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Global, regional, national epidemiology and trends of neglected tropical diseases in youths and young adults aged 15–39 years from 1990 to 2019: findings from the global burden of disease study 2019

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Abstract

Background In recent years, the escalating concern for neglected tropical diseases (NTDs) has been recognized as a pressing global health issue. This concern is acutely manifested in low- and middle-income countries, where there is an escalating prevalence among adolescents and young adults. The burgeoning of these conditions threatens to impair patients' occupational capabilities and overall life quality. Despite the considerable global impact of NTDs, comprehensive studies focusing on their impact in younger populations remain scarce. Our study aims to describe the global prevalence of neglected tropical diseases among people aged 15 to 39 years over the 30-year period from 1990 to 2019, and to project the disease burden of the disease up to 2040.

Methods Annual data on incident cases, mortality, and disability-adjusted life years (DALYs) for NTDs were procured from the Global Burden of Disease Study 2019 (GBD 2019). These data were stratified by global and regional distribution, country, social development index (SDI), age, and sex. We computed age-standardized rates (ASRs) and the numbers of incident cases, mortalities, and DALYs from 1990 to 2019. The estimated annual percentage change (EAPC) in the ASRs was calculated to evaluate evolving trends.

Results In 2019, it was estimated that there were approximately 552 million NTD cases globally (95% Uncertainty Interval [UI]: 519.9 million to 586.3 million), a 29% decrease since 1990. South Asia reported the highest NTD prevalence, with an estimated 171.7 million cases (95% UI: 150.4 million to 198.6 million). Among the five SDI categories, the prevalence of NTDs was highest in the moderate and low SDI regions in 1990 (approximately 270.5 million cases) and 2019 (approximately 176.5 million cases). Sub-Saharan Africa recorded the most significant decline in NTD cases over the past three decades. Overall, there was a significant inverse correlation between the disease burden of NTDs and SDI.

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Conclusion NTDs imposed over half a billion incident cases and 10.8 million DALYs lost globally in 2019—exerting an immense toll rivaling major infectious and non-communicable diseases. Encouraging declines in prevalence and disability burdens over the past three decades spotlight the potential to accelerate progress through evidence-based allocation of resources. Such strategic integration could substantially enhance public awareness about risk factors and available treatment options.

Keywords Global burden of disease, Neglected tropical diseases, Disability-adjusted life years, Global Burden of Disease, Social development index

Background

Neglected tropical diseases (NTDs), long overlooked and intrinsically linked to poverty, affect nearly 2 billion people globally [1, 2]. This figure parallels the combined burden of HIV/AIDS, tuberculosis, and malaria. NTDs encompass both communicable and noncommunicable diseases predominantly prevalent in tropical regions. In tropical countries, these infections account for 20–30% of intensive care unit (ICU) admissions and include a spectrum of conditions such as diarrheal diseases, malaria, dengue fever, typhoid fever, rickettsial diseases, and leptospirosis [1, 3]. Notably, NTDs are not exclusive to tropical areas; significant occurrences of these diseases are also reported in temperate zones. Factors contributing to the rise of these diseases include the return of military personnel, increased global travel, population mobility, advancements in commercial aviation, and the existence of key medical facilities [4–6]. Consequently, the prevalence of NTDs is rising in nations like the United States, United Kingdom, and Europe, primarily due to international travel and migration [2, 4]. Annually, tropical infectious and parasitic diseases claim approximately 15 million lives, predominantly in developing countries [7]. The proliferation of these diseases is exacerbated by poverty, substandard living conditions, malnutrition, HIV/AIDS, and inadequate health systems [7, 8].

The diagnosis of many NTDs is often hindered by unsuitable diagnostic methods, and the overlapping clinical features of tropical diseases pose significant challenges for initial diagnosis [3, 9]. A systematic diagnostic approach includes: (1) detailed travel history to specific continents or countries; (2) exposure to unique environmental conditions such as forests, farms, water bodies, or consumption of exotic foods; (3) assessment of the incubation period; (4) identification of subtle variances in patterns of organ involvement and clinical manifestations [3]. In 2012, the World Health Organization (WHO) released a roadmap for NTDs, setting 2020 targets, and initiated the London Declaration, where stakeholders pledged to control, eliminate, or eradicate 10 key NTDs [1]. The control and eradication of NTDs have since been integrated into a wider developmental framework, emphasizing the incorporation of medical interventions for NTDs in impoverished regions into universal health coverage (UHC) [10]. The year 2020 marked a pivotal moment in the global response to NTDs, heralding the introduction of the 2021–2030 NTD roadmap [1, 11].

There is a pressing need for continual reassessment of the Global Burden of Disease (GBD) database, especially concerning the impact of NTDs on young populations, to mitigate their long-term complications. Remarkably, there has been no global analysis to date that comprehensively examines the epidemiology of NTDs among adolescents using the 2019 GBD data. Our study, utilizing this database, explores trends in incidence, prevalence, and disability-adjusted life years (DALYs) of NTDs in this demographic from 1990 to 2019, and projects future disease burdens. Our aim is to cultivate a refined understanding of the global distribution of NTDs, thereby informing subsequent public health strategies.

Methods

Our data were derived from the Global Burden of Disease Study 2019 (GBD 2019), accessible at [http://ghdx.healthdata.org/gbd-results-tool]. This comprehensive study collated data encompassing 369 diseases and injuries, alongside 87 risk factors across 204 countries and territories [12]. The GBD's data compilation involved a diverse array of sources, including national censuses, population surveys, vital statistics, and various health data repositories. Three advanced methodologies—the Cause of Death Ensemble model, spatiotemporal Gaussian process regression, and the Bayesian meta-regression tool DisMod-MR 2.1—were employed to synthesize this extensive data set [13]. This integration ensures robust and precise estimations of disease burden. To specifically assess the incidence of NTDs based on age, we segregated patients into five age groups: 15–19, 20–24, 25–29, 30–34, and 35–39 years [13].

We utilized linear regression to determine the mean estimated annual percentage changes (EAPCs). Our study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. For the usage of deidentified data in GBD study, a waiver of informed consent has

been approved by the University of Washington Institutional Review Board.

