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Disparities and Trends in Liver Cancer Burden Due to Hepatitis B Across Five Asian Regions: Analysis from 1990 to 2023 with Projections to 2038

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Abstract

Objective

To analyze the spatial distribution, temporal trends, and mechanisms of liver cancer attributable to hepatitis B (LCHB) across Asia from 1990 to 2023, evaluate health inequalities, and project future burden.

Methods

Epidemiological data on the LCHB were extracted from the Global Burden of Disease (GBD) 2023 database. The age-standardized prevalence rate (ASPR), age-standardized incidence rate (ASIR), age-standardized mortality rate (ASMR), and age-standardized disability-adjusted life- years (DALYs) rate (ASDR) were calculated. Joinpoint regression, Das Gupta decomposition, data envelopment analysis (DEA), slope index of inequality (SII), concentration index (CI), and a Bayesian age-period-cohort (BAPC) model were applied to assess the trends, drivers, inequality, efficiency, and future projections.

Results

In 2023, Asia had ~ 244,300 prevalent cases (ASPR 4.398/100,000), 166,700 new cases (ASIR 3.000/100,000), 142,500 deaths (ASMR 2.572/100,000), and 4.42 million DALYs (ASDR 79.433/100,000). East Asia has the highest prevalence (75.5%). From 1990 to 2023, the overall ASPR, ASIR, and ASMR decreased (estimated annual percentage changes(EAPCs) − 0.734% to − 1.477%), whereas South Asia increased (EAPCs 0.192–0.335%). Post-2020 rebound was notable. Inequalities persisted, with the SII worsening in East Asia and the burden concentrated in countries with lower SDI. The BAPC projected a 23% increase in ASPR and 68% increase in prevalence by 2038.

Conclusions

LCHB burden in Asia declined in the long term, but rebounded after 2020, with significant regional disparities and persistent inequalities. Targeted prevention, screening, infection control, and optimized resource allocation are essential for reducing the burden and improving health equity.

Introduction

Liver cancer ranked among the most common malignancies worldwide, with an estimated 860,000 newly diagnosed cases and approximately 760,000 deaths reported globally in 2022, positioning it as the third leading cause of cancer mortality [1]. The development of liver cancer is associated with multiple etiological factors, among which chronic hepatitis B virus (HBV) infection is the predominant risk factor, accounting for approximately 50% of the liver cancer cases worldwide [2]. HBV infection progressively

leads to cirrhosis through mechanisms such as persistent inflammatory responses, hepatocyte necrosis and regeneration, and fibrosis progression, thereby substantially elevating the risk of hepatocellular carcinoma development [3]. Although widespread implementation of prophylactic HBV vaccination and antiviral therapy has significantly reduced the incidence of new infections in certain regions, liver cancer associated with hepatitis B (LCHB) continues to pose a severe threat to global public health due to the substantial population base of HBV-infected individuals, prolonged disease progression periods, and challenges in early diagnosis [4].

Asia has the heaviest burden of HBV infection and LCHB, globally. Epidemiological investigations revealed that approximately 72.5% of liver cancer cases occur in Asia in 2020, with diverse trends in liver cancer incidence observed across Asian populations [5]. Considerable heterogeneity existed among Asian countries regarding economic development levels, healthcare system infrastructure, vaccination coverage rates, and accessibility to antiviral treatment, which collectively influenced the evolutionary trajectory of LCHB disease burden [6].

In recent years, numerous studies had focused on the temporal changes in liver cancer disease burden across Asia. Several East Asian countries and regions achieved substantial reductions in new infection rates through promotion of neonatal HBV vaccination programs [7, 8]. However, the absolute numbers of liver cancer incidence and mortality might continue to rise due to accelerating population aging and previously infected cohorts entering the disease progression phase [9]. Simultaneously, disparities in disease prevention and control efficiency among countries at different developmental levels could potentially exacerbate health inequalities. Evidence suggested that countries and regions with lower socioeconomic statuses faced higher disease burdens, which were closely related to unequal healthcare resource allocation and limited accessibility to screening and treatment [10].

Although previous studies have reported the LCHB disease burden in Asia, most focused on individual countries or specific periods and lacked a systematic assessment of long-term regional trends. Quantitative evaluations of the drivers of burden changes (e.g., population growth, aging, and epidemiological effects), as well as analyses of prevention and control efficiency across countries with different development levels and the evolution of health inequalities, remain limited. In addition, projections of future disease burden trajectories are scarce, providing insufficient evidence for policy planning. Therefore, using data from the GBD(Global Burden of Disease)2023 Study, this study comprehensively assessed the spatial and temporal patterns of the LCHB burden in Asia from 1990 to 2023, explored factors associated with its changes, and projected future trends to provide evidence for improving prevention strategies and reducing health disparities.

Materials and Methods

2.1 Data Collection and Processing

This study drew upon the Global Burden of Disease (GBD) 2023 study database, from which country- and territory-level epidemiological records were individually extracted. Given that the GBD framework employs its own subregional schema, which does not align with conventional geographic boundaries, all downloaded records were manually reassigned and reaggregated according to the United Nations Statistics Division (UNSD) classification criteria before any analysis was undertaken. The resulting dataset spanned three decades from 1990 to 2023 and encompassed four core outcome measures: prevalent cases, incident cases, deaths, and disability-adjusted life years (DALYs). Age-standardized derivatives of each, namely age-standardized prevalence rate (ASPR), age-standardized incidence rate (ASIR), age-standardized mortality rate (ASMR), and age-standardized DALYs rate (ASDR), were computed using the corresponding population denominators obtained from the same source.

2.2 Trend Analysis

Joinpoint regression was employed to characterize long-term temporal patterns in age-standardized rates from 1990 to 2023. Prior to model fitting, the standard errors for each rate were calculated using R and subsequently imported into the Joinpoint Regression Program. The optimal number of joinpoints, ranging from zero to seven, was determined by weighted Bayesian information criterion (WBIC). Placement constraints required jointpoints to be positioned at least two data points from series endpoints and no fewer than two observations apart from one another. The annual percentage change (APC) and 95% confidence interval (CI) were estimated for each identified trend segment via the empirical quantile method across 5,001 permutation iterations, with trend significance evaluated at $P < 0.05$.

2.3 Decomposition Analysis

The Das Gupta decomposition method was used to attribute the observed changes in liver cancer with hepatitis B (LCHB) burden to specific demographic and epidemiological drivers. This approach partitioned the total burden change into three components: population growth, age structural shifts, and variation in underlying epidemiological rates. Analyses were conducted separately for pan-Asian estimates and for each of the five UNSD-defined subregions, with decomposition performed across multiple subperiods to capture the temporal dynamics within the study window.

2.4 Frontier Analysis

Data envelopment analysis (DEA) was performed to benchmark country-level LCHB mortality performance against the socioeconomic frontier defined by socio-demographic index (SDI). A total of 49 Asian countries and territories constituted decision-making units. A free disposal hull (FDH) model was specified to construct a nonparametric stepwise production frontier without imposing convexity assumptions. Locally weighted scatterplot smoothing (LOWESS) regression was subsequently applied to smooth the frontier curve. Observations identified as super-efficient—those falling below the frontier boundary—were excluded as outliers prior to interpretation. The resulting frontier represented the minimum theoretically achievable ASDR at each SDI level, enabling an objective assessment of how effectively each country converted its developmental status into reductions in liver cancer mortality.

2.5 Health Inequality Analysis

Socioeconomic gradients in the LCHB DALYs rates were evaluated using two complementary indices. The slope index of inequality (SII) quantified absolute inequality by estimating the total burden difference across the full socioeconomic spectrum, whereas the concentration index (CI) captured the relative concentration of the burden among lower-ranked populations. Both indices were computed for each year, from 1990 to 2023. Scatter plots comparing the index values at the two temporal endpoints were generated to determine whether health disparities converged or diverged over the study period.

2.6 Predictive Modeling

A Bayesian age-period-cohort (BAPC) model was constructed to project ASPR, ASIR, ASMR, and ASDR from 2024 to 2038. This model estimated the independent contributions of age, period, and cohort effects by establishing prior distributions for each component, and updating them through Bayesian posterior inference using observed historical data. The three effects were then recombined to generate probabilistic forecasts with the associated uncertainty intervals.

All statistical analyses and data visualizations were performed in R version 4.3.0, with a two-sided P-value threshold of 0.05 applied throughout.

