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Analysis and Prediction of the Disease Burden Trend of Rheumatic Heart Disease in China, Asia, and the World from 1990 to 2021

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Abstract: *This study uses the 2021 GBD dataset to analyze RHD epidemiological data in China, Asia, and globally from 1990 to 2021. It aims to provide a scientific basis for precise prevention and control strategies. The study assesses RHD incidence, prevalence, mortality, and DALYs using DisMod-MR and CODEm models and predicts future trends with Joinpoint software. Results show that global RHD incidence increased from 44.867 to 50.738 per 100,000 from 1990 to 2021, with rising prevalence but decreasing mortality and DALYs. In China, RHD cases and incidence significantly declined, with mortality dropping from 19.071 to 4.215 per 100,000 and DALYs also reduced. In Asia overall, RHD cases increased, but incidence and prevalence slightly decreased, and mortality and DALYs trended downward. Future predictions indicate that RHD incidence may rise among Chinese women but decline among men, with decreasing mortality for both genders. Recommendations include increasing government investment, enhancing early diagnosis and treatment, and mobilizing societal participation in prevention and education to reduce the global RHD burden.*

Keywords: *RHD, GBD, Disease burden, Global, Asia, China, Prediction*

1. Introduction

Rheumatic heart disease (RHD), an autoimmune cardiac valvular disease caused by streptococcal infection[1,2], currently affects over 33 million people globally[3], leading to approximately 250,000 deaths annually[4]. It has long posed significant challenges to public health systems, particularly in developing countries[5,6]. The threat to public health is evident, as RHD often results in early mortality and heart failure[7]. Despite advancements in medical technology and the effective implementation of public health measures that have led to a decline in RHD incidence in some regions, we cannot overlook the vast patient population and the significant disease burden it imposes[6].

This study conducted an in-depth analysis of the epidemiological data of RHD in China, Asia, and globally from 1990 to 2021, revealing trends in key indicators such as incidence, prevalence, mortality, and DALYs. It aims to provide a comprehensive understanding of the RHD disease burden and offer scientific evidence and data support for the development of precise and effective prevention and control strategies and policy recommendations [8,9].

By comprehensively analyzing the GBD dataset, we clarified the development trends of RHD globally and in different regions and assessed the achievements and shortcomings of China and Asia in addressing RHD [10,11]. This serves as an important reference for the rational allocation of public health resources in the future. We hope that this study will provide new perspectives for global RHD prevention and control efforts and promote the development of global public health.

2. Data Sources and Statistical Methods

2.1. Data Sources

This study uses the 2021 GBD dataset from 204 countries, covering over 300 diseases. It includes data from 46,749 studies. GBD helps assess disease burden by summarizing risks and exposures[12]. RHD, especially involving heart valves, is a serious result of streptococcal infections, causing early death and heart failure[^GBD etiology classification B.2.1, ICD-10 codes: I00-I02, I05-I09^].

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DisMod-MR and CODEm tools were used. DisMod-MR ensures consistent data and assesses epidemiological parameters. CODEm mines death data and selects covariates [13,14].

We extracted data on RHD incidence, prevalence, mortality, and DALYs in China, Asia, and globally from 1990 to 2021 through the Global Health Data Exchange (GHDx) platform, using these metrics as key indicators to assess the RHD disease burden[15,16]. In addition, we applied the ARIMA model in conjunction with historical data and current trends to forecast the RHD disease burden for the coming years[17-19], and used qualitative analysis methods to explore the main factors influencing the RHD disease burden and their mechanisms, thereby providing theoretical support for the development of prevention and control measures.

Given that the 2021 GBD data have been publicly released, and this study strictly adheres to principles of academic integrity and data protection, the institutional ethics committee has approved the exemption of ethical review requirements for this study. Furthermore, the reporting process of this study rigorously follows internationally recognized guidelines for accurate and transparent health assessment reports, ensuring the scientific rigor and credibility of the research findings.

2.2 Statistical Methods

We extracted data on rheumatic heart disease (RHD) in China, Asia, and globally from the Global Burden of Disease (GBD) database, including incidence, prevalence, mortality, DALYs, and age-standardized and crude rates[20-22].

