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Research article

Global, regional and national temporal trends in prevalence for cardiovascular diseases in women of childbearing age, from 1990 to 2019: An age-period-cohort analysis

Ben Hu [a,b], Jun Feng [a], Yuhui Wang [a], Yinguang Fan [c], Linlin Hou [a,b,*]

[a] Department of Cardiology, The Second People's Hospital of Hefei, Hefei Hospital Affiliated to Anhui Medical University, Hefei, 230011, Anhui, China
[b] The Fifth Clinical Medical School of Anhui Medical University, Hefei, 230000, Anhui, China
[c] Department of Epidemiology and Biostatistics, School of Public Health, Anhui Medical University, 81 Meishan Road, Hefei, 230000, Anhui, China

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ABSTRACT

Background: Epidemiological studies on cardiovascular diseases (CVD) among women of childbearing age (WCBA) remain scarce. Our research aims to delineate the prevalence trends of CVD within this population over the past three decades, considering age, period, and birth cohort dynamics.

Methods: Estimates of CVD prevalence for WCBA, along with their 95% uncertainty intervals (UI), were extracted from the Global Burden of Diseases 2019 (*GBD2019*). An age-period-cohort (APC) model was utilized to assess the annual percentage change (net drifts) in overall prevalence, annual percentage changes in prevalence for individual age groups (local drifts), and fitted longitudinal age-specific rates adjusted for age effects and period/cohort relative risks (period/cohort effect).

Results: In 2019, the global prevalence of CVD among WCBA was 53.42 million (95% UI: 47.77 to 60.18). Eight countries recorded a prevalence exceeding one million, accounting for 54.17% of the global CVD prevalence in WCBA. Over the past 30 years, the annual net drift in CVD prevalence among the global WCBA was 0.27% (95% CI: 0.25 to 0.29). This value was 0.01% (95% CI: 0.04 to 0.06) in regions with a high sociodemographic index (SDI) and 0.21% (95% CI: 0.19 to 0.22) in those with a low SDI. Seventy-seven countries demonstrated an increasing trend in CVD prevalence, while 53 showed a decrease, and 74 remained relatively stable. Notably, as shown in local drift, there was a rise in CVD prevalence among adolescents aged 15–19 and adults aged 40–49 in regions categorized by five distinct SDI levels. This drift varied by SDI regions. Regions with a high SDI consistently had elevated period risks throughout the study duration, while other regions had lower period risks until 2000–2004 and displayed increased adverse period risks. The prevalence in low-middle and low SDI regions manifested detrimental trends, whereas other regions demonstrated an initial decline followed by a surge in successive birth cohorts.

Conclusions: Resources dedicated to CVD care for WCBA are largely insufficient, especially in low SDI regions. Thus, there is an urgent need to allocate cardiovascular healthcare resources variably across different SDI regions, aiming to diminish risks among successively younger birth cohorts.

* Corresponding author. Department of Cardiology, The Second People's Hospital of Hefei, Hefei Hospital Affiliated to Anhui Medical University, Hefei, 230011, Anhui, China.
E-mail address: 2245012179@stu.ahmu.edu.cn (L. Hou).

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Throughout this endeavor, the formulation of targeted policies and the judicious distribution of resources are essential to reduce risks for women across all age groups.

1. Introduction

Cardiovascular diseases (CVD) are among the leading chronic conditions globally and are the principal cause of mortality among women, especially those of childbearing age [1]. In 2019, CVD accounted for 35% of all female mortalities [2]. They are leading causes of mortality and morbidity globally, imposing significant economic burdens on patients, their families, healthcare services, and societies [3,15]. Furthermore, women face unique cardiovascular risks due to conditions inherent to their gender, such as obstetric and gynecologic histories, which encompass hypertensive disorders of pregnancy, gestational diabetes, premature births, early menopause, and polycystic ovary syndrome [4–6]. Socio-economic and socio-cultural roles also impact women's cardiovascular health [7]. While the general awareness of CVD in women has improved over recent decades, the global research, understanding, diagnosis, and treatment of female CVD remains largely underrepresented.

In epidemiology, temporal trends are typically examined across multiple dimensions to gain profound insights. Delving deeply into prevalence trends, emphasizing their relations with age, period, and birth cohort effects, can expand our understanding of disease epidemiology and pinpoint potential discrepancies in CVD prevention and management among WCBA. Although several studies have reported burden in CVD among WCBA, they have used national data or focused on only one specific disease [8–11]. However, no studies have globally reported on the relative influence of age, period, and birth cohort on CVD prevalence at the global level for CVD. No study has systematically gauged global, regional, and national information on CVD prevalence trends among WCBA and their relationship to age, period, and birth cohort effects. Therefore, in this research, we extracted the 2019 Global Burden of Disease (GBD) data, calculated the age-standardized prevalence rate for WCBA aged 15–49, and employed an age-period-cohort (APC) model to investigate temporal trends from 1990 to 2019 in CVD across different regions and countries for WCBA.

2. Methods

2.1. Data source

The methodological details of the 2019 Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) have been previously published [3,12,13]. These studies detailed the burdens of 369 diseases and injuries in 204 countries and regions, broken down by gender and age group from 1990 to 2019, as well as 87 risk factors divided by incidence, prevalence, deaths, and disability-adjusted life-years (DALYs). We procured estimates of prevalence, specifically for CVD, for the years 1990–2019, and their 95% uncertainty intervals (UI), along with their corresponding gender and age for analysis from the Global Health Data Exchange (GHDx) query tool (http://ghdx.healthdata.org/gbd-results-tool) [14]. The definition of specific CVD used the codes from the tenth edition of the International Classification of Diseases (ICD-10) [15]. The definition of disease is shown in Table S1. In addition, the Socio-demographic Index (SDI) was also utilized, quantifying a country or region's developmental status via metrics like fertility rate, educational attainment, and per capita income, with an SDI scale from 0 to 1 [16]. Given the reliance on public datasets, this study was exempted from the Ethics Committee of the Second People's Hospital of Hefei.

