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RESEARCH

Trends and projections of hypertensive heart disease burden in China: a comprehensive analysis from 1990 to 2030

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Abstract

Background Hypertensive heart disease (HHD) is a significant public health concern in China. We intend to provide an updated estimate of the burden of HHD in China between 1990 and 2030.

Methods HHD prevalence, mortality, and disability-adjusted life years (DALYs) data were obtained from Global Burden of Disease (GBD) 2019 databases. Temporal trends of HHD from 1990 to 2019 were analyzed using Joinpoint regression models, and projections through 2030 were estimated by Bayesian age-period-cohort model.

Results In 2020, an estimated 334,695 newly prevalent cases and 13,196 deaths due to HHD occurred in China. From 1990 to 2019, age-standardized rate of prevalence (ASPR), mortality (ASMR) and DALYs (ASDR) showed a decreasing trend. The behavior-related risk, diet risk and excessive BMI were the most common reasons of death in HHD. According to our prediction, ASMRs and ASDRs will continue to decrease from 2020 to 2030. However, ASPRs will have a moderate rise.

Conclusion HHD continues to pose a significant threat to public health in China. To achieve the Healthy China 2030 objective, a tailored approach involving comprehensive strategies is essential. These strategies should include, but are not limited to, enhancing public awareness about hypertension through educational campaigns, improving access to healthcare services for early diagnosis and treatment, implementing policies to promote healthy lifestyles, such as regular physical activity and a balanced diet, and strengthening the surveillance and monitoring systems to track the prevalence and impact of HHD over time.

Keywords Hypertensive heart disease, Hypertension, Global burden of disease, Projection, China, Trends

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Introduction

The rapid economic development in China has been accompanied by significant lifestyle changes that have influenced the prevalence of hypertension. Economic growth has led to increased urbanization and westernization of diets, contributing to higher caloric intake and the consumption of energy-dense foods, which in turn has resulted in a rise in overweight and obesity [1]. This is further exacerbated by a decrease in physical activity levels due to more sedentary, occupations and reduced engagement in traditional labor-intensive activities [2]. On the other hand, lifestyle changes could also refer to beneficial practices, such as an increased awareness and adoption of healthier behaviors, including more physically active daily routines [2]. However, the overall impact of these positive changes might been overshadowed by the surge in obesity and its associated risks, which are the main drivers of the increasing trend in hypertension rates [3, 4], causing more fatalities than any other cardiovascular risk factors [5, 6]. Long-term hypertension causes left ventricle remodeling, leading to hypertensive heart disease (HHD), which is the primary cause of death [7, 8] and the second most common cause of heart failure [8, 9], following coronary artery disease (CAD). Early detection and effective blood pressure control are essential to prevent adverse complications of hypertension. 2017 American Heart Association/American Heart Association (AHA/ACA) guidelines defined hypertension as systolic blood pressure greater than 130 mmHg or diastolic blood pressure greater than 80 mmHg, based on an average of at least two readings obtained on two different occasions [10]. The stricter definition further emphasized the importance of blood pressure management. Despite substantial improvements in treating and managing arterial hypertension over the past few decades, the prevalence of HHD and the associated risk of heart failure continued to rise [11, 12]. A Global Burden of Disease (GBD)-based analysis found that the number of HHD in 2019 was about three times that of 1990 [13], indicating a rapid increase in hypertension.

China, being the second most populous country in the world, is confronted with a substantial burden of hypertension, with a staggering 245 million cases reported in 2021, but less than 15% received adequate treatment [14–16], indicating that HHD remains a significant public health concern deserving of a high level of attention and priority. To date, however, the overwhelming majority of HHD-related studies centered on pathogenesis and treatment protocols. Epidemiological studies could shed light on the burden of HHD on human health from a macro perspective and serve as the basis for enhancing public health at the national level, allocating medical resources prudently, and devising health strategies. A handful of observational studies on hypertension in China had been conducted using nationally representative samples [17, 18], but systematic research investigating their temporal changes and forecasting the prevalence of HHD were scarce [17, 19].

The Global Burden of Disease Study (GBD) database and United Nations (UN) population data allow researchers to conduct comprehensive analyses and projections [20]. In this study, using UN standard and projected population data, we examined the relationships between HHD burdens (prevalence, mortality, disability-adjusted life-years [DALYs], and corresponding age-standardized rate [ASR]) by gender, and present prevalence, mortality, and DALYs forecasts for China up to 2030 to provide detailed information to policymakers and decision-makers with detailed information to assist them in making prioritization and resource allocation decisions based on evidence to combat and mitigate the burden of HHD.

