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Original Article

Chronic Hepatitis B in the Asia-Pacific Region: Results of the 2023 Global Burden of Disease Study

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Abstract

Background and Aims: The Asia-Pacific region accounts for a larger share of the hepatitis B burden than any other regions of the world, presenting a challenge to meeting the World Health Organization (WHO) 2030 elimination targets. In this study, we aimed to quantify the burden of chronic hepatitis B (CHB) and project its trends through 2030 using the GBD 2023 framework, thereby identifying gaps and priorities for the Asia-Pacific region to achieve WHO 2030 targets. ***Methods:*** Using data from the Global Burden of Disease Study 2023, we analyzed chronic hepatitis B (CHB) prevalence, mortality, and disability-adjusted life years. We evaluated temporal trends (1990–2023) using average annual percent changes and projected the 2024–2030 burden using Bayesian age-period-cohort models. ***Results:*** In 2023, the Asia-Pacific region accounted for 63% of global CHB cases (178.0 million), 66% of deaths (259.1 thousand), and 65% of disability-adjusted life years (8.4 million). Regional prevalence and mortality rates exceeded global averages, although childhood (<5 years) prevalence was comparatively lower (590.3 vs. 1,325.3 per 100,000). East Asia bore the highest absolute burden (99.2 million cases), and South Asia had the largest pediatric caseload. Between 1990 and 2023, Western Asia showed the steepest decline in adult prevalence (−1.99%), whereas Southeast and Central Asia exhibited upward mortality trends. Projections indicate that the Asia-Pacific region is off track to meet the WHO 2030 disease elimination targets, as the prevalence rate in children under five years remains above the 0.1% target threshold and absolute mortality is projected to increase. ***Conclusions:*** The Asia-Pacific region continues to contribute the largest share of the global CHB burden and now faces persistent gaps despite progress. Although substantial progress has been made in reducing prevalence through immunization, the region is currently off track to meet the WHO 2030 targets for both incidence and mortality.

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Introduction

Chronic hepatitis B (CHB) is a major global health challenge and a leading cause of liver-related mortality. Despite effective vaccines and therapies, HBV infection causes significant liver cirrhosis and hepatocellular carcinoma (HCC).[1–3] In 2022, an estimated 257.5 million people were living with CHB globally. This resulted in approximately 0.5–0.8 million annual deaths.[4–6] CHB also imposes a heavy economic burden because of the high treatment costs associated with advanced liver disease and productivity losses from premature mortality.[7–9] Reducing this burden is critical for public health and economic development.

The Asia-Pacific region is the global epicenter of the HBV epidemic.[10–12] Historically driven by mother-to-child transmission, this region contains the world's largest reservoir of chronic HBV infections.[13,14] Although universal infant vaccination has significantly reduced prevalence among younger generations, a major challenge remains: the large popula-

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tion of adults infected prior to the vaccination era.[4,15] As this "aging cohort" advances in age, its risk of developing decompensated cirrhosis and HCC increases.[5,16] Consequently, the region continues to face a substantial burden of advanced liver disease that requires sustained healthcare resources.[11,12,17]

To guide progress toward elimination, the World Health Organization (WHO) Global Health Sector Strategy set 2030 targets for viral hepatitis, including a 90% reduction in new chronic HBV infections and a 65% reduction in HBV-related mortality from the 2015 baseline.[18] In 2022, the WHO further clarified its phased goals by aiming to reduce the prevalence of HBsAg in children under five years of age to 0.1% by 2030.[19] Although vaccination has successfully curbed incidence, the mortality target remains unattainable because of persistent gaps in the care cascade, particularly suboptimal diagnosis and treatment rates among eligible adults in high-burden countries.[20,21] Current surveillance data are also essential for guiding policy, and the Global Burden of Disease (GBD) Study 2023 provides the most rigorous assessment of health trends using updated methodologies and demographic data.[3,22] Therefore, using the GBD 2023 framework, this study aimed to quantify the current CHB burden in 2023, assess temporal trends from 1990 to 2023, identify demographic and epidemiological drivers of burden changes, and project the burden through 2030. By comparing global, regional, subregional, and key-country patterns, we sought to clarify the major gaps in achieving the WHO 2030 targets and identify priorities for CHB elimination in the Asia-Pacific region.

Methods

Data sources

Detailed GBD methodology has been described elsewhere.[3,22] The GBD 2023 study provides annual estimates of disease burden from 1990 to 2023 by age, sex, location, and year, covering 204 countries and territories, 375 diseases and injuries, and 88 risk factors. It was built on previous iterations by incorporating over 35,000 new data sources, including vital registration, surveillance systems, surveys, disease registries, hospital records, and published literature, and by applying advanced modeling tools, specifically DisMod-AT and refined MR-BRT, to generate point estimates and 95% uncertainty intervals (UIs) and improve the accuracy of CHB estimates. These updates improve the capture of outpatient and readmission-adjusted hospital data. All data utilized in this study were obtained from the Global Health Data Exchange (https://vizhub.healthdata.org/gbd-results/).

GBD estimation framework

We defined CHB as chronic HBV infection, including cases with and without cirrhosis, and extracted annual estimates (1990–2023) for prevalence, mortality, and disability-adjusted life years (DALYs) by age (5-year intervals) and geography (67 Asia-Pacific countries; Supplementary Table 1). Historical population data were obtained from the GBD database, and 2024–2030 projections were obtained from the United Nations World Population Prospects.[23] Consistent with established epidemiology, prevalence in children under five years served as a proxy for the incidence of new infections.[24,25]

Statistics

Statistical analysis was stratified by four geographic levels: global, regional (Asia-Pacific), subregional (six custom subregions), and national (Supplementary Table 1). For each geographic level, we systematically assessed all-age CHB prevalence, CHB prevalence among children under five years of age, deaths, and DALYs. At the national level, we identified and focused on 18 key countries, specifically the three countries with the highest numbers of prevalent CHB cases in 2023 within each subregion. These countries were then consistently evaluated across all major outcomes, including pediatric prevalence, mortality, DALYs, temporal trends, decomposition analysis, and projections toward 2030. This approach was used to capture both the major contributors to the regional burden and the heterogeneity of pediatric infection across subregions and countries.

Estimates are reported with 95% UIs. Regional point estimates were derived by summing country-level data. To estimate regional UIs, we used a Monte Carlo simulation (1,000 iterations) to account for nonlinear uncertainty propagation. Assuming a log-normal distribution, standard errors were calculated as (ln(Upper UI) - ln(Lower UI)) / 3.92, and random draws were aggregated to generate regional totals and rates, with the 2.5th and 97.5th percentiles of the simulated distribution defining the final 95% UIs.

Temporal trends were analyzed using Joinpoint regression to calculate the average annual percent change (AAPC), and trends were considered statistically significant if the 95% confidence interval (CI) excluded zero. To determine drivers of burden, we applied the Das Gupta decomposition method, partitioning changes in absolute numbers into three components: population growth, population aging, and epidemiological changes in rates.[14,26] In this decomposition framework, the epidemiological change component represents changes in age-specific burden rates after holding population size and age structure constant. It should be interpreted as a composite effect of multiple factors, including prevention, diagnosis, treatment, healthcare access, health education, and other unmeasured changes, rather than the effect of any single intervention. Future burden trends from 2024 to 2030 were projected using a Bayesian age-period-cohort (BAPC) model. Age-specific historical estimates of CHB prevalence, deaths, and DALYs from GBD 2023 for 1990–2023 were used as input time-series data. The BAPC model decomposes temporal trends into age, period, and cohort effects, which are smoothed using second-order random-walk priors to stabilize short-term projections. Projected age-specific rates were then combined with future population denominators from the United Nations World Population Prospects 2024 to estimate the numbers of prevalent cases, deaths, and DALYs through 2030. The model was implemented using the BAPC package in R.[23] All statistical analyses were performed using R statistical software (version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria) or the Joinpoint Regression Program (Version 5.1.0.0; Statistical Research and Applications Branch, National Cancer Institute).

Results

The current burden of CHB in the Asia-Pacific region in 2023

Prevalence of CHB in the general population: The Asia-Pacific region accounted for 63.1% of the global CHB burden in 2023, with 178.0 million prevalent cases (95% UI: 168.3–188.8 million) compared with the global total of 281.9 million (95% UI: 259.6–307.1 million). The regional prevalence rate was 3.7% (95% UI: 3.5%–3.9%), which exceeded the global average of 3.5% (95% UI: 3.2%–3.8%).

