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Trends in the Burden of Ischemic Heart Disease in Women: An Analysis of High Body Mass Index and Low Physical Activity Factors Based on GBD 2021 Data

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Abstract: *Objective:* This study systematically assessed temporal trends in the global burden of ischemic heart disease (IHD) attributable to high body mass index (BMI) and low physical activity (PA) among women from 1990 to 2021. *Methods:* Data were obtained from the 2021 Global Burden of Disease Database, which covers disability-adjusted life years (DALYs), mortality rates, years lived with disability (YLDs), years of life lost (YLLs), and age-standardized rates (ASRs) attributable to high BMI and low PA among women. ASRs and estimated annual percentage changes (EAPCs) were calculated over 32 years. Temporal trends were analyzed by country, region, and sociodemographic index (SDI). A decomposition analysis was performed, and future predictions were made using the ARIMA time-series method to assess these trends comprehensively. *Results:* DALYs associated with IHD attributable to high BMI in women increased from 5.17 million in 1990 to 9.87 million in 2021. Deaths increased from 243,512 to 461,122, YLDs from 85,634 to 238,639, and YLLs from 5.08 to 9.63 million. However, DALYs related to female IHD caused by low PA increased from 146 to 242 million. Deaths increased from 87,707 to 152,305, YLDs from 23,564 to 54,301, and YLLs from 144 to 236 million. Although the ASRs of DALYs, mortality, and YLLs associated with high BMI and low PA have decreased, the ASR of YLDs has remained relatively stable over 32 years. This overall increase in disease burden underscores the urgency of intervention strategies to address the risk factors of high BMI and low PA. Significant regional and national differences were observed, with the burden shifting from high-SDI areas to low- and low-middle-SDI areas, a trend further amplified by population growth and aging. Although overall health inequalities have decreased, predictions indicate that the ASR of female IHD will continue to decline over the next 29 years, whereas the ASR of YLDs is expected to increase. This indicates that although women's health awareness is increasing, more efforts are needed to maintain cardiovascular health, reduce the burden of IHD, and improve the quality of life for women. *Conclusions:* Since 1990, high BMI and insufficient PA have substantially contributed to the global burden of IHD in women, with profound variation by age, region, and sociodemographic context. These effects differ from those in men due to women's unique physiological and social roles, underscoring the need for targeted health strategies aimed at women. Nations should focus on managing BMI and promoting physical activity to reduce the IHD burden and inform public health policies to improve women's cardiovascular health and quality of life.

Keywords: Ischemic heart disease; Female; Burden of disease (GBD 2021); Estimated annual percentage change (EAPC); Decomposition analysis; Health inequality; ARIMA time series prediction

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1. Introduction

Cardiovascular diseases (CVDs) affect over 500 million individuals globally and accounted for approximately 20.5 million deaths in 2021, constituting nearly one-third of all global mortality [1]. According to the World Heart Federation's 2021 World Heart Report, Ischemic heart disease (IHD) is the leading cause of death globally. Therefore, IHD constitutes a major burden of cardiovascular disease on a global scale and is recognized as a substantial hindrance to sustainable development in the 21st century. Consequently, the effective prevention and management of IHD remains a critical global health priority.

A previous study demonstrated that the onset of IHD in females typically occurs approximately one decade later than in males [2]. These temporal gaps span approximately 20 years for major adverse cardiovascular events such as MI and sudden cardiac death. The prevalence of IHD is three times higher in women aged over 65 years than in younger women. Compared to men, women typically endure a higher burden of comorbidities and demonstrate poorer outcomes associated with IHD [3]. The primary behavioral risk factors for conventional IHD include unhealthy diet, elevated body mass index (BMI), inadequate physical activity (PA), tobacco use, and excessive alcohol intake. These factors substantially facilitate the progression of IHD in both genders. Previous studies have focused on risk factors such as tobacco use, elevated sodium consumption, red meat intake, and different metabolic parameters [4,5]. High BMI and inadequate PA are recognized as significant risk factors for IHD [6,7]. Numerous studies have confirmed the significant association between elevated BMI and cardiovascular diseases, with this risk further exacerbated by low levels of PA [8]. However, the specific effect of these two factors on the IHD burden in women, and research into their underlying mechanisms, remains insufficiently examined. Therefore, a comprehensive evaluation of the impact of elevated BMI and reduced PA on the incidence of IHD in women is crucial. This assessment is essential to clarify the underlying pathogenesis of IHD and formulate appropriate intervention strategies. The management of BMI and the promotion of PA are recognized as cost-effective and high-priority strategies for alleviating the burden of cardiovascular diseases. Consequently, it is essential to determine the global distribution of IHD burden in women due to high BMI and insufficient PA.

This study, for the first time using data from the GBD 2021, employed age-standardized rates (ASR) and estimated annual percentage change (EAPC) analyses to evaluate the evolving patterns in the IHD burden among women from 1990 to 2021 on global, national, and regional scales. The study aimed to assess the geographical and temporal patterns of the disease burden associated with IHD among females, resulting from elevated BMI and insufficient PA across various age demographics. The impact of the sociodemographic index (SDI) and prospective future trends was also analyzed. Through a comprehensive examination of these risk determinants, we aim to provide a scientific basis for the development of targeted public health treatments and the formulation of associated health policies. This initiative seeks to enhance the women's health status, reduce healthcare costs, and enhance their quality of life.

2. Methods

2.1. Study population and data sources

We employed data from the Global Burden of Disease (GBD) 2021 database to evaluate the impact of high BMI and low PA on IHD in women. The GBD 2021 database provides detailed data on 371 diseases and injuries and 88 risk factors across 204 countries and regions and 21 geographical areas [9,10]. In the analyses of high BMI and low PA, cases of women aged 20 to 95 and above were included. The data used in these analyses were all publicly available indicators, so no ethical approval was required.

2.2. Definitions

Body Mass Index (BMI) is used to assess overall health status. For people aged 20 and above, a BMI greater than 23 kg/m^2 is considered high. Low PA was assessed by weekly metabolic equivalent task (MET) minutes and included activity episodes lasting at least 10 minutes across occupational, household, transport, and leisure domains [10]. Sociodemographic index (SDI), a composite indicator based on income, education, and fertility, was used to classify countries and regions into low, lower-middle, middle, upper-middle, and high SDI groups. The main indicators were deaths, disability-adjusted life years (DALYs), years lived with disability (YLDs), years of life lost (YLLs), and corresponding age-standardized rates (ASRs) per 100,000 population. DALYs were calculated as the sum of YLLs and YLDs. We utilized EAPC to assess the trends of diverse indicators within a specified time range, encompassing prevalence and incidence [11].