We used Joinpoint software (version 4.9.1.0) to calculate the Average Annual Percent Change (AAPC) and its 95% Confidence Interval (95% CI), analyzing disease burden trends through regression models: AAPC greater than 0 indicates an increase, less than 0 indicates a decrease, and including 0 indicates stability[23,24].

Statistical analysis and data visualization were conducted using R (version 4.4.1) and Joinpoint, with a significance level of $P<0.05$. The study aims to provide data support for understanding and addressing the global and regional burden of RHD.[25]

3. Results

3.1. Incidence, Prevalence, Mortality, and DALYs of RHD in China, Asia, and Globally

Since 1990, China has made significant achievements in the prevention and control of Rheumatic Heart Disease (RHD): the number of cases and incidence rate have decreased markedly, while the prevalence rate has seen a slight increase but a downward trend after age-standardization; the mortality rate has been significantly reduced, and the health burden has also been greatly alleviated. Meanwhile, in the Asian region, the number of RHD cases has increased, but the incidence rate has slightly decreased, the prevalence rate has significantly risen yet slightly declined after age-standardization, and both the mortality rate and health burden have been mitigated. Globally, the incidence and prevalence rates of RHD have both significantly increased, while the mortality rate and health burden have shown a downward trend.*(see Table 1)*

Table 1: Age-specific and age-standardized incidence, prevalence, mortality, DALYs rates, and corresponding AAPCs for all age groups of patients in China, Asia, and global market in 1990 and 2021.

Location	Measure	1990		2021		1990-2021AAPC
		All-ages cases	Ages-standardlized rate per 100000 people	All-ages cases	Ages-standardlized rate per 100000 people	
		n (95%CI)	n(95%CI)	n(95%CI)	n(95%CI)	n(95%CI)
China	Incidence	620196 (484500-778536)	48.917 (38.617-60.365)	445473 (360394-544037)	39.856 (31.521-49.646)	-0.6621 (-0.7149-0.6092)
	Prevalence	8926340 (6909494-11186050)	708.27 (558.87-875.809)	9073096 (7393886-10994319)	619.846 (492.055-763.736)	-0.4279 (-0.4873-0.3685)
	Deaths	134209 (109949-157944)	19.071 (15.776-22.571)	78911 (61703-100718)	4.215 (3.301-5.372)	-4.8158 (-5.0561-4.5750)
	DALYs	4358673 (3628079-5149013)	476.327 (398.173-563.389)	2051187 (1658964-2526905)	111.69 (90.422-136.807)	-4.6303 (-4.7955-4.4649)
Asia	Incidence	1523784 (1198385-1906312)	42.847 (34.22-52.933)	1877523 (1495320-2324470)	42.713 (33.874-53.142)	-0.0074 (-0.0407-0.0259)
	Prevalence	19579103 (15226667-24415873)	610.12 (482.899-748.053)	29340990 (23128015-36210035)	609.356 (476.186-753.864)	-0.0123 (-0.0812--0.0566)

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	Deaths	334074 (270774-406380)	16.362 (13.272-19.807)	316110 (268277-388884)	6.578 (5.6-8.037)	-2.8966 (-3.0656-2.7273)
	DALYs	12833829 (10619475-15465370)	501.897 (410.968-608.697)	10714855 (9182838-12693979)	217.241 (186.557-256.806)	-2.648 (-2.8503-2.4989)
Global	Incidence	2582797 (2048575-3206438)	44.867 (36.005-55.32)	3854686 (3056085-4783798)	50.738 (40.097-63.057)	0.3961 (0.3723-0.4199)
	Prevalence	32335630 (25584153-40049558)	607.757 (488.157-744.058)	54785119 (43328407-67605542)	684.203 (540.406-848.901)	0.3796 (0.3563-0.4030)
	Deaths	418363 (349610-493410)	10.212 (8.563-11.99)	373345 (324140-444762)	4.471 (3.888-5.312)	-2.6298 (-2.7647-2.4948)
	DALYs	16280071 (13707291-19177011)	347.53 (292.457-409.571)	13426369 (11517021-15780164)	162.121 (139.057-190.523)	-2.4328 (-2.5778-2.2875)