Results

3.1 Overall Characteristics and Geographic Distribution of LCHB Burden in Asia

In 2023, Asia recorded 244,279.385 prevalent LCHB cases with an ASPR of 4.398/100,000 population. Incident cases totaled 166,688.197 (ASIR: 3.000/100,000), deaths reached 142,537.878 (ASMR: 2.572/100,000), and DALYs amounted to 4,422,923.180 person-years (ASDR: 79.433/100,000) (Tables 1 and 2).

Table 1

Prevalent cases, incident cases, ASPR, ASIR, and estimated annual percentage changes (EAPCs) from 1990 to 2023 for LCHB in Asia and five subregions in 2023. UI = uncertainty interval.

Location	Prevalence Number (95% UI)	ASPR (95% UI)	ASPR EAPC 1990–2023 (95% UI)	Incidence Number (95% UI)	ASIR (95% UI)	ASIR EAPC 1990–2023 (95% UI)
Asia	244,279.385 (169,996.213-341,876.046)	4.398 (3.053–6.169)	-0.734 (-0.876 to -0.591)	166,688.197 (113,589.223-237,058.434)	3.000 (2.041–4.270)	-1.283 (-1.430 to -1.136)
Central Asia	872.185 (501.419-1,346.875)	1.186 (0.677–1.843)	-2.400 (-2.580 to -2.220)	703.514 (396.117-1,092.853)	0.988 (0.553–1.544)	-2.447 (-2.641 to -2.253)
East Asia	184,503.145 (134,955.457-247,039.254)	7.283 (5.329–9.736)	-0.639 (-0.788 to -0.490)	120,478.191 (86,645.523-163,110.073)	4.629 (3.333–6.275)	-1.357 (-1.518 to -1.195)
Southeast Asia	29,781.818 (17,332.613-48,190.336)	3.909 (2.266–6.334)	-0.553 (-0.673 to -0.434)	22,777.967 (13,097.630-36,983.103)	3.032 (1.737–4.928)	-0.800 (-0.928 to -0.671)
South Asia	23,373.763 (14,060.982-35,895.718)	1.246 (0.749–1.912)	0.335 (0.178 to 0.492)	18,514.839 (11,177.076-28,957.640)	1.015 (0.611–1.589)	0.265 (0.109 to 0.421)
Western Asia	5,748.474 (3,145.742-9,403.863)	2.104 (1.140–3.460)	-0.426 (-0.591 to -0.260)	4,213.687 (2,272.878-6,914.764)	1.604 (0.856–2.651)	-0.697 (-0.867 to -0.527)

Table 2
Deaths, DALYs, ASMR, ASDR, and EAPCs from 1990 to 2023 for LCHB in Asia and five subregions in 2023. UI = uncertainty interval.

Location	Deaths Number (95% UI)	ASMR (95% UI)	AMSR EAPC 1990–2023 (95% UI)	DALYs Number (95% UI)	ASDR (95% UI)	ASDR EAPC 1990–2023 (95% UI)
Asia	142,537.878 (96,800.366-202,827.409)	2.572 (1.744–3.663)	-1.477 (-1.635 to -1.319)	4,422,923.180 (3,016,171.373-6,302,077.716)	79.433 (54.125-113.263)	-1.649 (-1.812 to -1.486)
Central Asia	658.653 (371.731-1,031.524)	0.949 (0.532-1.500)	-2.473 (-2.681 to -2.265)	21,624.949 (12,480.953-33,203.773)	29.025 (16.667–44.842)	-2.661 (-2.876 to -2.445)
East Asia	100,594.276 (72,525.130–135,351.946)	3.802 (2.743–5.120)	-1.638 (-1.819 to -1.457)	3,036,789.616 (2,205,469.766-4,082,326.293)	122.328 (88.916-164.654)	-1.768 (-1.948 to -1.587)
Southeast Asia	20,454.115 (11,699.071-33,417.760)	2.762 (1.572–4.522)	-0.881 (-1.002 to -0.759)	687,952.505 (398,116.587-1,119,977.788)	89.333 (51.580-145.570)	-0.820 (-0.958 to -0.682)
South Asia	17,073.687 (10,187.271-26,827.407)	0.956 (0.569–1.505)	0.192 (0.012 to 0.372)	559,530.145 (335,737.018-876,442.621)	29.492 (17.669–46.237)	0.200 (0.027 to 0.374)
Western Asia	3,757.147 (2,017.164-6,198.773)	1.471 (0.779–2.449)	-0.856 (-1.002 to -0.709)	117,025.966 (64,367.049-190,127.241)	42.268 (23.017–69.123)	-1.025 (-1.179 to -0.870)

Substantial variations in the disease burden were observed across the subregions. East Asia carried the heaviest burden, with an ASPR of 7.283/100,000, accounting for 75.5% of all prevalent cases in Asia. The corresponding ASIR, ASMR, and ASDR were 4.629/100,000, 3.802/100,000, and 122.328/100,000, respectively. Southeast Asia ranked second with ASPR, ASIR, ASMR, and ASDR values of 3.909, 3.032, 2.762, and 89.333/100,000, respectively. Western Asia exhibited intermediate values (2.104, 1.604, 1.471, and 42.268/100,000, respectively). South Asia (1.246, 1.015, 0.956, and 29.492 per 100,000, respectively) and Central Asia (1.186, 0.988, 0.949, and 29.025 per 100,000, respectively) demonstrated relatively lower disease burdens (Tables 1–2).

From 1990 to 2023, overall disease burden in Asia declined, with EAPCs for ASPR, ASIR, ASMR, and ASDR of − 0.734%, − 1.283%, − 1.477%, and − 1.649%, respectively. Central Asia showed the most pronounced decline (EAPC: −2.400% to − 2.661%), followed by East Asia (EAPC: −0.639% to − 1.768%).

Western and Southeast Asia also exhibited a declining trends. Notably, South Asia was the only subregion that showed an upward trend, with EAPCs ranging from 0.192% to 0.335% (Fig. 1A–D).

3.2 Age-Specific Distribution of LCHB Burden in Asia

Age-related analysis revealed distinct age distribution patterns of the LCHB burden across Asian subregions (Fig. 2). In absolute numbers, East Asia showed the highest values for all four indicators across age groups, followed by Southeast Asia and South Asia. In East Asia, the prevalence, incidence, and deaths peaked at 55–59 years of age (28,560, 17,912, and 14,268 cases, respectively), whereas DALYs peaked at 50–54 years of age (494,240 person-years). Southeast Asia and South Asia showed similar patterns, with peaks mainly between the ages of 50 and 64. In Southeast Asia, the four indicators peaked at ages of 50–54 (4,763 cases), 55–59 (3,555 cases), 60–64 (3,254 cases), and 50–54 (113,646 person-years). In South Asia, prevalence, incidence, and DALYs peaked at ages 55–59 years (3,321; 2,584 cases; and 78,247 person-years), whereas deaths peaked at ages 60–64 years (2,429 cases) (Fig. 2A–D).

Burden rates increased with age. In East Asia, the prevalence, incidence, mortality, and DALYs rates peaked at ages 80–84 (26.962/100,000), 80–84 (19.055/100,000), 85–89 (17.919/100,000), and 60–64 (388.120/100,000) years, respectively. In Southeast Asia, the corresponding peaks occurred at ages 60–64 (14.633/100,000), 60–64 (11.905/100,000), 80–84 (12.070/100,000), and 60–64 (319.395/100,000). Overall, the burden remained low in children and adolescents, but increased rapidly from ages 30 to 34 (Fig. 2A–D).

East Asia contributed the largest share of all indicators across Asia, with the proportion increasing with age. For prevalence, incidence, deaths, and DALYs, the shares rose from 63.823%, 59.190%, 46.970%, and 47.032% at ages 10–14 to 85.366%, 85.981%, 85.326%, and 85.209% at ages ≥ 95. Southeast Asia remained relatively stable, accounting for 7%–25% of all age groups. In contrast, South Asia and Western Asia showed declining proportions with age, decreasing from 16%-28% and 10%-15% in adolescence, and 3%–5% and 1%–2% in older ages, respectively. Central Asia contributed the smallest share, remaining below 2% across all the age groups.