Methods

Study data sources

This secondary analysis was based on the GBD 2019 [21]. The International Classification of Diseases, Ninth and Tenth Revision (ICD-9 and −10) codes defined HHD. HHD was identified for diseases classified 402-402.91 in ICD-9 or I11-I11.9 in ICD-10 [22, 23]. Using the Global Health Data Exchange (GHDx) query Tool (http://ghdx.healthdata.org/gbd-results-tool), prevalence, morta lity, DALYs, and their respective ASRs for HHD were extracted. The informed consent was waived because no identifying data were used.

Statistical analysis

To quantify changing temporal trends in HHD prevalence, mortality and DALYs from 1990 to 2019, we used the joinpoint regression model composed of continuous linear phases. The overall trends in HHD burden were reflected by the estimated annual percentage change (EAPC) in the age-standardized prevalence (ASPR), mortality (ASMR), and DALYs (ASDR) rates. ASRs are frequently used to compare two distinct periods or geographical regions, considering the age structure differences between the populations being compared. EAPC is a prevalent and significant evaluation of the ASR's trajectory over a specified period [24, 25]. A relevant mathematical linear regression model governed the natural logarithm of ASRs along with the year.

We studied the relationships between age, period, birth cohort, and HHD using age-period-cohort (APC) modeling. An individual's birth cohort could be calculated by subtracting their age from their period of diagnosis [26]. Period effects are caused by changes in the social, economic, cultural, or physical environments and affect all age groups simultaneously. Variations within groups of the same birth year are attributed to cohort effects.

Period and cohort relative risks (RRs) are the ratios of age-specific rates in each period and cohort relative to a control group. The age curve illustrates the expected age-specific rate in a reference cohort, taking into account period effects. Two essential parameters in APC models are net and local drifts: the former refers to the overall loglinear trend by period and birth cohort and represents the annual percentage change of the expected age-adjusted rates over time; the latter refers to the loglinear trend by period and birth cohort for each age group and represents the annual percentage change of the expected age-specific rates over time. We obtained the estimated parameters from the National Cancer Institute's APC web utility [26].

This paper utilized a Bayesian APC analysis (BAPC) with incorporated nested Laplace approximations to project the future trends of the HHD burden between 2020 and 2030. Previous research had demonstrated that the BAPC was superior to other prediction methods regarding coverage and accuracy [27]. The population estimate was derived from the United Nations World Population Prospects 2019 Revision, by year (up to 2100), age, and sex (https://population.un.org/wpp/Download/Standard/Population/) and the WHO World Population Data (WHO 2000–2025) standards. All statistical analyses were performed using R (version 4.3.0). A two-tailed $P < 0.05$ was considered statistically significant.

Results

Temporal trends of HHD from 1990 to 2019

Joinpoint regression analysis indicated that, except for ASPR in females, which stayed stable during the observed period, ASRs decreased among HHD in both sexes ($P < 0.05$). ASPR, ASMR, and ASDR all trended downwards (Fig. 1). The burden of HHD grouped by age was showed in Fig. 2.

In 2005–2014, the prevalence of HHD showed a transient increase in both sexes followed by a decline, and a similar condition was observed in mortality rates and DALYs rates. The prevalence in males was stable decreasing except during 1994–2000, where a decrease in hypertension prevalence was observed, but it was not

