Article

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Global Burden and Temporal Patterns of Hypertension-Related Chronic Kidney Disease Based on Age–Period–Cohort Modelling

Liuxia Deng[1], Wuyuan Tao[2,*]

[1]Department of Nephrology, Baoan District People's Hospital of Shenzhen, 518101 Shenzhen, Guangdong, China
[2]Department of Emergency, Baoan District People's Hospital of Shenzhen, 518101 Shenzhen, Guangdong, China
*Correspondence: twy2011@126.com (Wuyuan Tao)

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Background: Chronic kidney disease (CKD) attributable to hypertension represents a significant global health concern. Nonetheless data on the burden and trend of this condition remain scarce. This study aimed to evaluate the trend in the burden of hypertension-induced CKD across various age groups from 1992 to 2021 at a global, regional, and national level.

Methods: We extracted data on the population burden of CKD attributable to hypertension from the Global Burden of Disease 2021 study. Using age-period-cohort (APC) modeling, we assessed trends in disability-adjusted life years (DALYs), mortality, prevalence, and incidence. We further quantified several indicators describing temporal dynamics, including the overall yearly rate of change (net drift), age-specific temporal slopes (local drift), the modeled age profiles over time, and the relative risks associated with period and cohort effects.

Results: From 1992 to 2021, the global burden of CKD attributable to hypertension steadily increased, with significant variations across different Socio-Demographic Index (SDI) regions. The most substantial increase in DALYs (+60.0%) and mortality (+75.5%) were observed in high-SDI regions. The incidence of CKD showed a significant rise in medium-SDI regions (+36.6%) and low-middle SDI regions (+28.5%), while global prevalence slightly declined (–4.7%). The burden of CKD increased significantly with age, with DALYs, mortality, and prevalence rising across all SDI regions as age increased. Incidence peaked at 80–84 years. Cohort relative risks (RRs) for hypertension-related CKD exhibited a downward trend in both incidence and mortality, particularly in high-SDI regions.

Conclusion: Following long-term hypertension management, high-SDI regions have shown some improvement in mortality and DALYs. Nonetheless the persistent rise in incidence and the high burden in medium- and low-SDI regions remain prominent issues. Future efforts to alleviate the burden of CKD attributable to hypertension should prioritize addressing the adverse trends in these regions, particularly targeting elderly populations and areas with high incidence. More targeted preventive and intervention strategies are needed to mitigate this growing burden.

Keywords: chronic kidney disease; hypertension; socio-demographic index; disability-adjusted life years

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Introduction

Hypertension is a predominant risk factor for the global burden of disease, with its high prevalence and severe complications posing a major challenge to public health systems. A global epidemiological study on hypertension revealed that approximately 1.2 billion people were affected by the condition in 2021, with half unaware of their diagnosis [1]. Hypertension induces systemic complications through multiple pathological mechanisms, including sustained vascular endothelial dysfunction, arterial remodeling, and oxidative stress. These processes contribute to end-organ damage, manifesting as cardiovascular diseases, cerebrovascular accidents and chronic kidney disease (CKD) [2]. Previous studies have predominantly focused on the impact of hypertension on cardiovascular and cerebrovascular diseases, while its critical role in promoting CKD has been overlooked. A seminal etiological study of CKD identified hypertension as the second most prevalent cause after insulin resistance. The prevalence of hypertension among the CKD population was as high as 80–85% [3,4]. Over the last few decades, the burden of hypertension-induced CKD has shown a consistent upward trajectory, driven by global population aging and the widespread adoption of unhealthy lifestyles [5]. A previous study has shown that CKD is a common complication among hypertensive patients, with rapid disease progression that significantly impacts both quality of life and life expectancy [6].

According to the latest epidemiological data, the incidence and mortality of hypertension-related CKD are rising globally. Hypertension-induced end-stage renal disease

(ESRD) contributes significantly to higher mortality rates and increased disability-adjusted life years (DALYs) [7,8]. As hypertension prevalence continues to rise, the demand for medical services related to CKD is expected to increase further. This trend poses a significant challenge to global healthcare systems, particularly in low- and middle-income countries with relatively limited medical resources. In response, the World Health Organization (WHO) has emphasized the importance of preventing and controlling hypertension in its Global Hypertension Strategy to reduce the burden of CKD. WHO advocates prompt governmental action, including promotion of a healthy lifestyle, enhanced early hypertension screening and interventions, improved hypertension management, and patient education to reduce the incidence and mortality of hypertension-related CKD [9,10]. Additionally, WHO has included the prevalence of hypertension and CKD as key indicators in its global health monitoring system, aiming to drive policy improvements and resource allocation globally to address this growing public health issue [11]. This global focus and action reflect the significant impact of hypertension-induced CKD on public health. As the global burden of hypertension and CKD continues to rise, further research and policy support are needed to develop effective interventions to mitigate the dual burden of these diseases on global health.

In this context, an accurate assessment of the global trend of hypertension-induced CKD is crucial to promote evidence-based resource allocation and implement appropriate preventive and intervention measures worldwide. It is also vital to implement data-driven transformations in hypertension care systems to accomplish the objectives outlined in the WHO's Global Hypertension Compact. This study employed the age-period-cohort (APC) model to quantify the evolving burden and longitudinal trend of CKD attributable to hypertension, addressing critical gaps in understanding its population-level impact. The age effect captures variations in disease burden across different age groups. The cohort effect quantifies risk differentials among population groups with common historical exposure timelines. The period effect captures synchronous variations in population health outcomes across all age strata, driven by exogenous environmental or societal transitions [12]. Compared with other methods used to assess disease burden, this methodology successfully distinguishes the effects of period and cohort on overall temporal patterns. This helps evaluate the effectiveness of previous policy actions and identify potential areas of focus.