3.2. Trends in the Burden of Rheumatic Heart Disease in China, Asia, and Globally

3.2.1. Global Trends in the Burden of Rheumatic Heart Disease

From 1990 to 2021, the global age-standardized incidence rate (ASIR) and prevalence rate (ASPR) of rheumatic heart disease (RHD) initially declined and then significantly increased (P<0.05). The annual percentage change (APC) of ASIR was -0.02% from 1990 to 1996 and 0.41% from 2013 to 2021. The APC of ASPR was -0.13% from 1990 to 1996 and 0.40% from 2014 to 2021.During the same period, the age-standardized mortality rate (ASMR) and disability-adjusted life years (DALYs) generally decreased (P<0.05). The APC of ASMR was -1.5% from 1990 to 1992 and -2.82% from 2017 to 2021. The APC of DALYs was -1.54% from 1990 to 1992 and -2.30% from 2014 to 2021. (Figure 1).

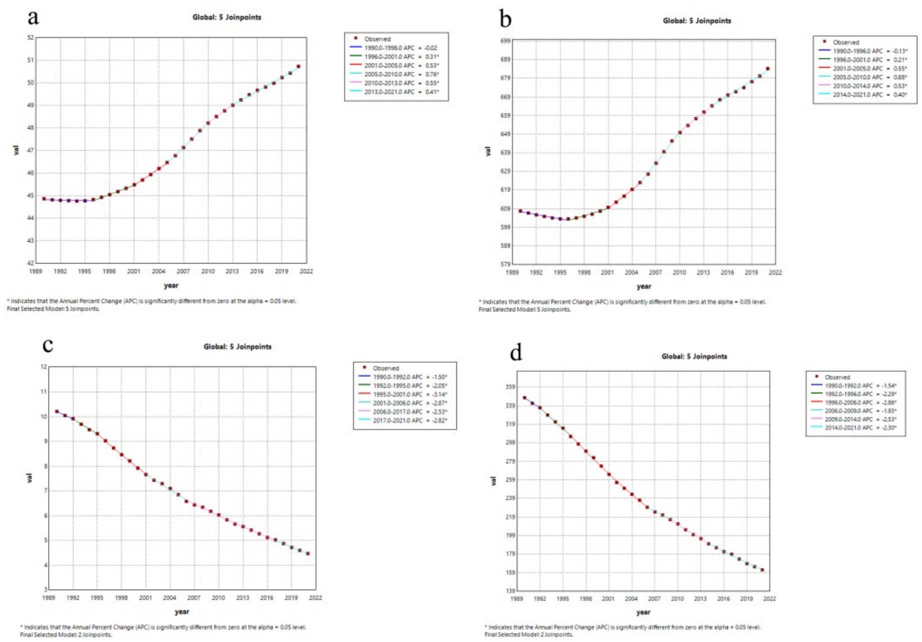

Figure 1: The APC of ASIR, ASPR, ASMR, and ASDR of RHD in Golabl from 1990 to 2021 (means p-values < 0.05 and significant results). (a) ASIR; (b) ASPR;(c)ASMR; (d) ASDR*

3.2.2. Trends in the Burden of Rheumatic Heart Disease in Asia

Figure 2 comprehensively presents the joinpoint regression analysis results of several key indicators of rheumatic heart disease (RHD) in Asia from 1990 to 2021. In Asia, the trends of ASIR and ASPR show significant similarities, both declining from 1990 to 2001 and then significantly increasing from 2001 to 2014. Subsequently, ASIR decreased from 2015 to 2019 and then rose again from 2019 to 2021, while ASPR slightly declined from 2014 to 2021 (P<0.05). In stark contrast to the fluctuating trends of ASIR and ASPR, both ASMR and DALYs consistently decreased in Asia from 1990 to 2021 (P<0.05). These complex fluctuations are visually represented in Figure 2.