In response to the impacts and relatively inconspicuous nature of certain diseases, along with the availability of preventive and treatment modalities, the World Health Organization (WHO) has identified 19 NTDs in its second NTD Roadmap as priority diseases. The GBD included 15 of these NTDs, accounting for over 80% of the global NTD DALYs. Thus, our analysis was confined to these 15 NTDs, classified according to the 10th edition of the International Classification of Diseases: Chagas disease, leishmaniasis (cutaneous/mucocutaneous and visceral), African trypanosomiasis, schistosomiasis, cysticercosis, cystic echinococcosis, lymphatic filariasis, onchocerciasis, trachoma, dengue, rabies, intestinal nematode infections (ascariasis, trichuriasis, and hookworm disease), foodborne trematodiases, leprosy, and guinea worm disease. Due to sparse data in GBD 2019, we report incidence data for some NTDs and mortality data for others, including Chagas disease, schistosomiasis, cysticercosis, leishmaniasis (visceral), African trypanosomiasis, cystic echinococcosis, dengue, rabies, and intestinal nematode infections.

Sociodemographic index

The Sociodemographic Index (SDI) is a composite indicator that reflects the level of development progress of a country or region [14]. The SDI is constructed using the geometric mean of three components: per capita income, mean educational attainment among individuals aged 15 years and older, and the total fertility rate. In the GBD 2019, countries and territories were stratified into five SDI categories: low (< 0.46), low-middle (0.46–0.60), middle (0.61–0.69), high-middle (0.70– 0.81), and high (> 0.81). It is important to note that lower SDI values are indicative of lesser degrees of societal development [15].

Statistical analysis

In our current investigation, we probed the effects of neglected tropical diseases (NTDs) on health outcomes. To quantify these impacts, we employed a suite of metrics, including incidence, prevalence, and disability-adjusted life years (DALYs), each complemented by their corresponding rates. DALYs, serving as an encompassing metric for disease burden, encapsulate both the years of life lost due to premature mortality and the years lived with disability. We meticulously estimated and articulated the disease burden, framing it within 95% uncertainty intervals (UIs) for enhanced precision. For a detailed understanding of the methodologies employed, we refer readers to the relevant scholarly literature [12, 13]. Given the varied age distributions and population demographics inherent in the Global Burden of Disease (GBD) dataset, it is crucial to make adjustments for disparate age structures. To this end, we computed the age-standardized rate (ASR) per 100,000 individuals, employing the following formula [16]:

$$\mathrm{ASR} = \frac{\sum_{i=1}^{A} a_i w_i}{\sum_{i=1}^{A} w_i} \times 10{,}000$$

(ai: the age-specific rate in the age group; w: the number of people in the corresponding in the age group among the standard population; A: the number of age groups) To examine the temporal patterns of incidence, mortality, and DALYs, we calculated the EAPC rates. The EAPC serves as a prevalent metric in epidemiological studies to ascertain temporal evolutions in ASRs of diseases. The coefficient, denoted as β, is derived from the natural logarithm of the ASRs. Herein, y represents ln(ASR) while. x corresponds to the calendar years. The EAPC, accompanied by its 95% confidence interval (CI), was determined utilizing the ensuing linear regression model:

$$y = \alpha + \beta x + \varepsilon$$

$$\mathrm{EAPC} = 100 * (\exp(\beta) - 1$$

The trend of the ASR can be discerned by analyzing the EAPC and its corresponding 95% CI. If the EAPC value and the lower limit of the 95% CI are both positive, this indicates an upward trend in the ASR. Conversely, if both the EAPC value and the upper limit of the 95% CI are negative, this suggests a downward trend in the ASR [16]. To predict the future disease burden from 1990 to 2045, we utilized a log-linear age-period-cohort model. This model restricts linear trend projection and curbs exponential growth, rendering it suitable for fitting recent trends. We implemented the model in R using the NORDPRED package. To explore the factors influencing the changes of disease burden, the relationships between ASRs and SDI were calculated globally and in 21 geographic regions using Pearson's correlation analysis from 1990 to 2019. Analyses and graphical representations were executed using the R statistical software (version 4.2.2). A two-tailed *P*-value below 0.05 was deemed statistically significant.

Results

Prevalence

The estimated global prevalence of NTDin 2019 was approximately 552 million cases (95% Uncertainty Interval [UI]: 519.9 to 586.3 million), signifying a 29% reduction from 1990 (713.5 million cases, 95% UI: 677.8 to 752.6 million) as illustrated in Table 1. Concurrently, the global age-standardized prevalence rate (ASPR) of

Table 1 Prevalence of tropical diseases between 1990 and 2019 in 15 to 39 years at the global and regional level