Methods

Data Sources and Definitions

The data used in this study were sourced from the Global Burden of Disease (GBD) 2021 database (available at: https://ghdx.healthdata.org/gbd-results-tool). The GBD 2021 database offers detailed evaluation of 371 diseases and injuries alongside 88 risk factors across 204 countries and regions from 1992 to 2021. It includes population estimates, incidence, prevalence, mortality, and DALYs. The GBD 2021 study employed a suite of standardized analytical methods, including spatiotemporal Gaussian process regression and DisMod-MR, to ensure data processing yielded consistent and comparable estimates [13].

The GBD 2021 study employed the Comparative Risk Assessment (CRA) framework to estimate the disease burden linked to different risk factors. This process entails synthesizing exposure data and associated relative risks, determining a theoretical minimum risk exposure level (TMREL), and calculating the population attributable fraction (PAF) to estimate the burden. A key methodological advancement in GBD 2021 was the incorporation of counterfactual risk analysis, a technique that addresses heterogeneity across data sources input and complements traditional relative risk estimates [14].

Hypertension is defined as systolic blood pressure (SBP) 140 mmHg or higher, a diastolic blood pressure (DBP) 90 mmHg or higher, or the use of anti-hypertensive medications. CKD is defined as permanent loss of kidney function, represented by estimated glomerular filtration rate (eGFR) and urine albumin-to-creatinine ratio [15]. The GBD 2021 classified hypertension-attributable CKD using the International Classification of Diseases, 10th Revision (ICD-10) codes I12.- and I13.- [14].

We assessed the burden of hypertension-attributable CKD using incidence, prevalence, mortality, and DALYs. DALY is a composite measure of overall population health, calculated as the years of life lost due to premature mortality and years lived with disability, adjusted for the severity of the disease. For analytical purposes, countries and territories were assigned to one of five Socio-Demographic Index (SDI) strata representing different levels of socioeconomic development, ranging from the lowest to the highest. The SDI reflects an integrated measure of social and economic conditions that shape population health. The geometric mean of three primary indicators—total fertility rate for individuals under 25 years of age, average years of schooling for individuals aged 15 years and older, and lag-distributed income per capita—is calculated [16]. A value of 0 represents the lowest educational attainment, markedly reduced income per person, and substantially elevated fertility levels. All GBD studies were conducted using publicly available secondary databases without identifiable information. Therefore, ethical approval was not required for this study.

Statistical Analysis

The APC framework was applied to describe global and SDI-specific patterns in DALYs, mortality, prevalence, and incidence associated with hypertension-related CKD. The identifiability problem arising from the perfect collinearity in APC modeling (where period = age + cohort) was resolved using the Intrinsic Estimator (IE) algorithm