3.3 Joinpoint Regression Analysis

The LCHB epidemiological indicators in Asia improved steadily before 2020, but reversed thereafter (Fig. 3). The ASPR declined rapidly from 2015 to 2019 (APC = − 3.249%), but rebounded from 2020 onward (APC = 2.715%). The ASIR showed a similar pattern, decreasing from 2015 to 2019 (APC = − 3.721%) before increasing from 2020 to 2023 (APC = 3.135%). Both ASMR and ASDR declined markedly from 2017 to 2019 (APC = − 5.673% and − 5.388%, respectively) and subsequently rebounded from 2020 to 2023 (APC = 2.802% and 2.724%, respectively).

East Asia showed the largest fluctuations with the most pronounced rebound after 2020. The ASIR declined rapidly during 2015–2019 (APC = − 4.371%) but increased sharply during 2020–2023 (APC = 3.863%). The ASMR showed similar contrasting changes, dropping from 2017 to 2019 (APC = − 7.167%)

before rebounding during 2020–2023 (APC = 3.314%), both of which represented the largest changes in Asia. South Asia showed a sustained increase after 2020, with ASPR increasing from 2020 to 2023 (APC = 3.913%), exceeding the Asian average, and ASIR increasing rapidly (APC = 3.778%). Notably, increases in ASMR and ASDR began in 2019, earlier than those in the other subregions. Southeast Asia showed more moderate changes, with the ASPR, ASIR, and ASMR increasing from 2020 to 2023 (2.197%, 1.942%, and 1.913%, respectively), while the overall fluctuations remained smaller than those in East Asia and South Asia.

Overall, East Asia and South Asia were the main contributors to the post-2020 increase in LCHB burden, whereas Southeast Asia showed relatively stable trends.

3.4 Decomposition Analysis of LCHB Burden

During 1990–1999, all indicators at the overall Asian level increased, driven mainly by population growth and aging, which together accounted for more than two-thirds of the total change. Population growth contributed 40–60% and aging 33–43% across prevalence, incidence, deaths, and DALYs, while epidemiological changes contributed less than 10% for most indicators. At the subregional level, aging contributed the most to East Asia (> 50% for all indicators). South Asia and Southeast Asia showed relatively higher epidemiological contributions (22%–32%), whereas Central Asia and Western Asia exhibited negative epidemiological contributions (Fig. 4A).

During 2000–2009, demographic factors strongly counterbalanced the epidemiological improvements. All the indicators continued to increase at the Asian level. Except for prevalence, the combined contributions of population growth and aging exceeded 100%, whereas epidemiological factors showed substantial negative contributions (− 68% to − 459%), indicating that prevention and control efforts partially offset demographic pressures. Epidemiological improvements were most pronounced in East Asia, with negative contributions exceeding − 50% for all indicators and reaching − 248% and − 360% for incidence and death, respectively. Central Asia achieved net declines across all indicators, representing the only subregion with an overall favorable trend. In contrast, South Asia showed positive contributions from all three factors, indicating a sustained burden pressure (Fig. 4B).

Epidemiological improvements were the dominant driver from 2010 to 2019. At the Asian level, DALYs declined for the first time, with epidemiological contributions reaching − 9,654%, far exceeding the positive effects of population growth and aging. Epidemiological contributions progressively strengthened from prevalence to incidence, death, and DALYs, reflecting the major progress in reducing disease progression and mortality. However, substantial regional heterogeneity was observed in this study. East Asia had achieved declines in incidence, deaths, and DALYs, with epidemiological improvements contributing over 350%. In Southeast Asia and South Asia, all indicators continued to rise, although epidemiological factors improved (− 23% to − 63%), which was insufficient to offset demographic pressures, with population growth and aging contributing 120%–160%. Western Asia also showed continued increases, with slightly positive epidemiological contributions (Fig. 4C).

The trends reversed during 2020–2023. All indicators at the Asian level increased rapidly, with epidemiological factors becoming the primary drivers, contributing approximately 48% or more to the prevalence, incidence, death, and DALYs, substantially higher than population growth (17%–25%) and aging (27%–36%). Similar patterns were observed across subregions, where epidemiological contributions accounted for 40%–67% of the total changes. East Asia and South Asia showed the highest values (57%–67% and 58%–62%, respectively), suggesting renewed challenges despite previous control successes. Even for severe outcomes such as incidence and deaths, epidemiological contributions remained above 45%, indicating possible simultaneous increases in disease intensity and pathogenicity (Fig. 4D).

3.5 Relationship Between LCHB Burden and Socio-Demographic Development Level

DEA frontier analysis indicated that the efficiency frontier declined progressively with increasing SDI. At low SDI levels (0.1–0.2), the frontier remained at relatively high levels of 30–36/100,000. It declined rapidly to 10–11/100,000 when the SDI entered the 0.2–0.3 range, reached a plateau at medium SDI levels, and further decreased to approximately 7–8/100,000 at high SDI levels (> 0.7). This pattern suggested that the medium developmental stage may represent a critical juncture for improving the efficiency of disease control (Fig. 5A).

A cross-sectional analysis for 2023 (Fig. 5B) revealed that the mean ASDR across the 49 Asian countries was 65.826/100,000, with a mean efficiency gap of 56.131/100,000. Most countries deviated substantially from their SDI-corresponding efficiency frontiers, indicating considerable room for improvement in the overall control. Regional comparisons showed that East and Southeast Asia had relatively high overall burdens, with Mongolia's ASDR far exceeding the regional levels and representing the most notable high-burden country. The Republic of Korea, Thailand, and the Democratic People's Republic of Korea also exhibited markedly higher levels of efficiency than the efficiency frontier. By contrast, some South Asian countries demonstrated higher control efficiency, with Nepal closest to the efficiency frontier and among the lowest-burden countries with minimal efficiency deviation. Western Asia showed pronounced differentiation. Kuwait theoretically approached optimal control levels, whereas Iraq's ASDR far exceeded the regional mean, reflecting substantial disparities in the disease control capacity within the region.

3.6 Health Inequality Analysis

Health inequality analysis of LCHB DALYs rates from 1990 to 2023 showed distinct SII and CI trajectories across subregions (Fig. 6A–B). At the Asian level, the SII declined from 19.14 in 1990 to 13.83 in 2023, while the CI changed from − 0.31 to − 0.33, indicating a moderate reduction in absolute inequality but a persistent concentration of burden in lower socioeconomic countries.

At the subregional level, Central Asia showed pronounced improvement, with the SII decreasing from 59.18 in 1990 to 16.47 in 2023 and the CI approaching zero. East Asia exhibited marked changes, with

SII declining from − 3.29 to − 138.50 and CI shifting from − 0.71 to near-zero positive values. The increasing magnitude of negative SII suggested a growing concentration of burden in higher socioeconomic countries, representing the most unusual pattern among the subregions. Southeast Asia showed an increase in SII (40.25 to 56.28) with a slight decline in CI to − 0.07, indicating increasing inequality. South Asia also showed an increased SII (14.40 to 27.88) with a relatively stable CI, suggesting mild inequality aggravation. Western Asia maintained negative SII values (− 12.63 to − 20.01) with a positive CI, indicating a distribution pattern distinct from that of other subregions.

Overall, Central Asia experienced the greatest improvement in inequality, whereas East Asia showed markedly deepening negative inequality. Southeast and South Asia showed increasing inequality.

3.7 BAPC Model-Based Projection of LCHB Epidemiological Trends

Based on the BAPC model, the LCHB burden in Asia is projected to rise over the next 15 years, with moderate increases in age-standardized rates but rapid growth in absolute case numbers. Substantial variation is expected across subregions (Fig. 7A–H).

At the Asian level, ASPR is projected to increase from 4.474/100,000 in 2024 to 5.505/100,000 in 2038 (23%), with prevalent cases increasing from 257,000 to 430,000 (68%) (Fig. 7A, 7E). ASIR is projected to increase from 3.118 to 3.932/100,000 (26%), with incident cases rising from from 179,000 to 323,000 (81%) (Fig. 7B, 7F). ASMR is projected to increase from 2.683 to 3.081/100,000 (15%), while the number of deaths increase from 153,000 to 301,000 (96%) (Fig. 7C, 7G). ASDR is projected to increase from 82.582 to 94.040/100,000 (14%), with total DALYs rising from 4.76 million to 8.25 million (73%) (Fig. 7D–H).