Location	1990		2019		EAPC_95%CI
	Number_95%UI	ASPR	Number_95%UI	ASPR	
Global	713,500,057.1 (677,754,578.7–752,559,359.8)	32,528 (30,898.4–34,308.7)	552,016,877.9 (519,888,657.3–586,325,584.4)	18,599.8 (17,517.3–19,755.8)	-2.04 (-2.13–1.96)
High SDI	7,155,044.3 (6,268,363.6–8,207,253.1)	2214.7 (1940.3–2540.4)	5,045,984.5 (4,350,024.2–5,827,932.9)	1523.1 (1313–1759.1)	-0.83 (-1.26–0.39)
High-middle SDI	77,907,457.5 (68,019,350.6–89,077,420.6)	16,112.8 (14,067.7–18,422.9)	42,068,709.9 (36,021,607.6–49,768,670.2)	8141.5 (6971.2–9631.7)	-2.25 (-2.62–1.89)
Low SDI	134,196,919.1 (129,738,000–138512220.7)	69,240.3 (66,939.7–71,466.8)	173,896,463.7 (165,120,821–183316215.4)	38,841.2 (36,881.1–40,945.2)	-2.03 (-2.28–1.78)
Low-middle SDI	223,325,203.1 (212,416,052.3–234,769,766.3)	50,147.4 (47,697.8–52,717.3)	176,495,559.7 (163,292,026–192112041.3)	24,003.4 (22,207.7–26,127.3)	-2.77 (-2.94–2.61)
Middle SDI	270,523,731.7 (251,414,718.1–293,202,479.1)	36,234.4 (33,674.9–39,272)	154,140,311.5 (142,477,684.8–168,596,754)	16,484 (15,236.8–18,030)	-2.83 (-3.01–2.64)
Andean Latin America	3,914,196.6 (3,551,617.3–4,312,577)	25,328.7 (22,982.5–27,906.6)	3,490,027.2 (3,076,689.5–3,928,015.1)	13,591 (11,981.3–15,296.6)	-2.35 (-2.55–2.15)
Australasia	15,327.8 (11,045.8–20,587.1)	188 (135.5–252.5)	11,606.3 (7300.9–17,596)	119.4 (75.1–181.1)	-1.7 (-1.98–1.42)
Caribbean	3,547,655.8 (2,883,324.7–4,713,686)	23,912.6 (19,434.7–31,772.1)	3,277,756.9 (2,808,802.2–3,812,028.4)	18,080.8 (15,494–21,028)	-1.24 (-1.55–0.93)
Central Asia	3,148,932.8 (2,824,580–3483767.2)	11,059.1 (9920–12235.1)	1,755,420.5 (1,511,265.7–2,036,016.6)	4633.5 (3989–5374.1)	-2.92 (-3.11–2.72)
Central Europe	267,702.5 (239,621.3–297,875.9)	581.7 (520.7–647.3)	144,218.7 (124,565.1–165,049.9)	405 (349.8–463.5)	-1.26 (-1.35–1.17)
Central Europe, Eastern Europe, and Central Asia	3,896,016.8 (3,546,195.7–4,261,954.3)	2430.7 (2212.4–2659)	2,216,059.1 (1,953,489.3–2,503,259.6)	1559.2 (1374.5–1761.3)	-1.57 (-1.74–1.4)
Central Latin America	27,696,077.6 (24,737,662.7–30,621,758.1)	40,603.5 (36,266.4–44,892.7)	20,463,619.8 (18,208,710.5–22,985,333.8)	20,264.2 (18,031.2–22,761.3)	-2.57 (-2.63–2.51)
Central Sub-Saharan Africa	16,680,203.6 (16,078,746.4–17,345,945.9)	80,344.7 (77,447.6–83,551.4)	27,606,176.8 (25,784,978.3–29,692,577.2)	53,294.3 (49,778.4–57,322.1)	-1.28 (-1.49–1.07)
East Asia	170,277,875.9 (139,881,133.8–203,725,659.7)	30,032.5 (24,671.3–35,931.8)	65,585,446.6 (50,938,885–83851233.1)	12,717.7 (9877.6–16,259.7)	-2.71 (-3.4–2.01)
Eastern Sub-Saharan Africa	49,122,344 (46,779,805.2–51,533,712.8)	69,675.7 (66,353–73,096)	68,085,537.7 (63,782,135.2–72,676,057.2)	40,829.1 (38,248.4–43,581.9)	-1.96 (-2.2–1.71)
North Africa and Middle East	27,724,376.7 (25,278,876.8–30,863,353.3)	20,418.2 (18,617.1–22,729.9)	29,139,300.4 (26,402,365.7–32,268,100.6)	11,267.2 (10,208.9–12,477)	-2.72 (-3.07–2.37)
Oceania	1,485,408.7 (1,220,755.5–1,870,539.1)	56,425.8 (46,372.5–71,055.7)	2,079,559.4 (1,634,688.6–2,915,177.4)	38,213.2 (30,038.4–53,568.2)	-1.56 (-1.71–1.41)
South Asia	225,421,632.5 (209,094,486.5–242,706,763.4)	52,184.6 (48,404.9–56,186.1)	171,738,747.3 (150,389,469.3–198,613,635.3)	22,336.6 (19,559.9–25,832)	-3.24 (-3.53–2.96)
Southeast Asia	101,141,751.5 (93,105,147.3–111,549,750.9)	51,390.9 (47,307.4–56,679.3)	57,402,827.1 (51,249,506.1–65,557,718.5)	21,135.5 (18,869.9–24,138.1)	-3.29 (-3.66–2.93)
Southern Latin America	3,863,394.3 (3,325,480.7–4,491,855.1)	20,242.4 (17,424–23,535.2)	1,804,639.6 (1,501,752.5–2,191,383.7)	7095.8 (5904.9–8616.5)	-3.11 (-3.55–2.67)
Southern Sub-Saharan Africa	10,147,544.1 (9,392,110.7–10,946,879.5)	46,281 (42,835.6–49,926.6)	5,830,292.3 (5,078,167.7–6,740,153.2)	17,309.9 (15,076.9–20,011.2)	-3.67 (-3.79–3.55)

Table 1 (continued)

Location	1990		2019		EAPC_95%CI
	Number_95%UI	ASPR	Number_95%UI	ASPR	
Tropical Latin America	11,423,714 (9,640,199.7–13,791,234.7)	17,761.7 (14,988.7–21,442.8)	11,061,611.6 (9,224,592.8–13,194,436.7)	12,415.5 (10,353.7–14,809.4)	-1.02 (-1.18–0.87)
Western Europe	269,403 (236,444.6–304,296.7)	187 (164.1–211.2)	153,208.4 (132,754.7–173,676.9)	116.9 (101.3–132.5)	-1.82 (-1.92–1.72)
Western Sub-Saharan Africa	53,758,657.6 (51,314,106.1–56,493,908.9)	75,604.3 (72,166.4–79,451.1)	80,738,440.4 (75,715,777.9–86,341,016.1)	45,068.3 (42,264.7–48,195.7)	-1.79 (-2.07–1.52)
High-income Asia Pacific	2,893,026.1 (2,249,667.1–3,732,757.8)	4283 (3330.5–5526.1)	1,127,977.8 (868,250–1448995.1)	2146.8 (1652.5–2757.8)	-1.86 (-2.47–1.26)
High-income North America	221,450.4 (184,767.3–260,498.8)	195.8 (163.4–230.4)	204,043.2 (158,461–259,090.7)	167.9 (130.4–213.2)	-0.46 (-0.93–0.01)

Abbreviations: EAPC Estimated annual percentage change, *ASPR* Age-Standardized Prevalence Rate, *SDI* Sociodemographic Index, *UI* Uncertainty interval

NTDs declined from 32,528 per 100,000 individuals in 1990 to 18,599.8 per 100,000 in 2019, with an estimated annual percentage change (EAPC) of -2.04 (95% Confidence Interval [CI]: -2.13 to -1.96). A decrement in NTD prevalence across all age groups from 1990 to 2019 was observed (Fig. 1A), while ASPR experienced declines across the same period in all demographics (Figure S1A). A gender-based analysis of ASPR indicated consistently higher rates in females than males globally, with the most significant disparity noted in the 20–24 age group (Figure S2A).