2.2. Study population

The population under study encompasses WCBA aged 15–49 years. Specifically, individuals aged 15–19 are classified as adolescents, and those aged 20–49 are considered adults, focusing on their CVD burden [17].

2.3. Overall temporal trends in CVD prevalence among WCBA

Prevalence numbers and age-standardized prevalence rates from 1990 to 2019 were used to evaluate the overall temporal trends of CVD prevalence in WCBA. Age-standardized prevalence rates for CVD in WCBA were estimated using the direct age-standardization method, premised on the assumption that CVD prevalence is a weighted sum of independent Poisson random variables [18,19]. Additionally, we calculated the relative proportions of CVD prevalence across seven age groups (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, and 45–49 years), elucidating the temporal variations in the age distribution of prevalence.

2.4. APC analysis of CVD prevalence among WCBA

Our study employed the age-period-cohort (APC) framework to dissect prevalence trends across various age groups, periods, and birth cohorts. The APC model is perceived as superior to traditional health and social sciences analyses. It zeroes in on discerning contributions of age-related natural histories, modern medical technologies and societal factors, and correlations between health behaviors and social exposures early in life with disease trends [20]. The model identifies the disease burden's net drift and local drift over time, representative of temporal trends within each age group, and estimates the effects of age, period, and birth cohort– the three fundamental temporal dimensions. Therefore, this model offers a profound understanding of disease epidemiology and aids in

Table 1
Trends of cardiovascular diseases prevalence in WCBA from 1990 to 2019 by SDI quintiles. Parentheses for GBD estimates denote 95% uncertainty intervals and parentheses for net drift denote 95% CIs. APC, age period cohort; GBD, Global Burden of Diseases; SDI, sociodemographic index; WCBA, women of childbearing age.

	Global		High SDI		High--middle SDI		Middle SDI		Low--middle SDI		Low SDI	
	1990	2019	1990	2019	1990	2019	1990	2019	1990	2019	1990	2019
Population												
No ($\times 10^6$)	5349.85	7737.46	822.01	1013.48	1150.43	1430.4	1716.76	2396.57	1129.65	1763.98	528.14	1128.68
Percentage of global level (%)	100.00	100.00	15.37	13.10	21.50	18.49	32.09	30.97	21.11	22.80	9.87	14.59
Prevalence												
No ($\times 10^6$)	32.03 (28.72 to 35.70)	53.42 (47.77 to 60.18)	6.42 (5.75 to 7.31)	6.98 (6.33 to 7.79)	6.02 (5.51 to 6.60)	8.67 (7.92 to 9.55)	9.60 (8.52 to 10.82)	16.37 (14.65 to 18.42)	6.45 (5.61 to 7.41)	12.71 (11.06 to 14.56)	3.51 (2.94 to 4.13)	8.66 (7.21 to 10.29)
Percentage of global level (%)	100.00	100.00	7.51	8.17	7.05	10.15	11.23	19.16	7.55	14.87	4.11	10.13
Percentage change of prevalence, 1990–2019 (%)	67.81 (64.38 to 69.35)		8.72 (5.06 to 12.38)		43.99 (40.86 to 47.34)		70.48 (65.39 to 75.77)		96.96 (92.43 to 101.89)		146.62 (141.77 to 151.61)	
Age--standardised prevalence rate												
Rate per 100, 000	2611.46 (2254.61 to 3070.65)	2688.44 (2287.78 to 3211.46)	2897.34 (2457.10 to 3489.88)	2654.30 (2312.52 to 3105.52)	2165.39 (1912.05 to 2475.48)	2149.91 (1877.69 to 2483.36)	2444.44 (2109.51 to 2859.01)	2503.96 (2140.67 to 2962.05)	2665.47 (2249.92 to 3174.38)	2815.96 (2354.90 to 3394.89)	2897.34 (2457.10 to 3489.88)	2654.30 (2312.52 to 3105.52)
APC model estimates												
Net drift of prevalence (% per year)	0.27 (0.25 to 0.29)		0.01 (-0.04 to 0.06)		0.10 (0.05 to 0.15)		0.15 (0.11 to 0.19)		0.21 (0.17 to 0.25)		0.21 (0.19 to 0.22)	