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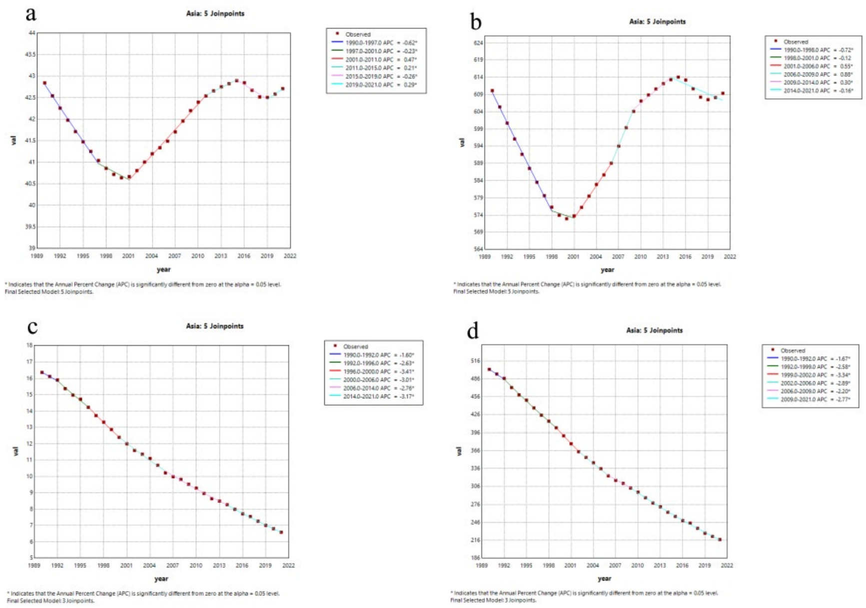

Figure 2: The APC of ASIR, ASPR, ASMR, and ASDR of RHD in Asia from 1990 to 2021 (means p-values < 0.05 and significant results). (a) ASIR; (b) ASPR;(c)ASMR; (d) ASDR*

3.2.3. Trends in the Burden of Rheumatic Heart Disease in China

Figure 3 shows the joinpoint regression analysis results of the four core indicators of rheumatic heart disease (RHD) in China from 1990 to 2021. The ASIR and ASPR exhibited significant fluctuations during this period: the ASIR decreased from 1990 to 2000, increased from 2000 to 2010, and decreased again from 2010 to 2021; the ASPR decreased from 1990 to 2002, increased from 2002 to 2009, and decreased from 2009 to 2021 (all $P<0.05$). In contrast, the ASMR and DALYs showed a consistent downward trend: the APC of ASMR remained negative throughout the period from 1990 to 2021, and the APC of DALYs also indicated a steady decline ($P<0.05$) (see Figure 3).

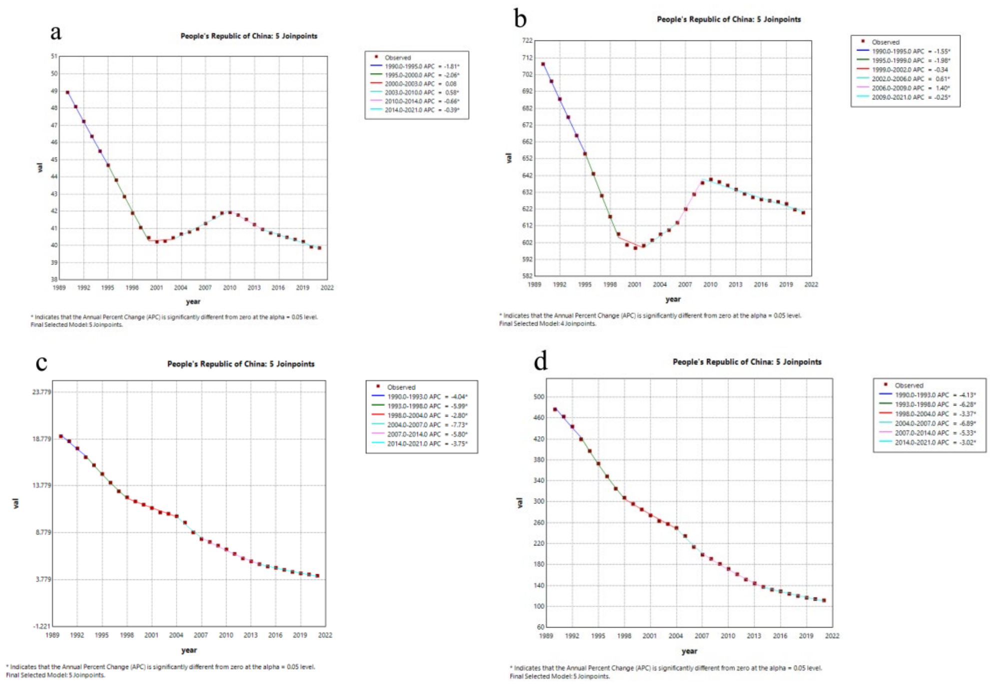

Figure 3: The APC of ASIR, ASPR, ASMR, and ASDR of RHD in China from 1990 to 2021 (means p-values < 0.05 and significant results). (a) ASIR; (b) ASPR;(c)ASMR; (d) ASDR*