2.3. Statistical analysis

By using a log-linear regression model based on ASR and calendar year, an analysis was conducted globally as well as by age group, GBD regions, countries or regions, and human development index (SDI) categories. The estimated annual percentage change rate (EAPC) was employed to reflect the temporal trend of ASR. The Das Gupta decomposition was used to separate the contribution of population growth, population aging, and epidemiological change to changes in burden [12]. Pearson correlation was used to evaluate associations between SDI and disease burden. Health inequality was assessed by the slope index of inequality and the concentration index [13]. Future trends were projected using autoregressive integrated moving average (ARIMA) models; stationarity, residual normality, autocorrelation, AIC, BIC, and Ljung-Box tests were used to evaluate model fit [14]. All analyses were performed in R version 4.3.3 [15].

3. Results

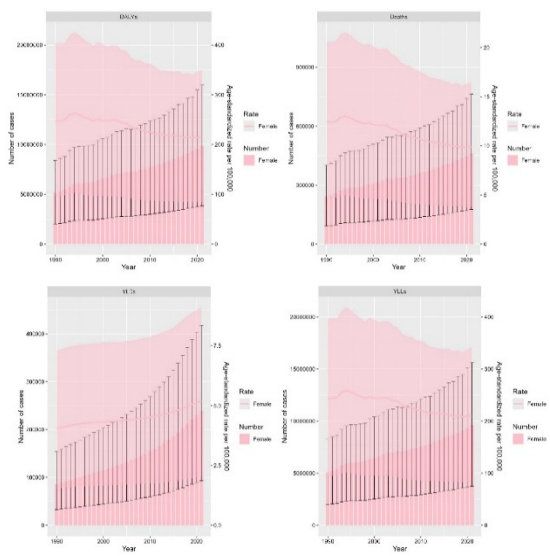
3.1. Global trends in the burden of IHD in women due to high BMI and low PA

The absolute burden of female IHD attributable to high BMI increased substantially from 1990 to 2021.

DALYs rose from 5.17 million to 9.87 million, deaths from 243,512 to 461,122, YLDs from 85,634 to 238,639, and YLLs from 5.09 million to 9.63 million. Despite these absolute increases, the age-standardized rates of DALYs, deaths, and YLLs declined from 247.28 to 216.05, 12.43 to 9.92, and 243.24 to 210.85 per 100,000, respectively. Their EAPCs were -0.69, -0.98, and -0.72, indicating downward age-standardized trends. In contrast, the ASR of YLDs increased from 4.04 to 5.20 per 100,000, with an EAPC of 0.69, suggesting a growing nonfatal disability component.

For low PA, the absolute burden also increased. DALYs rose from 1.46 million to 2.42 million, deaths from 87,707 to 152,305, YLDs from 23,564 to 54,301, and YLLs from 1.44 million to 2.36 million. However, the ASRs of DALYs, deaths, and YLLs declined from 73.85 to 51.88, 4.76 to 3.24, and 72.69 to 50.72 per 100,000, respectively, with EAPCs of -1.22, -1.29, and -1.24. The ASR of YLDs remained nearly stable, changing from 1.16 to 1.17 per 100,000. These findings indicate that mortality-related rates have improved, but population expansion, aging, and persistent disability have increased total burden (**Figures 1 and 2**).

(1)



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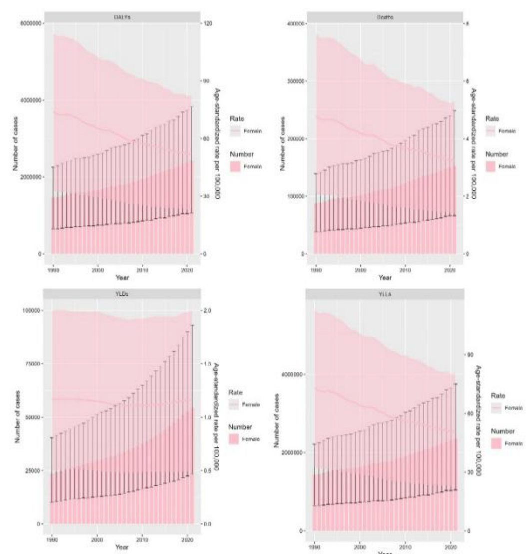
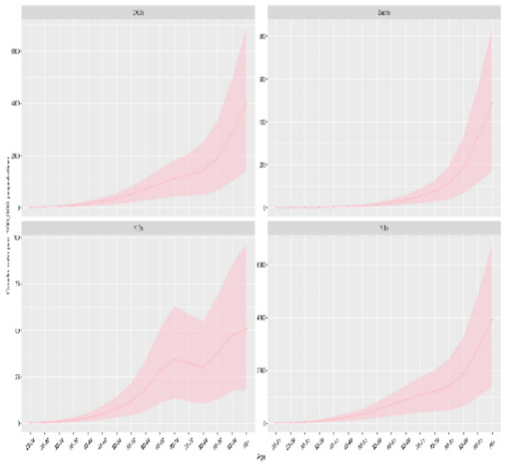


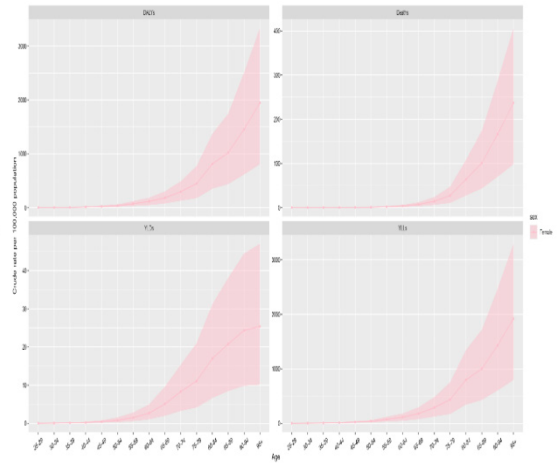
Figures 1 and 2. Trends in number and age-standardized rates of DALYs, Deaths, YLDs, and YLLs attributable to high BMI /low PA for all ages from 1990 to 2021.