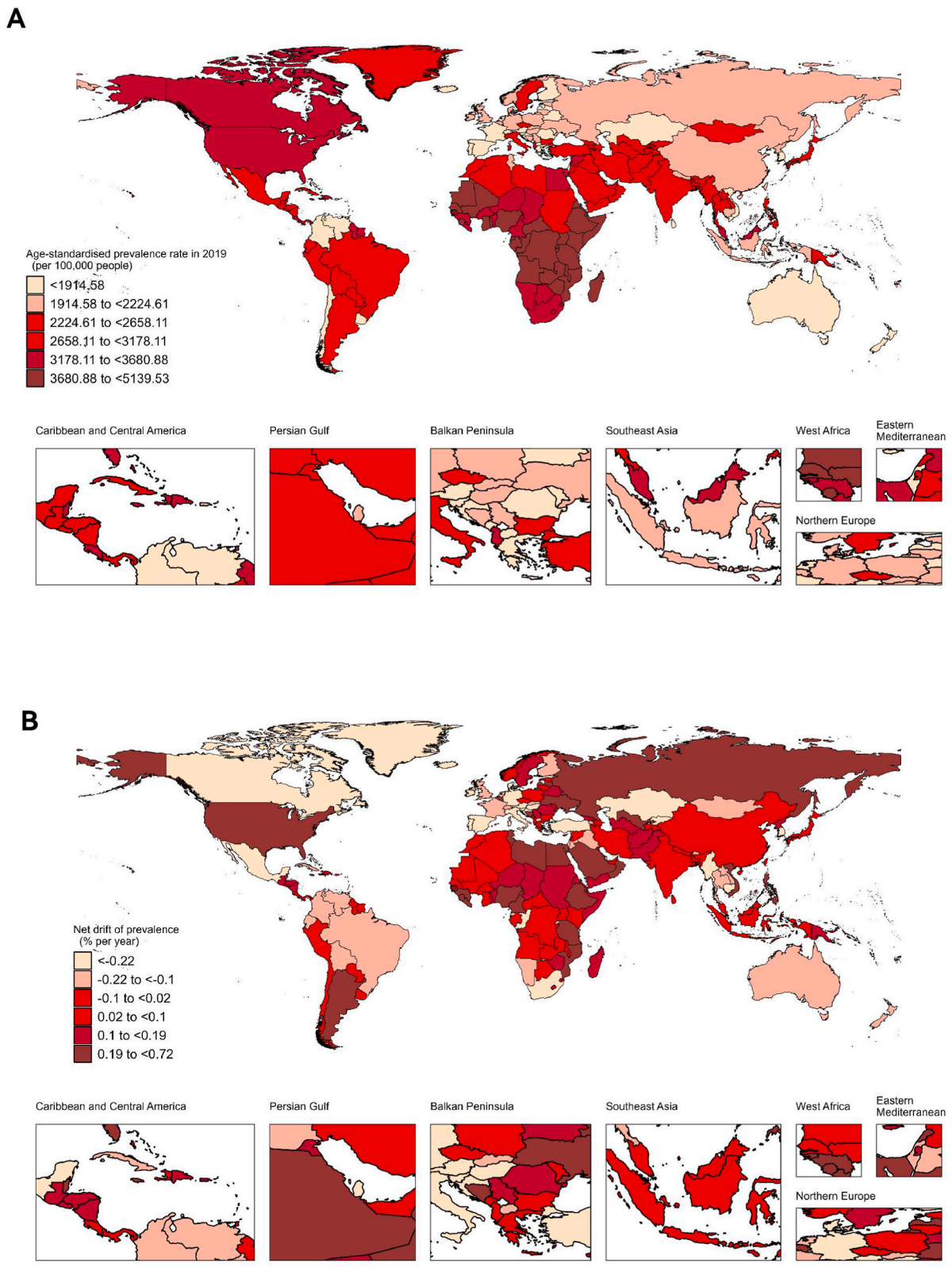

Fig. 1. The age-standardised prevalence rate in 2019 and net drift of prevalence from 1990 to 2019 for CVD in WCBA in 204 countries and territories. (A) World map of the age-standardised prevalence rate in 2019 for CVD in WCBA. (B) World map of the net drift of prevalence from 1990 to 2019 for CVD in WCBA. CVD, cardiovascular diseases; WCBA, women of childbearing age.

pinpointing potential discrepancies in various aspects of disease prevention, management, and treatment. The APC model is implemented using freely available R tools, and the methodology is elaborated in further detail in another study [21].

In preparing input data for the APC model, prevalence estimates of CVD in WCBA and population data from each country/region since the 2019 Global Burden of Disease (GBD) were utilized. Typically, the age interval should equate with the period interval. Thus, 5-year age groups should coincide with 5-year periods. Women's childbearing age was delineated as 15–49 years, and we further analyzed seven distinct age groups: 15–19, 20–24, …, and 45–49 years. The entire study duration (1990–2019) was segmented into six 5-year intervals: 1990–1994, 1995–1999, …, and 2015–2019. Consequently, we worked with 12 partially overlapping 10-year birth cohorts, including 1940–1949, 1945–1954, …, and 1995–2004.

The APC model estimated the temporal trends for overall prevalence and prevalence within each age group [22]. The former is denoted as the annual percentage change in prevalence or the net drift of prevalence (annual %), determined based on trends over the period and across continuous birth cohorts. The latter is expressed as the annual percentage change in age-specific prevalence or the local drift of prevalence (annual %) [22,23]. Even if the drift (annual %) is minimal, it could culminate in substantial variations in fitting rates over a span of 30 years. The Wald $\chi 2$ test was utilized to assess the significance of the annual percentage change. Furthermore, in the APC model, age effects are depicted by fitted longitudinal age-specific rates adjusted for period deviations within a given birth cohort [22,24,25]. The data was cleaned using the "dplyr," "tidyr," and "purr" package, the"ggplot2"package was utilized for data visualization and"epitools" package to calculate age-standardized prevalence rate. All analyses were performed using R software (V.4.3.0) (http://www.r-project.org).