Subregionally, East Asia bore the highest burden, with

Table 1. Main CHB Burden in Asia-Pacific Region, 2023

Location	Prevalence, All ages		Prevalence, Age under 5		Deaths, All ages		DALYs, All ages	
	Number, thousand (95% UI)	Rate, per 100,000 (95% UI)	Number, thousand (95% UI)	Rate, per 100,000 (95% UI)	Number, thousand (95% UI)	Rate, per 100,000 (95% UI)	Number, thousand (95% UI)	Rate, per 100,000 (95% UI)
Global	281,929.51	3,495.36	8,522.35	1,325.32	394.20	4.89	13,074.46	162.10
	(259,575.69–307,130.36)	(3,218.22–3,807.80)	(6,619.27–10,124.71)	(1,029.37–1,574.51)	(324.62–464.54)	(4.02–5.76)	(10,822.92–15,349.73)	(134.18–190.31)
Asia-Pacific Region	177,975.44	3,705.32	1,964.38	590.33	259.07	5.39	8,441.73	175.75
	(168,260.21–188,809.00)	(3,503.06–3,930.87)	(1,853.91–2,110.86)	(557.14–634.35)	(237.86–286.01)	(4.95–5.95)	(7,750.42–9,391.33)	(161.36–195.52)
East Asia	99,242.62	5,978.09	475.95	677.07	104.03	6.27	2,988.38	180.01
	(89,681.39–108,380.36)	(5,402.15–6,528.52)	(417.85–537.70)	(594.42–764.92)	(88.65–121.29)	(5.34–7.31)	(2,560.15–3,503.97)	(154.22–211.07)
China	91,190.03	6,374.05	358.65	576.95	90.88	6.35	2,630.08	183.84
	(81,716.34–100,342.69)	(5,711.85–7,013.81)	(305.07–412.58)	(490.76–663.71)	(76.28–108.63)	(5.33–7.59)	(2,230.14–3,113.54)	(155.88–217.63)
Japan	2,883.35	2,312.74	1.64	39.66	4.04	3.24	88.88	71.29
	(2,657.31–3,178.76)	(2,131.43–2,549.68)	(1.35–1.99)	(32.77–48.05)	(3.36–4.75)	(2.69–3.81)	(76.23–102.97)	(61.14–82.59)
Democratic People's Republic of Korea	2,202.65	8,340.03	107.67	7,226.16	2.41	9.12	78.03	295.44
	(1,898.68–2,497.71)	(7,189.09–9,457.21)	(83.19–132.74)	(5,583.07–8,908.88)	(1.43–3.53)	(5.40–13.35)	(48.31–113.14)	(182.92–428.41)
South Asia	40,460.95	2,072.32	714.10	426.10	76.18	3.90	2,763.57	141.54
	(37,580.92–43,611.26)	(1,924.82–2,233.68)	(632.86–823.44)	(377.62–491.34)	(62.95–92.95)	(3.22–4.76)	(2,249.75–3,422.93)	(115.23–175.32)
India	30,611.16	2,120.79	425.71	386.89	56.95	3.95	2,035.15	141.00
	(27,931.04–33,678.65)	(1,935.11–2,333.31)	(338.15–507.38)	(307.31–461.11)	(43.28–71.12)	(3.00–4.93)	(1,521.29–2,533.96)	(105.40–175.56)
Pakistan	5,450.61	2,234.31	222.73	722.49	10.65	4.37	420.13	172.22
	(4,870.40–6,038.13)	(1,996.47–2,475.14)	(184.72–259.76)	(599.18–842.62)	(5.96–14.53)	(2.44–5.96)	(238.98–579.83)	(97.96–237.68)
Bangladesh	3,184.52	1,831.68	24.00	148.37	4.14	2.38	158.86	91.37
	(2,823.00–3,603.79)	(1,623.75–2,072.84)	(14.85–33.39)	(91.82–206.41)	(2.58–7.41)	(1.48–4.26)	(99.98–274.47)	(57.51–157.87)
Southeast Asia	27,978.58	4,026.67	471.99	890.08	61.19	8.81	2,169.63	312.25
	(26,908.14–29,134.87)	(3,872.61–4,193.08)	(435.96–515.75)	(822.15–972.61)	(52.85–72.30)	(7.61–10.41)	(1,867.31–2,573.16)	(268.74–370.33)
Indonesia	10,002.01	3,479.36	185.27	849.67	28.40	9.88	1,014.52	352.92
	(9,169.43–10,866.33)	(3,189.73–3,780.03)	(155.32–213.85)	(712.34–980.77)	(21.26–36.67)	(7.39–12.76)	(754.59–1,305.99)	(262.50–454.31)
Vietnam	6,786.26	6,578.80	53.09	676.28	8.86	8.59	290.52	281.64
	(6,380.32–7,215.54)	(6,185.27–6,994.96)	(43.03–64.59)	(548.08–822.70)	(5.99–13.01)	(5.81–12.61)	(189.21–435.81)	(183.43–422.49)

(continued)

Table 1. *(continued)*

Location	Prevalence, All ages		Prevalence, Age under 5		Deaths, All ages		DALYs, All ages	
	Number, thousand (95% UI)	Rate, per 100,000 (95% UI)	Number, thousand (95% UI)	Rate, per 100,000 (95% UI)	Number, thousand (95% UI)	Rate, per 100,000 (95% UI)	Number, thousand (95% UI)	Rate, per 100,000 (95% UI)
Philippines	6,492.70	5,669.91	150.78	1,497.89	5.42	4.73	188.34	164.47
	(5,948.52–7,142.47)	(5,194.69–6,237.34)	(127.52–174.11)	(1,266.74–1,729.63)	(4.33–6.75)	(3.78–5.89)	(150.06–231.90)	(131.04–202.51)
Western Asia	6,649.40	1,795.44	157.73	541.55	12.05	3.25	324.87	87.72
	(6,445.48–6,859.22)	(1,740.38–1,852.09)	(137.71–186.05)	(472.80–638.79)	(10.53–14.29)	(2.84–3.86)	(291.68–378.48)	(78.76–102.19)
Turkey	1,761.91	2,051.94	25.07	462.72	4.40	5.13	102.80	119.73
	(1,670.34–1,846.78)	(1,945.29–2,150.78)	(19.91–30.44)	(367.38–561.75)	(3.15–5.81)	(3.67–6.77)	(78.02–132.05)	(90.87–153.79)
Yemen	1,635.29	4,599.95	97.33	1,960.25	1.37	3.86	39.91	112.25
	(1,491.20–1,757.32)	(4,194.63–4,943.21)	(72.89–116.81)	(1,468.00–2,352.43)	(0.81–2.08)	(2.28–5.85)	(23.89–61.34)	(67.21–172.55)
Iran	1,241.67	1,412.19	5.60	100.07	2.02	2.29	55.34	62.94
	(1,136.22–1,359.22)	(1,292.25–1,545.88)	(4.67–6.59)	(83.45–117.84)	(1.42–2.75)	(1.61–3.13)	(39.25–76.03)	(44.64–86.47)
Central Asia	2,124.40	2,679.22	24.16	270.45	4.50	5.68	157.63	198.80
	(1,965.42–2,298.72)	(2,478.72–2,899.08)	(19.99–30.54)	(223.69–341.81)	(3.87–5.30)	(4.89–6.68)	(134.01–190.29)	(169.01–239.99)
Uzbekistan	1,218.95	3,448.87	10.03	243.25	1.69	4.79	62.37	176.47
	(1,072.83–1,368.85)	(3,035.44–3,872.99)	(5.72–14.39)	(138.78–349.17)	(1.26–2.30)	(3.57–6.50)	(44.97–86.45)	(127.24–244.61)
Kazakhstan	466.71	2,287.52	4.98	240.14	1.49	7.28	45.57	223.35
	(411.03–529.14)	(2,014.60–2,593.54)	(3.51–6.04)	(169.12–291.05)	(1.13–1.98)	(5.53–9.69)	(32.79–62.94)	(160.73–308.48)
Tajikistan	194.83	1,823.13	4.40	326.06	0.42	3.89	14.97	140.11
	(158.38–234.89)	(1,482.10–2,198.05)	(2.58–6.44)	(191.17–477.25)	(0.27–0.57)	(2.50–5.36)	(9.09–21.45)	(85.07–200.77)
Oceania	1,519.49	3,287.99	120.45	3,183.98	1.13	2.44	37.65	81.47
	(1,438.72–1,605.08)	(3,113.21–3,473.19)	(98.20–146.96)	(2,595.99–3,884.76)	(0.97–1.33)	(2.11–2.88)	(32.31–45.08)	(69.93–97.54)
Papua New Guinea	810.41	7,296.64	110.41	6,716.28	0.24	2.14	9.76	87.90
	(738.80–886.50)	(6,651.85–7,981.70)	(86.72–132.70)	(5,274.92–8,072.21)	(0.14–0.34)	(1.28–3.10)	(6.12–13.81)	(55.08–124.31)
Australia	480.49	1,782.91	2.75	182.99	0.59	2.20	17.38	64.48
	(444.95–525.00)	(1,651.03–1,948.04)	(2.26–3.24)	(150.72–215.33)	(0.47–0.75)	(1.76–2.78)	(13.55–21.73)	(50.29–80.64)
New Zealand	92.85	1,813.79	2.22	746.09	0.06	1.24	1.78	34.80
	(84.15–102.96)	(1,643.75–2,011.29)	(1.86–2.60)	(623.89–873.55)	(0.06–0.07)	(1.08–1.45)	(1.55–2.06)	(30.31–40.17)

CHB, chronic hepatitis B; DALYs, disability-adjusted life years.