3.2. Global age trends in the burden of IHD in women due to high BMI and low PA

A primary prevention strategy that considers the demographic distribution of the population highlights the health concerns faced by different age groups. In 2021, the burden attributable to high BMI was concentrated among older women. DALYs, YLDs, and YLLs peaked in the 65-69-year age group, whereas deaths peaked among women aged 70-74 years. Age-standardized death, DALY, and YLL rates increased steadily with age and rose especially sharply after 80 years. YLD rates showed a decline in the 70-79-year groups and then increased again after 80-84 years. For low PA, deaths, DALYs, and YLLs were highest in the 80-84-year group, while YLDs peaked at 70-74 years. Mortality-related ASRs increased with age, particularly after 75-79 years, and YLD ASRs also rose progressively in older age groups. IHD in women attributable to elevated BMI and reduced PA presents a significant challenge to the elderly female population (**Figures 3 and 4**).

(3) (4)



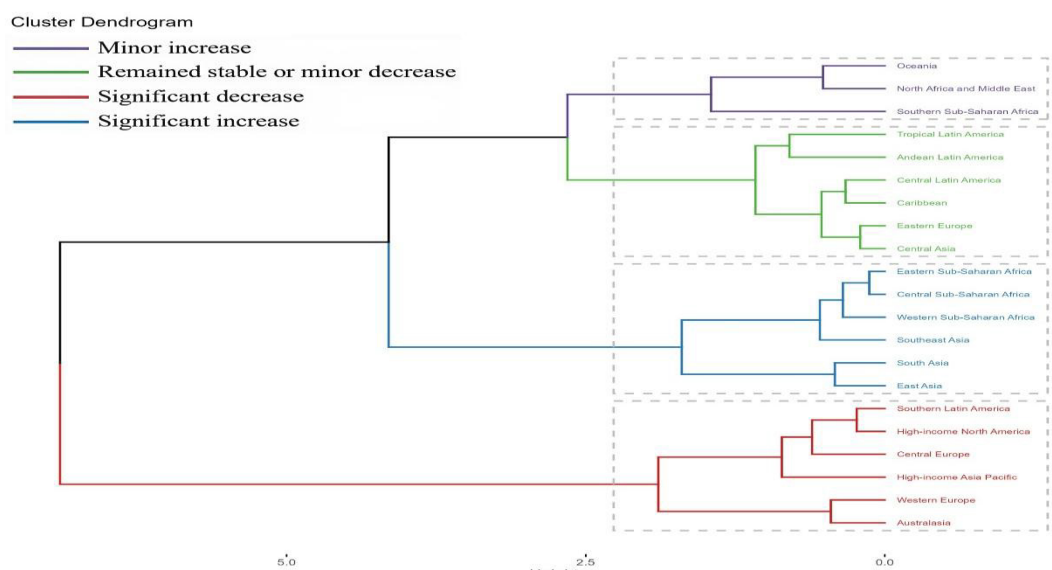


Figures 3 and 4. Trends in number and age-standardized rates of DALYs, Deaths, YLDs, and YLLs attributable to high BMI /low PA among women globally, by age group, 1990–2021.

3.3. Regional and national female IHD burden due to high BMI and low PA

The burden varied markedly across regions. For high BMI, seven of the 21 GBD regions showed increasing ASRs of DALYs and YLLs, with South Asia showing the most rapid increases in DALYs and YLLs. The ASR of deaths increased in seven regions, and the ASR of YLDs increased in 16 regions; East Asia had the largest increases in mortality and YLD rates. Australasia showed the most substantial decreases across DALYs, deaths, YLDs, and YLLs. For low PA, ASRs of DALYs and YLLs increased in three regions and death rates increased in five regions, with East Asia showing the largest increases in DALYs, deaths, and YLLs. YLD rates increased in 11 regions and rose most sharply in Western Sub-Saharan Africa, while Australasia again showed the strongest declines in all four indicators (**Figures 5 and 6**).

(5)



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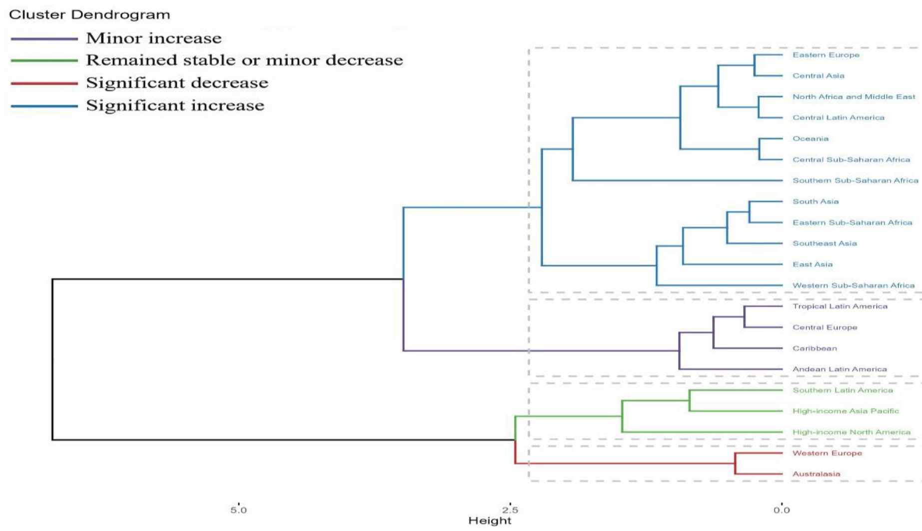


Figures 5 and 6. Cluster dendrogram of the Global Burden of IHD in Women Due to High BMI/low PA Across 21 Regions, 1990–2021.

At the national level, the 2021 burden showed large heterogeneity. For high BMI, the Marshall Islands had the highest ASR of DALYs, Nauru had the highest ASR of deaths, Qatar had the highest ASR of YLDs, and Egypt had the highest ASR of YLLs. Singapore had the lowest ASRs of DALYs and deaths, Ethiopia had the lowest YLD rate, and Japan had the lowest YLL rate. For low PA, Sudan had the highest ASRs of DALYs, deaths, and YLLs, whereas Tanzania had the lowest corresponding rates. The Marshall Islands had the highest YLD rate related to low PA, and Tanzania had the lowest. These national differences suggest that the combined influence of socioeconomic development, demographics, cardiometabolic risk, health-care access, and activity environments is substantial (**Figures 7 and 8**).