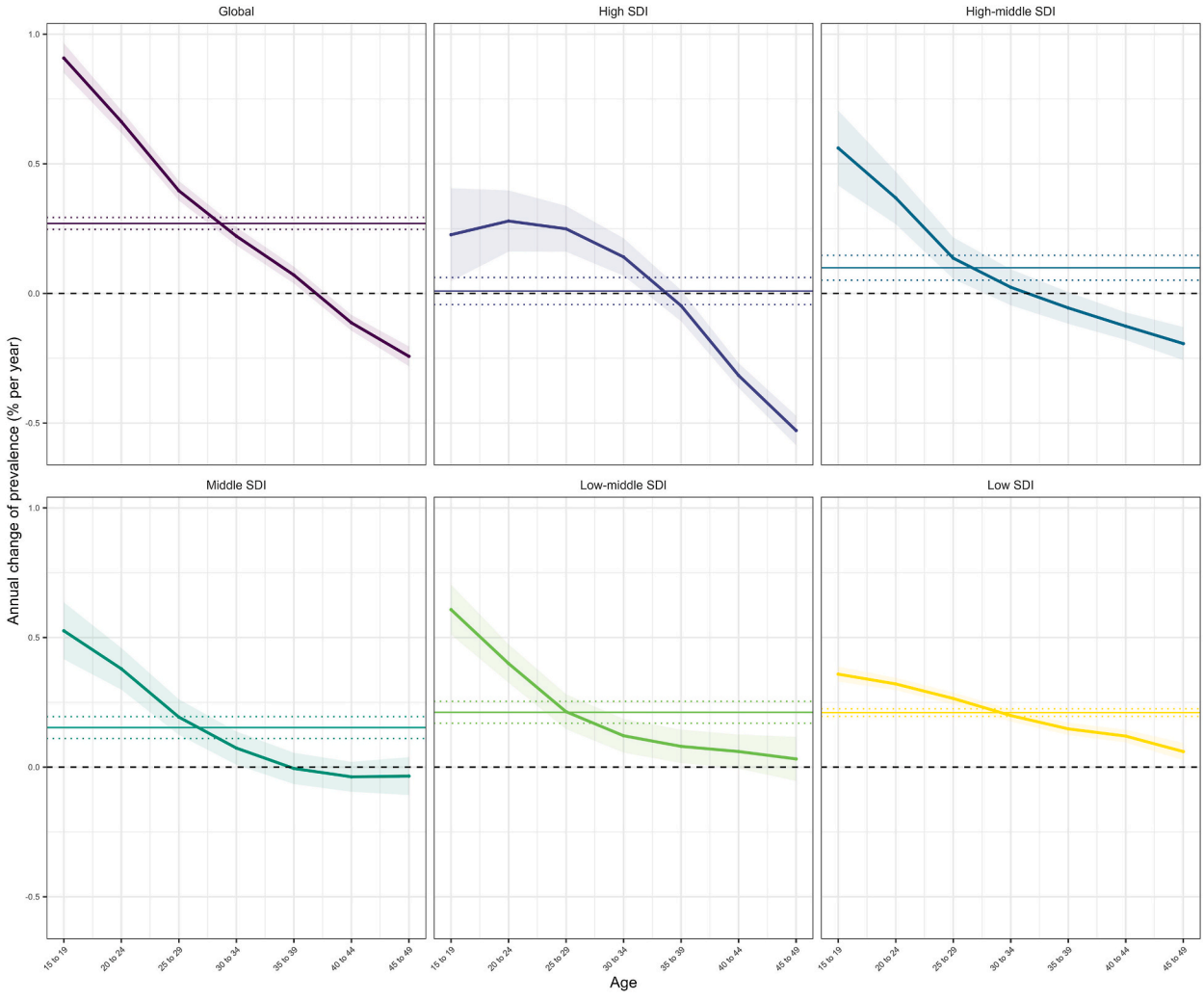

Fig. 2. Local drift of prevalence from 1990 to 2019 for CVD in WCBA across global and SDI quintiles. Notes: Local drift of prevalence from 1990 to 2019 for CVD in WCBA for seven age groups (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49 years). The dots and shaded areas denote the local drift (ie, annual percentage change of age-specific prevalence, % per year) and their corresponding 95% CIs.