99.2 million cases (rate: 6.0%), followed by South Asia (40.5 million; rate: 2.1%) and Southeast Asia (28.0 million; rate: 4.0%). Among the 18 key countries, China (91.2 million), India (30.6 million), and Indonesia (10.0 million) collectively accounted for 74.1% of the region's prevalent cases. The highest prevalence rates were observed in the Democratic People's Republic of Korea (DPRK) (8.3%), Papua New Guinea (7.3%), and Vietnam (6.6%) (Table 1).

Prevalence of CHB in children under five years old: There were 2.0 million (95% UI: 1.9–2.1 million) prevalent CHB cases among children under five years of age in the Asia-Pacific region in 2023, corresponding to a regional prevalence rate of 590.3 per 100,000 (95% UI: 557.1–634.4 per 100,000), which was lower than the global average of 1,325.3 per 100,000 (95% UI: 1,029.4–1,574.5 per 100,000). Subregionally, South Asia had the largest number of under-5 cases (714.1 thousand; 426.1 per 100,000), followed by East Asia (476.0 thousand; 677.1 per 100,000) and Southeast Asia (472.0 thousand; 890.1 per 100,000). Western Asia and Central Asia had smaller absolute numbers, whereas Oceania had the highest under-5 prevalence rate among the six subregions (3,184.0 per 100,000), indicating a disproportionate pediatric burden relative to its population size.

At the national level, the largest absolute numbers of under-5 cases were observed in India (425.7 thousand), China (358.7 thousand), and Pakistan (222.7 thousand), reflecting the effect of population size. In contrast, the highest under-5 prevalence rates were found in the DPRK (7,226.2 per 100,000), Papua New Guinea (6,716.3 per 100,000), and Yemen (1,960.3 per 100,000), indicating that smaller or medium-sized countries may still have very high pediatric infection intensity. Detailed estimates for all 18 key countries are presented in Table 1.

Mortality and DALYs due to CHB: The Asia-Pacific region recorded 259.1 thousand deaths (95% UI: 237.9–286.0 thousand) and 8.4 million DALYs (95% UI: 7.8–9.4 million) in 2023, accounting for 65.7% and 64.6% of the global burden, respectively. Regional mortality (5.4 per 100,000; 95% UI: 5.0–6.0) and DALY rates (175.8 per 100,000; 95% UI: 161.4–195.5) both exceeded global averages (deaths: 4.9; 95% UI: 4.0–5.8; DALYs: 162.1; 95% UI: 134.2–190.3). Subregionally, East Asia incurred the highest absolute losses (104.0 thousand deaths; 3.0 million DALYs), followed by South Asia (76.2 thousand deaths; 2.8 million DALYs). Southeast Asia also recorded the highest mortality (8.8 per 100,000) and DALY rates (312.3 per 100,000).

Nationally, China (90.9 thousand deaths; 2.6 million DALYs), India (57.0 thousand deaths; 2.04 million DALYs), and Indonesia (28.4 thousand deaths; 1.01 million DALYs) accounted for approximately 68% of the regional burden. Indonesia reported the highest rates (deaths: 9.9; DALYs: 352.9), followed by the DPRK (deaths: 9.1; DALYs: 295.4) and Vietnam (deaths: 8.6; DALYs: 281.6) (Table 1).

Age-specific burden of CHB in 2023

Prevalence by age: Age-specific prevalence in the Asia-Pacific region mirrored global patterns, rising from childhood to peak in the 35–59 age group before declining (Fig. 1A). Regional prevalence was lower than the global average for ages 0–29 years but higher for those aged 30 years and older. Subregionally, trends generally followed the regional pattern, except in Oceania, where prevalence in the 0–4 age group was significantly elevated. In Oceania, rates dipped to a minimum at ages 15–19 years, peaked again at 35–59 years, and then declined (Fig. 1B). Among adults (aged ≥20 years), East and Southeast Asia consistently had the highest rates, whereas Western and South Asia had the lowest.

Nationally, prevalence generally increased through adolescence, plateaued at high levels from ages 20–24 years through adulthood, and declined in older age groups (Supplementary Fig. 1A–F). Adult prevalence was markedly higher in the DPRK, Papua New Guinea, Vietnam, the Philippines, and China. Notably, the DPRK showed elevated prevalence in the 0–4 age group, as did the Philippines in the 5–9 age group. Papua New Guinea also followed the unique pattern observed in Oceania.

Mortality and DALYs by age: Regarding fatal and nonfatal health loss, age-specific mortality and DALY rates in the Asia-Pacific region were slightly higher than global levels in adult age groups. The mortality rate increased continuously with age (Fig. 1C), whereas the DALY rate increased in the 0–64 age groups and decreased in those aged 65 years and older (Fig. 1E). Subregional analysis showed that Southeast Asia had the highest DALY rates in the 20–79 age groups. Central Asia exhibited the highest mortality rates in the ≥80-year age group, with DALY rates increasing throughout the lifespan (Fig. 1D and F). At the national level, mortality rates in most countries increased with age, and sharp increases in mortality rates were observed in the oldest age groups in Yemen (Supplementary Fig. 1G–R).

Trends in CHB burden rates from 1990 to 2023

Prevalence in the general population: From 1990 to 2023, the prevalence rate of CHB declined significantly in both the Asia-Pacific region (AAPC = −1.79%, 95% CI: −1.91% to −1.67%) and globally (AAPC = −1.53%, 95% CI: −1.60% to −1.46%) (Figs. 2A and 3). At the subregional level, all six subregions exhibited statistically significant downward trends over the study period, and Western Asia recorded the steepest decline (AAPC = −1.99%, 95% CI: −2.10% to −1.88%). Notably, the two subregions with the highest baseline prevalence also achieved substantial reductions: South Asia (AAPC = −1.57%, 95% CI: −1.67% to −1.48%) and East Asia (AAPC = −1.52%, 95% CI: −1.58% to −1.47%) (Figs. 2B and 3). Among the 18 key countries, all demonstrated an overall decreasing trend in prevalence rates, with Iran (AAPC = −2.26%, 95% CI: −2.42% to −2.10%) and Yemen (AAPC = −2.15%, 95% CI: −2.27% to −2.03%) showing the largest average annual reductions (Supplementary Fig. 2A–F; Fig. 3).

Prevalence in children under five years old: The prevalence rate in children under five years of age declined more rapidly in the Asia-Pacific region (AAPC = −6.44%, 95% CI: −6.74% to −6.13%) than globally (AAPC = −3.95%, 95% CI: −4.29% to −3.61%), falling below the global level after 1995 (Figs. 2C and 3). Subregionally, Central Asia (AAPC = −7.62%, 95% CI: −8.79% to −6.43%) and East Asia (AAPC = −7.48%, 95% CI: −7.93% to −7.04%) recorded the steepest declines, whereas Oceania showed the slowest progress (AAPC = −1.29%, 95% CI: −1.76% to −0.83%) (Figs. 2D and 3). Among the 18 key countries, Iran (AAPC = −9.40%, 95% CI: −9.71% to −9.09%) and Japan (AAPC = −8.97%, 95% CI: −9.48% to −8.46%) achieved the most substantial reductions. In contrast, the trend in the DPRK was not statistically significant (AAPC = 1.06%, 95% CI: −3.28% to 5.60%), likely because of recent volatility (Supplementary Fig. 2G).