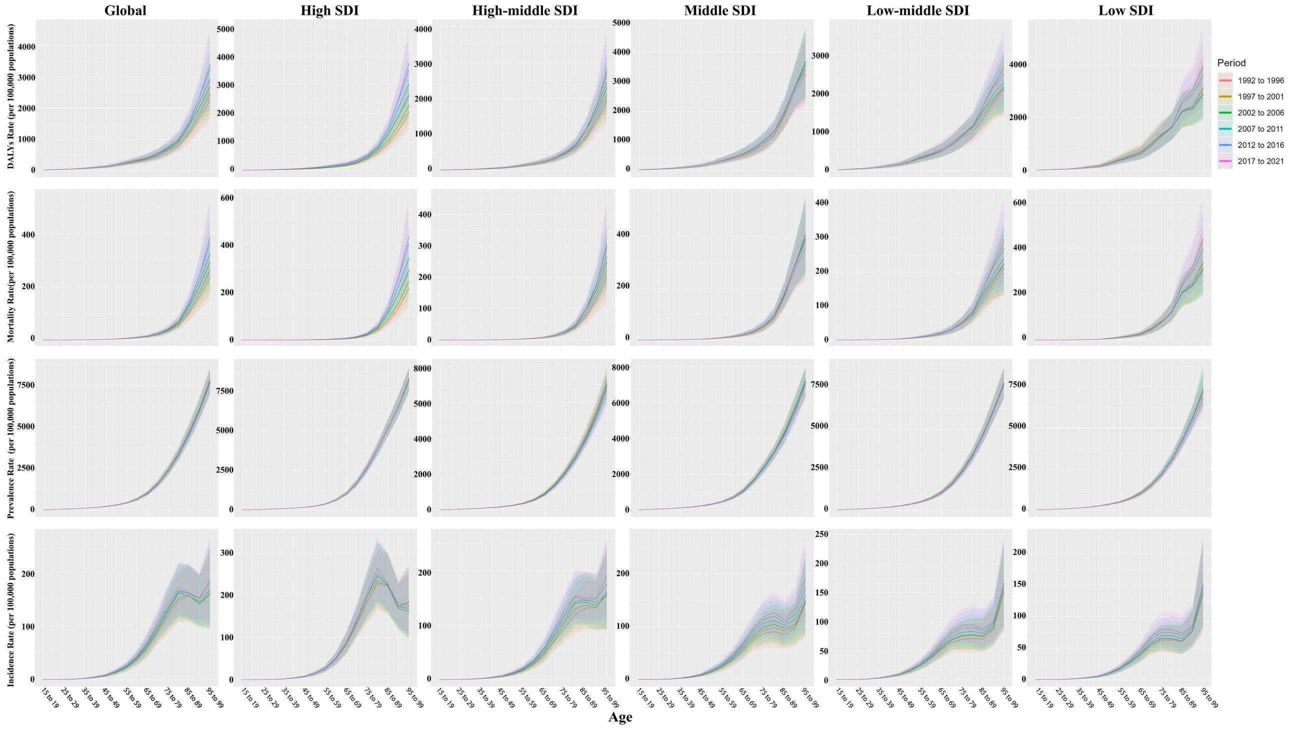

Fig. 1. Age-specific rate of DALYs, mortality, prevalence, and incidence for hypertension-related CKD across periods and SDI categories between 1992 and 2021. DALYs, disability-adjusted life years; CKD, chronic kidney disease; SDI, Socio-Demographic Index.

through the APC Web Tool (Version 2.0.0) developed by the United States National Cancer Institute [17]. The analysis was conducted using a weighted least squares regression framework, where the mid-interval population size for each age-period-cohort cell was applied as the analytical weight to account for heteroscedasticity in the rate data.

We estimated a comprehensive set of APC-derived parameters, encompassing local drift, net drift, period-relative risks (RRs), cohort RRs, and longitudinal age curves. In the APC model, net drift and local drift are vital indicators .Net drift indicates the yearly percentage change in age-standardized rates, reflecting the combined logarithmic linear trend by both period and birth cohort. Local drift represents the logarithmic linear trend of each age group across different periods and birth cohorts, indicating the yearly percentage change in rates for specific age groups over time. Age, period, and cohort effects are represented by longitudinal age curves, period RRs, and cohort RRs. The longitudinal age curve presents age-specific rates for the reference cohort (1945–1949) after accounting for period effects. Period RRs were obtained by comparing the age-standardized rate (ASR) for each period against the reference period (2000–004), whereas cohort RRs were determined relative to the reference cohort (1945–1949).

For the APC analysis, data were processed into continuous 5-year intervals for age (15–19 to 90–94 years), birth cohort (1895–1899 to 2000–2004), and period (1992–1997 to 2017–2021). The significance of the estimated variables was assessed using the Wald chi-square test. The APC analysis was performed using the APC online tool from the U.S. National Cancer Institute. All statistical computations and graphic visualizations were conducted in RStudio (version 4.2.2; Posit PBC, Boston, MA, USA), including data preprocessing, result extraction, and trend plotting.

Results

Burden of Hypertension-Related CKD: DALYs, Mortality, Prevalence, and Incidence

Table 1 and Fig. 1 describe the trend in DALYs, mortality, prevalence, and incidence attributable to hypertension-induced CKD globally and across different SDI regions from 1992 to 2021. From 1992 to 2021, the ASR of DALYs, mortality, and incidence due to hypertension-related CKD all showed an upward trend globally, with DALYs, mortality, and incidence increasing by 19.2%, 28.8%, and 20.5%, respectively. Prevalence nonetheless showed a decline of 4.7%. In high-SDI regions, the ASR of DALYs (+60.0%) and mortality (+75.5%) saw significant increases. The ASR of incidence in medium-SDI (+36.6%), high-middle SDI (+31.6%), and low-middle SDI (+28.5%) regions also rose significantly.

Table 1. Characteristics of DALYs, mortality, prevalence and incidence ASRs for CKD related to hypertension across global and SDI categories between 1992 and 2021.

Location	Global		High SDI		High-middle SDI	
Age-standardized rate of (per 100,000) (95% UI)	1992	2021	1992	2021	1992	2021
DALYs	107.77 (91.50, 126.17)	128.41 (109.14, 145.64)	52.97 (45.90, 60.33)	84.75 (74.60, 94.25)	74.20 (63.32, 88.19)	76.50 (64.72, 88.01)
Mortality	4.30 (3.58, 5.08)	5.54 (4.68, 6.41)	2.33 (1.91, 2.77)	4.09 (3.34, 4.71)	2.97 (2.43, 3.53)	3.42 (2.78, 4.13)
Prevalence	305.42 (284.94, 327.72)	291.19 (272.49, 311.88)	299.44 (278.70, 322.95)	298.79 (279.36, 320.13)	275.12 (256.75, 295.34)	246.07 (229.28, 263.95)
Incidence	12.42 (11.51, 13.52)	14.97 (14.02, 15.93)	17.02 (15.76, 18.54)	18.85 (17.60, 20.00)	10.08 (9.28, 11.00)	13.26 (12.33, 14.18)

Location	Middle SDI		Low-middle SDI		Low SDI	
Age-standardized rate of (per 100,000) (95% UI)	1992	2021	1992	2021	1992	2021
DALYs	156.30 (132.01, 183.60)	165.98 (138.89, 190.50)	138.66 (115.01, 167.34)	159.10 (131.98, 187.66)	192.34 (158.6, 232.94)	181.48 (150.00, 219.11)
Mortality	6.57 (5.43, 7.77)	7.13 (5.86, 8.28)	5.51 (4.47, 7.01)	6.62 (5.44, 7.85)	8.73 (7.06, 10.74)	8.62 (7.09, 10.51)
Prevalence	313.77 (290.49, 338.22)	293.80 (273.89, 315.54)	325.36 (302.50, 351.20)	311.16 (289.73, 333.12)	300.41 (277.51, 323.09)	286.50 (265.93, 307.27)
Incidence	10.51 (9.60, 11.53)	14.36 (13.41, 15.30)	9.71 (8.86, 10.67)	12.48 (11.52, 13.56)	7.62 (6.94, 8.32)	9.51 (8.66, 10.36)

Note: Age-standardized rates are presented as value and their 95% uncertainty interval (UI).