The subregional analysis reveals three distinct patterns. East Asia is projected to bear the largest burden, with prevalent cases accounting for approximately two-thirds of the Asian population by 2038. ASPR is expected to increase from 7.337 to 9.252/100,000 (26%), with prevalent cases rising from 192,000 to 288,000 (50%) and deaths from 108,000 to 214,000 (98%), accounting for 71% of the total deaths in Asia. South and Southeast Asia have grown rapidly. In South Asia, ASPR is projected to increase from 1.303 to 2.481/100,000 (90%), with 182% of prevalent cases and 203% of deaths. In Southeast Asia, the ASPR is expected to increase by 35%, with the DALYs rate rising by 39% (the highest among subregions) and the total DALYs increasing by 95%. Central Asia shows declining rates but increasing case numbers, with ASPR, ASIR, and ASMR decreasing by 7%, 11%, and 8%, respectively, whereas prevalent cases and DALYs increase by 33% and 57%, respectively. Western Asia shows a 43% increase in ASPR, with the number of prevalent cases increasing from 6,412 to 14,192 (121%).

Discussion

This study systematically assessed long-term trends in the disease burden of LCHB across Asia from 1990 to 2023 based on GBD 2023 data. The findings revealed that despite declining age-standardized

rates across Asia overall, absolute case numbers continued to rise, with a notable rebound observed after 2020 and significant heterogeneity between regions. East Asia bore the predominant burden, whereas South Asia remained the only region that experienced sustained increases, with persistent health inequalities remaining prominent. These findings provide crucial scientific evidence for understanding the epidemiological evolution of the LCHB in Asia, identifying weaknesses in prevention and control efforts, and formulating precise intervention strategies.

Based on Joinpoint regression and DasGupta decomposition analysis, the temporal evolution of the LCHB disease burden in Asia was systematically characterized by "sustained improvement from 1990–2019, followed by significant rebound after 2020." The 1990s marked the initial establishment phase of Asia's LCHB prevention and control system, during which the disease burden primarily increased naturally alongside population structural changes. Decomposition analysis indicated that the combined contribution of population growth and aging exceeded 70% during this period, whereas the epidemiological improvement effects remained relatively limited. This pattern reflected the evident time-lag effect of prevention and control measures. Although East Asia pioneered the incorporation of hepatitis B vaccine into routine immunization programs—for instance, South Korea launched its national immunization program in 1983 and China incorporated hepatitis B vaccine into recommended vaccination schedules in 1992 [11, 12]—the suppression of liver cancer incidence risk through vaccination required approximately 20–30 years through the natural disease history process [13], and its preventive benefits had not yet fully manifested during this stage. Additionally, the absence of systematic adult screening programs and standardized antiviral treatment strategies at that time prevented the effective containment of disease progression among previously infected populations.

In the 21st century, the development of Asia's LCHB prevention and control system accelerated markedly, with epidemiological improvement factors demonstrating significant negative contributions for the first time, although their magnitude remained insufficient to fully offset the sustained pressure from population growth and aging. This structural transformation was closely associated with the advancement of multiple key public health policies, including the global immunization vision and strategy proposed by the WHO in 1992, which promoted the incorporation of hepatitis B vaccine into immunization programs in more countries, along with the introduction of first-generation antiviral drugs such as lamivudine into clinical practice [14–16]. However, the prevention and control system during this stage still exhibited notable shortcomings, with vaccine coverage showing significant disparities between urban and rural areas, mother-to-child transmission prevention measures not yet comprehensively implemented, and limited accessibility to antiviral treatment with gradually emerging drug resistance issues. The regional decomposition results demonstrated that East Asia and Central Asia exhibited the most pronounced epidemiological improvement contributions, whereas South Asia showed positive contributions across population growth, aging, and epidemiological effects, suggesting substantial gaps in prevention and control capacity and health system maturity across different Asian regions.

The period 2010–2019 represented a critical phase when prevention and control achievements became concentrated in Asia, with the synergistic effects of multiple intervention measures driving a substantial reversal of disease burden. Epidemiological improvement became the dominant driving force, with DALYs declining for the first time. This transformation was primarily attributable to the systematic advancement of vaccination, screening, diagnosis, and antiviral treatment. The WHO updated hepatitis B vaccination recommendations, emphasizing first-dose administration within 24 h of birth, and East Asia, particularly China, rapidly increased newborn immunization coverage, significantly enhancing mother-to-child transmission prevention effectiveness [17]. Simultaneously, cohorts immunized in the early 1990s gradually entered young- and mid-adulthood, and the time-lag effects of vaccine prevention began to manifest. Improvements in screening and diagnostic capacity enhanced early disease detection levels, while the widespread application of highly effective antiviral drugs, such as entecavir and tenofovir, coupled with the WHO's publication of chronic hepatitis B treatment guidelines in 2015, further promoted treatment standardization and accessibility enhancement [18]. Implementation of a full-chain intervention under policy guidance established East Asia as a representative example of disease burden reduction in high-burden regions [17]. Nevertheless, overall improvement during this stage still exhibited marked regional disparities, with South Asia experiencing a sustained disease burden increase due to late prevention and control initiation and rapid population growth, while Southeast Asia and Central Asia remained in transitional phases of gradually accumulating prevention and control effectiveness.

The disease burden rebound after 2020 constituted a significant setback in Asia's LCHB prevention and control progress as the COVID-19 pandemic imposed a systematic disruption on the existing prevention and control systems. Epidemiological factors reemerged as the dominant driving force, disrupting the relative equilibrium of effective suppression of disease progression through prevention and control measures maintained over the preceding decade. Multiple studies had demonstrated that hepatitis screening and testing activities decreased significantly during the COVID-19 pandemic. A comparative survey across Bangladesh, Japan, and globally showed that HBV- and HCV-related services (including screening and testing) declined substantially during the most severe pandemic periods, more markedly than the global average [19]. Expert surveys also reported declining trends in HBV and HCV screening and confirmatory testing volumes during the pandemic [20], with comprehensive evidence supporting the disruption of routine hepatitis screening during the pandemic. Concurrently, changes in patients' healthcare-seeking behavior further exacerbated medical service interruptions [19], with screening and diagnostic delays accelerating disease progression.

Age-specific distribution patterns profoundly reflected the natural history, characteristics, and cohort effects of HBV infection. The rapid burden increase after age 30 stemmed from the high chronicity rates following childhood infection (reaching 90% before age 1), with sequential progression through immune clearance, liver fibrosis, cirrhosis, and liver cancer requiring 20–30 years [13]. The burden peak observed in the 50–60 age group was closely associated with accumulated disease progression among cohorts infected during high-prevalence periods before vaccine availability, reflecting concentrated disease onset characteristics among previously infected populations. Since young and middle-aged populations constitute the core workforce, their high incidence status not only intensifies healthcare system pressure

but also exerts long-term impacts on regional economic development [21]. Regional epidemic variations were partially related to the accessibility of prevention and control resources and the timing of vaccination strategies, with HBV epidemic patterns across different Asian countries largely reflecting the timing of vaccine promotion and imbalanced distribution of healthcare resources [22, 23]. These findings emphasized the need for life-course management approaches, including sustained promotion of newborn vaccination to interrupt new infections, enhanced HBV screening targeting populations above the age of 30 years for the early identification of liver fibrosis and initiation of antiviral treatment, and implementation of liver cancer surveillance among high-risk populations above the age of 50 years to improve early diagnosis rates.

DEA frontier analysis revealed a nonlinear relationship between prevention and control efficiency and socioeconomic development levels. The efficiency frontier exhibited a stepwise pattern of "low SDI plateau phase, middle SDI rapid decline, and high SDI convergence," reflecting the increasing marginal benefit pattern of prevention and control measures. The middle SDI phase (0.2–0.4) represented a critical window period for efficiency advancement, during which economic capacity became sufficient to support core interventions including universal vaccine coverage, screening network construction, and antiviral treatment promotion [24, 25], constituting a strategic opportunity period for breaking through the "high burden-low resource" trap.

Health inequality analysis revealed the complex evolution of the disease burden distribution. Overall absolute inequality (SII) in Asia moderated while relative concentration (CI) slightly increased, reflecting an unbalanced pattern of "universal improvement in prevention and control effectiveness but lesser gains among low-SDI countries," consistent with overall trends in global health inequality research indicating that infectious disease prevention and control progress often preferentially benefits high-resource regions [26]. Achieving health equity required systematic resource redistribution and service model innovations. Adoptable measures included establishing regional vaccine procurement alliances to reduce costs, promoting mobile screening and community-based antiviral treatment models to enhance grassroots accessibility, strengthening cross-border technical cooperation and human resource training, and incorporating hepatitis prevention and control into the UHC framework to ensure adequate support for low-SDI countries [27].

