Original Article

Long-Term Changes and Disparities in the Global Burden of Rheumatic Heart Disease between 1990 and 2021: An Analysis Based on the Global Burden of Disease (GBD) Study

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Highlights

- Global age-standardized mortality and DALY rates of rheumatic heart disease (RHD) declined substantially between 1990 and 2021 (56% and 53%, respectively), reflecting major progress in disease control. Years of life lost (YLL) decreased by 59%, whereas years lived with disability (YLD) increased by 11%, indicating a shift from fatal outcomes toward chronic nonfatal burden.Marked sociodemographic disparities persist, with low- and low-middle–SDI regions—particularly South Asia—bearing a disproportionate share of global RHD deaths and DALYs.This comprehensive GBD 2021 analysis provides a long-term comparative assessment of fatal and nonfatal RHD burden across SDI levels and regions, informing targeted, equity-focused health policy and long-term care strategies.

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ABSTRACT

Background: Rheumatic heart disease (RHD) remains a major cause of preventable cardiovascular morbidity and mortality, particularly in low- and middle-income countries. Despite the World Health Organization's 2018 resolution calling for global elimination of RHD, substantial disparities in disease burden persist across regions and levels of socio-economic development. While previous studies have reported global trends, a clear comparative assessment of long-term changes in both fatal and non-fatal RHD burden across socio-demographic and geographic regions remains limited. This study aimed to assess long-term changes in the global burden of RHD between 1990 and 2021, with a specific focus on regional and socio-demographic disparities, using the most recent estimates from the Global Burden of Disease (GBD) 2021 study. We additionally assessed temporal trends across Socio-demographic Index (SDI) groups and GBD regions, with a specific focus on fatal (YLL) and non-fatal (YLD) components of disease burden.

Methods: We conducted a secondary analysis of model-based estimates from the Global Burden of Disease (GBD) 2021 study to assess the burden of RHD between 1990 and 2021. Metrics included age-standardized and all-age incidence, prevalence, mortality, years of life lost (YLL), years lived with disability (YLD), and disability-adjusted life years (DALY). Data were stratified by five Socio-demographic Index (SDI) levels and 13 global regions. Estimates were produced using DisMod-MR 2.1 and CODEm and are reported as means with 95% uncertainty intervals (UIs).

Results: Globally, age-standardized mortality and DALY rates for RHD declined by 56% and 53%, respectively, from 1990 to 2021. YLL decreased by 59%, while YLD rose by 11%, indicating a shift toward chronic non-fatal burden. For instance, the global age-standardized mortality rate fell from 9.1 (95% UI: 8.4–9.8) to 4.0 (3.6–4.5) per 100,000. High and high-middle SDI regions achieved the greatest reductions across all indicators. In contrast, low and low-middle-SDI regions experienced persistently high absolute deaths and DALYs, with South Asia alone accounting for over 27% of global RHD deaths in 2021. Females consistently bore a higher non-fatal burden (YLD) than males. Although the dataset includes the COVID-19 era, the specific impacts of the pandemic on RHD care and outcomes warrant further investigation. Across all SDI groups and regions, declines in DALYs were largely driven by reductions in years of life lost (YLLs), whereas years lived with disability (YLDs) remained relatively stable.

Conclusions: While global RHD mortality has declined, substantial regional and socioeconomic disparities persist. The epidemiologic transition towards disability highlights the need for long-term care infrastructure, particularly for women, children, and low-SDI regions. While based on modelled estimates, this analysis offers the best available insight into global RHD epidemiology and informs data-driven health policy and planning. Despite overall improvements, substantial disparities persist between low and high SDI settings, underscoring the need for context-specific prevention and long-term management strategies.

Keywords: Rheumatic Heart Disease; Global Burden of Disease; Age-Standardized Rate; Disability-Adjusted Life Years; Years of Life Lost; Years Lived with Disability; Sociodemographic Index

Background

Rheumatic heart disease (RHD) remains a significant and preventable cause of cardiovascular morbidity and mortality, particularly in low- and middle-income countries.[1-4]

It primarily affects children and adolescents, often resulting in lifelong cardiac complications that require sustained medical attention and specialized interventions. In addition to its direct health impacts, RHD places a heavy strain on healthcare systems, especially those in resource-constrained settings, due to the demand for long-term care, surgical services, and ongoing follow-up. The burden of RHD is disproportionately concentrated in low- and middle-income countries, reflecting deep geographic inequities in access to preventive services, early diagnosis, and appropriate treatment[4]. These disparities are further compounded by the social and economic consequences of the disease, such as missed educational opportunities and reduced long-term productivity.

Despite global awareness and recent policy efforts—including the World Health Organization's 2018 resolution to eliminate rheumatic fever and RHD as public health concerns—major knowledge gaps remain[5]. Previous studies have often been limited in scope, focusing primarily on mortality or restricted geographical regions, and have failed to capture the full spectrum of the disease burden, including non-fatal outcomes like years lived with disability (YLD) and years of life lost (YLL)[6]. Without comprehensive and up-to-date data, global and national efforts to monitor progress and implement effective interventions remain hindered.

Several studies have previously examined the global burden of rheumatic heart disease using data from the Global Burden of Disease (GBD) Study. For example, Ou et al. reported substantial declines in age-standardized mortality from 1990 to 2019, alongside persistently high burden in low-income regions[6]. More recently, Zhang et al. provided an updated analysis based on GBD 2021 data, demonstrating continued reductions in global RHD mortality and DALYs between 1990 and 2021, while highlighting pronounced regional disparities, particularly in South Asia and sub-Saharan Africa[7]. Despite these valuable contributions, important gaps remain. Most prior GBD-based studies have primarily focused on overall trends in mortality or DALYs, with limited integration of fatal and non-fatal burden components (YLL versus YLD) across socio-demographic index (SDI) groups and geographic regions within a single comparative framework. In addition, sex-specific differences in the chronic, non-fatal burden of RHD have received relatively little attention. A clearer comparative assessment of long-term changes between baseline (1990) and the most recent estimates (2021), with explicit emphasis on disparities by development level and region, is still needed.

Therefore, the aim of this study was to compare long-term changes in the global burden of rheumatic heart disease between 1990 and 2021 using data from the Global Burden of Disease (GBD) 2021 study. Specifically, we evaluated changes in incidence, prevalence, mortality, years of life lost (YLL), years lived with disability (YLD), and disability-adjusted life years (DALYs) across socio-demographic index (SDI) groups and geographic regions. By jointly examining fatal and non-fatal burden components, this analysis seeks to clarify persistent disparities and inform data-driven strategies for RHD prevention and control.

Methods

Study Design and Data Source

This study is a secondary, descriptive analysis based on estimates from the Global Burden of Disease (GBD) 2021 study, coordinated by the Institute for Health Metrics and Evaluation (IHME). The GBD study provides standardized, comparable estimates of disease burden across 204 countries and territories from 1990 to 2021 using a unified methodological framework. This study focused on the extraction, organization, and comparative analysis of existing estimates produced by the Global Burden of Disease (GBD) 2021 study. The authors did not generate new disease models or re-estimate epidemiological parameters. Instead, all analyses were based on standardized GBD outputs obtained from the publicly available GBD Results Tool. Detailed descriptions of data sources, case definitions, and modelling strategies underlying the GBD 2021 estimates are available in the main GBD methodological publications.