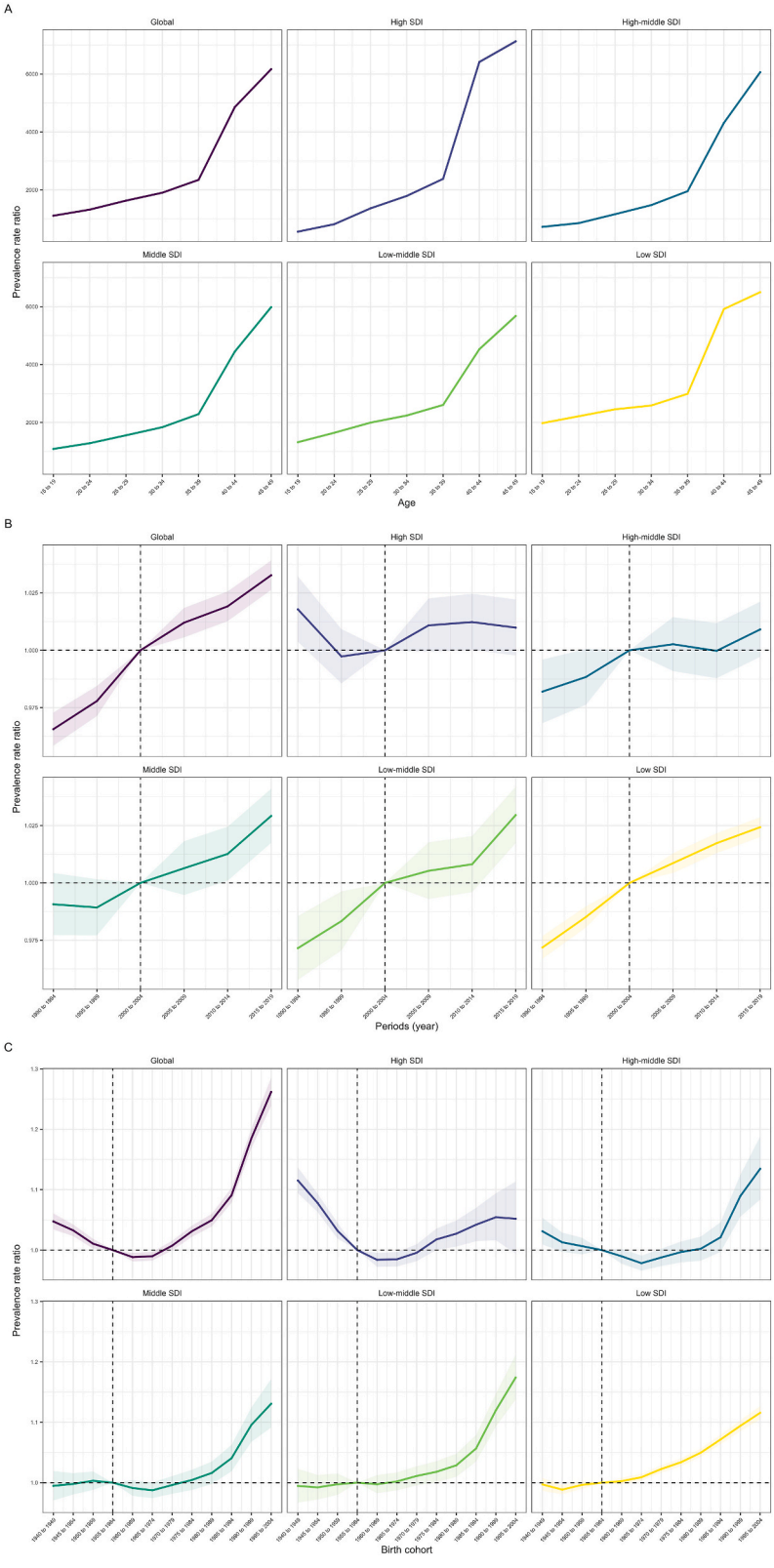

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Fig. 3. Age, period and birth cohort effects on CVD prevalence in WCBA across SDI quintiles. (A) Age effects are illustrated by the fitted longitudinal age-specific rates for a given number of birth cohorts adjusted for period deviations. (B) Period effects are illustrated by the period relative risk of prevalence (prevalence rate ratio) and calculated as the ratio of age-specific rates from 1990 to 1994 period to 2015–2019 period, with the reference period set at 2000–2004. (C) Birth cohort effects are illustrated by the cohort relative risk of prevalence (prevalence rate ratio) and calculated as the ratio of age-specific rates from 1940 to 1949 cohort to 1995–2004 cohort, with the reference cohort set at 1955–1964. The dots and shaded areas denote the prevalence rates or rate ratios and their corresponding 95% CIs. CVD, cardiovascular diseases; SDI, sociodemographic index; WCBA, women of childbearing age.

3. Results

3.1. Trends in cardiovascular disease prevalence among women aged 15–49 from 1990 to 2019

Between 1990 and 2019, alongside the global population increase, the global number of CVD prevalence in women aged 15–49 rose by approximately 67.81%, reaching 53.42 million in 2019 (95% UI: 47.77 to 60.18 million). In all SDI regions, the percentage change in prevalence numbers increased. By 2019, the age-standardized prevalence rate of CVD among women aged 15–49 globally had escalated to 2688.44 per 100,000 (95% UI: 2287.78 to 3211.46). The relative increase in the age-standardized prevalence rate was notable in the middle and low-middle SDI regions. Moreover, the APC model estimated a global net drift in CVD prevalence of 0.27% annually (95% CI: 0.25 to 0.29) for women aged 15–49, ranging from 0.01% in high SDI regions (95% CI: 0.04 to 0.06) to 0.21% in low SDI regions (95% CI: 0.19 to 0.22) **(Table 1)**. In 2019, among 204 countries and territories, eight countries had a prevalence of at least one million: India, China, the United States of America, Nigeria, Brazil, Pakistan, Indonesia, and Bangladesh, accounting for 54.17% of the global CVD prevalence in women aged 15–49. Ninety-nine countries exceeded the average global age-standardized prevalence rate, with 21 surpassing it by 1.5 times, mostly in low SDI regions of Eastern Sub-Saharan Africa (Fig. 1A). From 1990 to 2019, Belize experienced the highest increase in age-standardized prevalence rate (13.34%), with the annual net drift of prevalence being 0.39% (95% CI: 0.17 to 0.61), while Denmark witnessed the most significant decrease (20.13%) the annual net drift of prevalence being −0.53% (95% CI: 0.63 to −0.43). Although India and China, due to their large populations, exhibited the highest CVD prevalence among women aged 15–49, their changes in age-standardized prevalence rate and the net drift of prevalence were minimal. Among these 204 countries and territories, the APC model's estimated net drifts revealed that 77 displayed an upward trend in CVD prevalence, 53 showed a decline, and 74 remained relatively stable, highlighting strong heterogeneity in CVD prevalence trends among women aged 15–49 across all nations (Fig. 1B and Table S2).