BAPC model projections indicated that Asia's LCHB disease burden over the next 15 years would present the dual challenges of "moderate increases in standardized rates and rapid escalation of absolute case numbers." This trend was jointly driven by population aging and previously infected cohorts entering high-incidence periods, posing severe challenges to health system capacity, resource allocation, and service models. The regional projections exhibited divergent patterns. East Asia, as the primary burden region, would account for approximately two-thirds of Asia's total prevalence in 2038, requiring prioritized strengthening of the refined management of existing infections and allocation of liver cancer diagnosis and treatment resources. South Asia and Southeast Asia exhibited rapid growth patterns, urgently requiring the completion of vaccine coverage, grassroots diagnosis, and treatment gaps. Central Asia demonstrated "rate decline with volume increase," necessitating consolidation of prevention and

control achievements to sustain reductions in standardized rates. Western Asia required the targeted enhancement of prevention and control capacity, particularly in regions with relatively underdeveloped economies.

Based on the above findings, cross-regional cooperation and capacity building constituted key elements for achieving the viral hepatitis elimination targets. Specific strategies included promoting universal vaccine coverage, standardization of antiviral treatment, and standardized construction of liver cancer screening systems to establish solid prevention and control foundations [28]. East Asian prevention and control experiences could provide replicable paradigms for South and Southeast Asia, with cross-regional technical cooperation accelerating capacity enhancement in weak regions. Establishing unified surveillance systems and data-sharing mechanisms could enable the precise tracking of burden dynamics. Simultaneously, strengthening grassroots screening and diagnosis capacity building, advancing liver disease professional talent cultivation, and tiered diagnosis and treatment would enhance the resilience of prevention and control system resilience [29]. Integrating hepatitis elimination targets into UHC strategies, with policy coordination ensuring prevention and control effectiveness, aligns with the WHO 2030 viral hepatitis elimination framework.

Limitations

This study had several limitations. First, the GBD data were estimated based on multi-source information and statistical models subject to parameter settings and modeling assumptions, with results inevitably containing uncertainties that might deviate from the actual disease burden. Second, the analysis focused on Asian subregional levels, failing to adequately reveal heterogeneity among countries within regions, thus presenting certain limitations in refined policy guidance. Third, key influencing factors, such as policy implementation intensity and vaccine coverage rates, lacked unified and quantifiable cross-country data, making systematic incorporation into the driving factor analysis framework difficult and limiting in-depth mechanistic interpretations. Fourth, after 2020, disease surveillance and reporting delays or underreporting occurred in some countries due to the COVID-19 pandemic, potentially introducing data bias [30]. Fifth, the BAPC projection models were based on extrapolation of historical trends, with unforeseeable factors, such as future public health emergencies or major policy adjustments, potentially reducing projection stability and accuracy. Sixth, constrained by the GBD data structure, the study lacked individual-level information on risk factors such as HBV prevalence and vaccination rates, making further elucidation of causal associations between exposures and disease outcomes difficult. Seventh, this study did not differentiate between HBV genotypes, thus failing to assess the potential impact of genotype differences on disease progression, prevention, and control effectiveness. Future research should combine higher-resolution country-level data, integrate policy and behavioral indicators, and incorporate virological characteristic differences to further deepen our understanding of the LCHB disease burden evolution mechanisms.

Conclusion

This study showed that Asia had made substantial progress in reducing age-standardized LCHB rates; however, absolute cases continued to rise and post-2020 rebounds revealed vulnerabilities in prevention and control. Subregional disparities, particularly between stabilized East Aisa and rising South Asia, highlighted the need for context-specific interventions. Population aging, historical infection cohorts, and unequal access to vaccines, screening, and treatment posed ongoing challenges. Achieving the WHO 2030 elimination targets requires coordinated vaccination, expanded treatment and screening, strengthened surveillance, and resilient health systems integrated into UHC frameworks.

Declarations

Data Availability Statement

Data supporting the findings of this study are available from the corresponding author upon reasonable request. All data generated or analyzed during this study are included in this published article and its supplementary information files.

Author Contributions

Xu Yue conceptualized and designed the study. He Xu Chang acquired and curated the GBD data. Zhang Bin and Wang Jun performed the formal analysis and visualization. Xu Yue and Xia Feng developed the methodology and conducted statistical modeling. Xu Yue wrote the original draft of this manuscript. All the authors contributed to the review and editing of the manuscript. Luo En supervised the study and provided critical revisions. All authors have read and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest related to this study.

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Figures

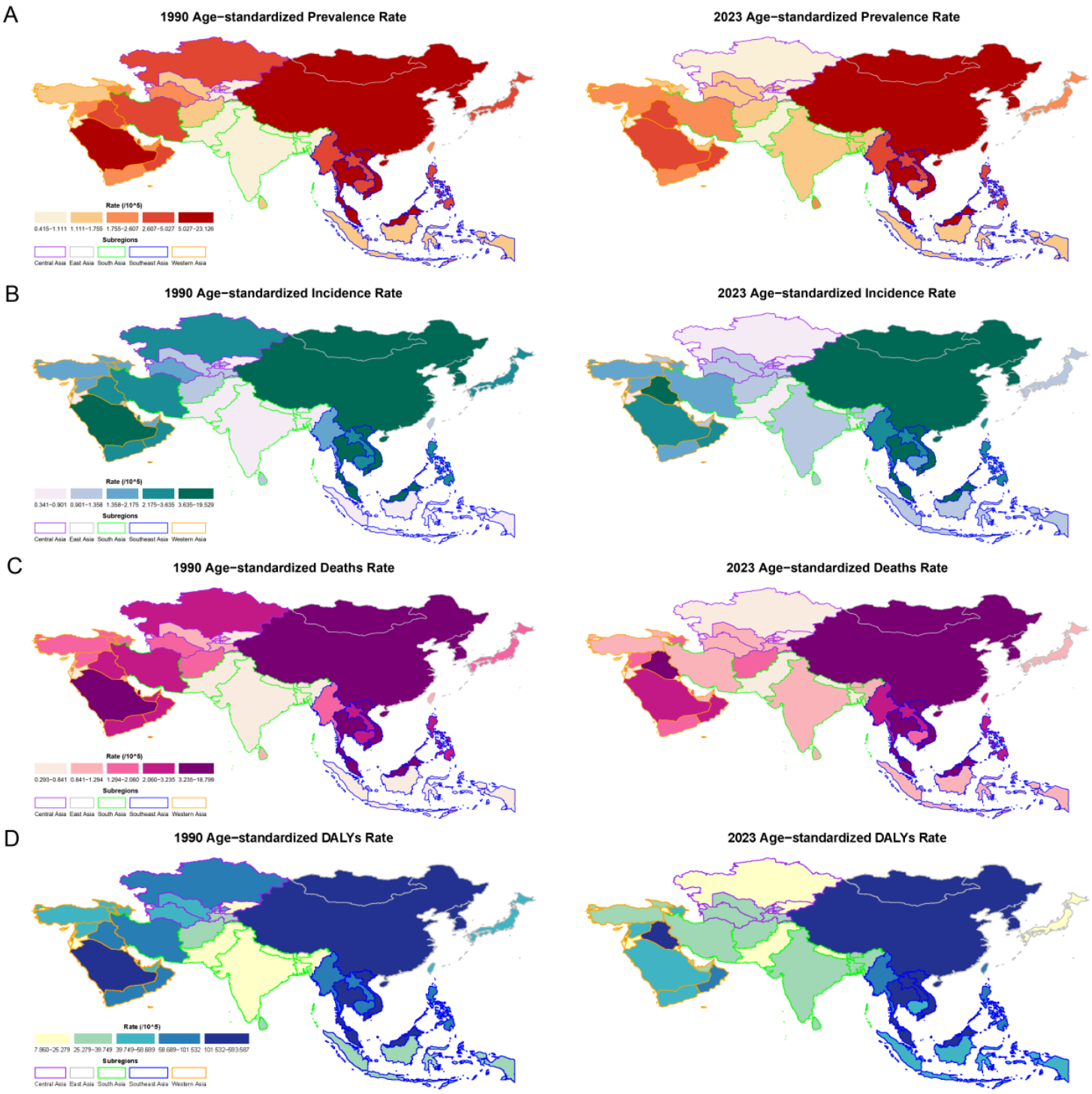


Figure 1

Spatial distribution and temporal trends of LCHB burden in Asia (1990–2023). Distribution and changes in age-standardized (per 100,000 population) prevalence rate (A), incidence rate (B), mortality rate (C), and DALYs rate (D) for LCHB in Asia. Each indicator comprises two sub-figures: the left panel shows the 1990 distribution and the right panel shows the 2023 distribution. Color intensity represents disease burden magnitude. Different colored borders denote different Asian subregions: purple (Central Asia), gray (East Asia), green (South Asia), blue (Southeast Asia), and orange (Western Asia).