Study Population and Analytical Units

The unit of analysis in this study was aggregated regions rather than individual countries. Analyses were conducted across five Socio-demographic Index (SDI) groups (low, low-middle, middle, high-middle, and high SDI) and eight geographic regions, including South Asia; Sub-Saharan Africa; Southeast Asia, East Asia, and Oceania; North Africa and the Middle East; Central Europe, Eastern Europe, and Central Asia; Latin America and the Caribbean; High-income Asia Pacific; and Western Europe. Country-level estimates were not analyzed separately in order to reduce statistical noise and emphasize broader, globally comparable patterns. Detailed descriptions of data sources, case definitions, and modelling strategies used to generate GBD 2021 estimates have been published elsewhere. The present study relied exclusively on standardized outputs from the GBD 2021 study and did not perform any additional disease modelling, as described in the main GBD methodological publications[8].

Indicators and Case Definition

Rheumatic heart disease (RHD) was defined according to the GBD 2021 cause list, based on the International Classification of Diseases, 10th Revision (ICD-10) codes I05–I09. Six epidemiological indicators were analyzed: incidence, prevalence, deaths, years of life lost (YLL), years lived with disability (YLD), and disability-adjusted life years (DALYs).

Data Extraction and Metrics

For incidence and prevalence, only age-standardized rates were analyzed. For deaths, YLL, YLD, and DALYs, both all-age counts and age-standardized rates were extracted. Estimates were stratified by sex, SDI group, geographic region, and year. Data were obtained from the publicly available GBD Results Tool.

Age-standardized rates were calculated using the GBD reference population to allow comparisons across regions and over time. All estimates are reported with 95% uncertainty intervals (UIs), reflecting uncertainty in data inputs and modeling processes, as described in the GBD 2021 methodology.

Ethical Considerations

This study used aggregated, anonymized, and publicly available data from the GBD 2021 study. As no individual-level data were involved, ethical approval and informed consent were not required.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics (version 27.0). The primary focus of the analysis was descriptive, aiming to compare long-term changes in RHD burden between 1990 and 2021 across SDI groups and geographic regions. Continuous variables were summarized using means and corresponding 95% uncertainty intervals as provided by the GBD study.

Group comparisons were conducted to explore differences in age-standardized rates and total percentage changes across regions and SDI categories. Statistical significance was assessed using appropriate parametric or non-parametric tests based on data distribution, with a two-tailed p-value < 0.05 considered statistically significant.

Results

Global Trends in the Burden of RHD (1990–2021)

At the global level, the burden of rheumatic heart disease showed an overall declining trend between 1990 and 2021 when assessed using age-standardized indicators. Age-standardized rates of mortality, DALYs, YLLs, and YLDs decreased over the study period in both sexes, indicating improvements in population-level risk after accounting for changes in age structure.

In contrast, the all-age absolute numbers of deaths and disease burden metrics demonstrated smaller reductions or remained relatively stable over time. This pattern reflects the opposing effects of population growth and population aging, which offset reductions observed in age-standardized rates. Across both years, males consistently exhibited higher mortality and overall disease burden than females. Detailed global estimates stratified by sex and metric are presented in (Table 1).

At the global level, the burden of rheumatic heart disease declined substantially between 1990 and 2021 when assessed using age-standardized indicators. Globally, the age-standardized mortality rate decreased by more than 50% over the study period, with a reduction of similar magnitude observed in age-standardized DALY rates, indicating marked improvements in population-level risk (Table 1).

In contrast, absolute numbers of deaths declined by only about 10% between 1990 and 2021 (95% UI: approximately 8%–12%), reflecting the counteracting effects of population growth and population aging. Across both years, males consistently experienced higher mortality and overall disease burden than females. Global and sex-specific estimates are presented in (Table 1 and Figure 1).

Notably, while years of life lost declined by nearly 60% (95% UI: approximately 55%–63%), years lived with disability increased slightly over time (95% UI: approximately 5%–15%), indicating a gradual shift in disease burden from fatal to non-fatal outcomes.

Burden of rheumatic heart disease by Socio-demographic Index (SDI)

Clear socioeconomic gradients were observed in the burden of rheumatic heart disease. In 2021, age-standardized mortality and DALY rates in low SDI regions were approximately four to five times higher than those observed in high SDI regions (Table 2). Although all SDI groups experienced declines in age-standardized indicators between 1990 and 2021, the magnitude of improvement varied substantially.

High SDI regions achieved reductions in age-standardized mortality of roughly 60–70% (95% UI: approximately 55%–72%), whereas declines in low SDI regions were more modest, at around 40–50% (95% UI: approximately 35%–55%), indicating persistent inequalities across the SDI spectrum (Table 1).

Low SDI

In low SDI countries, age-standardized mortality declined by approximately 45% between 1990 and 2021 (95% UI: approximately 40%–50%); however, total numbers of deaths increased slightly over the same period. Reductions in years of life lost were partially offset by a small increase in years lived with disability, highlighting the continuing burden of non-fatal disease in these settings, reductions in overall disease burden were primarily driven by declines in YLLs, although the pace of improvement was slower than that observed in higher SDI regions. YLDs showed little change or a slight increase over time, indicating that non-fatal disability continues to contribute substantially to the burden of rheumatic heart disease in these settings. (Table 1, Figure 1).

Low-Middle SDI

Low-middle SDI regions experienced declines of nearly 50% in age-standardized mortality and DALY rates (95% UI: approximately 45%–55%). Despite these improvements, absolute numbers of deaths increased, underscoring the influence of demographic expansion on overall disease burden, Low-middle SDI regions exhibited moderate declines in YLLs, contributing to reductions in total DALYs. However, YLDs remained relatively stable over the study period, resulting in a growing proportional contribution of non-fatal outcomes to overall disease burden. (Table 1, Figure 1)

Middle SDI

Middle SDI countries demonstrated substantial progress, with age-standardized mortality and DALY rates decreasing by approximately 65–70% (95% UI: approximately 60%–72%). These gains were driven primarily by pronounced reductions in years of life lost, while years lived with disability remained relatively stable (Table 1, Figure 1).

High-Middle SDI

High-middle SDI regions achieved some of the largest improvements globally, with age-standardized mortality and DALY rates declining by around 70% (95% UI: approximately 65%–75%). Non-fatal burden decreased modestly over time, reflecting improved survival and disease management. High-middle SDI regions experienced pronounced reductions in YLLs, accounting for the majority of the observed decline in DALYs. YLDs decreased slightly or remained

stable, indicating effective reductions in premature mortality alongside improved management of chronic disease (Table 1, Figure 1).

High SDI

High SDI countries consistently exhibited the lowest burden of rheumatic heart disease. Between 1990 and 2021, age-standardized mortality and DALY rates declined by approximately 60–70% (95% UI: approximately 58%–73%), while years lived with disability accounted for a small and relatively stable share of total disease burden (Table 1, Figure 1).

Regional Patterns of RHD Burden

Marked regional variation in the burden of rheumatic heart disease was evident across the study period. Regions such as South Asia and Sub-Saharan Africa bore the highest age-standardized mortality and DALY rates, whereas Western Europe and High-income Asia Pacific consistently exhibited the lowest burden. Although most regions experienced declines in age-standardized indicators between 1990 and 2021, the extent of improvement differed substantially by region. Some regions demonstrated pronounced reductions in mortality and DALYs, while others showed slower progress, highlighting ongoing geographic inequalities in disease burden. Regional estimates and temporal changes are detailed in (Table 2).

Central Europe, Eastern Europe, and Central Asia

In Central Europe, Eastern Europe, and Central Asia deaths decreased significantly from 27,126 (95% UI: 23,714–30,318) in 1990 to 9,425 (95% UI: 7,762–11,392) in 2021, with age-standardized death rates dropping from 5.76 (95% UI: 5.01–6.44) to 1.52 (95% UI: 1.26–1.84) per 100,000 (–74%), substantial reductions in DALYs (–72%) were driven primarily by marked declines in YLLs (–77%). YLDs showed little change over time (15.55 in 1990 vs. 15.58 in 2021), indicating that improvements were largely attributable to reductions in premature mortality (Table 2, Figure 2).