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3.3. Burden of RHD Across Different Age Groups in China in 1990 and 2021

Figure 4 provides a detailed comparison of the incidence, prevalence, mortality, and disability-adjusted life years (DALYs) of rheumatic heart disease (RHD) across different age groups in China between 1990 and 2021, accompanied by crude rate analyses.

3.3.1. Incidence

In terms of incidence, RHD is particularly prevalent among individuals under 50 years old, with the highest number of cases observed in the 0-35 age bracket. Notably, the crude incidence rate (CIR) of RHD in China shows an upward trend from the 0-14 to 15-19 age group in both 1990 and 2021, followed by a gradual decline in the 20-54 age group, with the highest incidence in the 0-14 age group. In contrast, the global CIR of RHD exhibits an upward trend across all age groups and is generally higher than that in China (see Figure 4a).

3.3.2. Prevalence

Regarding prevalence, the peak prevalence of RHD in China shifted from the 20-24 age group in 1990 to the 30-34 age group in 2021 (see Figure 4b). This shift reflects changes in the distribution of RHD cases over time.

3.3.3. Mortality

In terms of mortality, the age group with the highest number of deaths due to RHD was 70-74 years in 1990, while this shifted to the 80-84 age group in 2021. The crude mortality rate (CMR) of RHD increases significantly with age, a trend that remains consistent between 1990 and 2021, with the highest mortality observed in the 95+ age group (see Figure 4c).

3.3.4. DALYs

Similarly, the trend of increasing DALYs with age is also observed. Specifically, the peak DALYs for RHD in China shifted from the 55-59 age group in 1990 to the 65-69 age group in 2021 (see Figure 4d). This shift highlights the increasing burden of RHD-related disability and mortality among older age groups over time.

Overall, these changes reflect the evolving epidemiological characteristics of RHD across different age groups in China and its temporal trends. The shifting patterns of incidence, prevalence, mortality, and DALYs underscore the need for targeted interventions and policies to address the burden of RHD, particularly among vulnerable age groups.

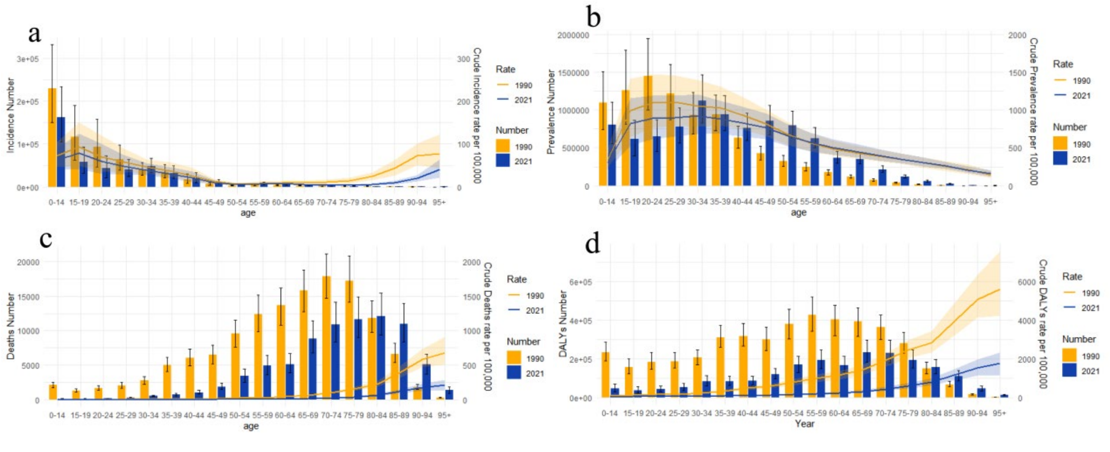

Figure 4: Comparative of the incidence, prevalence, deaths, and DALYs counts, along with their crude rates, by age group in China from 1990 and 2021; (a) Incident cases and CIR; (b) Prevalent cases and CPR; (c) Death cases and CMR; (d) DALYs counts and CDR .