7(a) 7(b)

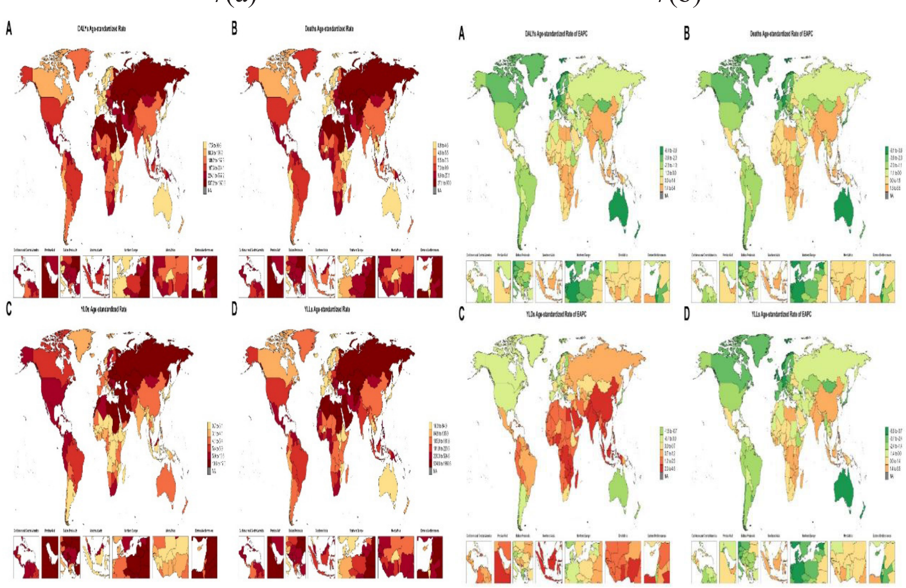
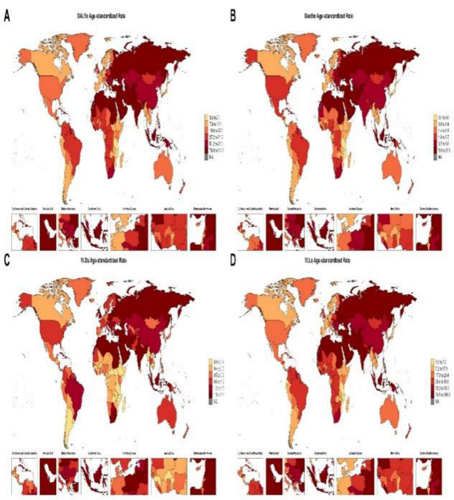


Figure 7 (a)(b). Global distribution of the burden of IHD among women and prevalence of EAPC attributable to High BMI in 2021 across 204 Countries from 1990 to 2021 (Calculated by Age-Standardized Rates of DALYs, Deaths, YLDs, and YLLs).

8(a) 8(b)



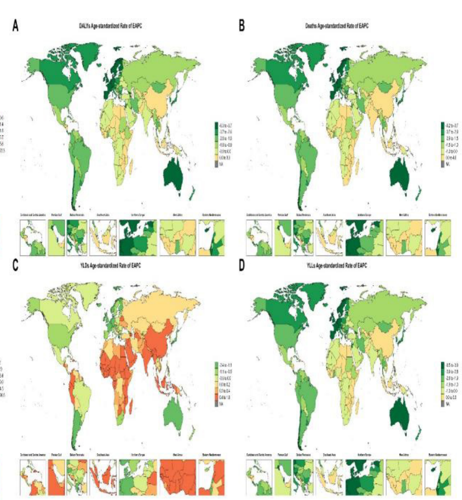
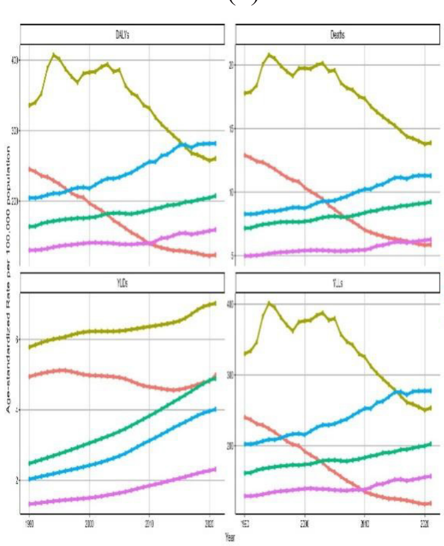


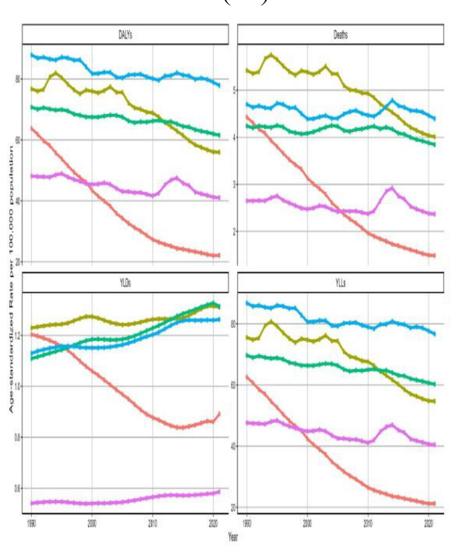
Figure 8(a)(b). Global distribution of the burden of IHD among women and prevalence of EAPC attributable to low PA in 2021 across 204 Countries from 1990 to 2021 (Calculated by Age-Standardized Rates of DALYs, Deaths, YLDs, and YLLs).Age-Standardized Rates (ASR); Estimated Annual Percentage Change (EAPC).

3.4. Research on SDI correlation

SDI-stratified analysis showed that high-SDI regions experienced the largest declines in mortality-related rates. For high BMI, the EAPCs for deaths, DALYs, and YLLs in high-SDI areas were -2.89, -2.52, and -2.59, respectively. Upper-middle-SDI regions also declined after approximately 2005, while lower-middle-SDI regions showed the most obvious increases. The ASR of YLDs declined slightly in high-SDI areas but increased in upper-middle-, middle-, lower-middle-, and low-SDI areas. For low PA, high-SDI regions again showed the greatest declines in death, DALY, YLL, and YLD rates. However, YLD rates increased slightly in middle- and lower-middle-SDI regions, indicating that nonfatal IHD burden is increasingly important in developing settings (**Figures 9 and 10**).