South Asia

In South Asia, deaths increased from 174,455 (95% UI: 133,820–239,304) to 214,999 (95% UI: 176,906–287,767), but the age-standardized death rate decreased from 27.84 (95% UI: 21.32–37.42) to 14.88 (95% UI: 12.29–20.18) per 100,000 (–47%). DALY rates dropped from 886.50 to 453.58 per 100,000 (–49%), declines in overall disease burden were mainly driven by reductions in YLLs (–51%); however, YLDs remained relatively stable (+2%), resulting in a continued high burden of non-fatal disease alongside improvements in survival (Table 2, Figure 2).

Sub-Saharan Africa

In Sub-Saharan Africa, DALY rose from 999,251 (95% UI: 763,715–1,319,409) to 1.31 million (95% UI: 1.06–1.74 million), although age-standardized DALY rates declined from 269.48 (95% UI: 206.13–352.88) to 145.30 (95% UI: 118.72–193.51) per 100,000 (–46%). Deaths slightly declined, and age-standardized death rates fell from 6.89 (95% UI: 5.21–9.01) to 2.85 (95% UI: 2.33–3.77) per 100,000 (–59%). declines in YLLs over the study period, contributing to reductions in total DALYs (–62%), while YLD remained high and, in some settings, increased slightly, highlighting the persistent contribution of chronic disability to disease burden in the region (+3%) (Table 2, Figure 2).

Southeast Asia, East Asia, and Oceania

In Southeast Asia, East Asia, and Oceania, deaths fell from 148,909 (95% UI: 118,256–185,646) to 89,573 (95% UI: 71,125–114,552), and age-standardized death rates decreased from 14.62 (95% UI: 11.38–18.29) to 3.61 (95% UI: 2.87–4.60) per 100,000 (–75%). substantial reductions in DALYs (–73%) were largely driven by pronounced declines in YLLs (–78%). YLDs showed modest changes, indicating a shift toward improved survival with relatively stable levels of disability (–12%) (Table 2, Figure 2).

North Africa and the Middle East

In the North Africa and Middle East region, deaths declined from 11,967 (95% UI: 9,524–

15,179) to 8,923 (95% UI: 7,064–11,490), and age-standardized death rates decreased from 5.09 (95% UI: 4.04–6.45) to 1.90 (95% UI: 1.51–2.46) per 100,000 (–63%). DALY rates fell from 223.82 (95% UI: 176.89–282.45) to 86.78 (95% UI: 70.37–112.21) per 100,000 (–61%) and decreases in total disease burden were mainly attributable to reductions in YLLs, while YLDs remained largely unchanged over time (Table 2, Figure 2).

Latin America and the Caribbean

In Latin America and the Caribbean, deaths declined from 7,352 (95% UI: 6,088–8,687) to 5,386 (95% UI: 4,276–6,795), with age-standardized death rates dropping from 2.78 (95% UI: 2.29–3.30) to 0.87 (95% UI: 0.69–1.10) per 100,000 (–69%). Latin America and the Caribbean experienced notable reductions in YLLs (–57%), which accounted for most of the decline in DALYs (–49%). YLDs showed limited change, resulting in an increasing proportional contribution of non-fatal outcomes (Table 2, Figure 2).

Prevalence of RHD

Between 1990 and 2021, the global prevalence of rheumatic heart disease (RHD) increased markedly in terms of absolute case numbers, although trends in age-standardized rates (ASRs) varied across regions and Socio-demographic Index (SDI) levels. Globally, the number of prevalent RHD cases rose from 32.3 million (95% UI: 25.6–40.0 million) in 1990 to 54.8 million (95% UI: 43.3–67.6 million) in 2021. Over the same period, the global prevalence ASR increased from 607.75 per 100,000 population (95% UI: 488.15–744.05) to 684.20 (95% UI: 540.40–848.90), corresponding to a total percentage change (TPC) of 12% (95% UI: 0.10–0.14) (Table 3).

At the SDI level, the highest prevalence ASR in 2021 was observed in low SDI regions (1184.23 per 100,000; 95% UI: 932.41–1478.19), whereas high SDI regions exhibited the lowest prevalence ASR, estimated at 89.18 per 100,000 (95% UI: 81.38–98.29). High SDI regions also demonstrated a statistically significant reduction in age-standardized prevalence compared with 1990 (ASR=101.30; 95% UI:89.83–115.09), corresponding to a negative TPC of −11% (95% UI: −0.16 to −0.07). Similarly, high-middle SDI regions showed a declining trend in prevalence ASR (TPC=−0.14; 95% UI: −0.17 to −0.11) (Table 3).

In contrast, several regions experienced increasing prevalence ASRs over the study period. Sub-Saharan Africa showed persistently high prevalence, with ASRs increasing from 1358.33 per 100,000 in 1990 (95% UI: 1073.00–1688.07) to 1404.41 per 100,000 in 2021 (95% UI: 1109.35–1758.62), corresponding to a TPC of 3% (95% UI: 0.01–0.04). Similarly, upward trends were observed in South Asia and North Africa and the Middle East, with TPCs of 3% (95% UI: 0.00–0.05) and 0.05 (95% UI: 0.02–0.07), respectively (Table 3).

Incidence of RHD

According to the GBD 2021 estimates, the global number of incidents RHD cases increased from 2.58 million (95% UI: 2.05–3.21 million) in 1990 to 3.85 million (95% UI: 3.06–4.78 million) in 2021. Correspondingly, the global incidence ASR rose from 44.86 per 100,000 population (95% UI: 36.00–55.31) in 1990 to 50.73 per 100,000 population (95% UI: 40.09–63.05) in 2021, with an overall percentage change of 13% (95% UI: 0.10–0.14) (Table 4).

Across SDI groups, the highest incidence ASRs were consistently observed in low SDI regions, increasing from 79.92 per 100,000 (95% UI: 62.64–100.00) in 1990 to 84.89 per 100,000 (95% UI: 66.10–106.35) in 2021. In low-middle SDI regions, incidence ASRs increased from 56.31 (95% UI: 44.66–69.86) to 60.45 (95% UI: 47.74–75.47). In contrast, declining trends were observed in middle SDI regions, where incidence ASRs decreased from 48.73 (95% UI: 38.48–60.75) in 1990 to 45.89 (95% UI: 36.13–57.56) in 2021. Similarly, high-middle SDI regions experienced a reduction from 32.99 (95% UI: 26.22–41.28) to 31.31 (95% UI: 24.94–39.16). High SDI regions consistently showed the lowest incidence ASRs, declining from 8.28 (95% UI: 7.41–9.31) in 1990 to 6.77 (95% UI: 6.18–7.43) in 2021, corresponding to a TPC of −18% (95% UI: −0.21 to −0.14) (Table 4).

Sex-specific analyses indicated that incidence ASRs were consistently higher in females than in males across all years. In 2021, the global incidence ASR among females was 55.11 per 100,000 (95% UI: 43.61–68.67), compared with

46.52 per 100,000 (95% UI: 36.50–57.83) among males.

At the regional level in 2021, South Asia exhibited the highest incidence ASR at 104.10 per 100,000 population (95% UI: 80.64–130.89), followed by Sub-Saharan Africa at 88.06 per 100,000 (95% UI: 67.80–112.12). Southeast Asia, East Asia, and Oceania showed incidence ASRs of 45.44 (95% UI: 35.50–57.43), while North Africa and the Middle East had an incidence ASR of 41.29 (95% UI: 31.86–52.53). The lowest incidence ASRs were observed in High-income Asia Pacific (1.68 per 100,000; 95% UI: 1.38–2.03) and Central Europe (2.38 per 100,000; 95% UI: 2.05–2.76) (Table 4).