Abbreviations: ASR, age-standardized rate.

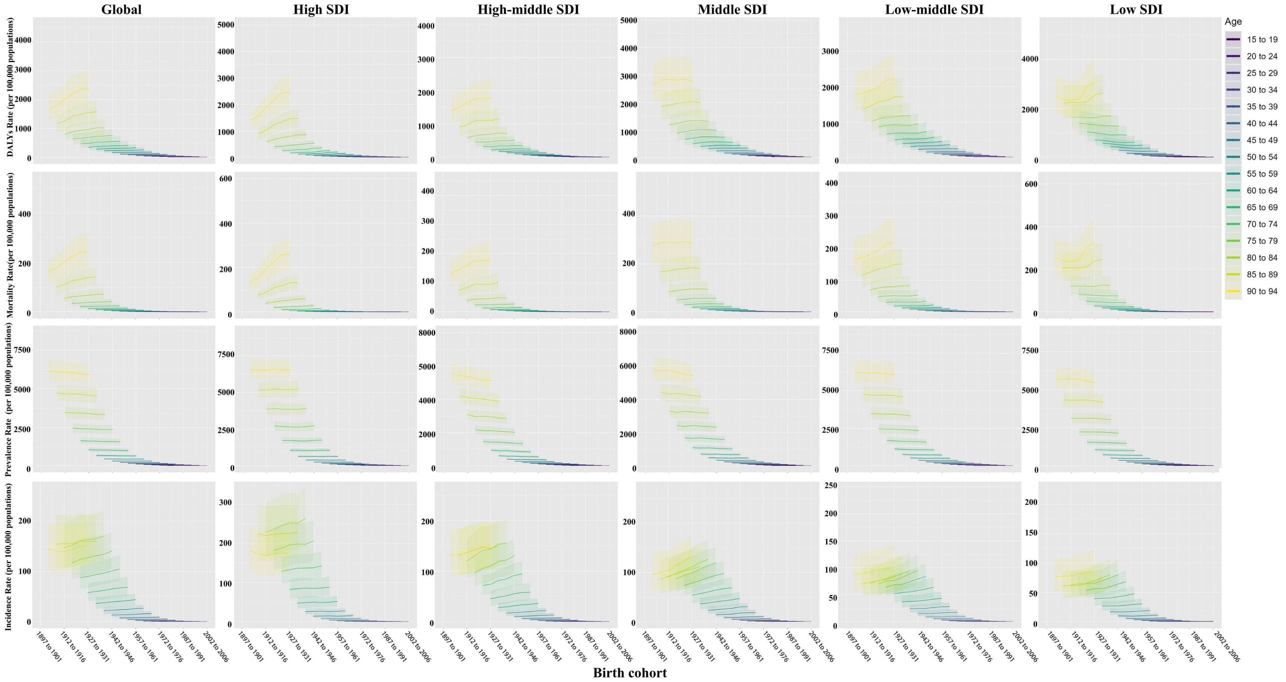

Fig. 2. Cohort-specific rate of DALYs, mortality, prevalence, and incidence for hypertension-related CKD across age and SDI categories between 1992 and 2021.

Age Patterns of DALYs, Mortality, Prevalence, and Incidence in Hypertension-Related CKD

As shown in Fig. 1, between 1992 and 2021, CKD attributable to hypertension varied by age and SDI region. In all SDI regions, mortality, DALYs, and prevalence of CKD attributable to hypertension exhibited an upward trend with age, particularly in high and low SDI regions. The incidence of hypertension-attributable CKD followed a U-shaped curve across age groups in all SDI regions, initially decreasing and then increasing with age. Overall, incidence increased over time, with the most significant rise observed in high SDI regions. Fig. 2 presents cohort-specific ratios for the burden of CKD attributable to hypertension by age group and SDI region. From 1992 to 2021, the burden of hypertension-attributable CKD generally increased across all birth cohorts, with the most notable increase in medium SDI regions.

Net and Local Drift Patterns Across Age Groups

The net drift in DALYs (1.94% [95% CI, 1.87% to 2.01%]) and mortality (2.61% [95% CI, 2.48% to 2.74%]) was greatest in high SDI regions, reflecting the greatest increases over the study period. In the medium-high and low SDI regions, the net drift in DALYs (–0.18% [95% CI, –0.23% to –0.12%], –0.32% [95% CI, –0.37% to –0.27%]) and mortality (–0.31% [95% CI, –0.38% to –0.23%], –0.38% [95% CI, –0.46% to –0.30%]) was negative, indicating improvements in both.

Regarding incidence, the net drift attributable to hypertension-related CKD was positive, indicating that CKD continued to be prevalent in relation to hypertension. In medium SDI regions, the largest increase in incidence (1.11% [95% CI, 1.07% to 1.14%]) was observed. Except in high SDI regions, the net drift value for prevalence (local drift value) was below zero. For the majority of age groups, local drift remained above zero, which corresponds to rising DALYs, mortality, and incidence levels (Fig. 3).