3.2. Temporal trends in cardiovascular disease prevalence across different age groups

Based on the local drift of prevalence calculated by the APC model, globally, CVD prevalence among women aged 15–49 exhibited an increasing trend between the ages of 15–19, 20–24, 40–44, and 45–49 (Fig. 2). This increase seemed to decelerate with age, with the most substantial rise observed among the 40 to 44 age group (0.18%, 95% CI: 0.17 to 0.18). Conversely, there was a declining trend between the ages of 25–29 and 35–39, with the most pronounced decline found in the 35 to 39 age group (−0.26%, 95% CI: 0.27 to −0.26). During the adolescent phase of 15–19, CVD prevalence escalated in all five SDI regions. In adults aged 20–39, the CVD prevalence trend in the five SDI regions was generally opposite to that of ages 15–19. The Table S4 presents the local drift trends for each country. Temporal variations in the age distribution of CVD prevalence among women aged 15–49 are illustrated in Fig. S1. Additionally, in all SDI regions, more than 50% of prevalence rates were concentrated among women over 40, especially in high and high-middle SDI regions.

3.3. Effects of age, period, and birth cohort on CVD prevalence among women aged 15-49

Firstly, age effects in various SDI regions showed comparable patterns: the risk was lowest during the adolescent phase (15–19 years) and increased with age. Moreover, the overall prevalence was higher and demonstrated greater variability for those over 40 in high SDI regions compared to other SDI regions (Fig. 3A and Table S5). Secondly, while the period effect displayed an initial decline followed by a rise in high SDI regions, other SDI regions consistently showed an upward trend. High SDI regions generally had higher period risks throughout the study, whereas other regions had lower risks before 2000–2004, followed by a greater adverse period risk after that. Relative to individuals from 2000 to 2004, those from 2015 to 2019 had a relative period risk of 1.010 (95% CI: 0.998 to 1.022) in high SDI regions, 1.009 (95% CI: 0.997 to 1.021) in high-middle SDI regions, 1.029 (95% CI: 1.017 to 1.041) in middle SDI regions, 1.030 (95% CI: 1.017 to 1.042) in low-middle SDI regions, and 1.024 in low SDI regions (95% CI: 1.020 to 1.029) (Fig. 3B and Table S6). Concerning the birth cohort effect, the prevalence risk in high, high-middle, and middle SDI regions initially declined and then rose. In contrast, the prevalence rates in low-middle and low SDI regions continuously deteriorated across successive birth cohorts. Compared to individuals born between 1955 and 1964, those born between 1995 and 2004 had a relative cohort risk of 1.135 (95% CI: 1.084 to 1.188) in high-middle SDI regions, 1.131 (95% CI: 1.091 to 1.171) in middle SDI regions, 1.174 (95% CI: 1.138 to 1.212) in low-middle SDI regions, and 1.116 (95% CI: 1.105 to 1.127) in low SDI regions (Fig. 3C and Table S7).

To better delineate the temporal trends in the global prevalence of CVD, Fig. 4 illustrates several representative nations with different SDI regions, showcasing favorable and unfavorable age, period, and birth cohort effects. The U.S. exemplifies the trend in high-SDI nations with unfavorable outcomes, with no observed decline in prevalence across all age groups. The period and cohort risks have recently deteriorated and remain constant (Fig. 4A). In contrast, Australia presents a favorable cardiovascular trend in nations