(9) (10)

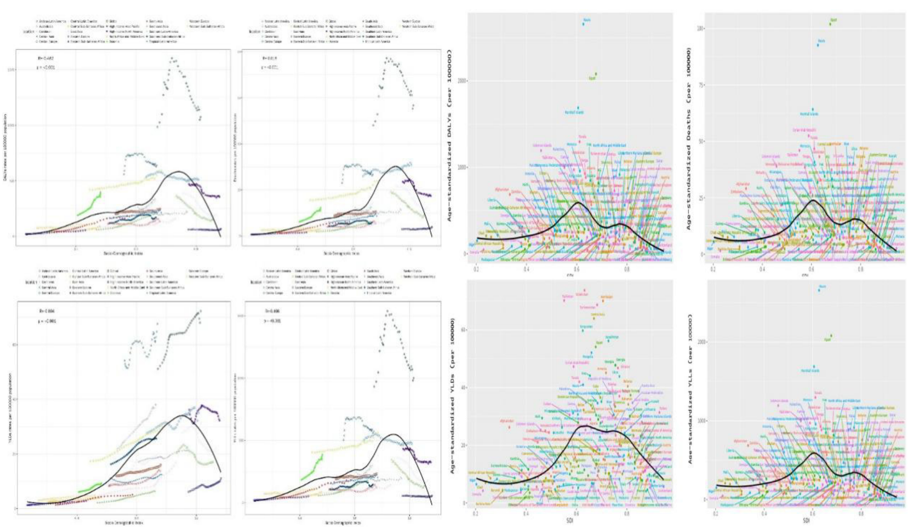




Figures 9 and 10. Time Trends in the Burden of IHD Among Women in SDI Regions Attributable to High BMI/ low PA from 1990–2021.

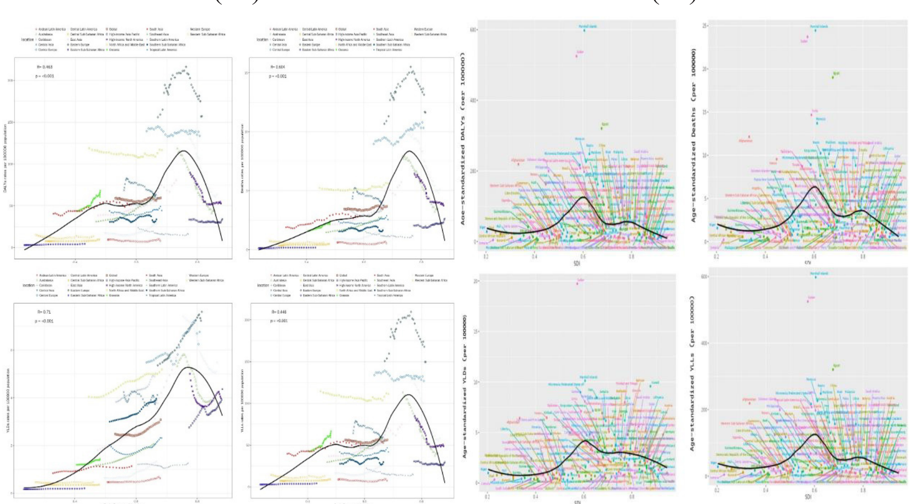
Across 21 regions and 204 countries, the association between SDI and IHD burden was nonlinear. For high BMI, ASRs generally followed an inverted or n-shaped relationship with SDI and declined markedly when SDI exceeded approximately 0.7. Eastern Europe, Central Asia, North Africa and the Middle East, and Oceania often had higher-than-expected burdens. The incidence of ischemic heart disease among global women due to insufficient physical activity (PA), after excluding the YLD (burden of disease) factor, is slightly higher than expected. It also presents a similar “n” shape relationship: it is more burdensome in several middle and higher development level regions. When the SDI exceeds 0.7, the correlation drops sharply. In 2021, across 204 countries, the SDI for female IHD attributable to low PA peaked at approximately 0.6, achieved a secondary peak at 0.8, and subsequently experienced a marked decline (**Figures 11 and 12** for high BMI) (**Figures 13 and 14** for low PA).

(11) (12)



Figures 11 and 12. Relationship between age-standardized rates of DALYs, Deaths, YLDs, YLLs, and SDI levels attributable to female IHD due to high BMI in 21 regions/204 countries from 1990 to 2021.Expected values for SDI and disease rates based on all sites are shown as a black line.

(13) (14)



Figures 13 and 14. Relationship between age-standardized rates of DALYs, Deaths, YLDs, YLLs, and SDI levels attributable to female IHD due to high BMI in 21 regions/204 countries from 1990 to 2021.Expected values for SDI and disease rates based on all sites are shown as a black line.

3.5. Decomposition analysis and health inequality analysis

Decomposition analysis indicated that the increase in population size and the aging demographic are recognized as primary contributors to the escalating incidence of IHD. The combined effect of high BMI and low PA makes the problem even more serious. For high BMI, population growth and aging increased global DALYs, deaths, and YLLs, whereas epidemiological changes partly offset mortality-related burden. For YLDs, epidemiological change contributed positively, consistent with the increasing nonfatal burden. By SDI category, low- and lower-middle-SDI settings were especially affected by population growth, whereas high-SDI settings showed reductions largely attributable to favorable epidemiological changes. For low PA, population growth and aging were also the dominant positive drivers of DALYs, deaths, and YLLs; epidemiological change had a negative contribution for fatal outcomes but little protective effect for YLDs (**Tables 1 and 2**)

Table 1. Changes in DALYs and Deaths by Determinants and Causes of Population Levels, 1990–2021