Incidence

In 2019, the estimated global incidence of NTDs was approximately 90.9 million cases (95% UI: 70.5 to 116.4 million), an increase of 17% since 1990, as delineated in Table 2. The age-standardized incidence rate (ASIR) of NTDs globally was relatively stable between 1990 and 2019, with rates of 3,528 and 3,062 cases per 100,000 individuals, respectively. Notably, an upsurge in new NTD cases was observed across all age groups, with the highest incidence among individuals aged 15 to 19 years (Fig. 1B). Trends in global ASIR mirrored those of ASPR for all age groups, peaking in the 25–29 age group and lowest in the 15–19 age group, as depicted in Figure S2B.

DALYs

In 2019, the global burden of DALYs attributable to NTDs was estimated at approximately 10.8 million (95% UI: 7.6 to 14.6 million), a 33% decrease from 1990 (14.5 million, 95% UI: 10.9 to 18.7 million), as shown in Table 3. However, the age-standardized DALY rate per 100,000 individuals modestly decreased, from 660.5 in 1990 to 364.8 in 2019. The EAPC for DALYs was -2.29 (95% CI: -2.47 to -2.11). The 15–19 age group exhibited the highest number of DALYs, followed by the 20–24 age group (Fig. 1C). Notably, the age-standardized DALY rate peaked in 2015 across all age groups, particularly in the 35–39 age group, with remaining age-standardized DALY rates inversely related to age (Figure S1B). Interestingly, rates of ASPR were consistently higher in males than females globally, with the highest burden observed in the 25–29-yearage group, indicating a significant impact on young and middle-aged males (Figure S2C).

SDI regional

Prevalence

In 1990, the middle SDI region exhibited the highest incidence of NTDs among the five SDI regions, with 270,523,731.7 cases (Table 1). Over the subsequent three decades, this region experienced a remarkable reduction in NTD prevalence, decreasing from 270,523,731.7 cases in 1990 to 154,140,311.5 cases in 2019. This decline corresponded to an Estimated Annual Percentage Change (EAPC) of -2.83 (95% Confidence Interval [CI]: -3.01 to -2.64). Conversely, in 2019, the low-to-moderate SDI regions reported the highest incidence, with 176,495,559.7 cases, down from 22,325,203.1 in 1990 (EAPC = -2.77; 95% CI: -2.94 to -2.61). The low SDI regions recorded the highest Age-Standardized Prevalence Rate (ASPR) in both 1990 (69,240.3 per 100,000) and 2019 (38,841.2 per 100,000). While significant reductions in NTD prevalence were observed in moderate and low-middle SDI regions, the low SDI region saw only modest changes (EAPC = -2.03; 95% CI: -2.28 to -1.78). The ASPR for NTDs across all five SDI regions demonstrated a general declining trend from 1990 to 2019. The low and low-medium SDI regions exhibited the most pronounced reductions, yet their rates remained above global averages. In contrast, the high and medium–high