Mortality and DALY rates: Regional mortality and DALY rates declined overall between 1990 and 2023 (mortality AAPC = −1.40%, 95% CI: −1.59% to −1.21%; DALY AAPC = −1.09%, 95% CI: −1.27% to −0.92%), outpacing global reductions (mortality: −1.07%; DALYs: −0.86%) (Fig. 2E and G; Fig. 3). Subregional trends varied. East Asia (AAPC = −1.93%) and South Asia (AAPC = −1.44%) exhibited

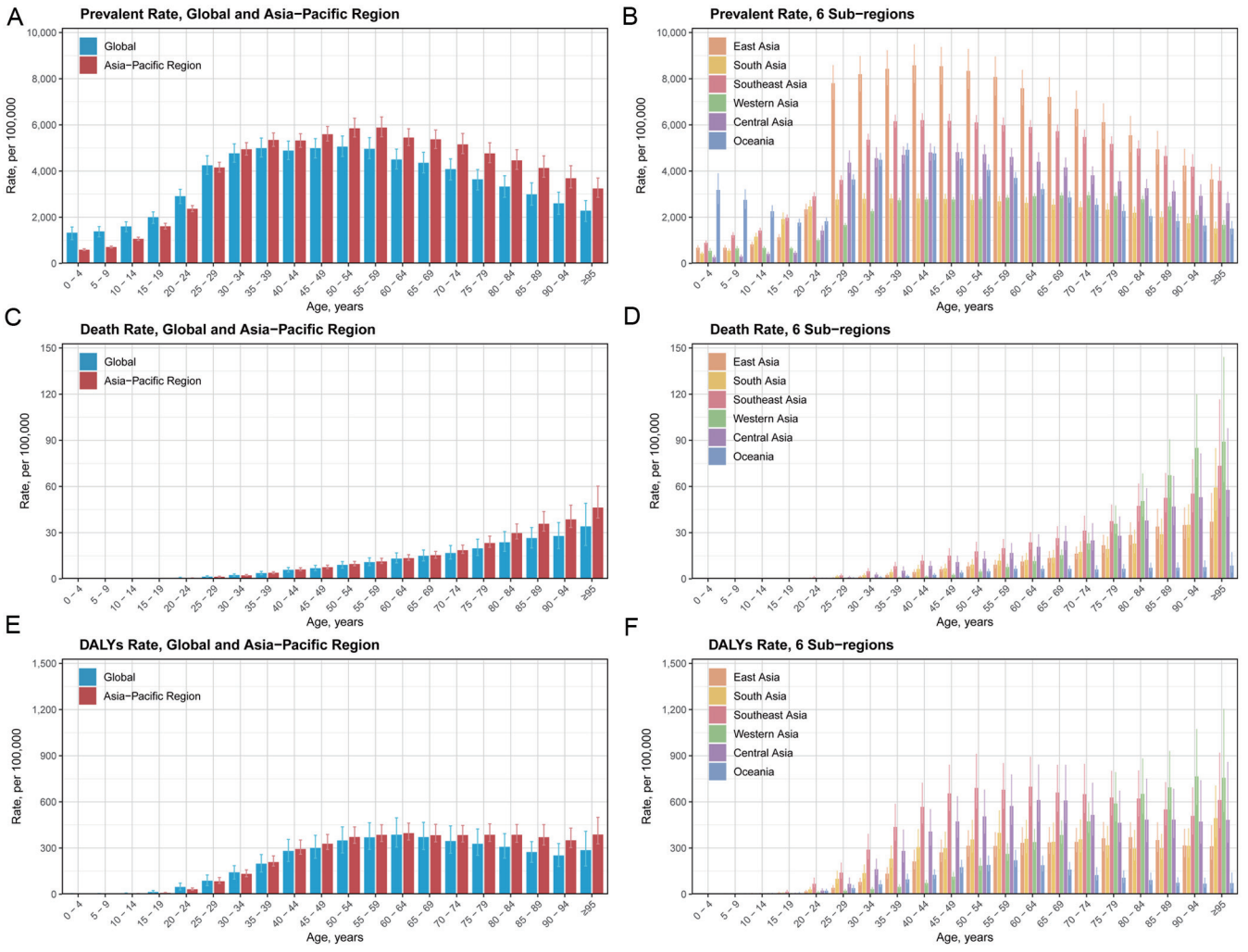

Fig. 1. Age-specific burden of CHB, 2023. (A) Prevalence rate, global and Asia-Pacific region; (B) prevalence rate, six subregions; (C) death rate, global and Asia-Pacific region; (D) death rate, six subregions; (E) DALY rate, global and Asia-Pacific region; (F) DALY rate, six subregions. CHB, chronic hepatitis B; DALYs, disability-adjusted life years.

robust mortality declines. In contrast, Central Asia showed significant increases in both mortality (AAPC = 0.77%) and DALY rates (AAPC = 0.78%). Southeast Asia showed stable mortality (AAPC = 0.03%) but increasing DALY rates (AAPC = 0.18%). Nationally, Kazakhstan recorded the sharpest increases in mortality (AAPC = 3.13%) and DALY rates (AAPC = 3.27%), followed by Vietnam (mortality AAPC = 0.38%). Bangladesh achieved the most rapid mortality reduction (AAPC = −4.05%) (Fig. 3).

Decomposition analysis

Between 1990 and 2023, changes in prevalent cases were driven by opposing forces: epidemiological improvements (declining rates) reduced the burden by 339.4% relative to the net change, whereas population growth (201.3%) and aging (38.1%) increased case numbers, partially offsetting these gains. Drivers varied by subregion. In South Asia, population growth (1,580.8%) was the primary driver of increased cases, whereas in East Asia, epidemiological improvements (171.4%) outweighed demographic factors, leading to a net decrease. Nationally, case increases in India (4,347.1%) and Pakistan (464.3%) were predominantly driven by population growth. In China, epidemiological changes (178.4%) dominated the reduction in burden. Uniquely, Japan experienced declines driven by both epidemiological changes (148.1%) and a shrinking, aging population (−43.5%).

For mortality and DALYs, population aging significantly increased the regional burden, largely offsetting epidemiological improvements. Subregionally, population aging was a major driver of mortality in East Asia, counteracting substantial epidemiological gains. In South Asia, population growth (311.1%) remained the primary driver, consistent with prevalence trends. Central Asia showed a distinct pattern in which limited or negative epidemiological progress, combined with demographic factors, drove increases in burden.

Nationally, China illustrated the impact of aging: epidemiological improvements contributed to a 433.3% reduction in deaths, but this was largely offset by aging. In Kazakhstan, epidemiological changes (contributing 62.8% to the increase) reinforced aging and growth effects. However, in Bangladesh, substantial epidemiological improvements (a 257.3% reduction) outweighed demographic pressures, resulting in a net decline in deaths (Supplementary Table 2 and Supplementary Fig. 3; Fig. 4).