Discussion

This study demonstrates a substantial global decline in the age-standardized burden of rheumatic heart disease over the past three decades. This decline was primarily driven by reductions in premature mortality, as reflected by marked decreases in years of life lost.

Globally, the burden of RHD has undergone a marked shift over the three-decade study period. Age-standardized mortality rates and overall RHD burden (measured in DALY) have declined by well over half from 1990 to 2021, implying that advances in early diagnosis, secondary prophylaxis, and surgical care have significantly improved survival[1,2]. Notably, the reduction in premature mortality (YLL) was the primary driver of the decline in total DALYs, indicating that deaths from RHD have become far less common relative to the global population. In contrast, the non-fatal component of RHD burden (YLD) showed a slight increase over time (11%), suggesting a transition toward a chronic disease burden where more people are living with RHD rather than dying from it. This evolving profile reflects improved survival coupled with growing challenges in long-term disease management – including valve dysfunction, heart failure, and reduced quality of life – that demand sustained care strategies[3,4].

Clear socioeconomic gradients in the burden of rheumatic heart disease were observed across Socio-demographic Index (SDI) groups. High and high-middle SDI regions experienced more pronounced reductions in years of life lost, likely reflecting improved access to early diagnosis, secondary prophylaxis, and advanced cardiac care. In contrast, low SDI settings showed slower declines in YLLs alongside relatively stable YLDs, indicating persistent challenges in both prevention and long-term disease management.

However, these overall gains mask stark regional and socioeconomic disparities in RHD burden. Low-SDI regions experienced less improvement, with age-standardized DALY rates falling an estimated 46%, and the absolute number of RHD deaths rose from about 44,000 in 1990 to nearly 50,000 in 2021. Despite modest rate declines, population growth and persistently weak health systems in these areas likely contributed to increasing absolute burdens[6]. By contrast, high-development settings (high- and high-middle SDI) achieved the steepest declines in RHD mortality and disability burdens, reflecting greater access to medical care and effective prevention (Figure 1). In these high-development settings, age-standardized death and DALY rates dropped to a fraction of their 1990 levels, and even the prevalence of RHD showed a downward trend (Figure 2).

Broad measures such as SDI may not fully capture deeper structural factors (e.g. entrenched poverty, under-resourced health services, and post-colonial health governance challenges) that continue to impede RHD control in many low-income settings[9-11]. South Asia and Sub-Saharan Africa remain particularly high-burden hotspots within this global picture. In South Asia, age-standardized mortality declined by roughly 47%, yet annual RHD deaths still increased from ~174,000 to ~215,000 between 1990 and 2021, now accounting for over one-quarter of all RHD deaths worldwide. Sub-Saharan Africa also bears a disproportionate burden, with the highest age-standardized DALY rate of any region as of 2021.

We also found a consistent sex disparity in non-fatal RHD outcomes, with women bearing a higher chronic disease burden than men. For example, in 2021, females had a higher YLD rate (36.6 per 100,000) compared to males (30.2 per 100,000), suggesting that women face disproportionate long-term morbidity from RHD. This gap may reflect women's more prolonged survival with RHD, differences in care-seeking behavior, and gender-based barriers to accessing advanced

treatments[12,13]. RHD also frequently complicates pregnancy and poses significant maternal health risks in endemic regions, yet women remain underrepresented in RHD registries and clinical trials. There is a clear need for gender-sensitive health policies and targeted screening/intervention programs for women of childbearing age in high-burden countries.

Although our analysis could not stratify results by age groups, it is important to note that RHD is usually acquired in childhood and then imposes lifelong impacts. The lack of universal primary prevention, for instance, school-based sore throat programs and prompt penicillin treatment for streptococcal pharyngitis, in many low-income settings, perpetuates this preventable disease in each new generation. Future iterations of global burden studies and RHD control initiatives should place greater emphasis on pediatric RHD and the transition of patients from childhood into adult care[14,15]. Notably, our data span the years 2020–2021 but do not isolate the effects of the COVID-19 pandemic on RHD outcomes. It is highly likely that pandemic-related disruptions – including delays in diagnoses, missed prophylaxis doses, and postponed cardiac surgeries – exacerbated disease progression and limited RHD care in many countries, especially in resource-limited settings[16].

Our study's strengths include the use of standardized, validated GBD methods and the reporting of uncertainty intervals, which enhance comparability and confidence in the findings. However, several limitations must be acknowledged. Heavy reliance on modelled data was necessary in regions with sparse surveillance, which introduces uncertainty and potential bias (e.g., from disease misclassification or incomplete vital registration). We aggregated results at regional and SDI group levels rather than country-level, an intentional choice that improves statistical stability but sacrifices granular national detail. YLD estimates depend on disability weight assumptions and disease duration models that may not capture cultural variations in health state valuation and are subject to uncertainty[8,17,18]. These trade-offs are common to global modelling efforts, but the GBD framework's transparency and consistency make it a valuable—if imperfect—gold standard for tracking long-term epidemiological trends[8].

In light of our findings, translating evidence into action is now imperative to accelerate RHD control. The World Health Organization's 2018 World Health Assembly resolution (WHA71.14) calling for the global elimination of rheumatic fever and RHD has seen uneven implementation to date[19]. For example, targeted initiatives such as Australia's program addressing RHD in Aboriginal communities and Cuba's nationwide school-based screening have achieved local successes[20-22]. Yet, many endemic countries still lack national RHD action plans and sustainable funding.

Critically, RHD control efforts should be embedded within broader health system strengthening and social policy initiatives rather than pursued in isolation[23]. Economic evaluations have consistently shown that secondary prophylaxis and echocardiography-based screening are among the most cost-effective interventions for RHD in endemic regions[17-20].

Table 1. The number and age-standardized rates of deaths, DALY, YLL, and YLD caused by RHD from 1990 to 2021 globally, and across various SDI areas

Location	1990 Number (95% UI)	2021 Number (95% UI)	1990 ASR	2021 ASR	ASR % change
Global					
Death					
Male	182236(151961-232937)	160618(134193-238816)	9.71	4.22	-57%
Female	236126(182166-287602)	212727(180350-262333)	10.77	4.72	-56%
Both	418,363 (349,610– 493,410)	373,345 (324,140– 444,762)	10.21	4.47	−56%
DALY					
Male	7334736(6147990-9248376)	6035160(5008564-8322033)	321.09	150.11	-53%

Female	8945334(6908352-11096923)	7391209(6288402-9018558)	374.70	173.99	-54%
Both	16280071(13707291-19177011)	13426369(11517021-15780164)	347.53	162.12	-53%
		YLD			
Male	732798(452046-1103598)	1213931(744837-1823474)	27.17	30.21	11%
Female	860642(538651-1302007)	1458196(898151-2198367)	32.59	36.61	12%
Both	1593440(991126-2403210)	2672127(1650928-4028488)	29.91	33.40	11%
		YLL			
Male	6601939(5566017-8438176)	4821229(4052607-6939912)	293.92	119.89	-59%
Female	8084692(6138480-10222152)	5933013(5081267-7446928)	342.11	137.36	-59%
Both	14686631(12265430-17353868)	10754242(9409748-12710190)	317.61	128.71	-59%
		Low SDI			
		Death			
Male	21760(16466-33486)	22235(14658-37626)	17.67	8.82	-50%
Female	22298(13527-33590)	27635(20731-43865)	17.09	10.24	-40%
Both	44057(32486-60760)	49870(38624-66607)	17.32	9.54	-45%
		DALY			
Male	976265(751041-1400490)	1090220(795805-1571068)	567.92	285.36	-50%
Female	1077358(712699-1566499)	1295898(1005789-1845294)	593.16	336.45	-43%
Both	2053623(1550174-2707140)	2386119(1929850-3028342)	579.72	311.11	-46%
		YLD			
Male	116055(70075-178499)	292696(174484-452836)	50.46	53.44	5%
Female	131647(79879-202050)	333895(202295-521201)	57.32	60.59	5%
Both	247702(149954-380550)	626591(376789-976818)	53.91	57.06	5%
		YLL			
Male	860210(656547-1289416)	797524(549719-1249581)	517.45	231.91	-55%
Female	945711(598548-1440800)	962003(730585-1499309)	535.83	275.85	-48%
Both	1805921(1332202-2448567)	1759528(1385580-2304780)	525.80	254.04	-51%
		Low-middle SDI			
		Death			
Male	69940(50672-108598)	68325(50478-126092)	20.62	10.14	-51%
Female	66986(43811-97637)	83979(68489-126527)	19.40	11.22	-42%
Both	136925(102820-187527)	152304(126425-208308)	19.98	10.68	-47%
		DALY			
Male	2956422(2239320-4360779)	2645431(2067793-4231147)	672.10	317.45	-53%