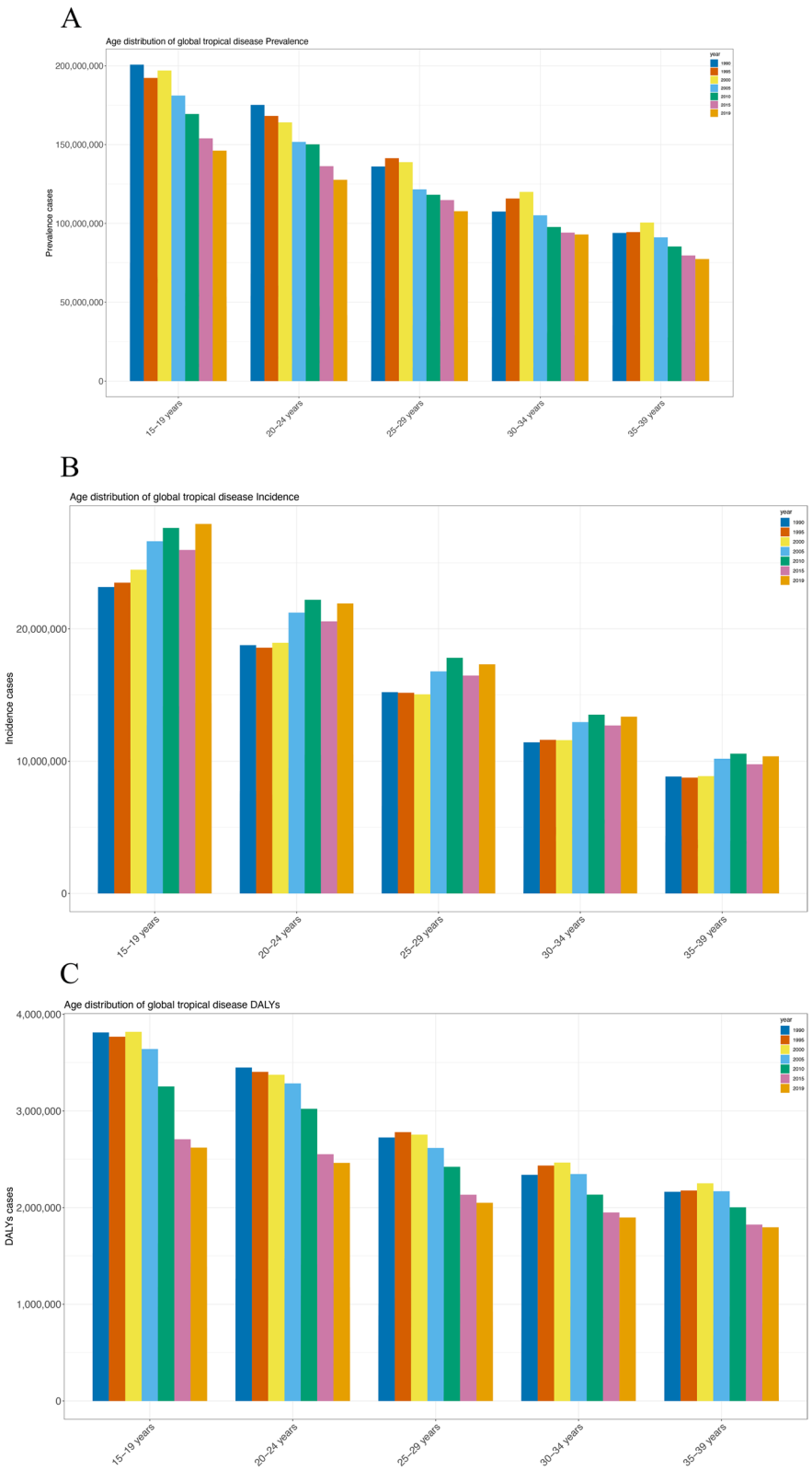

Fig. 1 Trends in NTDs prevalence, incidence and Disability-Adjusted Life-Years (DALYs) From 1990 to 2019. **A** Trends in prevalence cases. **B** Trends in incidence cases. **C** Trends in DALYs cases

Table 2 Incidence of tropical diseases between 1990 and 2019 in 15 to 39 years at the global and regional level

Location	1990		2019		EAPC_95%CI
	Number_95%UI	ASR	Number_95%UI	ASR	
Global	77,386,094.5 (60,187,034.1–99,502,432.3)	3528 (2743.9–4536.3)	90,875,573.1 (70,505,853.6–116,396,629.2)	3062 (2375.6–3921.9)	-0.43 (-0.55–0.31)
High SDI	234,300.1 (190,651.2–286,030.6)	72.5 (59–88.5)	385,412.4 (242,595.9–622,233.6)	116.3 (73.2–187.8)	2.12 (1.9–2.33)
High-middle SDI	2,785,374 (1,789,848.2–4,886,505.5)	576.1 (370.2–1010.6)	4,087,078.1 (2,173,892.1–6,425,048.5)	791 (420.7–1243.4)	1.45 (1.2–1.71)
Low SDI	28,026,224.4 (21,856,595.7–35,467,226.6)	14,460.4 (11,277.1–18,299.7)	41,918,720.9 (31,712,075.4–55,295,648.4)	9362.9 (7083.1–12,350.7)	-1.39 (-1.59–1.18)
Low-middle SDI	32,084,728 (22,421,203.5–46,676,045.3)	7204.6 (5034.7–10,481.1)	28,819,051.8 (19,642,262.1–43,445,776.2)	3919.4 (2671.4–5908.6)	-2.11 (-2.26–1.97)
Middle SDI	14,199,986 (11,088,081.5–18,609,012.7)	1902 (1485.2–2492.5)	15,601,830 (12,357,195.8–22,479,474.2)	1668.5 (1321.5–2404)	-0.36 (-0.56–0.16)
Andean Latin America	733,429.4 (460,630.7–1,268,440)	4746 (2980.7–8208.1)	289,890.3 (218,578.6–381,698.4)	1128.9 (851.2–1486.4)	-4.27 (-5.13–3.4)
Australasia	15,330.2 (2044.6–39,459.2)	188 (25.1–483.9)	19,050.6 (3885.7–45,650.2)	196 (40–469.8)	0.33 (0.21–0.45)
Caribbean	201,353.5 (149,049.5–267,397.8)	1357.2 (1004.7–1802.4)	199,015.5 (119,305–301078.5)	1097.8 (658.1–1660.8)	-1.09 (-1.81–0.37)
Central Asia	443,079.8 (39,061.3–935,185.7)	1556.1 (137.2–3284.4)	51,902.9 (26,170.9–98,656.7)	137 (69.1–260.4)	-7.67 (-8.65–6.68)
Central Europe	1150.4 (848.7–1614.2)	2.5 (1.8–3.5)	600.6 (462.2–781.7)	1.7 (1.3–2.2)	-1.39 (-1.5–1.29)
Central Europe, Eastern Europe, and Central Asia	451,603.6 (47,098.2–943,801.9)	281.8 (29.4–588.8)	58,563.6 (31,825.4–106,358.4)	41.2 (22.4–74.8)	-5.95 (-6.88–5.01)
Central Latin America	1,372,415.7 (1,240,464.9–1,535,130.7)	2012 (1818.6–2250.6)	1,747,226.1 (1,051,700.7–3,367,399.4)	1730.2 (1041.4–3334.6)	-1.05 (-1.83–0.28)
Central Sub-Saharan Africa	4,518,172.7 (3,080,839.5–6,229,334)	21,763 (14,839.7–30,005.3)	9,056,183.3 (5,953,847–12,590,352.7)	17,483.1 (11,494–24,305.9)	-0.85 (-1.05–0.65)
East Asia	1,110,053.3 (879,826.8–1,554,944.6)	195.8 (155.2–274.3)	3,150,306.6 (943,099.4–6,698,544)	610.9 (182.9–1298.9)	4.67 (4.44–4.9)
Eastern Sub-Saharan Africa	10,873,329.1 (7,727,041.4–13,950,072.9)	15,422.9 (10,960.1–19,787)	17,710,958.3 (12,494,031.3–23,627,552.4)	10,620.8 (7492.3–14,168.8)	-1.39 (-1.67–1.11)
North Africa and Middle East	2,131,681.3 (1,591,324.7–2,906,163.2)	1569.9 (1172–2140.3)	2,292,301.9 (1,334,205.4–3,626,203.8)	886.4 (515.9–1402.1)	-3.45 (-4.08–2.81)
Oceania	578,098.9 (354,293–845,552.9)	21,960.1 (13,458.4–32,119.8)	735,738.4 (320,302.9–1,326,946.7)	13,519.7 (5885.8–24,383.5)	-2.76 (-3.22–2.29)
South Asia	32,044,431.2 (20,219,908.7–50,101,934.4)	7418.2 (4680.9–11,598.5)	19,913,951.5 (9,713,433.9–39,441,385.7)	2590 (1263.3–5129.8)	-3.36 (-3.65–3.07)
Southeast Asia	5,136,745.9 (3,836,359–8,411,761.2)	2610 (1949.3–4274.1)	3,874,248.8 (3,192,762.5–4,774,834.1)	1426.5 (1175.6–1758.1)	-1.38 (-1.79–0.97)
Southern Latin America	49,681.3 (23,026.8–91,304.7)	260.3 (120.6–478.4)	57,407.6 (25,709.4–109,835.9)	225.7 (101.1–431.9)	-0.31 (-0.55–0.07)
Southern Sub-Saharan Africa	505,571.3 (364,420.5–751,357)	2305.8 (1662.1–3426.8)	436,568.4 (120,107.2–1,200,849.6)	1296.2 (356.6–3565.3)	-2.99 (-4.11–1.85)
Tropical Latin America	1,505,083 (1,295,526.6–1,723,989.1)	2340.1 (2014.3–2680.5)	1,190,536.5 (995,739.7–1,418,380.5)	1336.3 (1117.6–1592)	-1.41 (-2.04–0.77)
Western Europe	616.6 (471.7–837.1)	0.4 (0.3–0.6)	1373 (1064.1–1765.2)	1 (0.8–1.3)	-0.02 (-1.05–1.02)
Western Sub-Saharan Africa	16,121,359.4 (11,943,641.9–22,161,772.3)	22,672.5 (16,797.1–31,167.6)	30,106,369.8 (21,799,055.4–41,415,700.9)	16,805.4 (12,168.3–23,118.3)	-1.01 (-1.17–0.86)
High-income Asia Pacific	30,963.2 (18,761.1–50,346.8)	45.8 (27.8–74.5)	26,627.9 (19,478.7–35,704.1)	50.7 (37.1–68)	1.87 (1.32–2.43)
High-income North America	6175 (3942.6–8296.5)	5.5 (3.5–7.3)	9255.3 (5993.4–12,298.8)	7.6 (4.9–10.1)	2.78 (1.84–3.73)