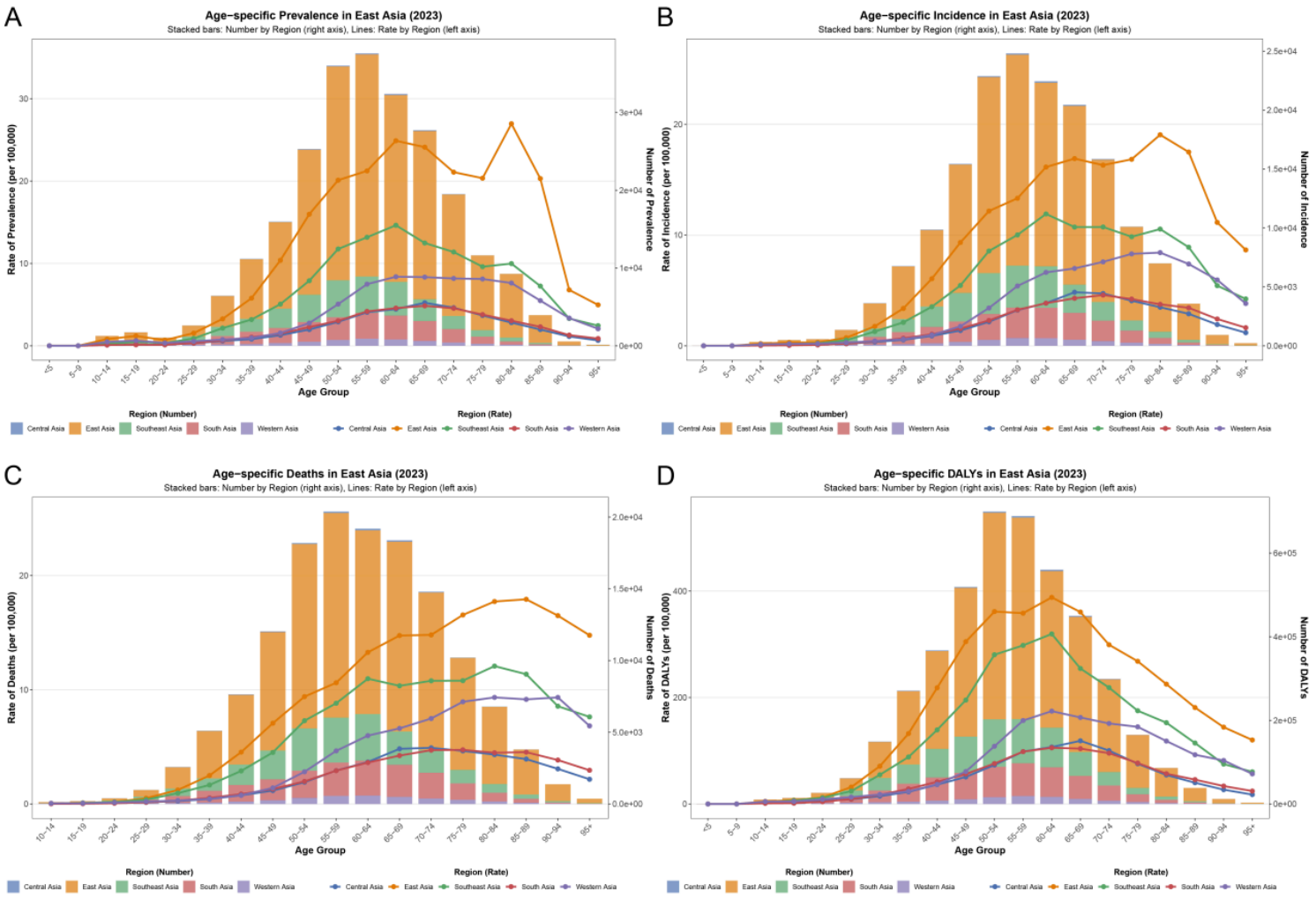


Figure 2

Age-specific distribution characteristics of LCHB burden in Asia. (A–D) Age-specific prevalence, incidence, deaths, and DALYs rates and numbers, along with their distribution patterns for LCHB.

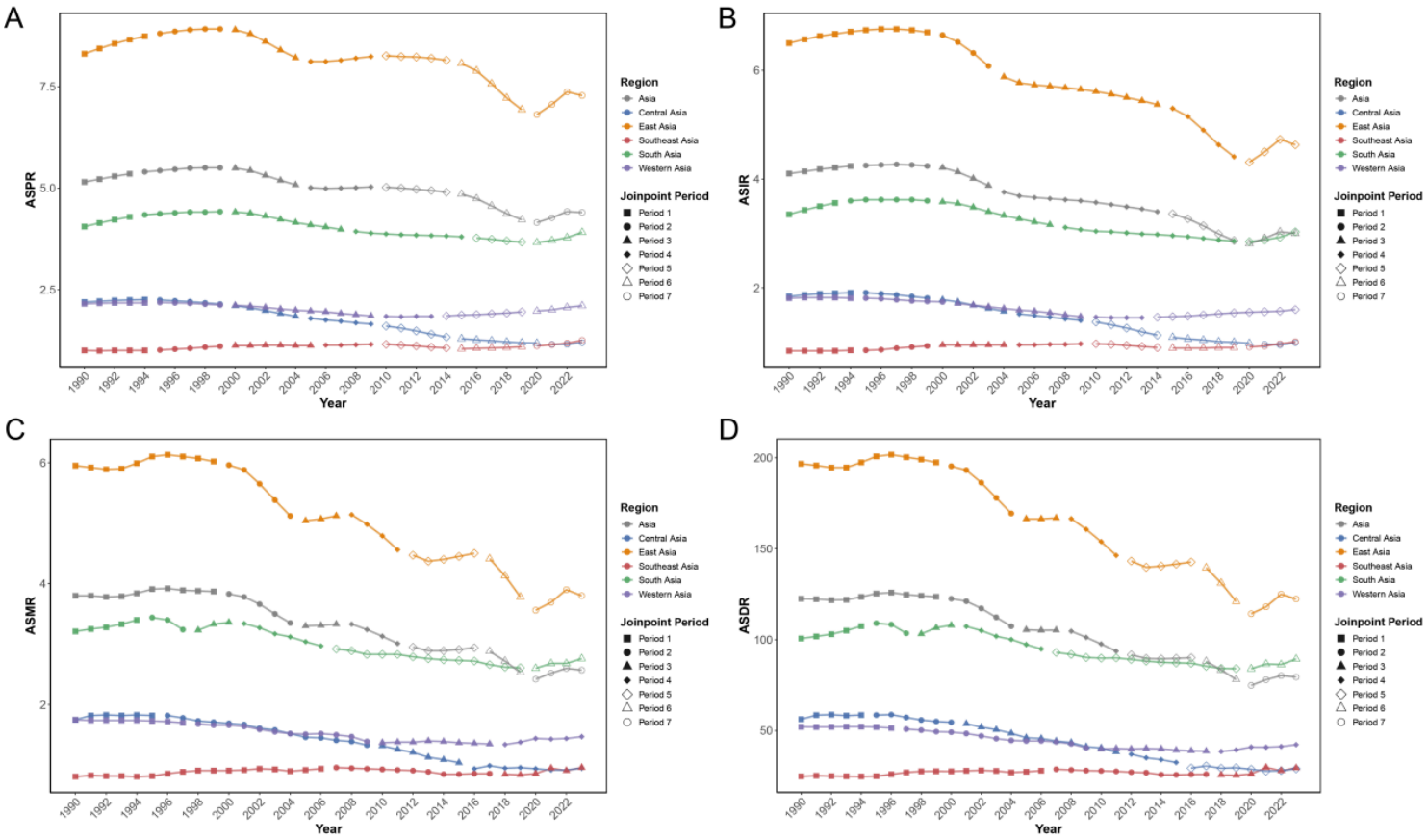


Figure 3

Joinpoint regression analysis of age-standardized rates for LCHB in Asia (1990–2023). Joinpoint regression trends for age-standardized (per 100,000 population) prevalence rate (A), incidence rate (B), mortality rate (C), and DALYs rate (D) for LCHB in Asia. Different colored lines represent different regions (gray = Asia, blue = Central Asia, orange = East Asia, green = Southeast Asia, red = South Asia, purple = Western Asia). Different shaped points denote different Joinpoint periods.