3.4. Gender Differences in the Burden of RHD Across Different Age Groups in China

Figures 5 and 6 offer a comprehensive view of the trends in RHD health indicators among males and females across different age groups in China between 1990 and 2021.

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3.4.1. Incidence

The incidence of RHD peaks in the 0-14 age group and then gradually declines. In 1990, females had lower incidence than males in the 0-14 and 30-44 age groups, while they had higher incidence in other age groups. By 2021, males had higher incidence in age groups under 45 years, while females had higher incidence in age groups over 45 years (see Figures 5a and 6a).

3.4.2. Prevalence

The prevalence for both sexes increases from the 0-14 age group, peaks in the 20-24 age group, and then declines with age. In 1990, males had a higher prevalence than females in the 0-20 age group, while females had a higher prevalence after the age of 20. By 2021, except for the 0-30 age group, females generally had a higher prevalence than males (see Figures 5b and 6b).

3.4.3. Mortality

The mortality rate from RHD increases with age for both genders, reaching a peak and then declining. In 1990, females had higher mortality than males in all age groups except 15-19, with both genders peaking at 70-74 years. By 2021, while females still had higher mortality in most age groups, the peak shifted to 80-84 years for both genders (see Figures 5c and 6c).

3.4.4. DALYs

In 1990, females had lower DALYs than males only in the 15-19 age group, while they had higher DALYs in other age groups, with peaks at 55-59 years for females and 65-69 years for males. By 2021, males had higher DALYs in the 0-35 age group, while females had higher DALYs after this age group, with peaks at 65-69 years for females and 70-74 years for males (see Figures 5d and 6d).

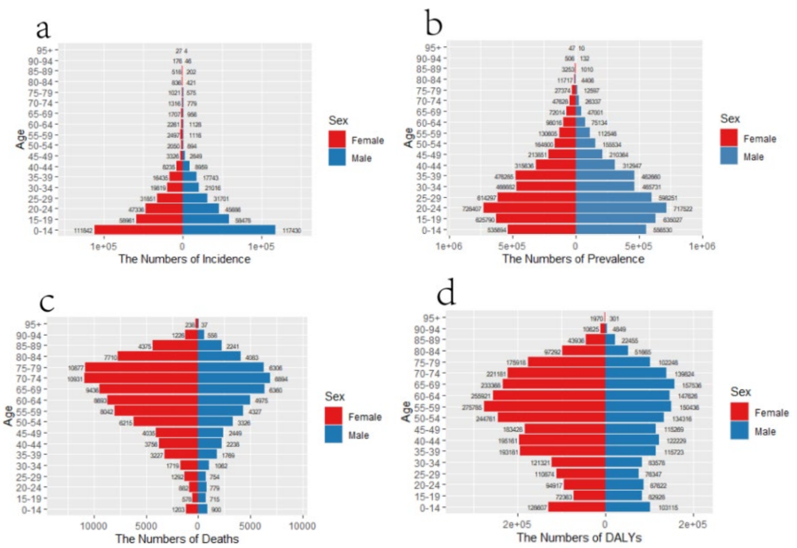
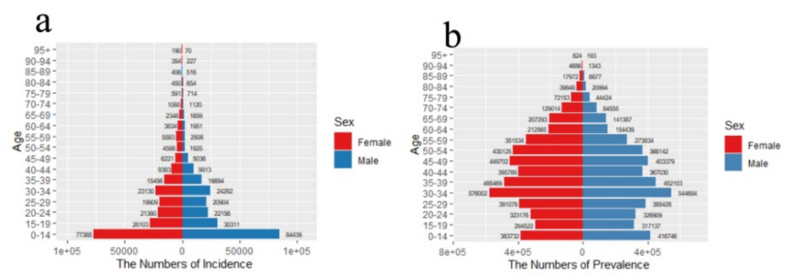


Figure 5: Displays the gender differences in RHD burden across different age groups in 1990; (a) Incident cases; (b) Prevalent cases; (c) Death cases; (d) DALYs counts.