Abbreviations: EAPC Estimated annual percentage change, *SDI* Sociodemographic Index, *UI* Uncertainty interval

Table 3 DALYs of tropical diseases between 1990 and 2019 in 15 to 39 years at the global and regional level

Location	1990		2019		EAPC_95%CI
	Number_95%UI	ASR	Number_95%UI	ASR	
Global	14,487,652.7 (10,917,165.1–18,714,435.7)	660.5 (497.7–853.2)	10,826,237.5 (7,648,308.6–14,622,611.4)	364.8 (257.7–492.7)	-2.29 (-2.47–2.11)
High SDI	56,200.2 (39,149.1–77,469.1)	17.4 (12.1–24)	33,481.9 (22,731.6–47,160.6)	10.1 (6.9–14.2)	-1.76 (-2.07–1.44)
High-middle SDI	759,375.5 (534,565.6–1,064,912.4)	157.1 (110.6–220.2)	409,917.3 (294,839.1–545,571.3)	79.3 (57.1–105.6)	-2.45 (-2.63–2.27)
Low SDI	5,422,153.3 (4,032,840.3–7,176,758.4)	2797.6 (2080.8–3702.9)	5,077,469.3 (3,485,819.9–7,152,417.9)	1134.1 (778.6–1597.6)	-3.2 (-3.48–2.92)
Low-middle SDI	4,767,256.1 (3,391,024.2–6,710,288.9)	1070.5 (761.5–1506.8)	3,205,809 (2,278,303.1–4,332,598.7)	436 (309.8–589.2)	-3.35 (-3.57–3.12)
Middle SDI	3,473,991.5 (2,619,204.8–4,557,477.7)	465.3 (350.8–610.4)	2,092,702.1 (1,541,186.5–2,740,096.7)	223.8 (164.8–293)	-2.97 (-3.13–2.81)
Andean Latin America	80,493.3 (52,704.9–120,214.1)	520.9 (341.1–777.9)	38,621.8 (24,928.2–56,542.6)	150.4 (97.1–220.2)	-4.62 (-5.07–4.17)
Australasia	395.2 (172.5–795.1)	4.8 (2.1–9.8)	356.8 (127–779.7)	3.7 (1.3–8)	-0.95 (-1.15–0.75)
Caribbean	61,173.4 (42,138–84,259.9)	412.3 (284–567.9)	43,952.7 (25,820.5–78,884.7)	242.5 (142.4–435.1)	-3.23 (-3.98–2.46)
Central Asia	30,932.2 (19,405.2–47,492.5)	108.6 (68.2–166.8)	26,687.2 (14,781.1–46,208.4)	70.4 (39–122)	-1.91 (-2.05–1.77)
Central Europe	12,525.6 (7016.3–31,418.1)	27.2 (15.2–68.3)	5028.4 (3098.2–7704.6)	14.1 (8.7–21.6)	-2.32 (-2.52–2.13)
Central Europe, Eastern Europe, and Central Asia	64,384.1 (42,799.9–90,598.2)	40.2 (26.7–56.5)	43,792.6 (27,834.2–66,105.1)	30.8 (19.6–46.5)	-1.33 (-1.48–1.19)
Central Latin America	159,574.4 (114,765.5–215,060.5)	233.9 (168.3–315.3)	134,713.7 (94,447.1–186,594.8)	133.4 (93.5–184.8)	-2.63 (-2.93–2.32)
Central Sub-Saharan Africa	999,248.4 (758,381.6–1,252,924.6)	4813.1 (3652.9–6035)	1,101,315.3 (790,743.5–1,468,541.5)	2126.1 (1526.5–2835)	-3.7 (-4.19–3.21)
East Asia	1,115,243.4 (654,794.8–1,800,557.5)	196.7 (115.5–317.6)	303,786.4 (169,877.4–487,197.8)	58.9 (32.9–94.5)	-3.9 (-4.41–3.38)
Eastern Sub-Saharan Africa	2,165,626.3 (1,670,401.9–2,821,629.3)	3071.8 (2369.3–4002.2)	1,582,734.8 (1,074,007.2–2,310,696.7)	949.1 (644.1–1385.7)	-4.38 (-4.71–4.05)
North Africa and Middle East	714,554.3 (441,683.9–1,141,268.4)	526.2 (325.3–840.5)	552,012.1 (297,076.4–948,921.8)	213.4 (114.9–366.9)	-4.12 (-4.5–3.74)
Oceania	48,066.6 (29,272.8–83,394.9)	1825.9 (1112–3167.9)	58,349.4 (33,411.2–104,308.3)	1072.2 (614–1916.7)	-1.58 (-2.22–0.94)
South Asia	4,544,191.9 (2,960,345.4–7,043,866.2)	1052 (685.3–1630.6)	2,021,563.8 (1,415,744.1–2,785,220.9)	262.9 (184.1–362.3)	-4.96 (-5.12–4.8)
Southeast Asia	1,363,048.7 (984,329.8–1,903,487.8)	692.6 (500.1–967.2)	553,818.5 (407,929.8–730,348.2)	203.9 (150.2–268.9)	-4.25 (-4.66–3.84)
Southern Latin America	23,226 (15,588.9–36,048.9)	121.7 (81.7–188.9)	9763.1 (6557.5–14,509.6)	38.4 (25.8–57.1)	-3.87 (-4.11–3.64)
Southern Sub-Saharan Africa	176,788.8 (114,022.3–270,092.8)	806.3 (520–1231.8)	96,131 (57,887.5–198,244.3)	285.4 (171.9–588.6)	-4.12 (-4.86–3.38)
Tropical Latin America	260,103 (174,545.1–353,274.6)	404.4 (271.4–549.3)	145,920.5 (95,870.1–221,010.3)	163.8 (107.6–248.1)	-2.91 (-3.16–2.66)
Western Europe	6992.2 (4088.5–14,840.5)	4.9 (2.8–10.3)	3760 (2344.4–5905.1)	2.9 (1.8–4.5)	-1.78 (-2.04–1.53)
Western Sub-Saharan Africa	2,676,516.7 (1,902,624.4–3,755,078.8)	3764.2 (2675.8–5281)	4,119,446.1 (2,502,037–6363543)	2299.5 (1396.6–3552.1)	-1.66 (-2.11–1.21)
High-income Asia Pacific	17,879.5 (12,251.5–25,218.9)	26.5 (18.1–37.3)	7786.8 (5123.9–11,074.5)	14.8 (9.8–21.1)	-2.09 (-2.49–1.69)
High-income North America	10,146.6 (5759.7–16,554.8)	9 (5.1–14.6)	8412.2 (5093.7–12,948.3)	6.9 (4.2–10.7)	-0.52 (-0.73–0.31)

