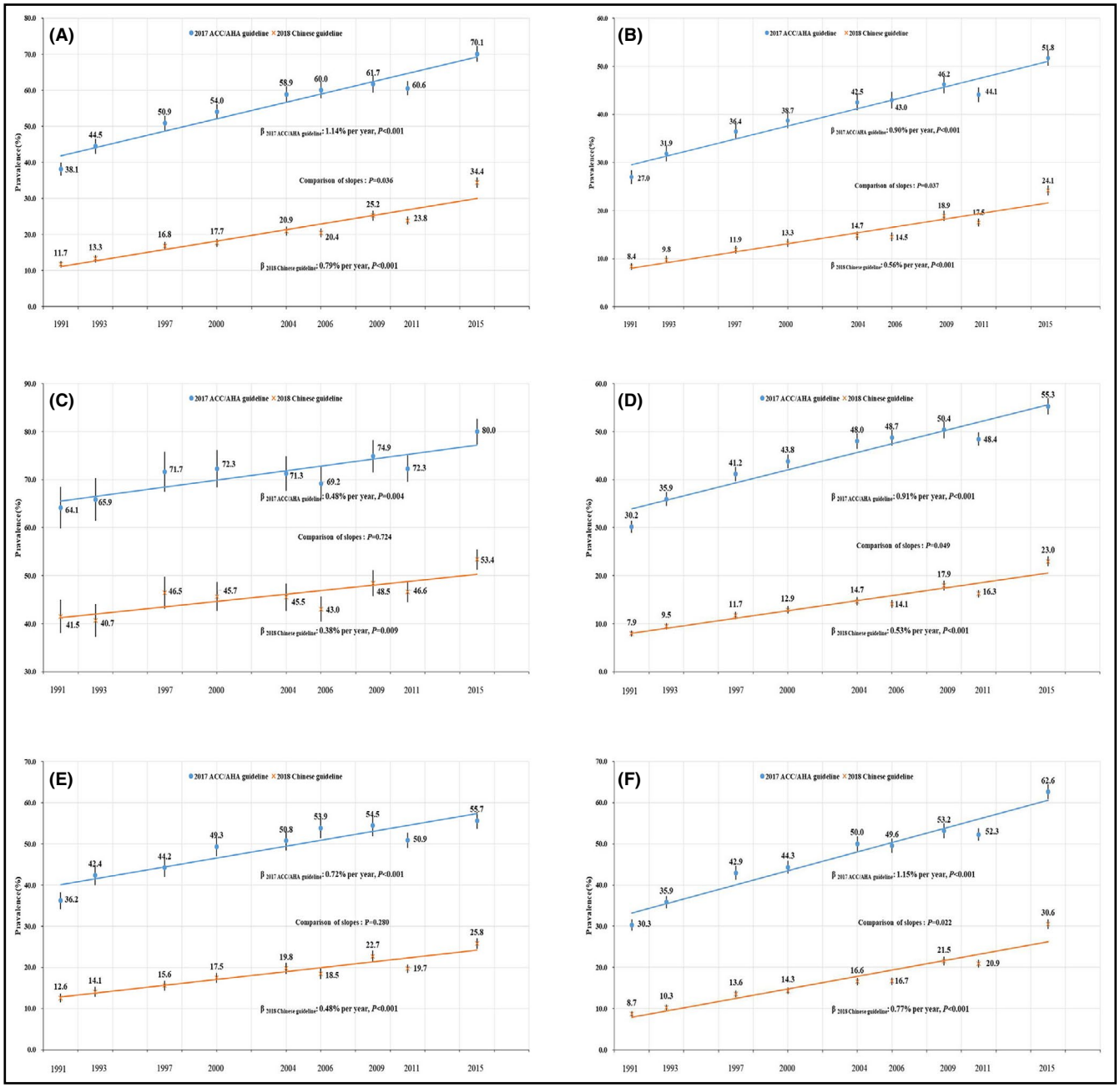

FIGURE 2 Secular trends of age-adjusted prevalence of hypertension among predefined subgroups among men (A), women (B), aged ≥60 y (C), aged <60 y (D), urban region (E), and rural region (F) according to 2017 ACC/AHA guideline and 2018 Chinese criteria among Chinese adults, 1991 to 2015. ACC = American College of Cardiology; AHA = American Heart Association [Color figure can be viewed at wileyonlinelibrary.com]

may be induced misclassification. In addition, the research sample analyzed during the current study does not provide a national representative sample of general Chinese population. However, the CHNS data are considered as a reliable source to estimate the prevalence and trends of hypertension in the general population, and they have been widely used in previous literature.[14,18,21] Finally, the impact of the 2017 ACC/AHA guideline and the JNC 7 on the prevalence of hypertension was not compared. However, we expect the outcomes and comparisons to be similar because the definition of hypertension according to the JNC 7 is the same as that of the 2018 Chinese guideline.