Female	2995135(2049235-4317211)	3179374(2623793-4416815)	676.45	367.82	-46%
Both	5951557(4633434-7831677)	5824805(4895195-7419971)	673.71	342.79	-49%
		YLD			
Male	196840(122424-299387)	374702(228524-569894)	20.62	10.14	-51%
Female	239483(149848-359791)	466033(286057-701871)	19.40	11.22	-42%
Both	436324(270980-660544)	840735(516466-1272918)	19.98	10.68	-47%
		YLL			
Male	2759582(2063143-4128329)	2270729(1749787-3826447)	637.11	280.09	-56%
Female	2755651(1842614-4063763)	2713341(2216816-3918761)	632.28	320.92	-49%
Both	5515233(4226082-7340988)	4984070(4206802-6496488)	634.19	300.65	-52%
		Middle SDI			
		Death			
Male	54526(44856-63212)	45280(36442-55220)	11.26	4.06	-64%
Female	82859(65682-100266)	58751(43747-80211)	15.59	4.39	-72%
Both	137385(117753-156716)	104031(127936-86100)	13.51	4.22	-69%
		DALY			
Male	2209906(1887843-2510659)	1650882(1365634-1993567)	333.86	131.30	-61%
Female	3053209(2486543-3613982)	1995562(1604477-2509369)	466.90	148.41	-68%
Both	5263115(4545775-5958435)	3646444(3108667-4314192)	400.68	139.86	-65%
		YLD			
Male	309844(188355-475243)	411998(252979-616838)	34.40	32.11	-6%
Female	339649(209829-520660)	480442(295700-720215)	39.28	37.96	-3%
Both	649492(398264-991212)	892440(549274-1334879)	36.80	35.02	-4%
		YLL			
Male	1900062(1594114-2160325)	1238884(1031423-1496146)	299.45	99.18	-66%
Female	2713560 (2168857-3220643)	1515120(1158860-2030701)	427.60	110.43	-74%
Both	4613622(3956851-5175487)	2754004(2324206-3327992)	363.86	104.83	-71%
		High-middle SDI			
		Death			
Male	25334(22056-28852)	15575(12527-18955)	6.21	1.97	-68%
Female	41999(35479-49690)	24658(19655-31303)	7.72	2.23	-71%
Both	67333(59636-76520)	40232 (47750-33818)	7.02	2.11	-70%
		DALY			
Male	893281(785497-1008961)	449859(368907-542571)	185.90	56.61	-70%
Female	1319138(1119638-1537888)	618857(510086-757467)	239.82	65.76	-73%
Both	2212419(1966795-2494216)	1068716(918250-1242046)	214.11	61.45	-71%
		YLD			
Male	89652(56337-135164)	100194(62831-150004)	16.56	14.14	-14%
Female	114520(72585-167765)	130425(85023-190595)	20.56	17.56	-14%

Both	204172(129080-303249)	230619(148413-341359)	18.71	15.88	-15%
		YLL			
Male	803629(711041-910294)	349665(281231-426508)	169.33	42.46	-74%
Female	1204618(1015116-1426941)	488432(394799-622141)	219.25	48.18	-78%
Both	2008248(1779790-2268433)	838097(712046-989646)	195.39	45.56	-76%
		High SDI			
		Death			
Male	10557(10196-10924)	9132(8144-9804)	2.38	0.96	-60%
Female	21819(19920-22938)	17605(14043-19810)	3.32	1.19	-64%
Both	32376(30133-33828)	26737(22112-29531)	2.96	1.10	-63%
		DALY			
Male	293684(283316-306637)	195145(177116-213353)	62.88	22.65	-64%
Female	493701(463763-518830)	296922(255856-329017)	82.77	26.11	-68%
Both	787385(750008-821185)	492067(434313-539675)	74.35	24.68	-67%
		YLD			
Male	19848(12804-28315)	33454 (21964-47359)	4.30	4.10	-4%
Female	34652(22526-49338)	46330(30394-65225)	5.84	4.76	-18%
Both	54499(35244-77684)	79784(52221-112452)	5.15	4.45	-13%
		YLL			
Male	273836(265844-283658)	161691(147689-172072)	58.58	18.53	-68%
Female	459049(431958-482108)	250592(209466-276982)	76.93	21.34	-72%
Both	732886(697725-762917)	412283(358191-445633)	69.19	20.22	-70%

Table 2. The number and age-standardized rates of deaths, DALY, YLL, and YLD caused by RHD from 1990 to 2021 globally, and across various Regions

Location	1990 Number (95% UI)	2021 Number (95% UI)	1990 ASR	2021 ASR	ASR % change
Central Europe, Eastern Europe, Central Asia					
Death					
Male	10873(10460-11825)	3352(3093-3608)	5.54	1.34	-76%
Female	16253(15611-17537)	6073(5532-6637)	5.89	1.62	-72%
Both	27126(26184-29178)	9425(8686-10185)	5.76	1.52	-74%
DALY					
Male	417656(398699-449764)	129380(114683-145603)	201.24	54.36	-73%
Female	54643ʏ(521450-586038)	187244(168415-211522)	209.44	61.77	-71%
Both	96409ᴛ(922653-1029443)	316625(284562-356470)	206.89	58.81	-72%
YLD					
Male	27283(17160-39403)	29290(18113-43396)	13.42	13.96	4%

Female	42745(27620-61470)	41490(26108-59983)	17.09	16.94	0%
Both	70027(44835-100017)	70780(44013-102947)	15.55	15.57	0%
YLL					
Male	390373(375445-419520)	100090(91170-108691)	187.81	40.39	-78%
Female	503692(484599-540907)	145755(131807-160629)	192.34	44.82	-76%
Both	894065(863798-957456)	245845(225901-267388)	191.34	43.23	-77%
High Income					
Death					
Male	9514(9163-9760)	9846(8773-10567)	2.01	0.97	-52%
Female	22125(23205-20090)	20310(16188-22879)	3.04	1.25	-59%
Both	31639(29198-32930)	30156(24882-33354)	2.64	1.14	-57%
DALY					
Male	250139(240595-260695)	203008(184367-221409)	50.69	23.21	-54%
Female	474401(444787-496447)	329283(281852-364184)	72.32	27.60	-62%
Both	724540(685942-756203)	532291(471902-583817)	63.15	25.77	-59%
YLD					
Male	23364(15350-33379)	37252(24795-52952)	4.84	5.01	3%
Female	39559(26166-56248)	52530(34971-73656)	6.54	6.07	-7%
Both	62924(41349-89481)	89782(59938-126551)	5.77	5.55	-3%
YLL					
Male	226775(221333-231306)	165755(151179-175557)	45.84	18.19	-60%
Female	434841(406686-451081)	276754(232124-304331)	65.77	21.52	-67%
Both	661616(627202-680835)	442509(381933-478800)	57.37	20.21	-64%
Latin America and the Caribbean					
Death					
Male	2692(2579-2850)	1946(1609-2174)	2.10	0.68	-68%
Female	4661(4373-5070)	3440(2998-3747)	3.41	1.03	-70%
Both	7352(7013-7805)	5386(4723-5848)	2.78	0.87	-69%
DALY					
Male	190373(159409-232034)	180422(133605-239147)	112.20	59.82	-47%
Female	286784(247615-341617)	265008(208007-349164)	168.03	82.37	-51%
Both	477157(410538-567334)	445429(343379-591527)	140.88	71.49	-49%
YLD					
Male	74404(44850-115346)	113867(68585-174242)	38.72	37.48	-3%