		DALYs								Deaths							
			Change due to Population-level determinants (%contribute to the total change)							Change due to Population-level determinants (%contribute to the total change)					
Cause	Location	Overall difference	Aging	Percent%	Population	Percent%	Epidemiological change	Percent%	Overall difference	Aging	Percent%	Population	**Percent%**	**Epidemiological change**	**Percent%**
IHD attributable To High Body Mass Index	Global	46944 24.42	17646 93.13	37.59	39445 97.57	84.03	-10148 66.29	-21.62	2176 10.36	1115 38.30	51.26	1861 98.70	85.57	-801 26.60	-36.82
	Low SDI	3045 05.14	-676 9.14	-2.22	2523 48.78	82.87	5892 5.51	19.35	1032 8.60	-192.43	-1.86	847 5.70	82.06	204 5.32	19.80
	Low-middle SDI	15529 23.72	2050 03.20	13.2	9268 63.14	59.69	4210 57.33	27.11	5843 6.24	1013 0.29	17.34	3319 8.42	56.81	1510 7.52	25.85
	Middle SDI	20327 26.59	6244 79.41	30.72	10043 74.69	49.41	4038 72.49	19.87	9075 0.59	3261 9.23	35.94	4049 9.02	44.63	1763 2.34	19.43
	High-middle SDI	10149 31.59	7890 25.04	77.74	8400 49.42	82.77	-6141 42.87	-60.51	6615 3.92	5335 3.52	80.65	4455 8.71	67.36	-317 58.31	-48.01
	High SDI	-2127 18.48	4728 40.77	-22 2.28	4646 69.19	-218.44	-11502 28.44	540.73	-819 8.77	3740 3.30	-45 6.21	2679 6.94	-32 6.84	-7239 9.01	883.05
IHD attributable to Low Physical Activity	Global	9532 73.41	5070 18.47	53.19	1154 612.19	121.12	-7083 57.26	-74.31	6459 8.03	4111 2.12	63.64	7142 0.80	110.56	-479 34.89	-74.2
	Low SDI	4575 6.05	-64 1.04	-1.4	603 63.74	131.93	-1396 6.65	-30.52	238 3.91	64.04	2.69	284 2.44	119.23	-522.56	-21.92
	Low-middle SDI	3002 63.42	7306 7.30	24.33	2866 76.67	95.48	-5948 0.56	-19.81	1672 2.84	470 4.05	28.13	1383 7.71	82.75	-181 8.92	-10.88
	Middle SDI	4957 17.03	2151 03.49	43.39	3703 36.24	74.71	-8972 2.70	-18.10	3187 0.09	1503 0.18	47.16	2047 1.59	64.23	-363 1.68	-11.40
	High-middle SDI	2514 23.84	1958 02.49	77.88	2249 09.32	89.45	-1692 87.97	-67.33	2140 0.12	1710 1.65	79.91	1565 6.70	73.16	-1135 8.23	-53.08
	High SDI	-1401 95.31	1557 84.90	-11 1.12	1391 61.79	-99.26	-4351 42.01	310.38	-780 8.23	1471 1.42	-18 8.41	1038 7.07	-133.03	-3290 6.72	421.44

Table 2. Changes in YLDs and YLLs by Determinants and Causes of Population Levels, 1990–2021

Cause	Location	**YLDs** Overall difference	Change due to Population-level determinants (%contribute to the total change) Aging	Perc ent%	Popul ation	Perc ent%	Epidemi ological change	Perc ent%	**YLLs** Overall differ ence	Change due to Population-level determinants (%contribute to the total change) Aging	Perc ent%	Popul ation	Perc ent%	Epidemi ological change	**Perc ent%**
IHD attributable To High Body Mass Index	Global	1530 04.72	3491 7.33	22.82	7985 3.94	52.19	3823 3.45	24.99	45414 19.69	1729 775.80	38.09	3864 743.63	85.10	-10530 99.74	-23. 1930
	Low SDI	504 6.85	-93.18	-1.85	310 1.76	61.46	203 8.27	40.39	2994 58.29	-667 5.96	-2.23	2492 47.02	83.23	5688 7.24	19.00
	Low-middle SDI	2496 2.24	274 9.80	11.02	1137 3.22	45.56	1083 9.22	43.42	15279 61.48	2022 53.44	13.24	9154 89.92	59.92	4102 18.12	26.85
	Middle SDI	5643 9.39	1291 4.35	22.88	2033 9.30	36.04	2318 5.74	41.08	19762 87.20	6115 65.06	30.95	9840 35.39	49.79	3806 86.75	19.26
	High-middle SDI	4346 7.50	1543 9.45	35.52	1832 0.65	42.15	970 7.40	22.33	9714 64.09	7735 85.60	79.63	8217 28.76	84.59	-6238 50.27	-64.22
	High SDI	2294 1.50	1070 8.08	46.68	1232 9.32	53.74	-95.89	-0.42	-2356 59.98	4621 32.69	-196.10	4523 39.87	-191.95	-11501 32.54	488.05
IHD attributable to Low Physical Activity	Global	30736.74	8902.39	28.96	21767.17	70.82	67.18	0.22	9225 36.67	4981 16.08	53.99	1132 845.02	122.80	-708 424.43	-76.79
	Low SDI	797.73	-3997.00	-0.50	725.54	90.95	76.18	9.55	449 58.32	-637.04	-1.42	596 38.19	132.65	-140 42.83	-31.24
	Low-middle SDI	5712.32	1142.44	20.00	3988.58	69.82	581.30	10.18	2945 51.10	719 24.86	24.42	2826 88.09	95.97	-600 61.86	-20.39
	Middle SDI	12695.14	3943.38	31.06	6940.32	54.67	1811.44	14.27	4830 21.89	2111 60.12	43.72	3633 95.92	75.23	-915 34.15	-18.95
	High-middle SDI	8287.20	3196.49	38.57	4418.07	53.31	672.64	8.12	243 136.63	1926 05.99	79.22	2204 91.25	90.69	-1699 60.61	-69.90
	High SDI	3218.43	3031.80	94.20	3293.51	102.33	-3106.89	-96.53	-1434 13.74	1527 53.10	-106.51	1358 68.29	-94.74	-43203 5.12	301.25

Given the identified correlation between female IHD and the SDI, we conducted a comprehensive analysis of health disparities. Health inequality analysis suggested that the absolute burden attributable to both high BMI and low PA remained concentrated in countries with higher SDI, but the degree of inequality decreased from 1990 to 2021. This pattern indicates that the burden is gradually spreading toward lower-SDI populations as demographic growth, aging, and lifestyle transitions accelerate (**Figures 15 and 16**).