5 | CONCLUSION

The hypertension prevalence based on hypertension criteria defined by 2017 ACC/AHA guideline would be significantly increased, compared to the prevalence estimates based on 2018 Chinese guideline. Moreover, the secular trend of hypertension prevalence according to 2017 ACC/AHA guideline has a steeper rate of increase than that based on 2018 Chinese guideline. Although different secular trends of hypertension prevalence are reported based on different hypertension guidelines, public health initiatives are required to focus on

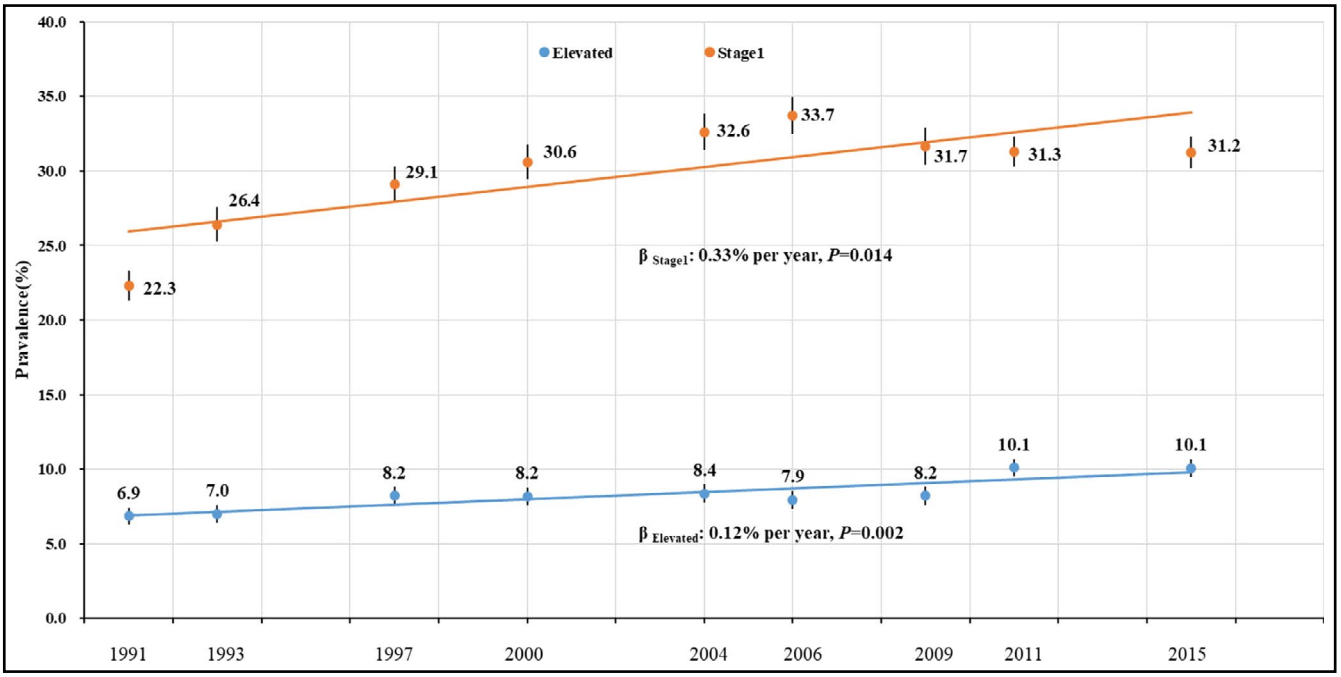

FIGURE 3 Secular trends of age-adjusted prevalence of stage 1 hypertension and elevated blood pressure according to 2017 ACC/AHA guideline among Chinese adults, 1991 to 2015. ACC = American College of Cardiology; AHA = American Heart Association [Color figure can be viewed at wileyonlinelibrary.com]

the current status of hypertension in China because of its high prevalence and concomitant vascular risks.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

Tiesheng Niu and Liqiang Zheng had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Tiesheng Niu and Liqiang Zheng involved in study concept and design. Yue Dai involved in statistical analysis. Liqiang Zheng involved in drafting of the manuscript. Peng Fu and Tiangui Yang involved in critical revision of the manuscript for important intellectual content. Yanxia Xie, Jia Zheng and Jinyue Gao involved in review the English language and grammar. All authors read and approved the final manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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