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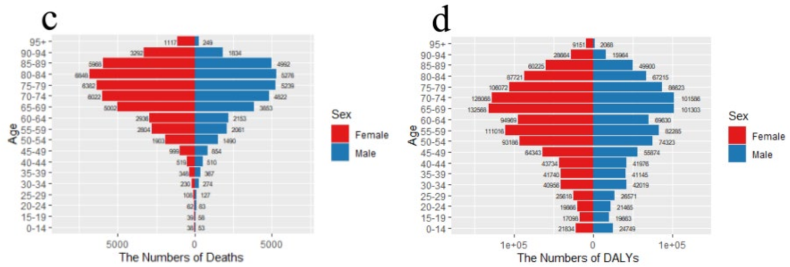


Figure 6: Displays the gender differences in RHD burden across different age groups in2021; (a) Incident cases; (b) Prevalent cases; (c) Death cases; (d) DALYs counts.

3.5. Differences in the Burden of RHD among Different Age Groups and Genders in China from 1990 to 2021

Figure 7 provides a comprehensive overview of the trends in the burden of rheumatic heart disease (RHD) and its age-standardized rates (ASIR, ASPR, ASMR, ASDR) among males and females across different age groups in China from 1990 to 2021.

3.5.1 Age-Standardized Incidence Rate (ASIR)

Figure 7a reveals that both males and females experienced peak ASIR values for RHD in 1990, followed by a steady decline in subsequent years. This indicates a gradual improvement in the incidence trends of RHD.

3.5.2 Age-Standardized Prevalence Rate (ASPR)

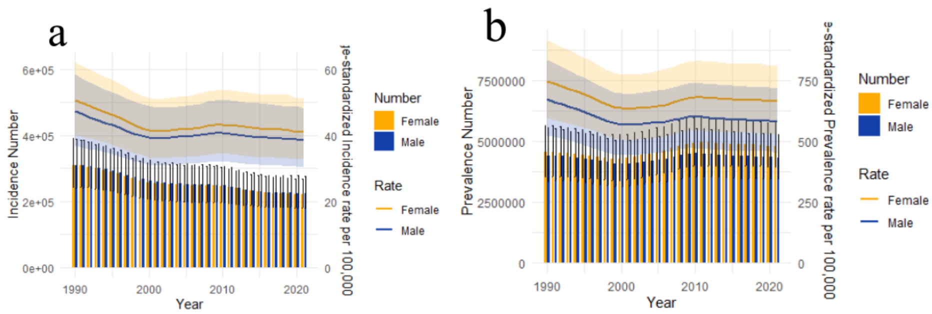
According to Figure 7b, the ASPR for RHD decreased steadily from 1990 to 2000 but showed a slight increase between 2001 and 2010, before stabilizing thereafter. Notably, females consistently had higher ASPR values than males throughout the observation period, highlighting the relatively higher risk of RHD prevalence among females.

3.5.3 Age-Standardized Mortality Rate (ASMR)

Figure 7c demonstrates significant gender differences in RHD mortality and ASMR across age groups in 1990. Notably, female ASMR was significantly higher than that of males. However, over time, this gender gap has gradually narrowed, with an overall downward trend in ASMR, reflecting positive impacts of RHD prevention and control measures.

3.5.4 Age-Standardized Death Rate (ASDR)

The trends in ASDR shown in Figure 7d mirror those of ASMR, confirming the overall decline in RHD mortality and the narrowing of the gender gap. These findings provide robust evidence for the effectiveness of public health policies aimed at reducing the burden of RHD.



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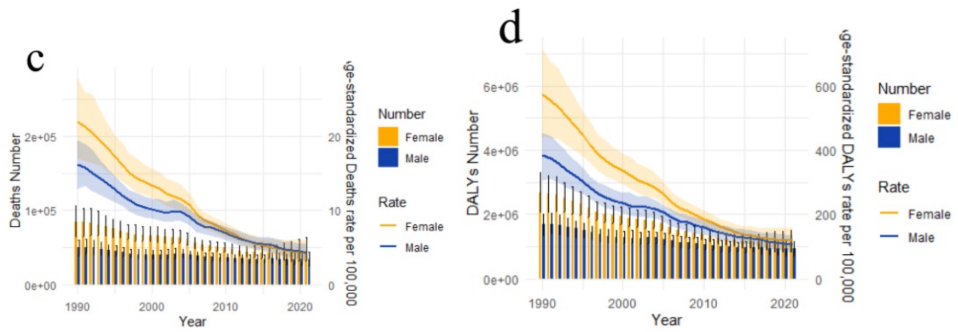

Figure 7: Comparison of full-age cases and age-standardized rates of incidence, prevalence, mortality and DALYs among men and women in China from1990 to 2021. (a) Incident cases and ASIR; (b) Prevalent cases and ASPR; (c) Death cases and ASMR; (d) DALYs counts and ASDR.