Abbreviations: EAPC Estimated annual percentage change, *SDI* Sociodemographic Index, *UI* Uncertainty interval

SDI regions showed more stable ASPR trends, consistently lower than the global rate (Fig. 2). Notably, the prevalence of NTDs varied by gender in different SDI regions, with specific age groups exhibiting distinct patterns (Figure S2A).

Incidence

In 1990 and 2019, the highest numbers of NTD cases were recorded in low-middle and low-SDI areas, with 32,084,728 and 41,918,720.9 cases, respectively. These regions exhibited the most significant shifts, with EAPCs of -2.11 (95% CI: -2.26 to -1.97) and -1.39 (95% CI: -1.59 to -1.18), respectively. Additionally, low SDI regions had the highest Age-Standardized Incidence Rates (ASIR) of 14,460.4 in 1990 and 9,362.9 per 100,000 population in 2019 (Table 2). The incidence of NTDin the middle SDI region rose from 14,199,986 cases in 1990 to 15,601,830 in 2019 (Table 2), while ASIR in these regions slightly decreased from 1902 to 1668.5 per 100,000 population during the same period. In contrast, the incidence of migraine in middle-high SDI regions saw a substantial increase from 2,785,374 cases in 1990 to 4,087,078.1 in 2019, with a slight rise in ASIR from 576.1 to 791 per 100,000. The incidence in high SDI regions also escalated from 234,300.1 cases in 1990 to 385,412.4 in 2019, alongside a minor increase in ASIR from 72.5 to 116.3 per 100,000 population (Table 2). From 1990 to 2019, the ASIR of NTDs across the five SDI regions indicated an overall downward trend, with the low SDI region displaying the most marked decrease. However, these rates were substantially higher than the global rate. The ratios in medium, medium–high, and high SDI regions