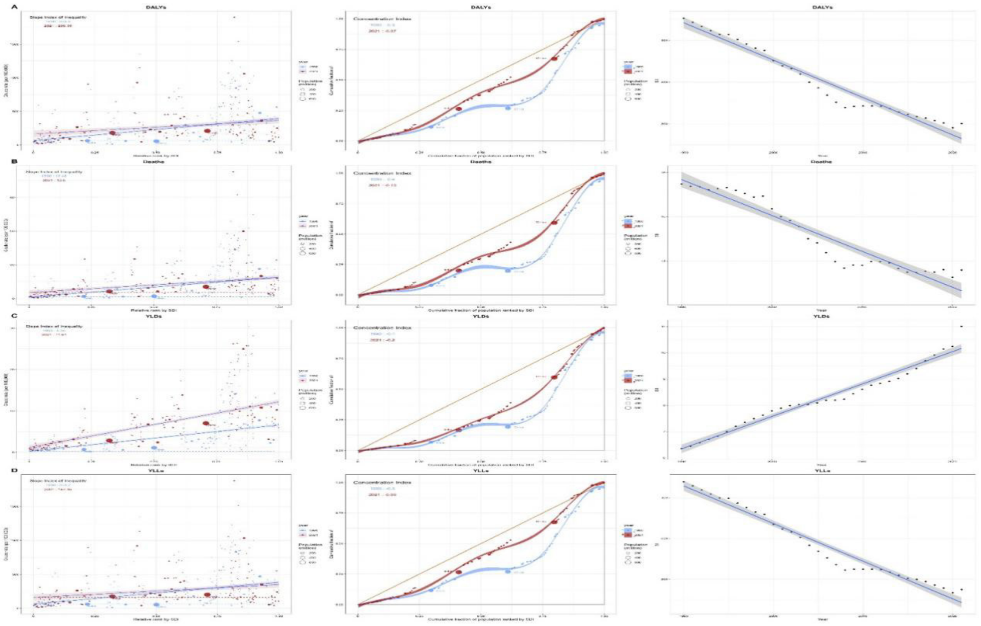


Figure 15. Absolute income-related health inequality for DALYs, Deaths, YLDs, YLLs of female IHD attributable to high BMI in SII analysis, 1990 and 2021.

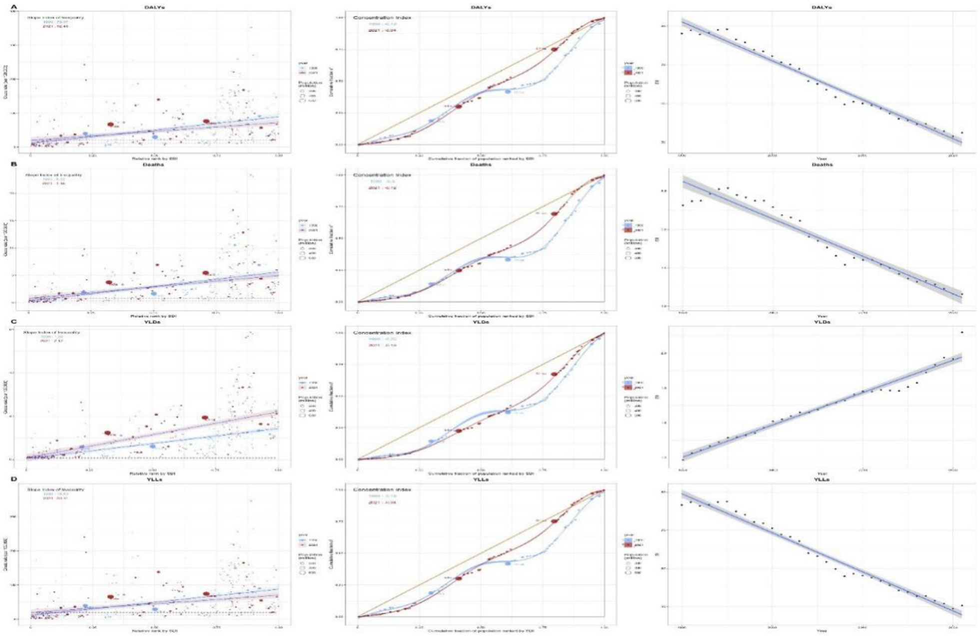
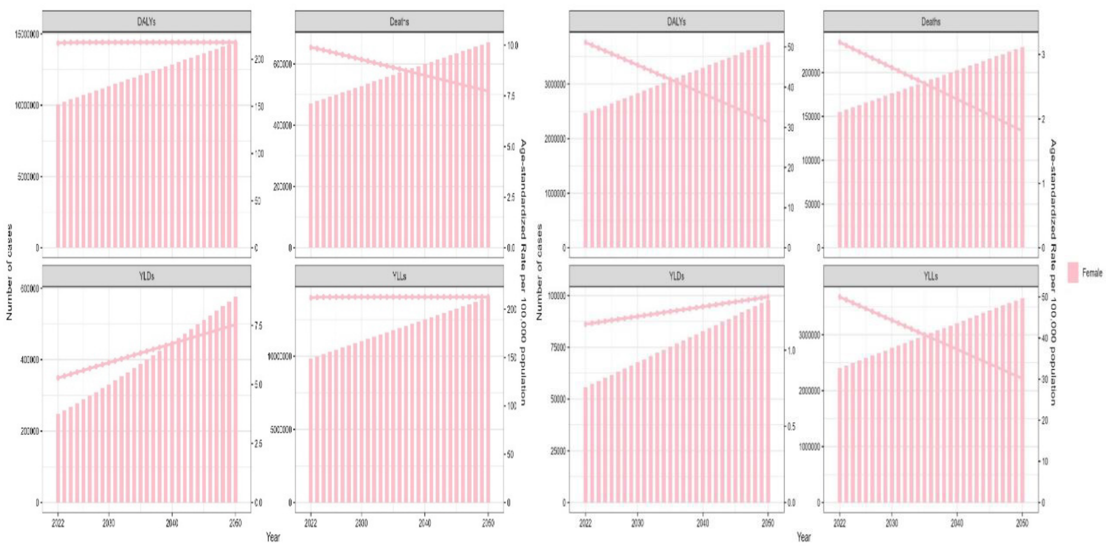


Figure 16. Absolute income-related health inequality for DALYs, Deaths, YLDs, YLLs of female IHD attributable to low PA in SII analysis, 1990 and 2021.

3.7. Projections of IHD burden in women due to high BMI and low PA over the next 29 years

We applied the auto. The ARIMA function was used to analyze global data pertaining to IHD among women, specifically due to high BMI and low PA over the period from 1990 to 2021. ARIMA projections suggested that ASRs of DALYs, deaths, and YLLs attributable to high BMI and low PA will continue to decline to 2050, while YLD rates may remain stable or increase. This indicates that the non-fatal health burden associated with ischemic heart disease (IHD) and the increasing burden of chronic diseases caused by population aging are both escalating. Therefore, public health initiatives should advance from a primary focus on mortality reduction to enhancing quality of life, disability, functional limitation, and quality of life among women with IHD will become increasingly important (**Figures 17 and 18**).