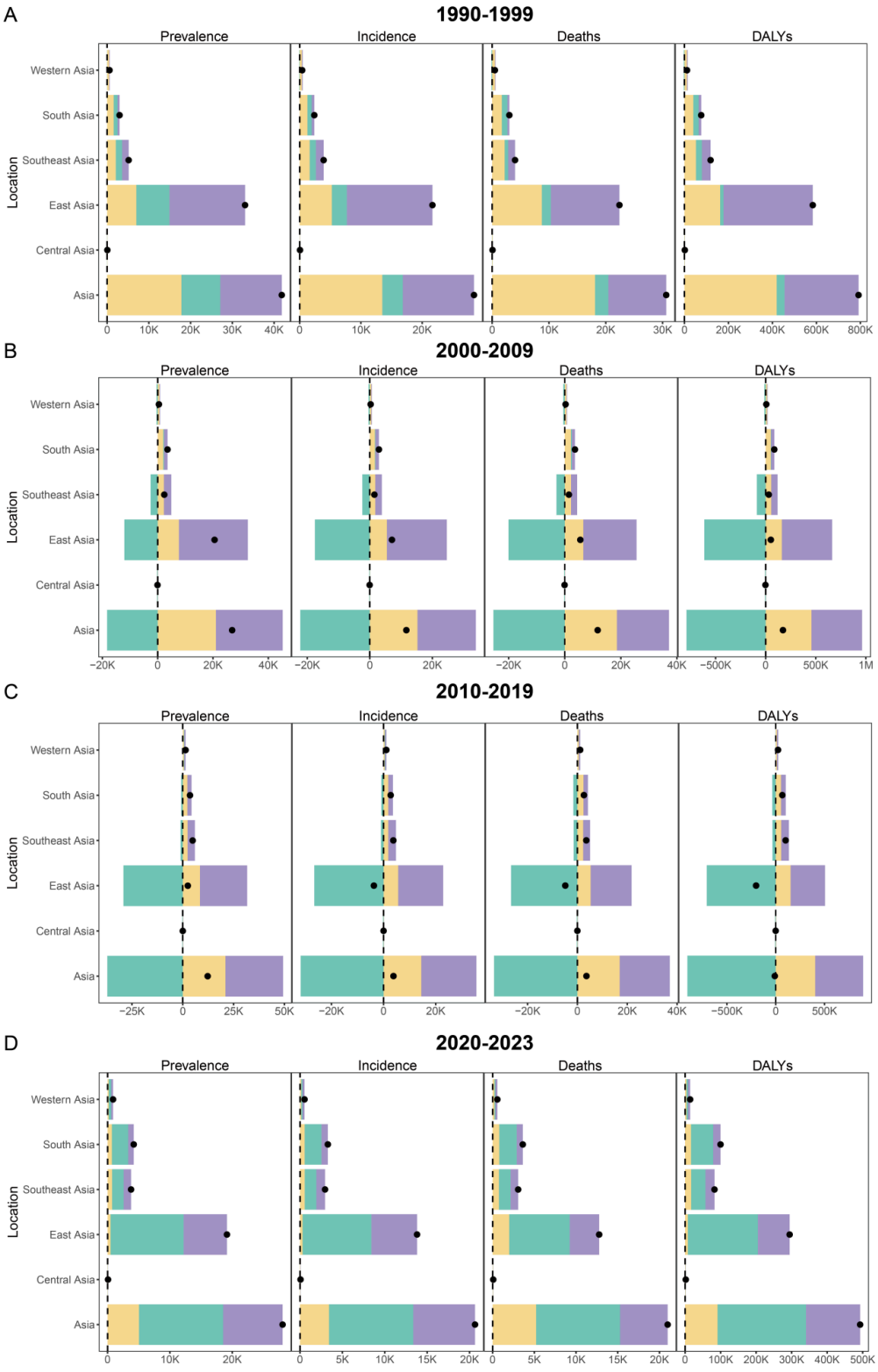


Figure 4

Decomposition analysis of changes in LCHB prevalence, incidence, deaths, and DALYs burden in Asia and five subregions. 1990–1999 (A); 2000–2009 (B); 2010–2019 (C); 2020–2023 (D). The five Asian subregions are Central Asia, East Asia, Southeast Asia, South Asia, and Western Asia.

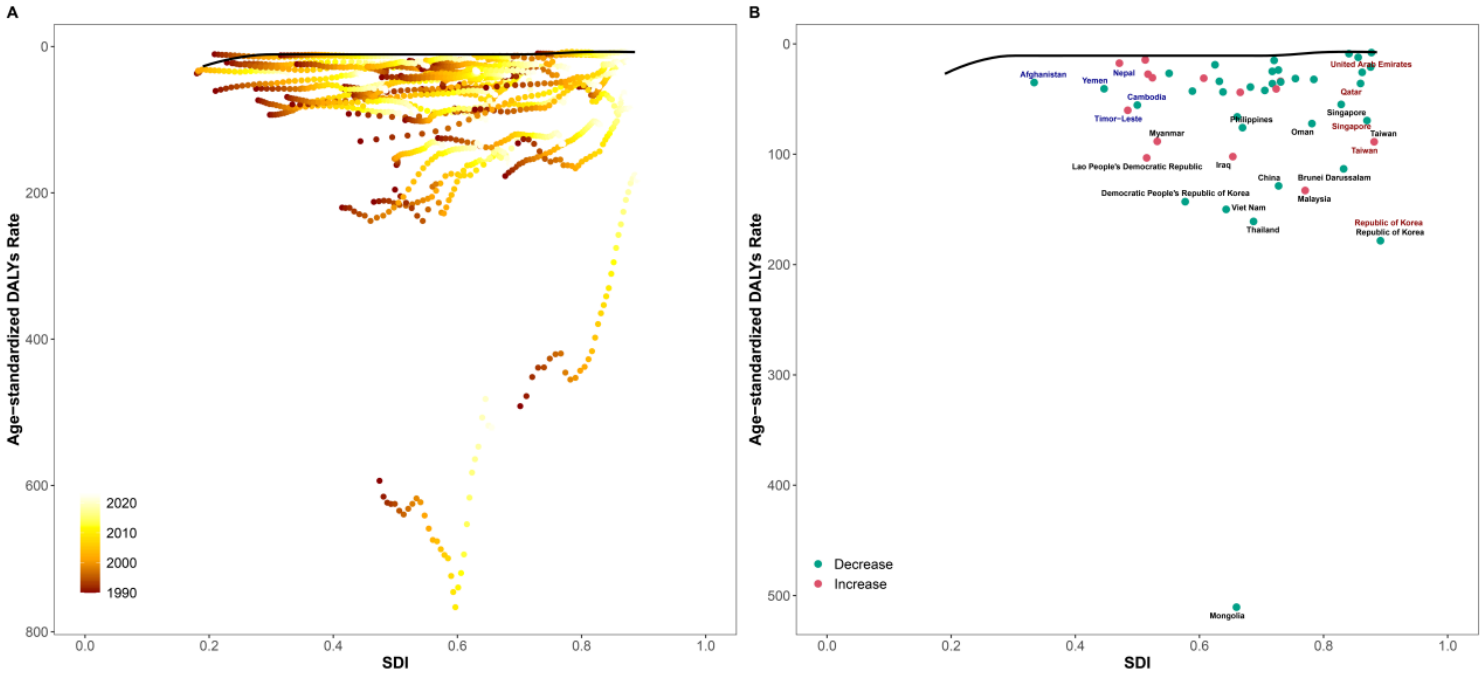


Figure 5

Relationship between SDI and age-standardized DALYs rate for LCHB (1990–2023). (A) Scatter plot of SDI versus age-standardized DALYs rate for LCHB across 49 Asian countries from 1990 to 2023. The black curve represents the fitted frontier production function, indicating the minimum achievable DALYs rate at a given SDI level. Different colored points represent different years. (B) Trends in age-standardized DALYs rate for LCHB across Asian countries in 2023. The solid black line represents the fitted frontier production function curve, and colored dotted lines indicate DALYs rate changes for individual countries. Black text labels denote the 15 countries with the largest distance gaps; blue text labels indicate the 5 low-SDI countries with the smallest distance gaps; red text labels indicate the 5 high-SDI countries with the largest distance gaps.