APC Components Influencing the Burden of Hypertension-Related CKD

Fig. 4 shows the effect of age on DALYs, mortality, prevalence, and incidence of CKD attributable to hypertension. Globally and across most SDI regions, DALYs, mortality, and prevalence rose with age. When analyzing the age distribution of incidence, distinct trends were observed across different regions. Globally, as well as in high SDI and high-middle SDI regions, the incidence followed a unimodal trend, peaking in the 80–84 years age group. Nonetheless in medium SDI, low SDI, and medium-low SDI regions, the incidence first peaked in the 75–79 years age group, then began to decline, before rising again in the 85–89 years age group, forming a second peak. Notably, the second peak was higher than the first. The most pronounced trends in both prevalence and incidence were observed in high SDI regions.

Fig. 5 shows the phase-specific impact of hypertension-related CKD on DALYs, mortality, prevalence, and incidence from 1992 to 2021. The phase-specific RR for DALYs and mortality increased over time globally and across all SDI regions, with the most significant

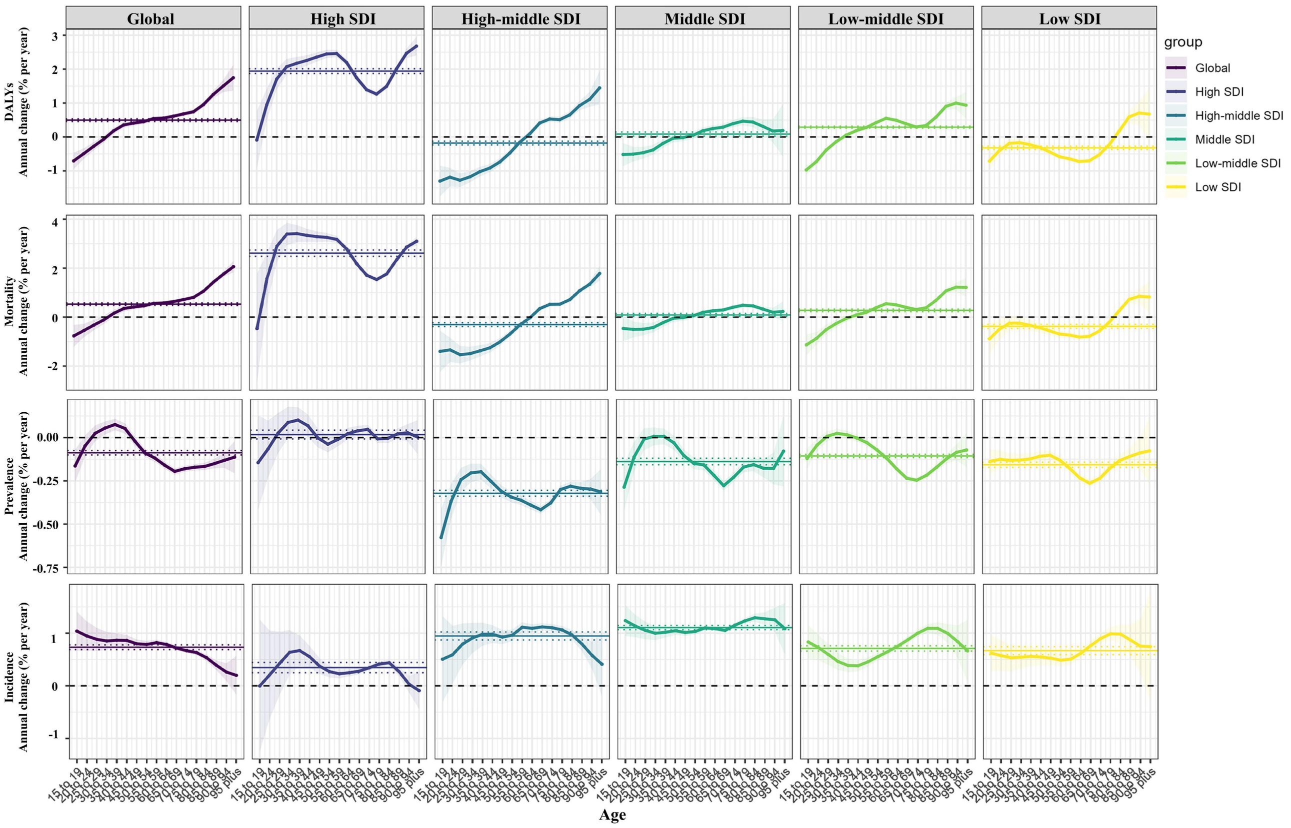

Fig. 3. Local and net drift in rates of DALYs, mortality, prevalence and incidence for CKD related to hypertension across age and SDI categories between 1992 and 2021.