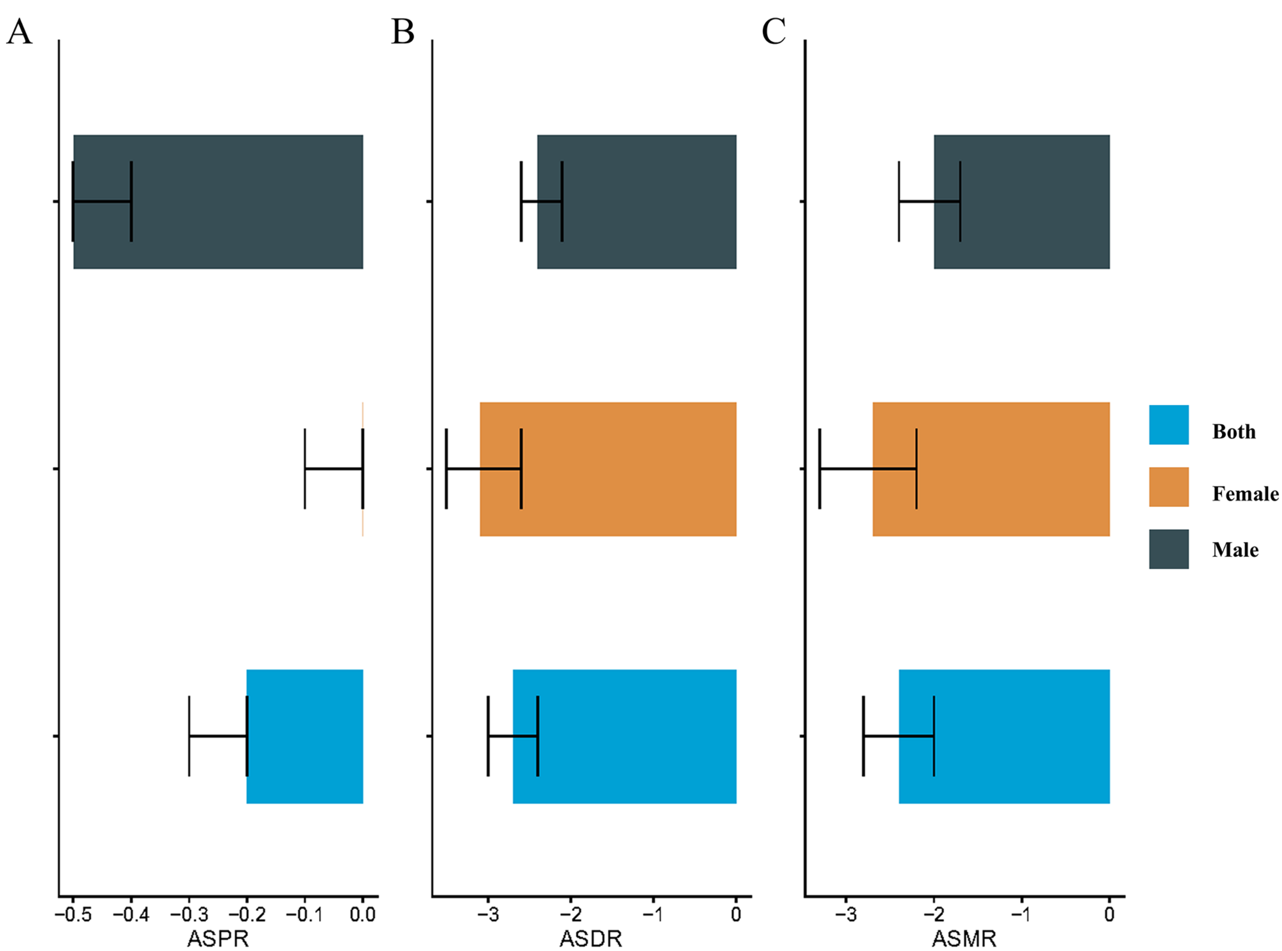

Fig. 1 The AAPC of the ASPR (left panel), ASMR (middle panel), and ASDR (right panel) of HHD from 1990 to 2019. HHD: hypertensive heart disease; AAPC: average annual percent change; ASIR: age-standardized incidence rate; ASMR: age-standardized mortality rate; ASDR: age-standardized DALYs rate