(17) (18)



Figures 17 and 18. Time trends in age-standardized rates of DALYs, Deaths, YLDs, and YLLs attributable to ischemic heart disease in women due to high BMI/ low PA from 2022 to 2050.The pink dots and vertical bar represent the predicted trend and its 95% CI.

4. Discussion

This study, based on GBD 2021 data, systematically evaluated the global burden of IHD among women attributed to high BMI and insufficient PA from 1990 to 2021. The results indicated that during this period, the ASR of DALYs, mortality rates, YLDs, and YLLs of IHD among women due to high BMI and inadequate PA all exhibited an upward trend, indicating that these two major risk factors remain the focus of current IHD prevention and control in women. Our result is consistent with the latest Lancet GBD 2021 report, which identifies IHD as one of the major threats to women’s health globally. Moreover, its disease burden is closely linked to obesity and physical inactivity [16]. Nevertheless, compared to some previous studies, we further revealed the heterogeneity of disease burden distribution among different age groups, SDI regions, and countries. Particularly among middle-aged and older adult women, and in regions with moderate SDI, the effects of high BMI and low PA on IHD exhibited different age patterns and regional shifts in disease burden.

This may be associated with changes in population structure, the phase of economic development, and the specific physiological and social factors of women.

The study found that the impact of high BMI and reduced PA on the burden of IHD in women exhibited variations in age distribution: deaths and YLLs related to high BMI increased rapidly after 80–84 years, whereas indicators related to low PA began to increase significantly from 75–79 years. Additionally, the changing trend of YLDs suggests that disability associated with low PA lasts longer, particularly increasing rapidly after 70–74 years. These patterns may be associated with the sudden decrease in estrogen levels, lipid metabolism disorders, and atypical IHD symptoms during and after perimenopause in women, resulting in an increased risk of functional disability [17]. Meanwhile, older adult women frequently have multiple chronic diseases, including cancer and diabetes, and competing risks of death may affect the age distribution of the IHD burden [18,19]. Regarding PA, the duration of disability after IHD in women is prolonged, although the BMI factor generally contributes to the extended overall burden. Consequently, we must prioritize the primary and secondary prevention of IHD in women and highlight the importance of regular physical exercise, which can alleviate the significant economic burden associated with health care costs and mitigate its effects on mortality and overall well-being.

The innovation of this study lies in its systematic depiction of the global spatiotemporal distribution of the burden of IHD in women due to high BMI and insufficient PA, and the related differences in the SDI. Additionally, it designates areas with moderate SDI as current weak prevention and control zones. Our findings indicate that as the SDI increases, the disease burden changes in an “n” shape. In low-income areas, the problems of low-calorie intake due to insufficient food and the problems of high energy consumption caused by physical labor are less common. High-income countries have adequate resources and infrastructure to enhance healthy diets. Primary healthcare disseminates knowledge on obesity prevention and offers intervention measures, including bariatric surgery, thereby reducing the incidence of elevated BMI [20]. However, middle-income regions have become newly susceptible areas regarding the burden of IHD due to factors such as Westernized dietary patterns, insufficient sports facilities, and the pressure of women’s social roles [21]. Women in low-income areas face significantly reduced PA opportunities because of the shortage of sports facilities and the distribution of family responsibilities, whereas women in middle-income areas have had fewer opportunities to engage in physical activities because of extended working hours and increasing stress levels brought about by rapid economic growth [22]. Although high SDI regions have better medical resources, the increase in white-collar occupations and reliance on electronic devices has resulted in a significant decline in PA [23]. Therefore, we advocate for implementing a regional differentiation strategy: regions with low SDI should enhance primary medical care and community health facilities; medium SDI regions require the integration of policy and environmental transformation to foster structural health support; and in areas with high SDI, individualized risk assessment and long-term prevention mechanisms should be emphasized [24,25].

Based on the data analysis of IHD in females and the factors of high BMI and low PA over the past 32 years, the prediction for the next 29 years (2022–2050) indicates that we should continue to enhance primary and secondary prevention efforts, promote a healthy diet and regular exercise to control weight, and reduce the risk of the disease at its source. The focus of work should be on maintaining and enhancing physical activity levels as well as enhancing cardiac rehabilitation, chronic disease management, and long-term care systems, to improve the quality of life of patients, mitigate the increase in YLDs, reduce the burden of disability, and optimize health benefits, including morbidity and mortality reduction. Moreover, interventions aimed at reducing low physical activity are anticipated to be more effective than those addressing high BMI before 2050, as measured using DALYs.

This study has some limitations. First, the GBD data relied on the reporting systems of various countries. The data quality and completeness in regions with low SDI might be inadequate, affecting the accuracy of cross-regional comparisons. Second, BMI, as an obesity indicator, failed to differentiate between types or distribution of body fat. Future research should combine indicators such as waist-hip ratio and bioelectrical impedance to enhance assessment accuracy. Moreover, PAs' data were primarily derived from self-reported questionnaires, which introduced recall bias. In the future, smart wearable devices can be employed for objective monitoring. Multiple factors, including physiology and social factors, influence female IHD. Subsequently, methods, such as Mendelian randomization, can be employed to investigate further the causal relationships and biological mechanisms [26]. Furthermore, this study did not analyze differences across racial groups or between urban and rural populations, nor did it include the latest GBD data from 2021. All these factors must be considered in future research.

5. Conclusion

This study demonstrated that ASR of the disease burden caused by IHD among global women decreased between 1990 and 2021, although the absolute number of cases continued to increase, indicating that the actual impact of IHD on women's health is still intensifying. Significant differences were observed among different regions and SDI levels. Women in medium-high and high SDI areas need to be vigilant about the persistent threat induced by high BMI. Women in areas with medium to low SDI are facing an increasing burden of IHD, which urgently requires more attention from health authorities and policymakers. Population growth and aging facilitate the increase in the number of IHD cases due to a larger population size and age-related risk. By 2050, the burden of IHD due to high BMI is expected to stabilize; however, it will be characterized more by chronic disability rather than premature death. Moreover, increasing women's physical activity continuously reduces IHD burden, especially helping to reduce premature death and YLLs. To address this challenge, it is essential to enhance women's health awareness, promote balanced diets, encourage regular exercise, and establish a health care support system for women at all life stages. Additionally, the medical system should be strengthened, resource allocation maximized, and collaboration among the government, communities, families, and individuals encouraged to collectively undertake targeted intervention measures to mitigate the overall burden of IHD on women globally.

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Disclosure statement

The authors declare no conflict of interest.

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