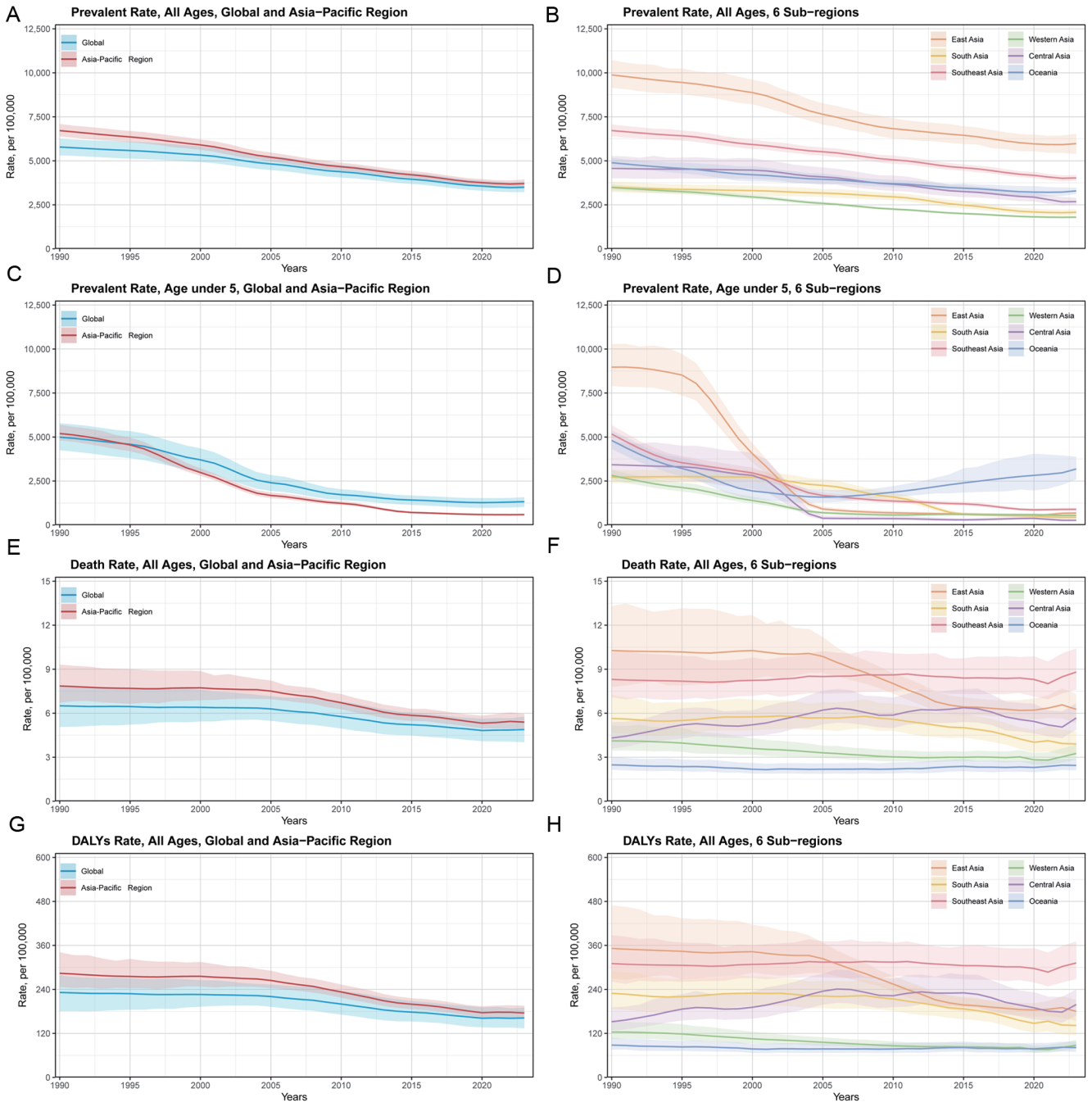

Fig. 2. Historical trends of CHB burden, 1990–2023. (A) Prevalence rate, all ages, global and Asia-Pacific region; (B) prevalence rate, all ages, six subregions; (C) prevalence rate, age under five years, global and Asia-Pacific region; (D) prevalence rate, age under five years, six subregions; (E) death rate, all ages, global and Asia-Pacific region; (F) death rate, all ages, six subregions; (G) DALY rate, all ages, global and Asia-Pacific region; (H) DALY rate, all ages, six subregions. CHB, chronic hepatitis B; DALYs, disability-adjusted life years.

Projected CHB burden and progress toward WHO 2030 targets

Projections of all-age prevalence: Projections from 2024 to 2030 indicate continued declines in all-age CHB prevalence rates across the Asia-Pacific region, its six subregions, and the 18 key countries (Fig. 5A and B). However, because of population growth and aging, the trajectory of the absolute number of prevalent cases varies. In the Asia-Pacific region and East Asia, for example, the total number of people living with CHB is projected to decline slowly, whereas in South Asia and Southeast Asia, the absolute burden is expected to remain high or plateau (Fig. 5A and B; Supplementary Fig. 4A–F).

Projections of prevalence in children under five years old and progress toward incidence targets: Using under-5 prevalence as a proxy for incidence, projections for 2024–2030 show stable or slowly declining rates across

	Prevalence All ages AAPC, % (95% CI)	Prevalence Age under 5 AAPC, % (95% CI)	Deaths All ages AAPC, % (95% CI)	DALYs All ages AAPC, % (95% CI)
Global	-1.53 (-1.60 to -1.46)	-3.95 (-4.29 to -3.61)	-1.07 (-1.17 to -0.97)	-0.86 (-0.93 to -0.78)
Asia-Pacific Region	-1.79 (-1.91 to -1.67)	-6.44 (-6.74 to -6.13)	-1.40 (-1.59 to -1.21)	-1.09 (-1.27 to -0.92)
East Asia	-1.52 (-1.58 to -1.47)	-7.48 (-7.93 to -7.04)	-1.93 (-2.13 to -1.72)	-1.40 (-1.61 to -1.19)
China	-1.60 (-1.66 to -1.54)	-8.28 (-8.51 to -8.06)	-2.04 (-2.27 to -1.81)	-1.45 (-1.70 to -1.21)
Japan	-0.55 (-0.58 to -0.53)	-8.97 (-9.48 to -8.46)	-1.09 (-1.46 to -0.71)	-0.20 (-0.64 to 0.24)
DPRK	-0.83 (-1.08 to -0.59)	1.06 (-3.28 to 5.60)	-0.28 (-0.36 to -0.20)	-0.05 (-0.16 to 0.06)
South Asia	-1.57 (-1.67 to -1.48)	-5.49 (-5.81 to -5.16)	-1.44 (-1.75 to -1.12)	-1.10 (-1.41 to -0.80)
India	-1.58 (-1.64 to -1.52)	-5.98 (-6.37 to -5.59)	-0.99 (-1.54 to -0.44)	-0.58 (-0.99 to -0.16)
Pakistan	-1.83 (-2.00 to -1.66)	-4.36 (-4.71 to -4.01)	-1.21 (-1.35 to -1.07)	-1.17 (-1.35 to -1.00)
Bangladesh	-1.51 (-1.67 to -1.34)	-7.52 (-7.87 to -7.18)	-4.05 (-4.53 to -3.57)	-3.72 (-4.23 to -3.20)
Southeast Asia	-1.55 (-1.63 to -1.47)	-5.20 (-5.34 to -5.07)	0.03 (-0.06 to 0.12)	0.18 (0.05 to 0.32)
Indonesia	-1.23 (-1.32 to -1.14)	-4.19 (-4.46 to -3.92)	-0.21 (-0.42 to 0.01)	-0.07 (-0.32 to 0.19)
Vietnam	-1.57 (-1.62 to -1.52)	-7.18 (-8.19 to -6.15)	0.38 (0.29 to 0.48)	0.39 (0.28 to 0.51)
Philippines	-1.93 (-2.04 to -1.82)	-5.09 (-5.60 to -4.57)	-0.04 (-0.21 to 0.14)	0.29 (0.11 to 0.47)
Western Asia	-1.99 (-2.10 to -1.88)	-4.90 (-5.15 to -4.64)	-1.05 (-1.16 to -0.93)	-0.72 (-0.82 to -0.61)
Turkey	-2.08 (-2.13 to -2.04)	-6.27 (-6.98 to -5.54)	-0.57 (-0.74 to -0.41)	0.02 (-0.15 to 0.20)
Yemen	-2.15 (-2.27 to -2.03)	-4.40 (-4.60 to -4.20)	-1.89 (-2.10 to -1.68)	-1.74 (-1.96 to -1.52)
Iran	-2.26 (-2.42 to -2.10)	-9.40 (-9.71 to -9.09)	-0.93 (-1.10 to -0.76)	-0.53 (-0.73 to -0.33)
Central Asia	-1.64 (-1.75 to -1.54)	-7.62 (-8.79 to -6.43)	0.77 (0.37 to 1.17)	0.78 (0.43 to 1.14)
Uzbekistan	-1.56 (-1.73 to -1.40)	-8.50 (-10.02 to -6.96)	-0.46 (-0.75 to -0.17)	-0.45 (-0.80 to -0.10)
Kazakhstan	-1.82 (-1.91 to -1.73)	-7.49 (-9.39 to -5.54)	3.13 (1.65 to 4.63)	3.27 (1.62 to 4.95)
Tajikistan	-1.60 (-1.91 to -1.30)	-5.91 (-6.34 to -5.47)	0.28 (-0.03 to 0.59)	0.08 (-0.32 to 0.48)
Oceania	-1.20 (-1.27 to -1.13)	-1.29 (-1.76 to -0.83)	-0.22 (-0.51 to 0.07)	0.01 (-0.29 to 0.31)
Papua New Guinea	-1.53 (-1.61 to -1.45)	-1.32 (-1.46 to -1.18)	-0.91 (-1.18 to -0.64)	-0.90 (-1.13 to -0.67)
Australia	-1.56 (-1.65 to -1.46)	-7.19 (-7.41 to -6.97)	0.07 (-0.73 to 0.87)	0.35 (-0.50 to 1.19)
New Zealand	-1.80 (-1.86 to -1.74)	-2.85 (-3.35 to -2.34)	0.06 (-0.17 to 0.29)	0.28 (0.05 to 0.51)

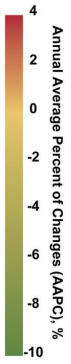

Fig. 3. AAPC of CHB burden in the Asia-Pacific region, 1990–2023. AAPC, average annual percent change; CHB, chronic hepatitis B; DALYs, disability-adjusted life years; CI, confidence interval.

most of the Asia-Pacific region (Fig. 5C and D), with the notable exception of the DPRK, which is expected to fluctuate significantly following a sharp recent increase. However, the region is off track for the WHO target of reducing under-5 prevalence to 0.1%. By 2030, the regional rate is projected to reach 0.60%, well above the target but lower than the global projection of 1.33% (Fig. 6A). Subregionally, Central Asia is projected to achieve the lowest rate (0.28%), followed by South Asia (0.34%), Western Asia (0.55%), East Asia (0.69%), and Southeast Asia (0.89%). Oceania remains the only subregion projected to exceed 1.0%. Among the key countries, only Japan (0.04%) is projected to meet the target, with Iran (0.10%) approaching the threshold.