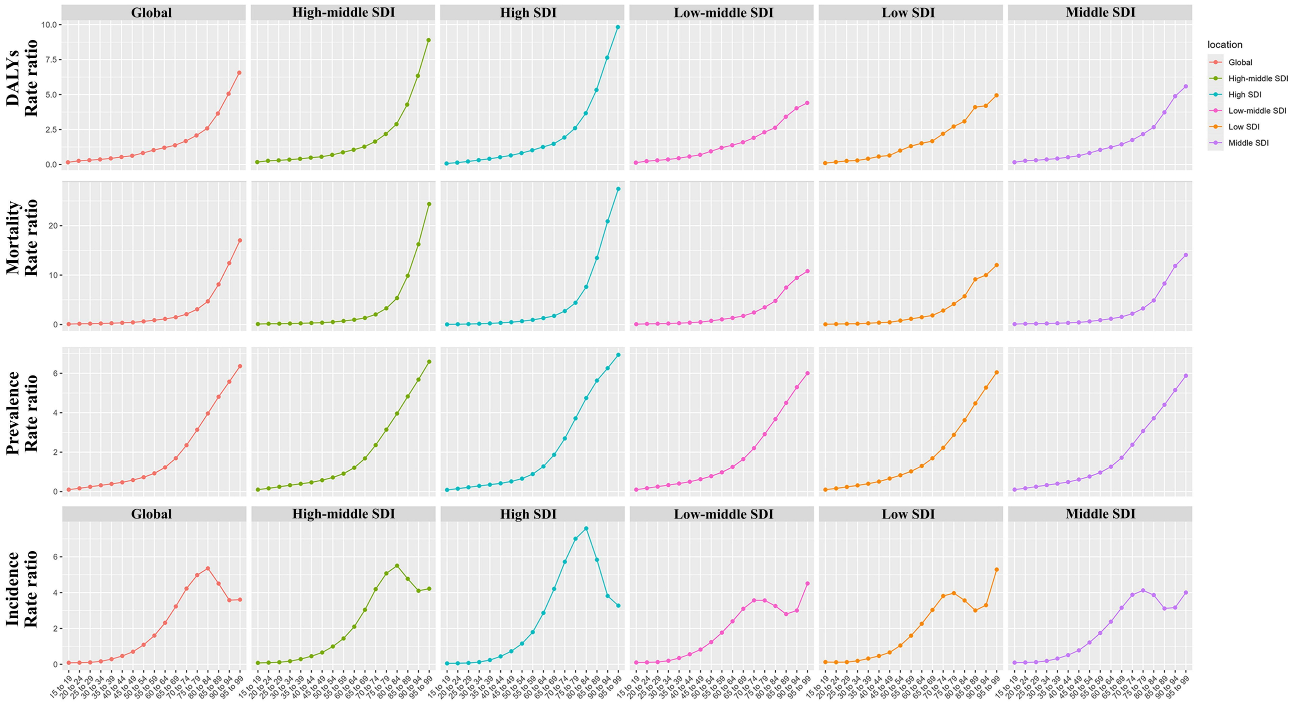

Fig. 4. Age-related variation in the rate of DALYs, mortality, prevalence and incidence for CKD related to hypertensionglobally and across SDI categories between 1992 and 2021.

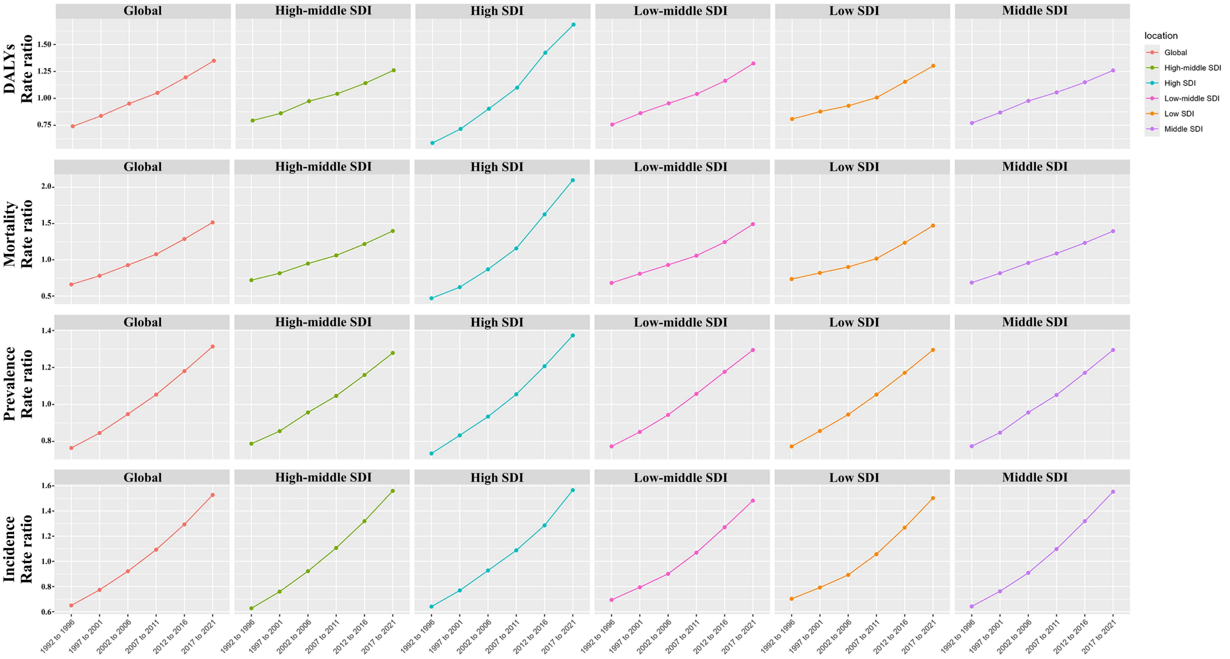

Fig. 5. Period-related variation in the rate of DALYs, mortality, prevalence and incidence for CKD related to hypertension globally and across SDI categories between 1992 and 2021.