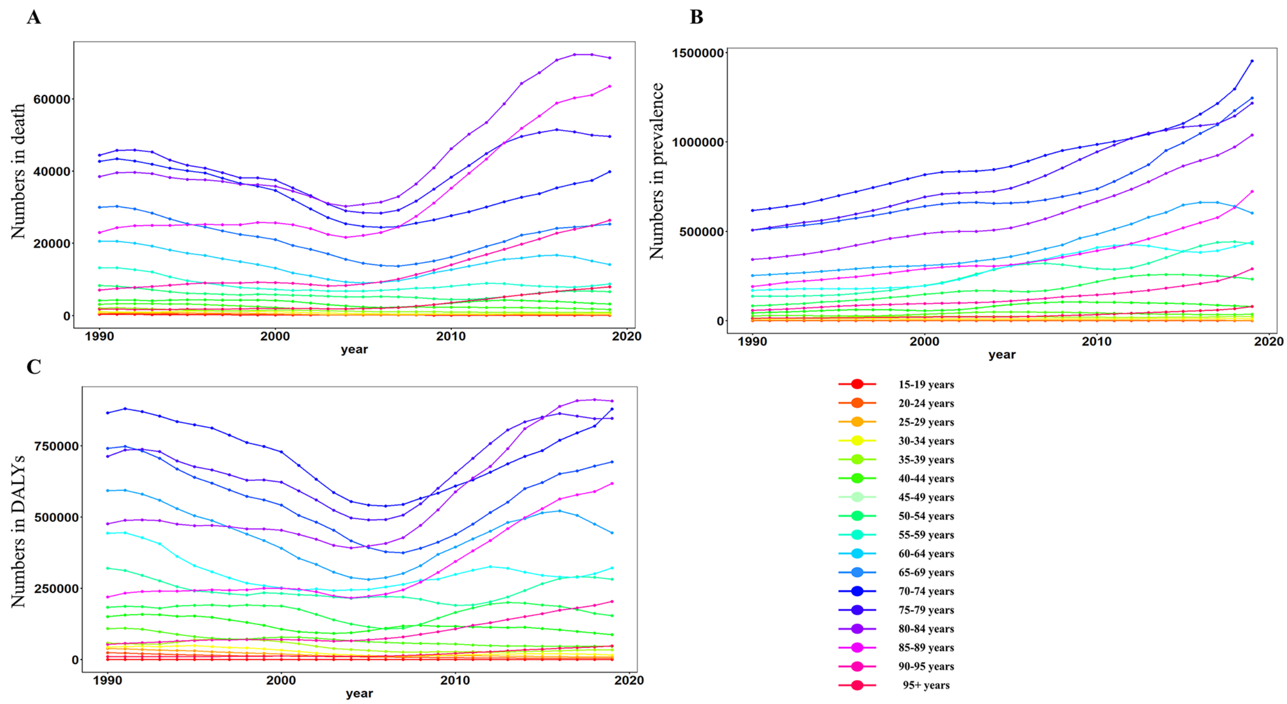

Fig. 2 Number of deaths (**A**), prevalence (**B**), and DALYs (**C**) by age group in HHD population HHD: hypertensive heart disease; DALYs: disability-adjusted life-years

statistically significant. HHD burden was showing an unfavorable upward trend during 2005–2014 and 2017–2019 in females (Supplemental Table 1, Supplemental Figs. 1–2).

Risk factors of HHD from 1990 to 2019

The main risk factors of HHD were showed in Fig. 3. The behavior-related risk was the most common causes of death in HHD. Despite the decline, this proportion remained the highest. Diet and excessive BMI were the following risk factors. And the proportion of BMI was rising annually. Other risk factors included alcohol use, lead exposure, non-optimal temperature and other environmental/occupational risks.

Burden of HHD in China, 2020

In 2020, an estimated 334,695 newly prevalent cases and 13,196 newly deaths due to HHD occurred in China. From 1990 to 2019, ASPR showed a declining trend (percentage change in both sexes: -6.0 [-6.0 to -7.1], in males: -12.3 [-11.1 to -13.0] and in females: -0.3 [-0.4 to -1.5]), as shown in Table 1. This trend was also on the decline in 2020 (ASR/100,000 in both sexes: 378.4 [365.3 to 391.6]; in males: 377.9 [363.9 to 391.9] and in females: 372.8 [360.7 to 384.8]). The downward trend of ASMR from 1990 to 2019 was more obvious (percentage change in both sexes: -51.2 [-62.1 to -49.9], in males: -45.1 [-54.6 to -43.6] and in females: -55.8 [-64.3 to -54.0]). And the estimated ASMR in 2020 was in decline (ASR/100,000 in both sexes: 14.9 [13.9 to 15.9], in males: 18.4 [17.1 to 19.8], and in females: 12.6 [11.4 to 13.7]). Age distribution of HHD-related deaths peaked in 90–94 years (Supplemental Fig. 3).

Projection on burden of HHD in China through 2030

The prevalent rate of HHD was predicted to continue to increase, from 7,903,479 in 2019 to 12,410,680 in 2030, of which 3,605,043 in males or 4,298,437 in females in 2019 to 5,561,563 in males or 6,849,117 in females in 2030 (Fig. 4). ASPRs were predicted to moderately increase to 403.0.2 (317.4-488.6) in 2030 in both sexes, to 395.7 (309.8-481.6) in 2030 in males and to 409.8 (319.6-500.1) in 2030 in females.