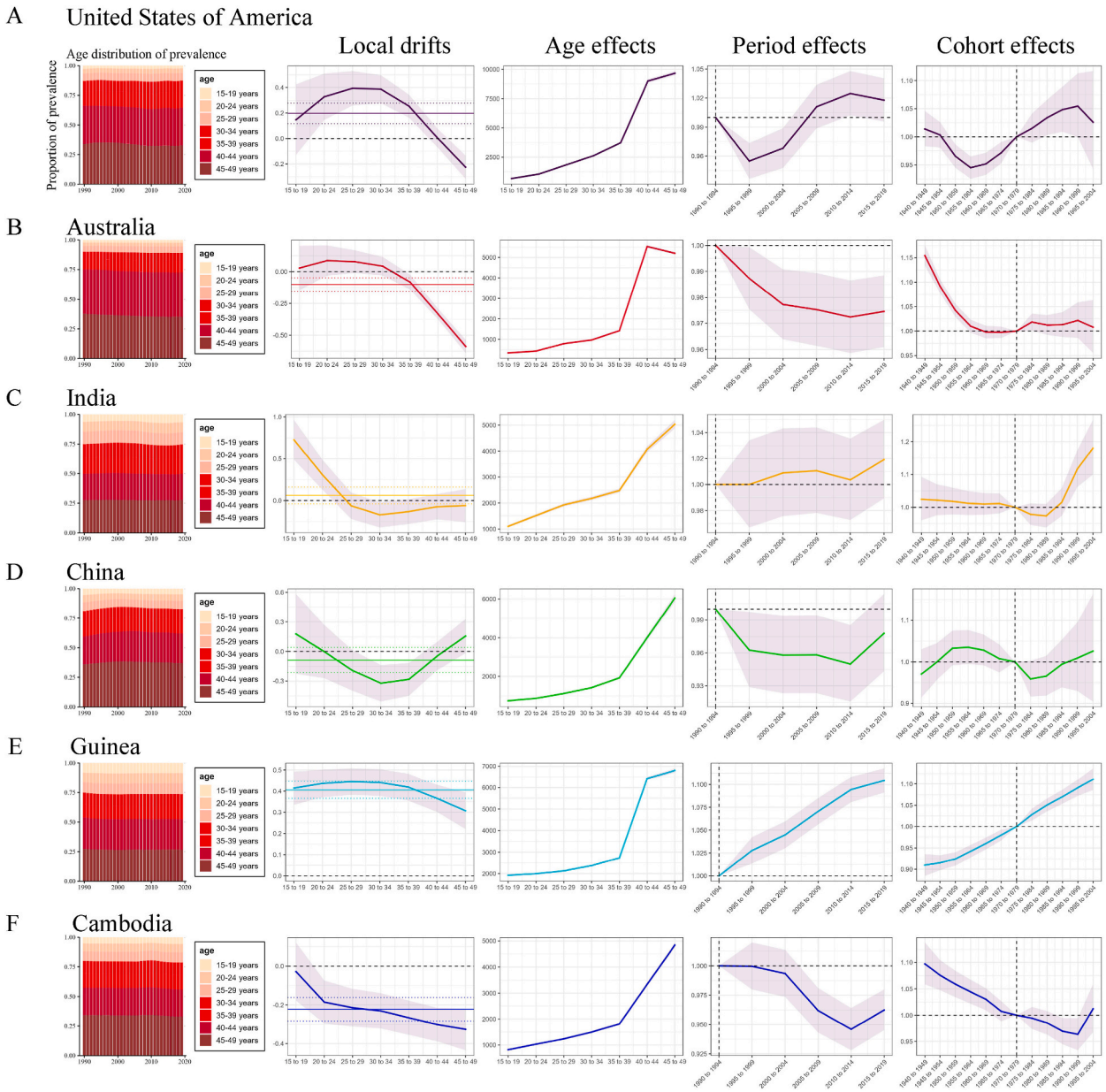

Fig. 4. Age, period and birth cohort effects on CVD prevalence in WCBA in exemplary countries (A-United States of America, B-Australia, C-India, D-China, E-Guinea, F-Cambodia). Notes: Age distribution of prevalence demonstrates the temporal changes in relative proportion of prevalence from 1990 to 2019 across seven age groups (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49 years). Local drift denotes the annual percentage change of age–specific prevalence (% per year) from 1990 to 2019 for seven age groups (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49 years). Age effects are illustrated by the fitted longitudinal age-specific rates for a given number of birth cohorts adjusted for period deviations. Period effects are illustrated by the period relative risk of prevalence (prevalence rate ratio) and calculated as the ratio of age–specific rates from 1990 to 1994 period to 2015–2019 period, with the reference period set at 2000–2004. Birth cohort effects are illustrated by the cohort relative risk of prevalence (prevalence rate ratio) and calculated as the ratio of age–specific rates from 1940 to 1949 cohort to 1995–2004 cohort, with the reference cohort set at 1955–1964. The dots and shaded areas denote the prevalence rates or rate ratios and their corresponding 95% CIs. CVD, cardiovascular diseases; SDI sociodemographic index; WCBA, women of childbearing age.

with a higher SDI. The local drift for most age groups annually is <0%, and over time, with successive birth cohorts, the risk significantly diminishes (Fig. 4B). India and China are examples of densely populated medium SDI nations exhibiting prevalence trends from adolescence to adulthood. In both India and China, the prevalence has been rising. However, the two populous nations display disparate patterns in period effects, with the former's cohort risk worsening recently while the latter remains stable, especially for those born post 1985–1994 (Fig. 4C and D). Guinea has the highest net drift among low-SDI countries, with almost every age group

experiencing a significant increase in prevalence and the period and cohort risks consistently deteriorating (Fig. 4E). Conversely, in Cambodia, another nation with a lower SDI, risks have been markedly declining with the passage of birth cohorts (Fig. 4F). In addition, the age, period and birth cohort effects on CVD prevalence in WCBA for each country were shown in Table S8-S10.

3.4. Potential inequities

From 1990 to 2019, with a 45% global population increase, the total number of CVD cases surged by 67.81%, the most substantial increase being in lower SDI regions (146.62%). Notably, this immense growth in these regions is primarily driven by population increase, with an overall population growth of 114%, while the age-standardized rate has slightly decreased **(Table 1)**. Our further analyses estimated the local drift of CVD prevalence among women aged 15–49 to capture the temporal trend across each age group. Moreover, regions with a higher SDI witness more age groups experiencing a decline in prevalence, and the burden predominantly lies in the older age groups, especially the 40–44 and 45–49 age groups. In contrast, regions with a lower SDI showed more age groups with rising prevalence, which may indicate potential SDI-related disparities (Fig. S1).

4. Discussion

Over the past three decades, CVD among WCBA globally has exhibited adverse temporal trends. Significant heterogeneity exists in the risk across age, period, and birth cohorts across different countries. Regions with a high SDI consistently demonstrated heightened period risk throughout the study. Conversely, the prevalence in low-middle and low SDI regions showed progressive deterioration across successive birth cohorts. Within the WCBA, the substantial population growth in low SDI regions and the burden in older women (ages 40–49) from high SDI regions have together accentuated the detrimental burden of CVD. The persisting health disparities across various regions are concerning.

Globally, the incidence of CVD in WCBA is rising, with an increasing emphasis from adolescence to adulthood. This trend poses novel challenges for healthcare system infrastructures and policy-making. Key risk factors, such as hypertension, dyslipidemia, diabetes, obesity, unhealthy diets, sedentary lifestyles, and smoking, lead to CVD development [26]. Women appear to have an elevated risk for hypertension-related acute myocardial infarction [27]. In addition, this phenomenon is also related to the pervasive increase in body mass index (BMI) driven in part by expanding urbanization. Women tend to have higher BMIs than men, particularly in developed nations [28]. Obesity is also implicated in adverse pregnancy outcomes, such as hypertensive disorders of pregnancy and gestational diabetes. Central obesity, a primary characteristic of the metabolic syndrome, is more prevalent in women than men [29]. Another study indicated that women with diabetes have a 44% higher risk of developing coronary heart disease than men with the same condition [30]. Hence, early diabetes management is vital to prevent disease progression and reduce cardiovascular risk. Women exposed to these risk factors, given their heightened risk of type 2 diabetes and cardiovascular disease later in life, necessitate particular attention and follow-up, especially those with elevated fasting blood glucose levels during pregnancy [31]. Together, obesity and diabetes significantly contribute to the prevalence and mortality rates of cardiovascular diseases in women and should be primary targets for health interventions.