Projections of mortality and progress toward death targets: Although age-standardized death rates may stabilize or decline in some areas, the absolute number of deaths is projected to rebound between 2024 and 2030 in both the Asia-Pacific region and globally (Fig. 5E and F). This rebound is expected to be most pronounced in subregions with aging populations and high baseline burdens, such as Southeast and East Asia. Regarding the WHO target of a 65% reduction in mortality, the region faces a significant reversal. By 2030, total CHB-related deaths are projected to increase by 19.6% relative to 2015, mirroring a global increase of 21.1% (Fig. 6B). Subregionally, all areas except South Asia are projected to experience rising death tolls. Western Asia is projected to experience the steepest increase (45.6%), followed by Southeast Asia (33.3%), Oceania (32.3%), Central Asia (24.0%), and East Asia (17.6%). South Asia is the only subregion projected to achieve a reduction (0.6%) (Fig. 6B).

Nationally, Bangladesh (−15.5%) and India (−0.2%) are the only key countries projected to achieve reductions. Deaths are projected to increase by >50% in Yemen, Iran, Tajikistan, and Papua New Guinea, and significant rebounds are also expected in China, Indonesia, and Turkey (Fig. 6B).

Discussion

In 2023, the Asia-Pacific region accounted for 63.1% of the global CHB burden (178.0 million cases), with a prevalence

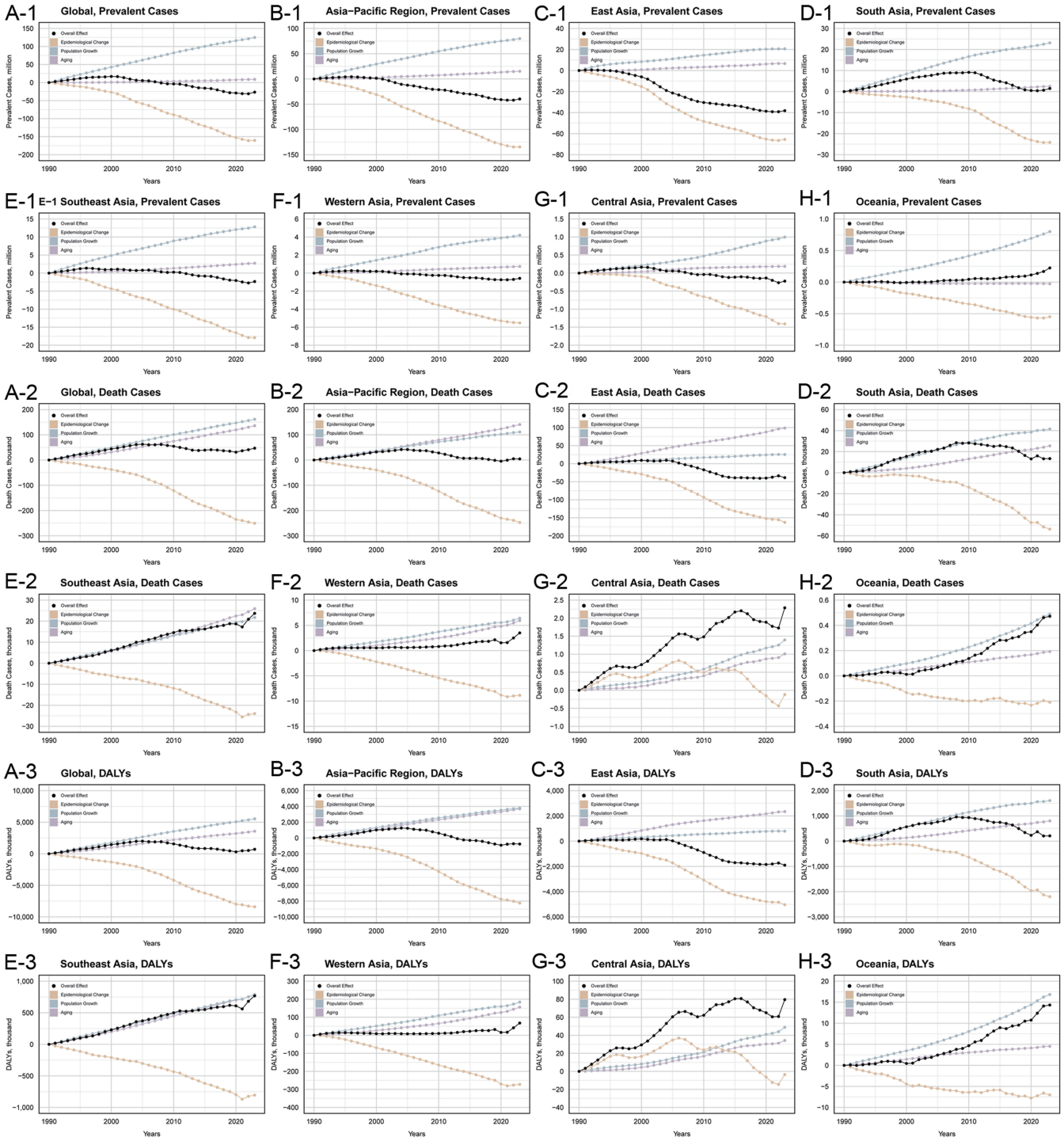

Fig. 4. Decomposition of changes in CHB burden, 1990–2023. (A-1) Global, prevalent cases; (B-1) Asia-Pacific region, prevalent cases; (C-1) East Asia, prevalent cases; (D-1) South Asia, prevalent cases; (E-1) Southeast Asia, prevalent cases; (F-1) Western Asia, prevalent cases; (G-1) Central Asia, prevalent cases; (H-1) Oceania, prevalent cases; (A-2) global, death cases; (B-2) Asia-Pacific region, death cases; (C-2) East Asia, death cases; (D-2) South Asia, death cases; (E-2) Southeast Asia, death cases; (F-2) Western Asia, death cases; (G-2) Central Asia, death cases; (H-2) Oceania, death cases; (A-3) global, DALYs; (B-3) Asia-Pacific region, DALYs; (C-3) East Asia, DALYs; (D-3) South Asia, DALYs; (E-3) Southeast Asia, DALYs; (F-3) Western Asia, DALYs; (G-3) Central Asia, DALYs; (H-3) Oceania, DALYs. CHB, chronic hepatitis B; DALYs, disability-adjusted life years.

rate of 3.7%, which surpassed the global average. The burden was concentrated in East, South, and Southeast Asia, with China (91.2 million), India (30.6 million), and Indonesia (10.0 million) accounting for nearly 75% of regional cases, whereas Western Asia (6.6 million), Central Asia (2.1 million), and Oceania (1.5 million) contributed smaller burdens.