The estimated dead number of HHD in 2030 was 398,469 in both sexes, 201,452 in males and 197,017 in females. ASMRs were gradually decreasing from 20.6 (12.7–23.9) in 2019 to 10.6 (1.2–20.0) in 2030 in both sexes, 25.6 (15.2–30.8) in 2019 to 12.6 (0.5–24.7) in 2030 in males and 17.6 (21.5–10.8) in 2019 to 9.2 (0.7–17.8) in 2030 in females. ASDRs were also in decreasing trend from 312.9 (214.1-363.7) in 2019 to 202.2 (29.9-374.5) in 2030 in both sexes, 378.3 (235.8-459.4) in 2019 to 234.0 (30.6 to 437.4) in 2030 in males and 263.3 (175.5 to 320.0) in 2019 to 170.5 (15.9–325.0) in 2030 in females.

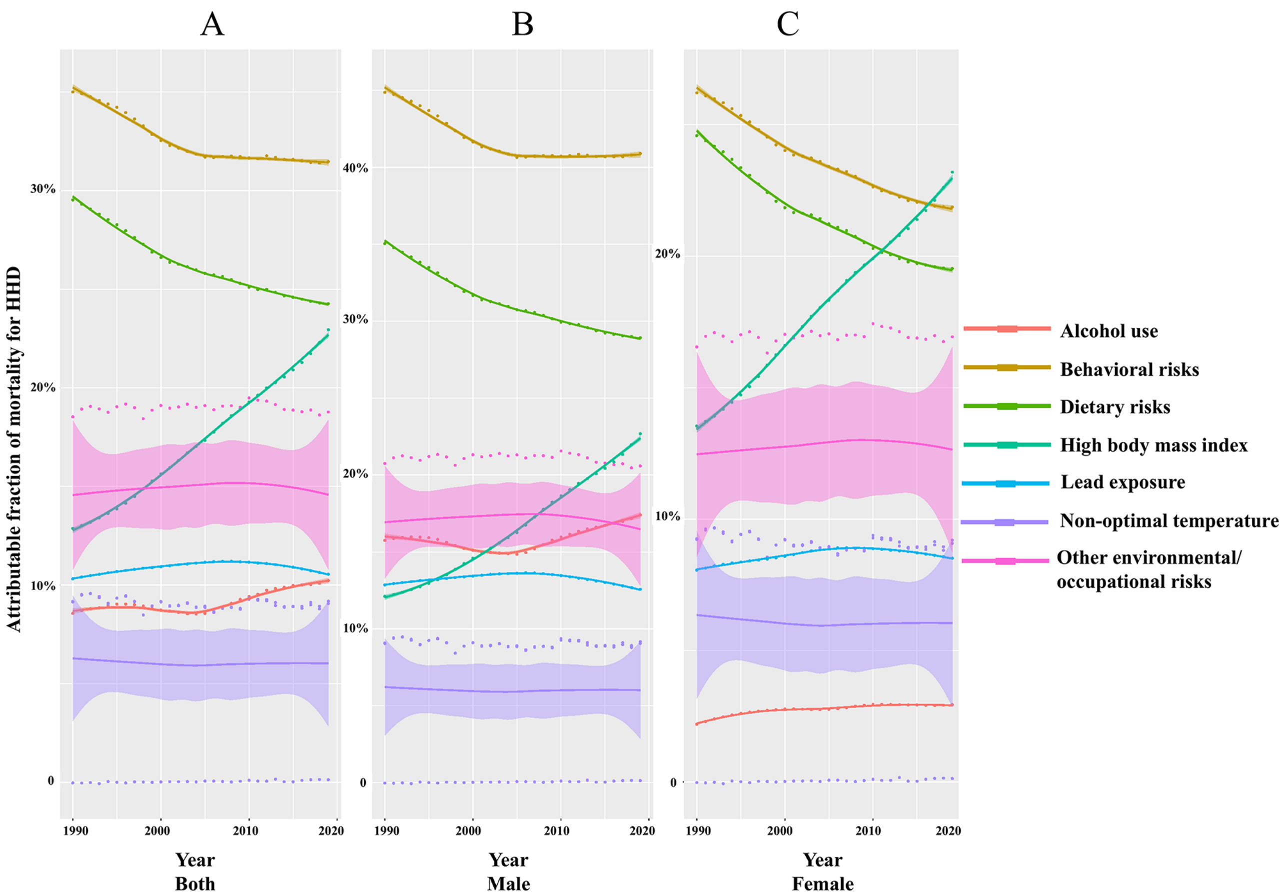

Fig. 3 Temporal trends of fractions of mortality for HHD, attributable to risk factors (**A**) in both sexes, (**B**) in males and (**C**) in females in China, 1990–2019. HHD: hypertensive heart disease