3.6. Predicted Trends in Incidence and Mortality Rates of RHD for Chinese Males and Females Over the Next 15 Years

Figure 8, based on the ARIMA model, forecasts the incidence and mortality trends of RHD among Chinese males and females over the next 15 years. The results indicate that the incidence rate among males will remain low, while the incidence rate among females may increase; mortality rates for both genders are expected to continue declining. These findings suggest the need for targeted interventions, especially to prevent the rise in female incidence, while maintaining the downward trend in mortality. This highlights the importance of developing gender-specific RHD prevention and control strategies.

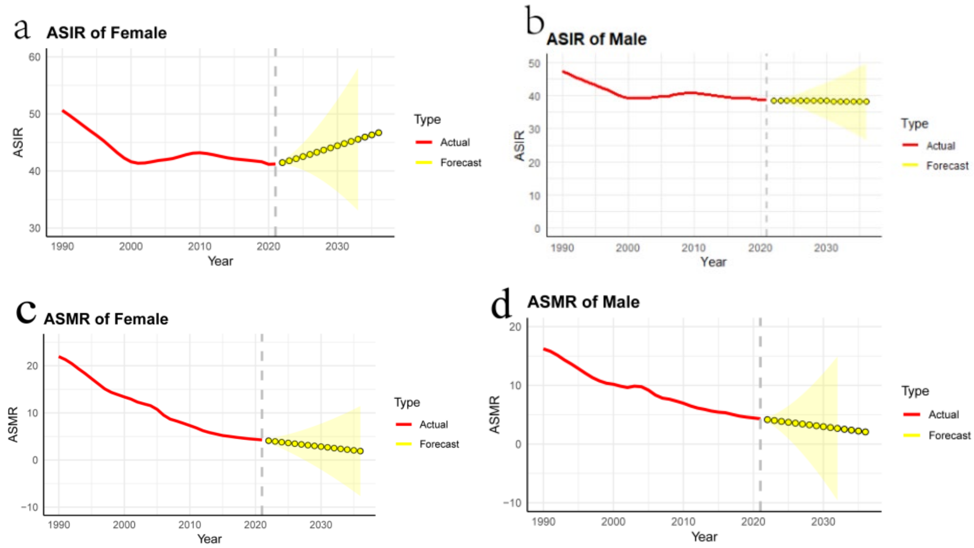

Figure 8: Shows the predicted trends in incidence and mortality rates for Chinese women and men over the next 15 years. (a) Female ASIR; (b) Male ASIR; (c) Female ASMR; (d) Male ASMR

4. Conclusion and Outlook

Although China and Asia show different trends in the burden of RHD, the global incidence and prevalence of RHD are still rising, posing a challenge to global public health [26, 27]. However, the mortality rate of RHD is declining globally, in Asia, and in China, with a particularly significant reduction in China. This reflects China's achievements in the prevention, diagnosis, and treatment of RHD and provides valuable experience for other countries and regions [28].

Looking Ahead: Using the ARIMA model and historical data, we forecast the incidence and mortality rates of RHD among different genders and age groups in China over the next 15 years, including confidence intervals. The predictions suggest that the incidence rate among females may rise over the next 15 years, while it is expected to decline among males. However, mortality rates for both genders are projected to continue falling, indicating progress in RHD prevention and control [29-32].

Policy Recommendations: To address the impact of RHD on global public health, we recommend

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that governments increase investment and develop scientific policies; medical institutions enhance early diagnosis and treatment capabilities; and all sectors of society participate in prevention and education activities to improve public health literacy. Through global cooperation, we can gradually reduce the incidence, mortality, and DALYs associated with RHD and advance global public health [33-35].

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