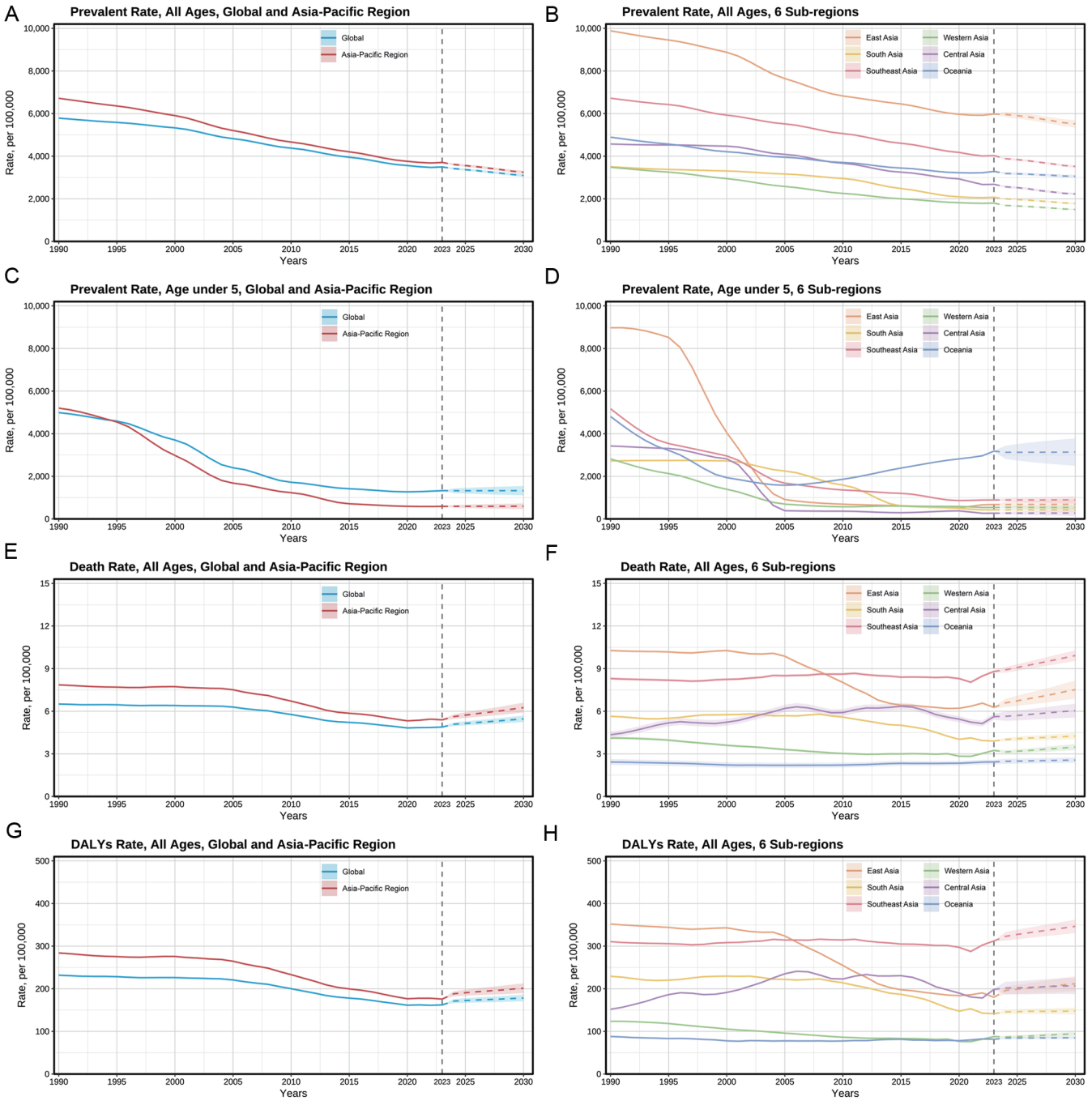

Fig. 5. Projections for CHB burden, 2024–2030. (A) Prevalence rate, all ages, global and Asia-Pacific region; (B) prevalence rate, all ages, six subregions; (C) prevalence rate, age under five years, global and Asia-Pacific region; (D) prevalence rate, age under five years, six subregions; (E) death rate, all ages, global and Asia-Pacific region; (F) death rate, all ages, six subregions; (G) DALY rate, all ages, global and Asia-Pacific region; (H) DALY rate, all ages, six subregions. CHB, chronic hepatitis B; DALYs, disability-adjusted life years.

Decomposition analysis identified divergent drivers of burden trends (1990–2023). In South Asia, population growth was the dominant driver, overwhelming epidemiological gains and leading to a net rise in absolute cases. In India, although prevalence rates declined, an approximately 1.7-fold increase in the adult population and rapid population growth (contributing a 4,347.1% relative increase) drove absolute numbers higher.[23] Furthermore, longitudinal surveillance indicates stagnation in HBsAg prevalence in some cohorts (2.96% in 2013 vs. 2.5% in 2022).[27,28] This suggests that low endemicity does not guarantee a decline in transmission without adequate birth-dose coverage and adult test-and-treat strategies. In contrast, East Asia, particularly China, exhibited an inverse dynamic in which epidemiological improvements neutralized demographic pressures. China's national infant vaccination program (initiated in 1992), for

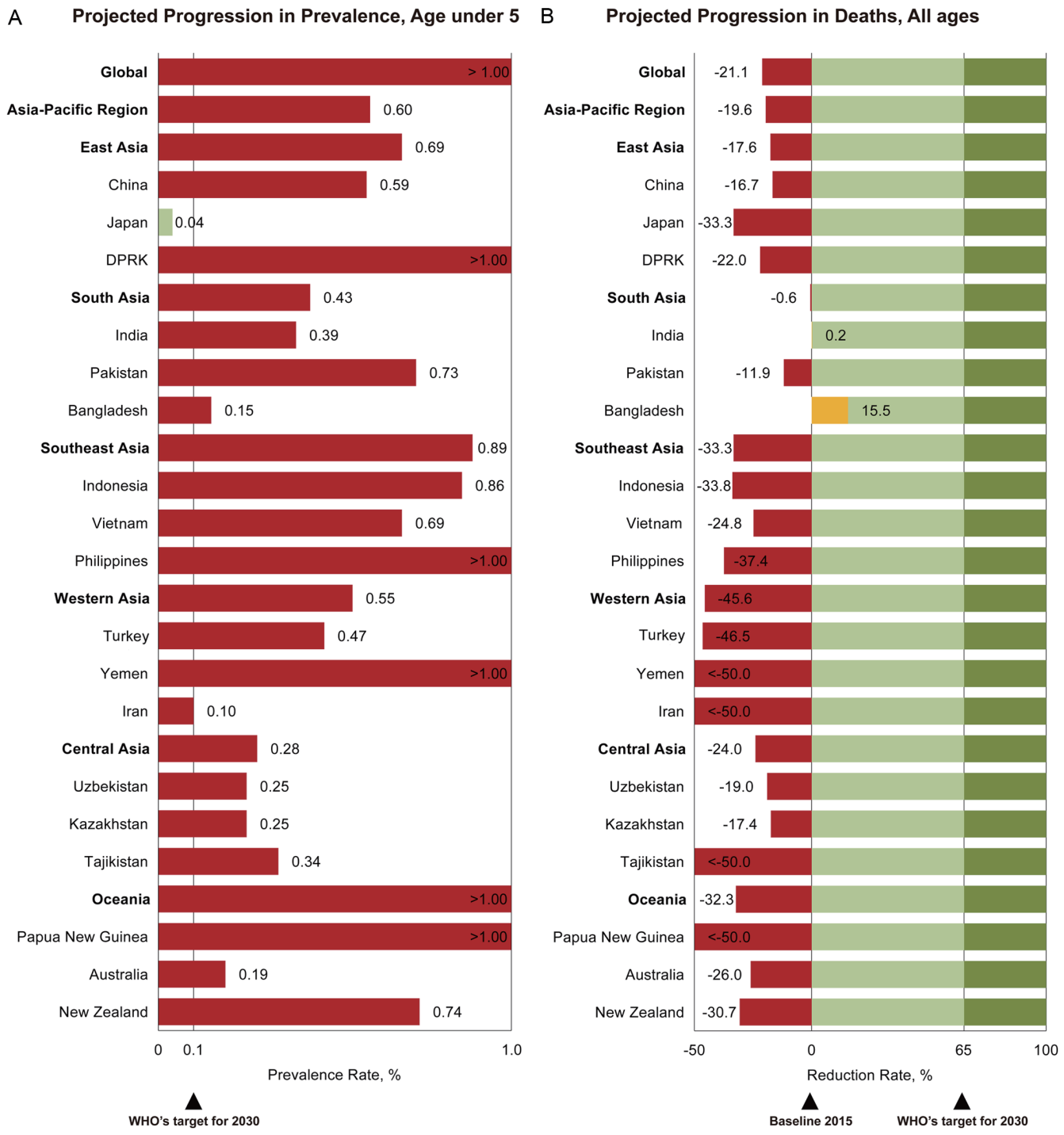

Fig. 6. Projected progression toward the WHO 2030 targets for (A) prevalence in children under five years and (B) deaths, all ages. WHO, World Health Organization; DALYs, disability-adjusted life years.

example, reduced HBsAg prevalence from 9.7% in 1992 to 5.6% in 2022.[29] This robust epidemiological effect (178.4% reduction contribution) led to a net decline in cases. However, given its massive population and historically high endemicity, China still bears a colossal burden of chronic infections.[26,30] Southeast Asia showed an intermediate pattern between South and East Asia. The subregion still carried a large all-age prevalence burden in 2023. Population growth largely offset epidemiological gains, resulting in a persistently high absolute burden. The all-age prevalence rate was low in Western Asia and Central Asia (Western Asia: 1.8%; Central Asia: 2.1%), with the largest declines among the six subregions over time (AAPC: Western Asia: −1.99%; Central Asia: −1.64%), suggesting substantial epidemiological

improvement, although demographic expansion partly counterbalanced this progress. Oceania contributed the smallest absolute burden and prevalence rate, with a relatively small decline (AAPC = −1.20%), suggesting limited epidemiological improvement that was offset by population growth. Regarding under-5 control, the region achieved significant progress, with under-5 HBsAg prevalence declining annually by 6.44% (1990–2023), outpacing the global average (3.95%). However, regional differences remain substantial. South Asia had the largest number of under-5 CHB cases (714.1 thousand), followed by East Asia (476.0 thousand) and Southeast Asia (472.0 thousand), whereas Oceania had the highest under-5 prevalence rate (3.2%). Projections to 2030 suggest that all six subregions will remain above the WHO target of 0.1% under-5 HBsAg prevalence, with Oceania and Southeast Asia remaining the highest-rate subregions and Central Asia projected to have the lowest rate. In 2023, 3-dose hepatitis B vaccine coverage was relatively high in East Asia, South Asia, Central Asia, and Western Asia, but lower in Southeast Asia and especially in Oceania excluding Australia and New Zealand (Philippines, birth-dose coverage: 57%, 3-dose coverage: 77%; Papua New Guinea, birth-dose coverage: 26%, 3-dose coverage: 40%; Vietnam, birth-dose coverage: 82%, 3-dose coverage: 65%).[24,25]