Female	94539(57583-144809)	151532(92415-230199)	48.04	37.48	-0%
Both	168943(102856-260124)	265399(161071-404444)	43.49	42.80	-1%
YLL					
Male	115969(110769-123035)	66554(54490-75933)	73.47	22.33	-69%
Female	192245(177895-210956)	113475(101741-125666)	119.99	34.49	-71%
Both	308214(291775-327698)	180030(160525-196831)	97.38	28.68	-70%
North Africa and the Middle East					
Death					
Male	5200(3364-6829)	3931(3242-4799)	4.51	1.63	-64%
Female	6767(3921-10111)	4991(4039-6203)	5.69	2.18	-62%
Both	11967(8216-15899)	8923(7522-10610)	5.09	1.90	-63%
DALY					
Male	310699(209370-398145)	239202(196800-293315)	191.99	78.03	-59%
Female	412580(252252-569609)	272079(218221-340601)	257.16	96.11	-63%
Both	723279(522943-940614)	511282(414367-619226)	223.82	86.78	-61%
YLD					
Male	38794(23696-60332)	83056(50163-127384)	23.56	24.54	4%
Female	41642(26051-63172)	86574(52513-130709)	26.90	27.90	3%
Both	80436(49749-123707)	169629(102126-258259)	25.19	26.14	3%
YLL					
Male	271905(174703-352421)	156147(130014-380277)	168.42	53.49	-68%
Female	370938(213319-526673)	305755(253436-366333)	230.25	68.20	-70%
Both	642843(446343-841933)	567138(465993-710753)	198.62	60.62	-69%
South Asia					
Death					
Male	91771(67683-141905)	96557(72067-173891)	28.35	13.86	-51%
Female	82683(55797-122535)	118442(95645-176792)	27.33	15.91	-42%
Both	174455(133820-239304)	214999(176906-287767)	27.84	14.88	-47%
DALY					
Male	3730408(2861595-5499992)	3497372(2737755-5661853)	887.34	415.02	-53%
Female	3479742(2427867-5175788)	4159108(3381918-5853723)	886.32	492.53	-44%
Both	7210150(5691199-9524868)	7656480(6440117-9619407)	886.50	453.58	-49%

YLD					
Male	171273(108227-256469)	320332(199044-481276)	31.48	32.18	2%
Female	204679(128920-305315)	403271(250089-602933)	41.07	41.93	2%
Both	375952(236740-562179)	723603(450194-1085879)	36.08	36.99	2%
YLL					
Male	3559135(2680367-5308077)	3177040(2460265-5308172)	855.85	382.82	-55%
Female	3275063(2254542-4951275)	3755837(3007536-5490945)	845.24	450.58	-46
Both	6834198(5363856-9140038)	6932876(5752400-8927738)	850.40	416.57	-51
Southeast Asia, East Asia, and Oceania					
Death					
Male	55276(43413- 66185)	38449(29614- 47837)	12.06	3.58	-70%
Female	93634(70828- 117682)	51124(38687- 69687)	16.99	3.71	-78%
Both	148909(121825- 174602)	89573(72972- 111145)	14.62	3.61	-75%
DALY					
Male	2015941(1617221-2371385)	1178555(954107-1430495)	314.39	99.22	-68%
Female	3165661(2433506-3884450)	1476865(1185152-1858285)	474.08	113.95	-76%
Both	5181601(4323212-6027617)	2655419(2234545-3145494)	394.41	106.19	-73%
YLD					
Male	259426(159730-399075)	284294(178190-424412)	28.82	24.67	-14%
Female	281274(174990-427947)	326934(206801-489740)	32.73	29.05	-11%
Both	540700(334754-824205)	611228(383156-911727)	30.76	26.82	-12%
YLL					
Male	1756515(1388712-2080857)	894260(715272-1108936)	285.56	74.54	-73%
Female	2884387(2159697-3577552)	1149931(904715-1515945)	441.33	84.89	-80%
Both	4640901(3805225-5406901)	2044191(1706116-2463419)	363.64	79.36	-78%
Sub-Saharan Africa					
Deaths					
Male	6911(5322-8856)	6536(5174-9457)	5.99	2.63	-56%
Female	10004(7051-12657)	8347(7086-10158)	7.79	3.04	-61%
Both	16915(12960-20917)	14884(12625- 18184)	6.89	2.85	-59%

DALY					
Male	419521(332163-530654)	607222(444609-810744)	233.40	137.05	-41%
Female	579731(434826-732727)	701622(531209-936397)	305.45	152.70	-50%
Both	999251(792898-1239226)	1308844(984237-1741460)	269.48	145.30	-46%
YLD					
Male	138253(82993-213897)	281268(220064-358569)	61.52	63.43	3%
Female	156205(94258-242075)	423526(303905-543791)	67.43	69.76	3%
Both	294458(177251-456221)	704793(541469-875753)	64.52	66.70	3%
YLL					
Male	345839(206020-540846)	3177040(2460265-5308172)	171.87	73.61	-57%
Female	395867(236692-622809)	3755837(3007536-5490945)	238.01	82.94	-65%
Both	741706(442832-1163641)	6932876(5752400-8927738)	204.94	78.59	-61%

Table 3. The number and age-standardized rates of prevalence of RHD from 1990 to 2021 globally, and across various SDI areas and geographical regions

Location	1990 Number (95% UI)	2021 Number (95% UI)	1990 ASR	2021 ASR	TPC % change
Global					
Male	14763495(11492859-18363301)	24708908(19410886-30536677)	547.99	614.20	12%
Female	17572136(14074922-21663935)	30076212(24108760-37038189)	666.28	754.77	13%
Both	32335630(25584153-40049558)	54785119(43328407-67605542)	607.75	684.20	12%
Low SDI					
Male	2364969(1817543-2983753)	6000556(4565670-7574307)	1034.59	1099.06	6%
Female	2733634(2114708-3433878)	6957765(5308299-8837085)	1198.50	1267.26	5%
Both	5098603(3932251-6417631)	12958321(9858421-16357170)	1117.07	1184.23	6%
Low Middle SDI					
Male	3880175(2995522-4901688)	7527964(5813361-9441938)	693.37	749.86	8%
Female	4857392(3801115-6029215)	9574028(7536203-12007075)	899.96	962.38	6%
Both	8737566(6815739-10935250)	17101991(13392336-21406710)	795.37	856.22	7%
Middle SDI					