Table 1 Percentage changes HHD from 1990 to 2019 and estimated numbers of new cases, deaths, prevalence and mortality of HHD in 2020 in China

Sex	Prevalence (95% UI)			Deaths (95% UI)		
	Percentage changes in ASPR from 1990 to 2019	New cases (× 1,000) in 2020	ASPR in 2020	Percentage changes in ASMR from 1990 to 2019	New deaths (× 1,000) in 2020	ASMR in 2020
Both	-6.0 (-6.0 to -7.1)	334.7	378.4 (365.3 to 391.6)	-51.2 (-62.1 to -49.9)	13.2	14.9 (13.9 to 15.9)
Men	-12.3 (-11.1 to -13.0)	302.3	377.9 (363.9 to 391.9)	-45.1 (-54.6 to -43.6)	-3.6	18.4 (17.1 to 19.8)
Women	-0.3 (-0.4 to -1.5)	32.4	372.8 (360.7 to 384.8)	-55.8 (-64.3 to -54.0)	16.7	12.6 (11.4 to 13.7)

HHD: hypertensive heart disease; ASPR, age-standardized prevalence rate; ASMR, age-standardized mortality rate

Discussion

To the best of our knowledge, this is the first study which comprehensively provided the burden of HHD in China during 1990–2019 and the projection through 2030. The behavior-related risk, diet risk and excessive BMI were the most common reasons of death in HHD. According to our prediction, ASMRs and ASDRs will continue to decrease from 2020 to 2030. However, ASPRs will have a moderate rise.

HHD is highly linked to a long-term rise in systemic blood pressure, which can lead to diastolic dysfunction, left ventricular hypertrophy, and heart failure with a lower left ventricular ejection fraction [28]. Hypertension is extremely prevalent within the population with heart failure. In the Framingham study, 91% of newly diagnosed heart failure patients had hypertension [29]. Up to 70% of patients in the PARADIGM-HF trial also had a hypertension history [30].Pressure excess of the left ventricle and loss of reciprocal regulation between profibrotic and antifibrotic molecules were associated with increased collagen synthesis and decreased collagenase activity, which contributed to ventricular fibrosis