Despite this, the region remains off track for the WHO 2030 target of 0.1% under-5 prevalence. Projections estimate a 0.60% rate by 2030, with the burden concentrated in India, China, and Pakistan. Among the key countries, Japan is the only one projected to meet the under-5 prevalence target (0.04% vs. 0.1%), likely reflecting its long-standing prevention of mother-to-child transmission program and universal infant HBV vaccination.[31,32] Unlike many high-burden countries, the decomposition analysis shows that Japan's CHB prevalence is less affected by the negative pressures of population growth and aging, although mortality remains influenced by the aging of previously infected cohorts. Iran is also close to the under-5 target (0.1% vs. 0.1%), suggesting the benefit of early nationwide infant vaccination and sustained primary prevention.[33,34] In China, coverage for the 3-dose HepB series and the timely birth dose (TBD) reached 99.6% and 95.6%, respectively, by 2020.[35] Despite these high national averages, however, disparities in TBD coverage persist. A 2019–2021 study in three provinces reported TBD coverage of only 71.41% for preterm infants,[36] and rural western China lags behind eastern regions.[37] To bridge the gap between 0.30% and the <0.1% target, strategies must shift from general coverage to targeting underserved groups, including preterm infants, migrant populations, and remote rural communities. Elsewhere in South Asia, particularly in India and Pakistan, there is a major gap between routine immunization and birth-dose administration. India achieved approximately 93% third-dose coverage in 2023 following the National Viral Hepatitis Control Program,[1,38,39] and Pakistan similarly reduced pediatric HBsAg prevalence to 0.3% in 2019, supported by 74% third-dose coverage. However, TBD coverage remains suboptimal: India reports 63%,[38] and Pakistan reports only 3%,[40] far below the WHO's 90% target. Given the significance of perinatal transmission, the discrepancy between high routine coverage and low TBD coverage represents a major missed opportunity. Without scaling up TBD administration, particularly for noninstitutional deliveries, South Asia is unlikely to meet global elimination targets. This highlights that, despite favorable trends, the population scale of high-burden countries sustains a large reservoir of pediatric infections.

Despite effective vaccines and therapies, the Asia-Pacific region accounts for nearly two-thirds of global CHB-related deaths. Decomposition analysis shows that distinct demographic forces drive this mortality burden within high-burden nations. In China and East Asia, population aging is the dominant factor increasing deaths, neutralizing healthcare gains; in India and South Asia, population growth primarily drives the rising death toll; and Indonesia and Southeast Asia face a "double burden" of aging and population growth. Western Asia had the steepest decline in all-age prevalence among the six subregions (AAPC = −1.99%, 95% CI: −2.10% to −1.88%), and epidemiological improvements substantially reduced prevalent cases. However, population expansion and aging still contributed to a modest increase in absolute deaths. Central Asia showed a more concerning pattern: although all-age and under-5 prevalence declined, mortality (AAPC = 0.77%, 95% CI: 0.37% to 1.17%) and DALY rates (AAPC = 0.78%, 95% CI: 0.43% to 1.14%) increased. Decomposition analysis suggested that this increase was mainly driven by population growth and aging, whereas the protective contribution of epidemiological change was limited. Kazakhstan was especially notable, with the steepest increases in mortality and DALY rates among the key countries, and epidemiological change itself contributed positively to the increase in deaths. Projections further showed that India and Bangladesh are the only key countries expected to achieve reductions in all-age deaths, but neither is projected to meet the 65% mortality-reduction target (Bangladesh: 15.5%; India: 0.2%). This should not be interpreted as evidence of sufficient diagnosis or treatment coverage, because both countries still have substantial gaps in the HBV care cascade.[21] Rather, the decomposition analysis suggests that the decline in Bangladesh was mainly driven by a favorable epidemiological change component that outweighed demographic pressure, whereas in India, epidemiological gains were largely offset by population growth, aging, and a large reservoir of chronic infections, resulting in a near-stable trend in mortality rates.[38] Taken together, these findings indicate that declining prevalence alone is insufficient to achieve mortality reduction. Without expanded adult screening, diagnosis, antiviral treatment, and long-term surveillance, population aging and growth will continue to sustain CHB-related deaths and keep the region off track for the WHO 2030 mortality target.

Timely diagnosis and antiviral treatment are crucial for preventing progression to cirrhosis and HCC. Long-term nucleos(t)ide analogue therapy can suppress HBV replication and reduce the risks of cirrhosis, hepatic decompensation, HCC, and liver-related death.[41] Yet coverage in major burden countries remains far below WHO targets (90% diagnosis, 80% treatment). In many high-burden Asia-Pacific countries, diagnosis rates remain low, treatment initiation among eligible patients is inadequate, and long-term retention in care and surveillance for cirrhosis and HCC are insufficient.[4] In China, for example, although diagnostic capacity has improved, a substantial treatment gap persists: in 2022, only 24% of approximately 79.7 million infections were diagnosed, and only 15% of eligible patients received treatment.[4] In South and Southeast Asia, screening gaps are major obstacles. India reports negligible diagnosis and treatment rates (2.4% and nearly 0%, respectively),[38] with similarly low figures in Indonesia.[26] Therefore, the projected failure to achieve the mortality target does not primarily reflect a lack of effective treatment, but rather insufficient coverage across the HBV care cascade.[21,42] Modeling further indicates that maintaining the status quo will increase mortality, whereas scaling up test-and-treat strategies is cost-effective and lifesaving.[43] To reduce the projected mortality rebound, a multidimensional approach

is imperative: (1) high-level advocacy to demonstrate the cost-effectiveness of antiviral therapy[44]; (2) simplifying treatment algorithms and expanding indications according to updated guidelines[45]; (3) capacity building to decentralize care to local practitioners; (4) strengthening surveillance with HBV-specific notification mechanisms; and (5) piloting micro-elimination programs to test task-shifting and digital linkage-to-care models.

This study has several strengths. First, it uses GBD 2023 data, which incorporate >35,000 new sources and methodological upgrades to increase accuracy. Second, the standardized methodology enables robust comparisons, distinguishing regions that need intensified prevention from those facing rising mortality. Third, decomposition and Bayesian analyses provide insights into demographic drivers and future trends relative to the WHO 2030 targets. However, two limitations should be noted. First, estimates depend on the availability of primary data; in resource-limited settings, reliance on modeling may introduce uncertainty, although consistent frameworks ensure trend validity. Second, this study could not explicitly quantify the effects of specific programmatic or health-system interventions on CHB burden. In the decomposition analysis, the epidemiological change component reflects changes in age-specific burden rates after accounting for population growth and aging, but it could not be further separated into specific drivers such as vaccination, timely birth-dose administration, maternal screening, antiviral treatment coverage, healthcare access, or long-term retention in care. Similarly, the BAPC projections were based on historical GBD estimates and future population projections and did not explicitly incorporate future country-specific policy changes. Because these indicators were not consistently available across all included countries and years, our projections should be interpreted as baseline estimates under current trends rather than scenario-based predictions. Future studies integrating GBD data with country-level programmatic indicators and intervention scenarios are needed to estimate how intensified vaccination, diagnosis, treatment, and surveillance may alter the future CHB burden.

Conclusions

This study demonstrates that the Asia-Pacific region remains the global center of CHB burden, accounting for more than 60% of global prevalent cases, deaths, and DALYs in 2023, despite having a lower under-5 prevalence rate than the global average. Under current trends, all subregions are projected to miss the WHO 2030 targets for both under-5 prevalence and mortality reduction. Because population aging and growth are expected to sustain CHB-related deaths, future efforts should prioritize adult screening, diagnosis, antiviral treatment, and long-term surveillance while maintaining pediatric prevention in areas with limited healthcare resources.

Supporting information

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Conflict of interest

JJ has been an Executive Associate Editor of Journal of Clinical and Translational Hepatology since 2013, HY has been an Editorial Board Member of Journal of Clinical and Translational Hepatology since 2021. The other authors have no conflict of interests related to this publication.

Author contributions

Study concept and design (XZ, HY), data collection (ZL, DX), statistical analysis (ZL, XZ, WJ, JZ, TX, DW), visualization (ZL), drafting of the manuscript (ZL, XZ, HY), and critical revision of the manuscript for important intellectual content (YK, JJ, HY, XZ). All authors have approved the final version and publication of the manuscript.

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2024). This study utilized publicly available data from the Global Burden of Disease study, which comprises population-level data and does not include any individual-level information. Consequently, neither ethical approval nor informed consent was required.

Data sharing statement

The data used or analyzed during this study are included in this article and are available from the corresponding author upon reasonable request.

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