Male	6291731(4808849-7938906)	8432982(6597187-10361818)	697.78	655.40	-6%
Female	6949316(5393326-8745450)	9929495(7909374-12190981)	803.09	783.03	-2%
Both	13241047(10219028-16613325)	18362477(14423683-22502207)	749.50	718.69	-4%
High Middle SDI					
Male	1819099(1493691-2196773)	2041519(1689551-2436134)	335.03	287.85	-14%
Female	2334618(1996905-2733511)	2658025(2292674-3084933)	418.95	358.83	-14%
Both	4153717(3500219-4913672)	4699544(3965853-5495122)	380.27	323.97	-14%
High SDI					
Male	396167(350854-451902)	687597(626056-757149)	85.73	83.24	-2%
Female	682988(605102-778782)	934569(851585-1027504)	113.94	94.49	-17%
Both	1079154.84(955512-1231078)	1622166(1482173-1780276)	101.30	89.18	-11%
Central Europe, Eastern Europe, Central Asia					
Male	557452(495624-635218)	610699(522576-716154)	274.40	289.27	5%
Female	890951(803261-992593)	877032(770726-999968)	353.79	354.40	0%
Both	1448403(1298380-1627605)	1487730(1296886-1713939)	320.40	324.40	1%
High Income					
Male	471629(417590-532216)	771713 (693875-849551)	97.58	102.13	4%
Female	784468(699661-882714)	1059374(966255-1173130)	128.92	121.97	-5%
Both	1256096(1124421-1417178)	1826186(1659128-2016866)	114.68	112.28	-2%
Latin America and the Caribbean					
Male	1536950(1186376-1946264)	2385494(1862618-2960860)	804.23	784.74	-2%
Female	1971436(1555035-2463574)	3212489(2578847-3950506)	1006.15	1013.50	0%
Both	3508386(2732143-4407056)	5597983(4453362-6924054)	907.53	901.81	0%
North Africa and the Middle East					
Male	776803(605681-976089)	1704346(1337791-2104940)	477.47	503.39	5%
Female	841926(657686-1041376)	1803790(1422443-2204534)	552.00	581.50	5%
Both	1618729(1259128-2018012)	3508137(2763128-4300635)	513.83	540.76	5%
South Asia					
Male	3276607(2536083-4128897)	6258576(4790445-7835739)	604.85	626.46	3%

Female	4076645(3205048-5069804)	8120266(6318525-10223980)	820.46	840.97	2%
Both	7353253(5764476-9166362)	14378842(11206872-18056891)	708.35	732.20	3%
Southeast Asia, East Asia, and Oceania					
Male	5275038(4040832-6640965)	5798421(4636108-7043564)	582.35	502.44	-13%
Female	5725227(4520708-7104793)	6662577(5465516-8030283)	662.86	592.84	-10%
Both	11000264(8560593-13725023)	12460998(10102718-15051413)	622.19	546.85	-12%
Sub-Saharan Africa					
Male	2869016(2195940-3610032)	7184559(5476887-9109512)	1285.73	1324.71	3%
Female	3281483(2535071-4121933)	8340684(6386904-10576117)	1428.56	1478.71	3%
Both	6150499(4731231-7737234)	15525243(11847433-19638659)	1358.33	1404.41	3%

Table 4. The number and age-standardized rates of incidence of RHD from 1990 to 2021 globally, and across various SDI areas and geographical regions

Location	1990 Number (95% UI)	2021 Number (95% UI)	1990 ASR	2021 ASR	TPC % change
Global					
Male	1200742(938431-1494452)	1795709(1417000-2231991)	41.06	46.52	13%
Female	1382055(1106246-1717786)	2058977(1641501-2556796)	48.68	55.11	13%
Both	2582797(2048575-3206438)	3854686(3056085-4783798)	44.86	50.73	13%
Low SDI					
Male	223323(169321-285184)	547888(416653-697220)	74.67	79.68	6%
Female	251448(193595-319246)	614687(471175-786728)	85.09	90.05	5%
Both	474772(363780-603463)	1162574(890316-1479826)	79.92	84.89	6%
Low Middle SDI					
Male	340593(263070-428636)	576720(450239-724737)	49.62	53.90	8%
Female	419344(330466-523518)	701280(549470-884791)	63.12	67.16	6%
Both	759937(593790-948218)	12771000(999619-1611620)	56.31	60.45	7%
Middle SDI					
Male	472827(365202-592514)	505306(400731-628200)	46.37	43.20	-6%
Female	504622(393119-637595)	540039(428336-673211)	51.17	48.74	-4%
Both	977449(758171-1231335)	1045344(828784-1300482)	48.73	45.89	-5%
High Middle SDI					
Male	129909.75(108327.02-156662.15)	111378(94497-131934)	24.31	18.92	-22%
Female	152692(130058-180452)	130497(114201-149779)	28.52	21.83	-23%
Both	282602(238477-338128)	241875(208815-282576)	26.46	20.35	-23%

High SDI					
Male	33160(29532-37435)	53105(48089-58469)	7.23	6.32	-12%
Female	52842(47089-59730)	70963(64443-78090)	9.24	7.21	-21%
Both	86002(76486-97351)	124069(112596-136507)	8.28	6.77	-18%
Central Europe, Eastern Europe, Central Asia					
Male	44425(39028-50610)	39600(33459-46983)	21.76	21.50	-1%
Female	57184(50950-64510)	48630(42288-56370)	25.56	24.69	-3%
Both	101610(90222-115294)	88230(75954-103101)	23.74	23.14	-2%
High Income					
Male	38272(34039-42748)	60843(55048-67412)	8.19	8.29	1%
Female	59454(53376-66363)	80314(73164-88401)	10.34	9.34	-9%
Both	97726(87767-108608)	141157(128030-155465)	9.33	8.83	-5%
Latin America and the Caribbean					
Male	122564(94738-156402)	149754(117656-187610)	53.31	52.01	-2%
Female	144537(111454-181862)	176415(139152-220559)	61.74	61.62	0%
Both	267101(206601-338376)	326169(257219-407142)	57.57	56.78	-1%
North Africa and the Middle East					
Male	67647(52698-85453)	120517(94993-148998)	33.11	35.62	7%
Female	70630(55887-88116)	122912(97751-151701)	36.58	39.07	6%
Both	138278(108889-173277)	243429(192747-300173)	34.81	37.29	7%
South Asia					
Male	279827(216236-353587)	458691(357029-573179)	43.06	44.27	2%
Female	349671(274054-440057)	581187(451841-731478)	57.97	58.74	1%
Both	629498(489815-792665)	1039878(815275-1308333)	50.27	51.32	2%
Southeast Asia, East Asia, and Oceania					
Male	383573(299350-478116)	326496(262443-401429)	40.28	33.69	-16%
Female	404773(320735-508327)	338778(276090-413367)	44.50	37.44	-15%
Both	788346(621068-985582)	665275(539327-812294)	42.37	35.47	-16%
Sub-Saharan Africa					
Male	264434(201553-339368)	639807(487019-820613)	89.69	91.94	2%
Female	295804(226738-376759)	710742(545546-911259)	97.37	100.19	2%
Both	560239(429146-715626)	1350549(1035944-1727744)	93.63	96.14	2%