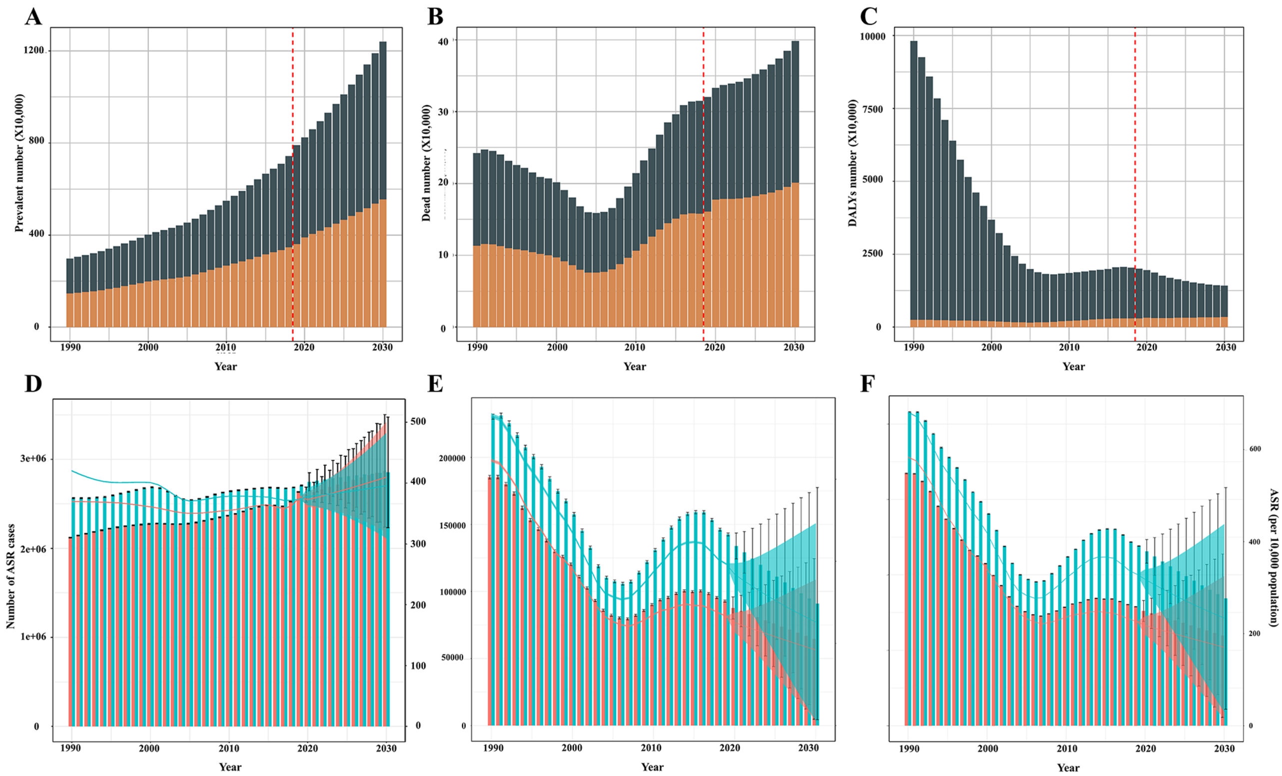

Fig. 4 The number of prevalence (**A**), mortality (**B**), and DALYs (**C**) and ASPR (**D**), ASMR (**E**) and ASDR (**F**) of HHD during 1990–2019 and the projections to 2030 in China. HHD: hypertensive heart disease; DALYs: disability-adjusted life-years; ASR: age-standardized rate

[31]. Numerous studies in the past have demonstrated that intensive blood pressure control can improve left ventricular ejection fraction and rectify cardiac remodeling. Lower systolic blood pressure (less than 130 mm Hg) may be advantageous for certain high-risk patients. With the widespread adoption of the 2017 revisions to the hypertension diagnostic criteria, intensive blood pressure control will significantly improve the prognosis of HHD patients.

When HHD-related burden data were age-normalized, they tended to increase slowly or even decrease slightly, indicating that substantial number increases are driven primarily by aging and population growth. The overall trend of ASPRs in China from 1990 to 2019 still decreased. However, our prediction model found that the ASPRs will gradually increase both in males and females in the following 11 years. The possible reasons might be that individuals began to value their health, and physical examinations became more prevalent. In addition, measuring blood pressure is straightforward and can be performed at home. Thus, the diagnostic rate increased. Besides, the rising number of Chinese that gradually adopt a Western lifestyle (i.e., sedentary behavior, physical inactivity, consumption of calorie-dense, fatty foods, and high sodium intake) is believed to be a significant factor in the global increase in hypertension prevalence [32]. Additionally, in the current age of digitalization, there has been a noted increase in stress and anxiety levels, which may also contribute to the rise in hypertension [33, 34]. Besides, AHA/ACA published authoritative hypertension management in 2017 and lowered the hypertension threshold from 140/90 mmHg to 130/80 mmHg, which may also contribute to an increase in the diagnosis rate of hypertension. However, the control rate of hypertension in China was still low, which might be associated with those with less education, a lower income, and the absence of cardiovascular risk factors — individuals who may have limited contact with the health care system, and HHD remains a significant public health concern deserving of a high level of attention and priority [35]. It is important to note that while medication is not universally free across all regions, patient awareness and self-management remain the primary issues. The disparity in hypertension control rates between different regions highlights the need for targeted measures to improve patient education and self-management skills, which are crucial for effective hypertension control.

From 1990 to 2019, the ASMRs and ASDRs of HHD generally decreased; this trend will persist over the next 11 years. There are numerous plausible explanations for the significant declines in HHD mortality rates. Large reductions in smoking, a decline in mean blood pressure, an increase in hypertension treatment, and medical treatments supported by scientific evidence all played a role. In addition, diabetes and obesity are modifiable HHD risk factors [36–38]. To reduce the burden of disease caused by HHD, therapeutic lifestyle modifications, such as smoking cessation, a low-salt and low-fat diet, and appropriate exercise, and stress management must be addressed. Monitoring heart disease mortality rates at the provincial and county levels is essential to ensure these gains persist. In the latter half of the 20th century, heart disease mortality rates decreased due to a combination of primary, secondary, and tertiary prevention measures, such as enhanced resuscitation, revascularization, and medication use [39].