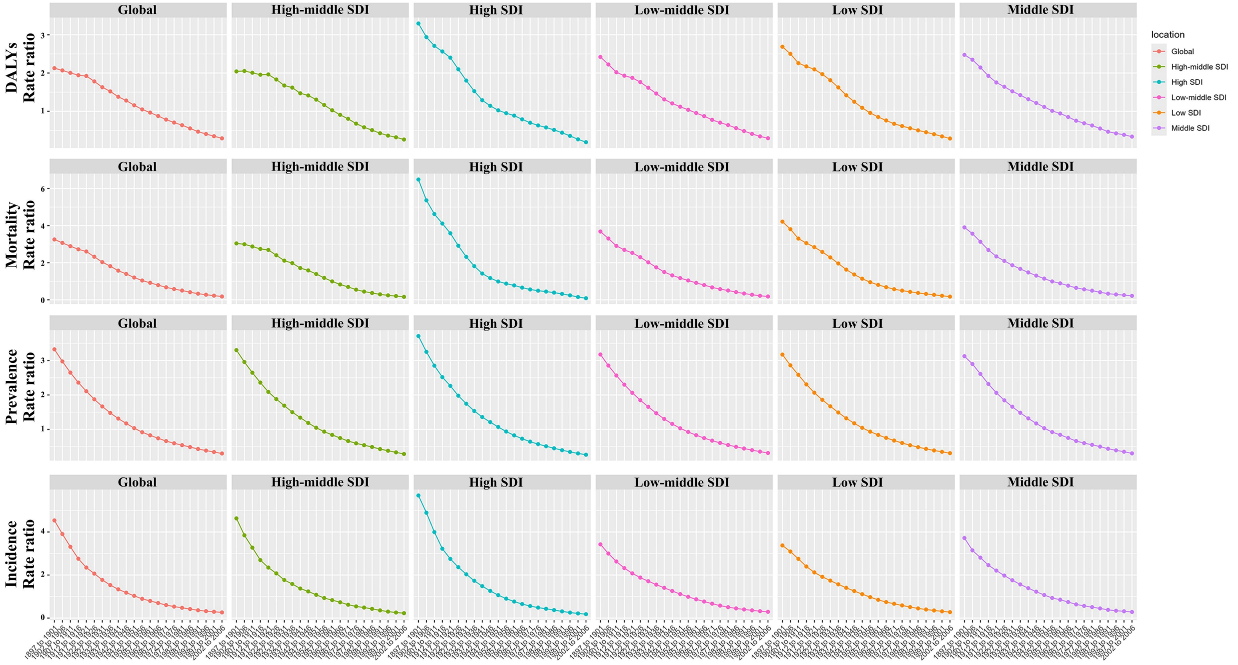

Fig. 6. Cohort-related variation in the rate of DALYs, mortality, prevalence and incidence for CKD related to hypertension globally and across SDI categories between 1992 and 2021.

rise observed in high SDI regions. From 1992 to 2021, the phase-specific RR for prevalence also showed an increasing trend globally and in all SDI regions, with the most noticeable increase in high SDI regions. Similarly, from 1992 to 2021, the phase-specific RR for incidence increased across all SDI regions.

Fig. 6 shows the cohort-specific impact of hypertension on DALYs, mortality, incidence, and CKD prevalence. In the 1897–1901 birth cohort, the cohort-relative risk for DALYs and mortality were highest globally and across all SDI regions, experiencing a substantial decline in subsequent birth cohorts. The most pronounced decrease was observed in high SDI regions.

Discussion

This study examined in-depth the global burden of CKD caused by hypertension, assessing data spanning 1992 to 2021 in various regions categorized by SDI level. These data, through their demonstration of APC trends, deepen our insight into the burden and temporal dynamics of hypertension-related CKD. Key findings from our study include: (1) a marked escalation in hypertension-related CKD burden worldwide and across the majority of SDI regions between 1992 and 2021; (2) age-stratified analysis revealed escalating DALYs and mortality with increasing age, while incidence and prevalence showed peak effects in the 75–79 and 80–84 year ranges; (3) significant increases in the period-relative risk for hypertension-attributable CKD, particularly in high-development regions where DALYs and mortality showed maximal increases, contrasting with medium-development regions that exhibited the highest incidence growth; (4) an initial increase and then a decrease in the cohort-relative risks for hypertension-attributable CKD; nonetheless in the most recent cohorts, incidence and prevalence showed adverse trends, particularly in medium-low SDI regions.

Regions with higher development level exhibited the strongest correlation of advancing age with CKD burden, a pattern largely attributable to their aging demographics and reduced fertility rate. The sustained damage to renal microvasculature from long-term hypertension, coupled with age-related decline in kidney function, leads to a continuous rise in CKD incidence and mortality [18]. Hypertension, common in elderly patients, accelerates the progression of CKD, significantly impacting prognosis and quality of life.

Globally, the period-RR for incidence and prevalence have significantly increased, while the period-RR for DALYs and mortality have remained relatively stable. This trend may reflect global advancements in healthcare and improvements in CKD treatment. Although hypertension is a major driver of CKD, other metabolic risk factors—such as diabetes, obesity, and metabolic syndrome—may exert synergistic effects on renal outcomes [19]. Due to the independent attribution framework used in the GBD study, these risk factors were modeled separately to avoid overlapping risk estimation. Consequently, the current analysis does not directly capture the interactive effects of these comorbidities. High sodium intake and obesity are major contributors to the development of hypertension, and the increased exposure to these risk factors further exacerbates the burden of hypertension-related CKD. For example, dietary salt intake in China far exceeds the WHO recommendation, directly driving the prevalence of hypertension and leading to an increased renal burden [20]. Metabolic disorders, particularly obesity and related syndromes, constitute significant factors contributing to the worldwide burden of hypertension-related CKD. Obesity not only increases blood pressure but also worsens kidney function by promoting chronic low-grade inflammation and insulin resistance [21]. Recent studies have found that the impact of hypertension caused by obesity on CKD is particularly pronounced globally, especially in medium SDI regions. For example, in Brazil, the significant rise in obesity rates has been closely linked to the surge in CKD cases attributable to hypertension [22]. In addition, occupational risks are important factors in the increasing burden of hypertension and CKD. In high-intensity work environments, prolonged physical labor and mental stress can lead to elevated blood pressure, increasing the renal burden [23].