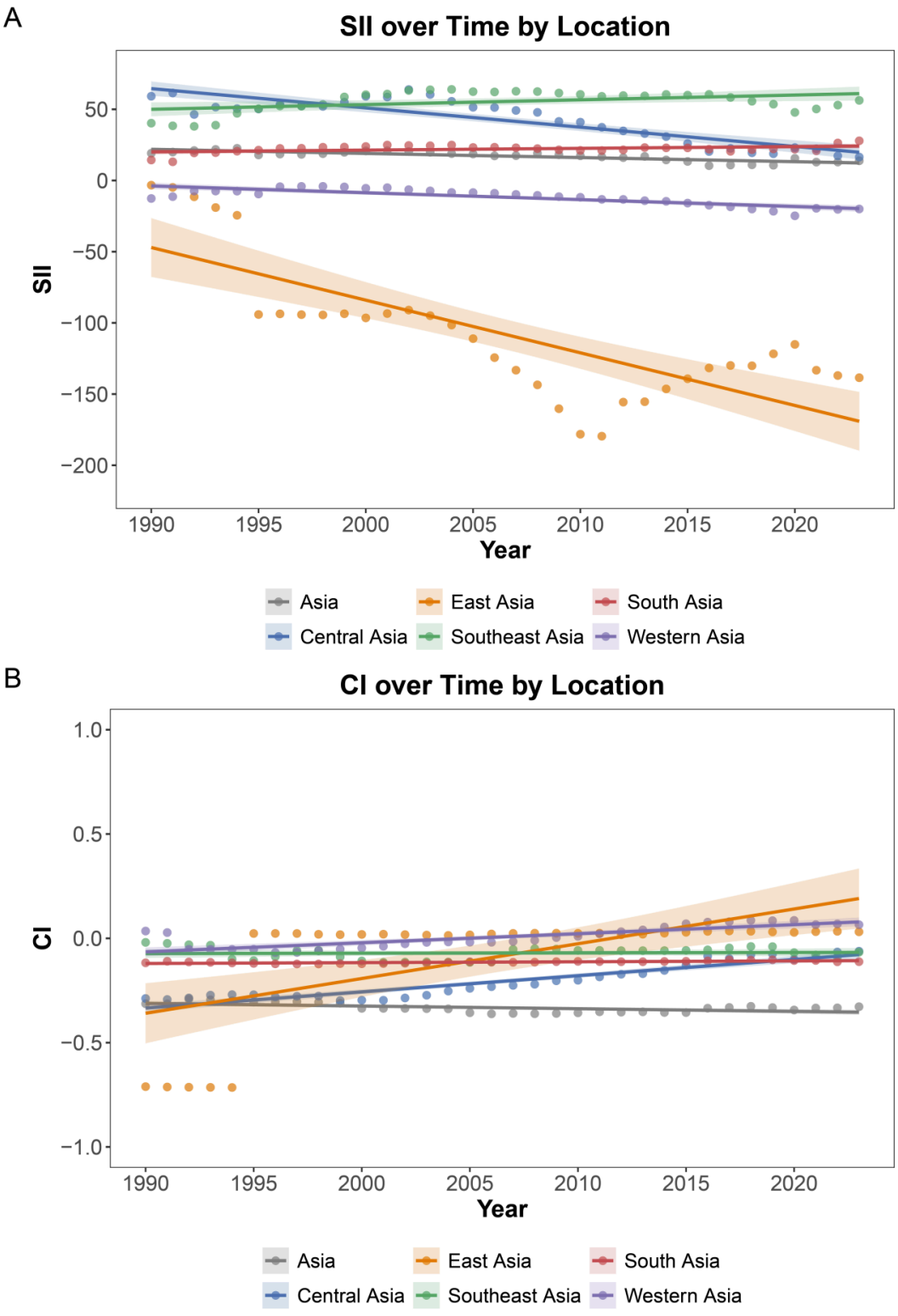


Figure 6

Health inequality analysis of LCHB DALYs rates (1990–2023). (A) Scatter plot of SII for LCHB DALYs rates from 1990 to 2023. (B) Scatter plot of CI for LCHB DALYs rates from 1990 to 2023. The SII measures absolute inequality in LCHB burden, while the CI measures relative inequality. Higher absolute values of either index indicate greater inequality.

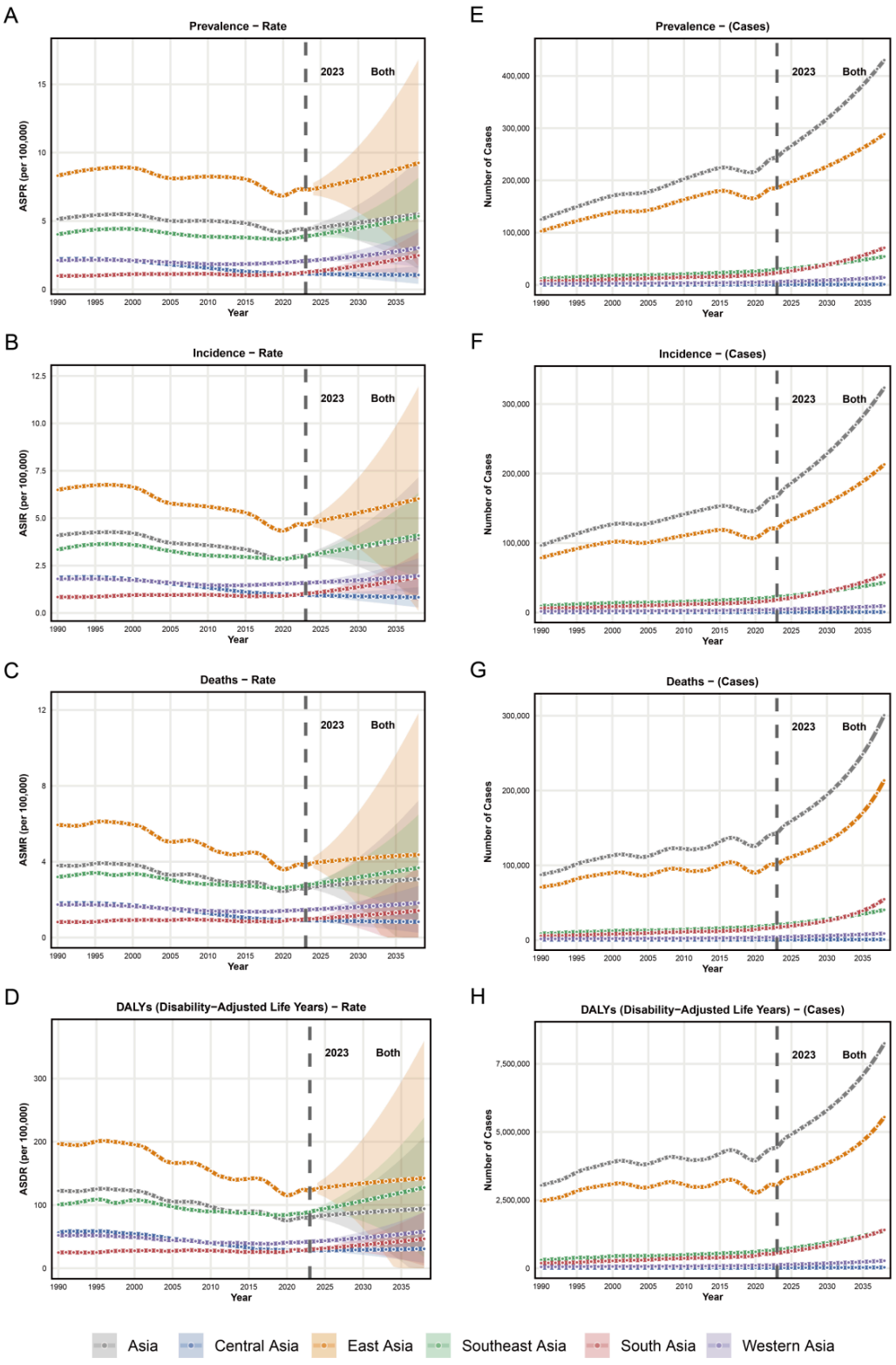


Figure 7

BAPC model-based projections of LCHB epidemiological trends in Asia (2024–2038). Age-standardized prevalence, incidence, mortality, and DALYs rates (A–D); prevalence, incidence, deaths, and DALYs numbers (E–H).