Concerning the gender disparity in HHD, our findings revealed that the prevalence rates were higher in females, indicating that females are more susceptible to HHD. This trend reversed after age 60 years old [40–42]. These patterns may result from an increase in postmenopausal hypertension and life expectancy, a higher risk of developing HHD among females, and an inferior response to treatments [43, 44]. This trend may be attributed to factors such as postmenopausal hypertension, longer life expectancy, and a greater risk of developing HHD in women, along with a less favorable response to treatments. The influence of gender on blood pressure is notable, with premenopausal women generally having lower levels than age-matched men, likely due to the modulating effects of ovarian hormones on blood pressure regulation. In addition, components of the RAAS, such as plasma renin, fluctuate throughout the menstrual cycle in females in response to fluctuating estradiol levels [45]. Previous studies indicated that activation of estrogen receptor (ER) and binding to the nuclear estrogen response element are required for basal renin expression in juxtaglomerular cells expressing renin [46]. Mouse model showed that low doses of Ang II even decreased BP in female (but not male) rats [47].Therefore, the RAAS in females is substantially influenced by estrogen status. However, females were typically more aware of their hypertension, which led to a higher blood pressure control rate, partially offsetting their disadvantages [48, 49].

The transient increase in the prevalence of HHD during 2005–2014 can be attributed to several factors. Firstly, rapid urbanization, economic development, and demographic and epidemiological transitions in China, along with the aging of the population, might have contributed to these increases in the age-standardized prevalence rate (ASPR) of HHD since 2005. Additionally, the prevalence of hypertension, which is the leading risk factor for HHD, has increased in China since 2005. This increase in hypertension detection was due to the adoption of reduced cutoff points (140/90 mmHg for hypertension and 120/80 mmHg for normal blood pressure) established in the 2005 edition of the Chinese Guidelines on Prevention and Control of Hypertension, compared with those (160/95 mmHg for hypertension) used in previous national surveys [50].

The study acknowledges a significant limitation in that it lacks data specific to urban and rural areas within China, as well as data from various cities. This absence of localized data may affect the comprehensiveness and applicability of the study's findings, as it does not capture the diverse health profiles and healthcare infrastructure that exist across different regions in China. The inclusion of such data could provide a more nuanced understanding of the prevalence and management of hypertension, taking into account the economic, environmental, and social factors that vary by location. These data were corrected to account for variations in disease reporting across health systems. However, varying practices, resources, patient populations, and data recording quality will likely cause differences in data quality and uniformity.

Conclusion

While there has been progress in reducing the burden of HHD in China, the disease remains a significant public health concern. The increasing prevalence and the continued presence of key risk factors, particularly related to diet and BMI, underscore the need for sustained efforts in prevention and management. The projected increase in HHD cases by 2030 highlights the importance of strategic planning and resource allocation to address this growing challenge. To achieve the Healthy China 2030 objective, comprehensive strategies, including health education, promotion of a healthy lifestyle, and alcohol- and tobacco-control policies, must be tailored.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-21313-6.

Supplementary Material 1: Supplemental Table 1. Joinpoint results. HHD: hypertensive heart disease; APC: age-period-cohort; AAPC: average annual percent change.

Supplementary Material 2: Supplemental Figure 1. Age-Period-Cohort analysis results (longitudinal age, left panel; cohort effect, middle panel; period effect, right panel) on hypertensive heart disease

Supplementary Material 3: Supplemental Figure 2. Joinpoint analysis results on HHD age-standardized prevalence rates in both sexes(A), men (B), and women (C), respectively; mortality rates in both sexes(D), men (E), and women (F), respectively; DALYs rates both sexes(G), men (H), and women (I), respectively. HHD: hypertensive heart disease; DALYs: disability-adjusted life-years

Supplementary Material 4: Supplemental Figure 3. Age distribution of HHD burden in China, 2020: new HHD prevalence (A); new HHD- related deaths (B)HHD: hypertensive heart disease.

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None.

Author contributions

The manuscript has been read and approved by all authors. Drs Ru-Jie Zheng created the concept and designed the study, Drs Li-You Lian and Jia-Jia Lu acquired and analyzed the data. Drs Li-You Lian draft the manuscript. Drs Li-You Lian and Ru-Jie Zheng revised the manuscript. All the authors had full access to all the data in the study, and take responsibility for the integrity and accuracy of the data.

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Data availability

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The informed consent was waived because no identifying data were used.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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