Recent advancements in hypertension management and CKD treatment have significantly improved patient health outcomes, reducing DALYs and mortality risks. Antihypertensive medications with proven efficacy in both blood pressure control and renal protection—notably ACEI/ARB and SGLT2 inhibitors—play a pivotal role in clinical management [24]. A South Korean cohort study of hypertension revealed that compliance with antihypertensive medication after initial diagnosis led to a significant 70% decrease in cardiovascular disease incidence [25]. These findings underscore that effective management of hypertension is essential to mitigate associated cardiovascular and renal vascular complications. With advancements in medical technology, personalized treatment regimens and remote health monitoring have become increasingly popular in hypertension management. Wearable devices such as smart blood pressure monitors and remote health platforms offer more precise health management, enabling patients to more frequently monitor their blood pressure and adjust treatment plans in a timely manner. A randomized controlled trial of digital intervention for home blood pressure management versus conventional hypertension care found that after one year, patients using the digital blood pressure intervention achieved better blood pressure control and lower incremental costs compared with the standard care group [26]. This low-cost digital healthcare approach represents an important future direction for chronic disease management.

The varying APC patterns across countries and regions with different SDI level partially indicate the diverse stages of social transition and the disparities in hypertension prevention, treatment, and CKD management. In high SDI regions, hypertension management measures were implemented earlier, and effective prevention and management policies have been developed [4]. The National High Blood Pressure Education Program (NHBPEP) in the United States was an early global initiative to promote hypertension control and has helped reduce the burden of hypertension-related CKD [27]. Nonetheless the high prevalence of hypertension in high SDI regions has hindered significant improvements in cohort or period effects, highlighting the need for enhanced prevention and control measures. Despite unfavorable trends from 1992 to 2021 in the prevalence and incidence of hypertension-induced CKD in high SDI regions, there were significant improvements in DALYs and mortality, largely due to advancements in early screening, medication, and health education for hypertension. For instance, Canada and several European countries have effectively increased hypertension awareness and treatment rates through community health education and remote health management, thus reducing the risk of CKD progression [28,29].

In contrast, in medium-low SDI regions, although the relative percentage of the CKD burden is lower, the trends in incidence and prevalence have shown the most significant increase. In these regions, insufficient medical resources and low hypertension control rates have led to a continued rise in the CKD burden [30]. For example, in Africa and South Asia, many countries have extremely low awareness of and treatment coverage for hypertension. Resource scarcity and weak healthcare systems mean that fewer than 10% of hypertensive patients receive comprehensive care according to international guidelines, further exacerbating the CKD burden [31]. The situation is particularly severe in low SDI regions. Although the hypertension-attributable CKD burden was at its lowest from 1992 to 2021, its incidence showed a significant upward trend. In these regions, inadequate healthcare spending, scarce medical resources, food insecurity, and the lack of hypertension-related policies have severely hindered progress in hypertension prevention and control [32]. Many countries lack early screening systems for hypertension, and the public has very limited awareness of the connection between hypertension and CKD.

Given that our study reveals unfavorable trends and unresolved gaps in health management, strengthening hypertension management strategies remains crucial. Countries should create and execute public health strategies tailored to their specific epidemiological profile, socio-economic context, and healthcare resources to effectively tackle the global impact of hypertension-induced CKD. This will alleviate the impact and enhance overall health outcomes.

Limitations of the Study

Our study has limitations that should be considered. First, our findings are limited by the sole use of the GBD database without external validation, potentially impacting their generalizability and robustness. The accuracy of GBD estimates is limited by data availability and quality, especially in regions with sparse data where statistical modeling from nearby areas is used. Future studies should incorporate external data sources—such as national cohort studies or renal registries—to validate and strengthen these results [32]. Second, as the GBD primarily integrates population-level data, it cannot elucidate the specific underlying drivers of changes in disease burden, such as the utilization of antihypertensive medications or shifts in dietary patterns. Finally, the APC model explains changes in disease burden through age, period, and cohort effects, but overlooks factors like regional genetic traits and healthcare resource distribution. Although these factors may have limited impact, they should be considered in future research.

Conclusions

This study indicates that between 1992 and 2021, the global burden of CKD attributable to hypertension significantly increased across different SDI regions. Although some high-income regions have made progress in reducing DALYs and mortality, there remains significant room for improvement, particularly regarding the burden of CKD among the elderly. To decrease the global burden, future public health policies should concentrate on strengthening hypertension management, promoting a healthy lifestyle, and enhancing healthcare resource accessibility, particularly in low and middle-income countries.

Availability of Data and Materials

The datasets analysed during the current study are available in the [Global Burden of Disease Study] repository [https://ghdx.healthdata.org/gbd-results-tool].

Author Contributions

LXD participated in the study conception and design, data extraction and analysis, interpretation, and manuscript drafting. WYT contributed to study concepts and design and critical manuscript revisions. Both authors have read and agreed to the final manuscript. Both authors have agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

All GBD studies are conducted using publicly available secondary databases without identifiable information. Ethical approval was not required.

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Conflict of Interest

The authors declare no conflict of interest.

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