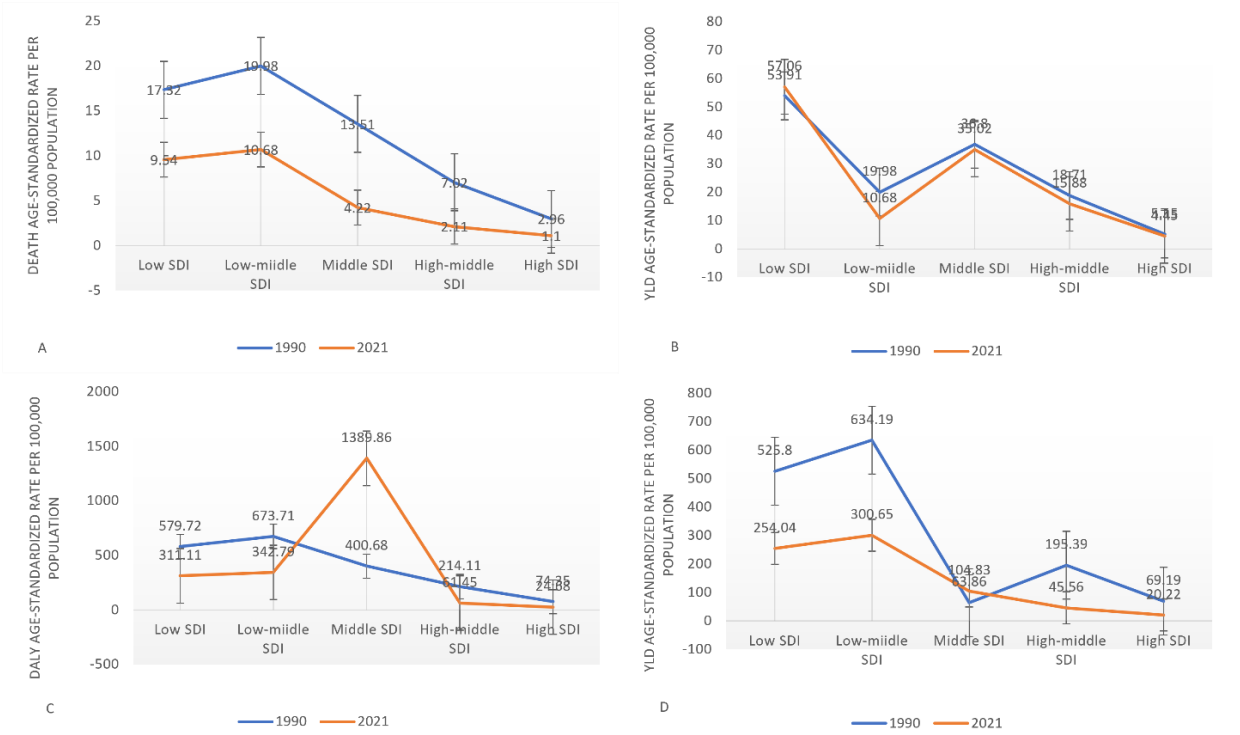

Figure 1. Age-standardized rates of (A) death, (B) YLDs, (C) DALYs, and (D) YLLs attributable to Rheumatic Heart Disease across the five Sociodemographic Index (SDI) categories in 1990 and 2021. The lines represent temporal trends from 1990 (blue) to 2021 (orange), and error bars indicate the corresponding 95% uncertainty intervals. Overall, higher SDI categories show substantially lower burdens across all metrics in both years, with marked reductions over time, particularly in mortality and YLL rates.

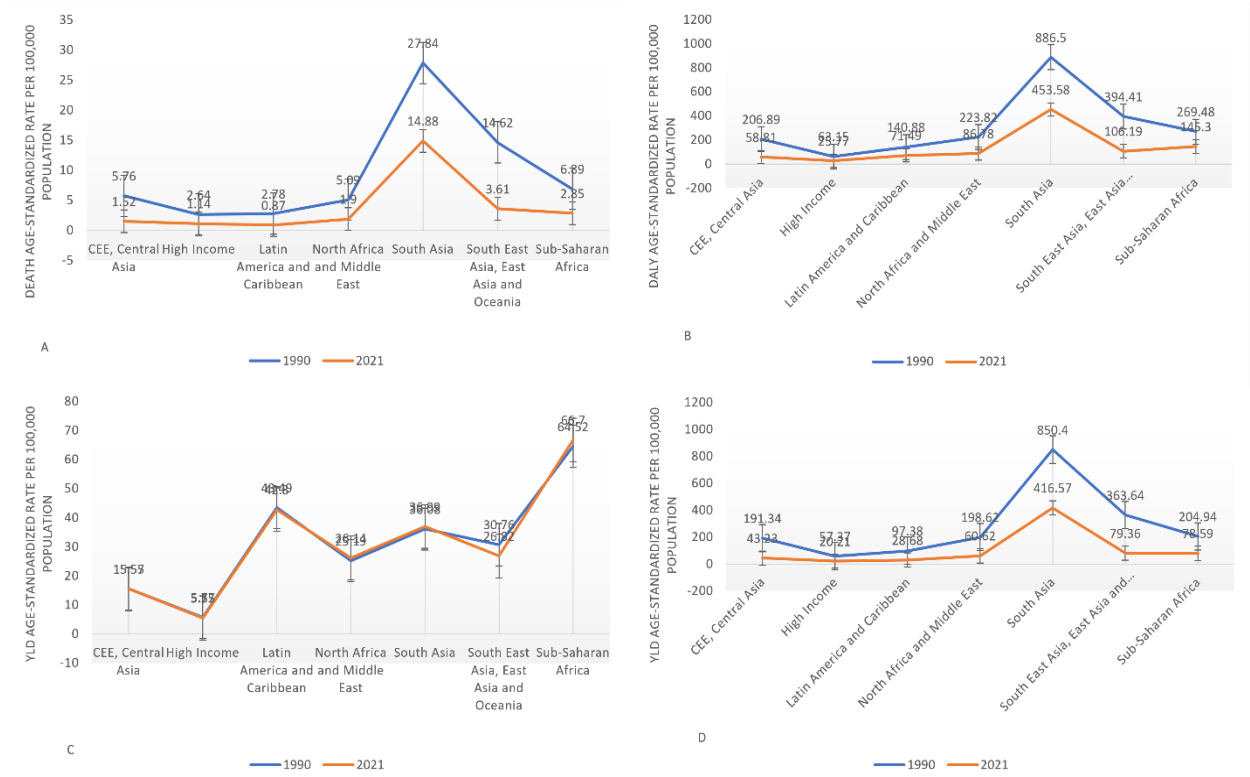

Figure 2. Age-standardized rates of (A) death, (B) DALYs, (C) YLDs, and (D) YLLs attributable to Rheumatic Heart Disease across seven Global Burden of Disease (GBD) regions in 1990 and 2021. The blue lines represent rates in 1990 and orange lines in 2021, with error bars indicating 95% uncertainty intervals. South Asia shows the highest burden across all metrics, followed by Sub-Saharan Africa, while high-income and East Asia regions display the lowest burdens. A consistent decreasing trend from 1990 to 2021 is observed for death, DALY, and YLL rates, reflecting improvements in health outcomes over time, whereas YLD rates show relatively stable patterns across most regions.

Conclusions

Rheumatic heart disease remains a major global health challenge despite substantial reductions in age-standardized burden since 1990. These improvements were largely driven by declines in premature mortality, while non-fatal disability persists, particularly in lower SDI settings. Strengthening primary prevention, secondary prophylaxis, and long-term care in low-resource settings is essential to further reduce global inequities. While global RHD mortality has declined, substantial regional and socioeconomic disparities persist. Closing the remaining gaps will require prioritizing the most vulnerable populations – children, adolescents, and women in low-SDI communities – through the comprehensive measures outlined in this study. Although based on modelled estimates, our study provides the best currently available evidence on global RHD trends to inform data-driven policies and guide the intensified efforts needed to control RHD as a public health threat.

Supplementary Information

Additional methodological details, extended data analyses, and complete results of the statistical comparisons performed in this study are provided in the supplementary files. These supplementary materials include supplementary notes describing statistical approaches, comprehensive tables of regional and SDI-stratified data, and additional figures illustrating trends and geographical disparities.

Declarations:

Ethical Approval

This study utilized secondary data without individual-identifiable information, thus not requiring ethical approval. Data access followed the ethical standards and privacy policies of the Institute for Health Metrics and Evaluation (IHME). According to the ethical guidelines of the Institute for Health Metrics and Evaluation (IHME), studies based on GBD data do not require approval from an Institutional Review Board (IRB) or Ethics Committee. Furthermore, this study adhered to the principles outlined in the Declaration of Helsinki for the ethical conduct of medical research. Since the analysis was based on aggregated, de-identified data, obtaining informed consent from participants was not applicable.

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Conflict of Interest

The authors declare that they have no competing interests.

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