Regarding smoking among women in Western and Central Europe, the prevalence among women in certain developed countries considerably surpasses the global average. Notably, the prevalence is especially high among women aged 15 to 19 [32]. Despite extensive tobacco control efforts, the prevalence of smoking among women has largely remained unchanged and has even increased in many countries [33]. There is a pressing need for innovative solutions for targeted management, and there's a demand for evidence to support gender-specific treatment and interventions.

Pregnancy is an inevitable concern during the adult life of WCBA. Compared to the general population, pregnant female with CVD face higher risks of adverse maternal and fetal outcomes, including hypertensive disorders of pregnancy, pre-eclampsia, cesarean delivery, preterm birth, low birth weight, and stillbirth [34]. These risks might be associated with medication use. Furthermore, compared to men, women have reported increased gender-specific adverse effects related to antihypertensive medications [35]. Hence, understanding the CVD burden in WCBA is paramount for providing cardiovascular care to women with CVD both before and during pregnancy.

Among WCBA, the age effect on cardiovascular diseases presents a similar risk across different SDI regions with increasing age, consistent with the overall trend of CVD prevalence. Regarding the cohort effect, later-born individuals demonstrate higher overall risk than those born earlier, except in high SDI regions. On the one hand, countries in high SDI regions, relying on robust and accessible healthcare systems, are better equipped to address and manage cardiovascular diseases, significantly contributing to improved diagnosis and cure rates. On the contrary, in many nations with lower socioeconomic development, the expanding population has limited access to primary healthcare and lacks expert guidelines, medications, and healthcare personnel, potentially resulting in graver outcomes [36]. On the other hand, over the past 30 years, most countries have witnessed increasing urbanization and modernization, leading to heightened exposures to harmful substances such as light and chemical pollutants, escalating urban carbon emissions, and deteriorating air quality, thereby fueling the prevalence of CVD [37]. It's noteworthy that, excluding high SDI regions, period and cohort effects synergistically contribute to rising prevalence. Moreover, among 204 countries and territories, the effects of age, period, and birth cohort on the prevalence of CVD in women are highly heterogeneous, underscoring diverse disease patterns worldwide and the necessity for each country to formulate health policy solutions for early detection and targeted management.

To the best of our knowledge, this is the first study targeting the WCBA, utilizing the APC model to comprehensively analyze the temporal trends of CVD at global, regional, and national levels. We provide a deeper understanding of the temporal trends of CVD in the WCBA, offering valuable insights for epidemiology and health policy formulation.

Several limitations should be noted. Firstly, due to the imperfections in the healthcare systems of underdeveloped countries, misdiagnosis and missed diagnoses could occur in GBD studies. These could pose challenges to the accurate assessment of CVD. Secondly, to overcome the unbalanced quality caused by massive original data from different countries, the GBD collaborators adopted efficient data cleaning methods and advanced statistical modeling. However, this could lead to an over-reliance on modeled data in GBD studies and a failure to consider sociocultural and ethnic differences. Although countries were classified according to SDI, there may be differences from a microscopic perspective because disease burden may vary depending on SDI even within a country. Additionally, variability and inconsistencies in data collection methods and tools in GBD data across countries and over time may influence geographic variation and temporal trends. Finally, it is important to recognize the latency inherent in GBD data and the study's inability to explore prevalence trends within different regions of individual countries.

5. Conclusion

In summary, the overall temporal trend in the global prevalence of cardiovascular diseases among WCBA is largely unfavorable. Approximately a third of the countries worldwide have witnessed an adverse increasing trend, with many experiencing a deterioration in period/cohort risks. This result suggests that resources allocated to cardiovascular healthcare for WCBA are largely insufficient, especially in low SDI regions. It is also worth noting that global cardiovascular healthcare for WCBA should pivot more towards adolescents (those under 20) and middle-aged women (those over 40). There is an urgent need for different resources and investments in cardiovascular healthcare across varying SDI regions, aiming to mitigate risks in successively younger birth cohorts. Targeted policies and resource allocation are essential throughout this process to reduce risks for women across all age groups.

Funding

No funding.

Availability of data and materials

Data are available (http://ghdx.Health data.org/gbd-results-tool) [14].

Ethics approval and consent to participate

Given the reliance on public datasets, this study was exempted from the Ethics Committee of the Second People's Hospital of Hefei.

Declarations

The authors are not part of the GBD Collaborator Network, but have accessed the results using the publicly available tools. All work was performed in compliance with the GBD data use agreement for the publicly available tools. All the methods were performed in accordance with the relevant guidelines and regulations.

Consent for publication

Not applicable.

CRediT authorship contribution statement

Ben Hu: Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jun Feng:** Validation, Supervision. **Yuhui Wang:** Methodology, Investigation. **Yinguang Fan:** Writing – review & editing, Visualization, Validation, Supervision. **Linlin Hou:** Writing – review & editing, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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The authors are grateful to all members who participated in the 2019 GBD study.

Abbreviations

CVD	cardiovascular diseases
WCBA	women of childbearing age

UI	uncertainty intervals
GBD2019	Global Burden of Diseases 2019
APC	age-period-cohort
SDI	sociodemographic index
DALYs	disability-adjusted life-years
GHDx	Global Health Data Exchange
ICD-10	the tenth edition of the International Classification of Diseases
BMI	body mass index

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e28526.

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