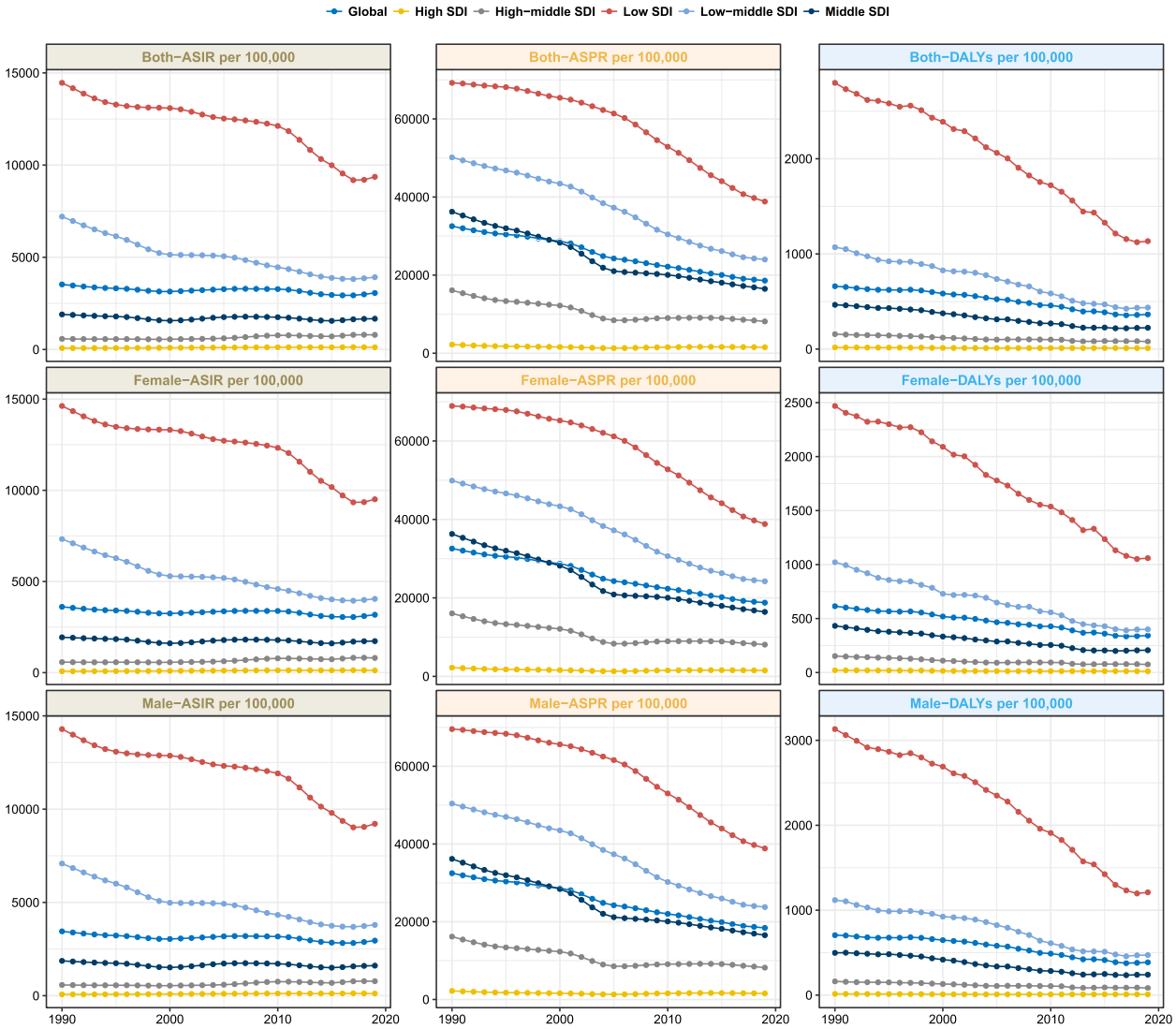

Fig. 2 Trends of ASIR, ASPR and DALYs of neglected tropical diseases in different SDI regions from 1990 to 2019

remained stable and lower than the global rate throughout this period (Fig. 2). An examination of ASPR by gender revealed a consistently higher ASIR rate in women worldwide, with the male-to-female incidence ratio gradually increasing with age in all SDI regions except for the high and medium–high categories (Figure S2B).

DALYs

Over the past thirty years, the most significant reduction in DALYsdue to NTDs was observed in the middle SDI region. Here, total DALYs diminished by 66%, from 347,399,91.5 in 1990 to 2092,702.1 in 2019 (Table 3). Although low SDI regions maintained the highest age-standardized DALYs among the five SDI regions, they only achieved a slight reduction in total DALYs, decreasing from 54,222,153.3 in 1990 to 50,777,469.3 in 2019 (Table 3). Other SDI regions also experienced declines in age-standardized DALYs during this period. DALYs in low and middle SDI regions decreased slightly, from 4,767,256.1 in 1990 to 3,205,809 in 2019, alongside a significant reduction in age-standardized DALYs from 1070.5 to 436 per 100,000 people. The middle and high SDI areas also reported substantial decreases in DALYs, from 759,375.5 in 1990 to 409,917.3 in 2019. Additionally, high SDI areas saw a modest decline in DALYs, from 56,200.2 in 1990 to 33,481.9 in 2019. Apart from the low SDI region, the age-standardized DALYs for NTDs in the other four SDI regions exhibited stable trends from 1990 to 2019. The low SDI region demonstrated a significant downward trend, yet its rate was much higher than the global average. The ratios in low-medium, medium, medium–high, and high SDI regions remained stable throughout this period (Fig. 2). Intriguingly, except for the high SDI regions, the other four SDI regions had age-standardized DALY ratios greater than 1 for both men and women, with an overall trend of these ratios forming an inverted "U" shape, peaking in the 20–29 age group (Figure S2C).

Geographic regions level

Prevalence

This study, encompassing 21 geographic regions, revealed that South Asians exhibited the highest prevalence of NTDs, with 171,738,747.3 cases (95% Uncertainty Interval [UI]: 150,389,469.3 to 198,613,635.3). In stark contrast, Australasia reported the lowest prevalence at 11,606.3 cases (95% UI: 7,300.9 to 17,596, see Table 1). Notably, over the past three decades, sub-Saharan Africa experienced the most rapid decline in NTD prevalence, as indicated by an Estimated Annual Percentage Change (EAPC) of -3.67 (95% Confidence Interval [CI]: -3.79 to -3.55). The highest Age-Standardized Prevalence Rate (ASPR) for NTDs was observed in Central sub-Saharan Africa, at 53,294.3 per 100,000 population (95% UI: 49,778.4 to 57,322.1), while Western Europe recorded the lowest at 116.9 per 100,000 (95% UI: 101.3 to 132.5) (Table 1). A notable negative correlation between ASPR and the Socio-Demographic Index (SDI) for NTDs was observed ($R = -0.92$, $P < 0.001$), as shown in Figure S3A. Seven regions, including Central, Western, and Eastern Saharan Africa, reported prevalence rates exceeding the global average (18,599.8), whereas 14 regions, such as East Asia and Central Europe, recorded prevalence below this threshold.

In 2019, Liberia reported the highest prevalence of NTDs among 204 countries, with 77,059.7 cases per 100,000 population (95% Uncertainty Interval [UI]: 70,481.6 to 83,802.6, Table S1, Fig. 3A). Conversely, Iceland observed the lowest prevalence, with 32.9 cases per 100,000 (95% UI: 14.4 to 62.2, Table S1, Fig. 3A). Over the same period, the Northern Mariana Islands experienced the most pronounced increase in NTD prevalence (Estimated Annual Percentage Change [EAPC]: 0.63; 95% Confidence Interval [CI]: 0.25 to 1, Table S1, Fig. 4A), whereas American Samoa exhibited the largest decrease (EAPC: -6.84; 95% CI: -9 to -4.63, Table S1, Fig. 4A).

Incidence

In our cross-sectional analysis of 21 regions, Western Saharan Africa emerged with the highest incidence of NTDs, at 30,106,369.8 cases (95% UI: 21,799,055.4 to 41,415,700.9; Table 2). Conversely, Central Europe documented the lowest incidence at 600.6 cases (95% UI: 462.2 to 781.7; Table 2). The incidence of NTDs in East Asia has seen a substantial increase over the past thirty years, with an EAPC of 4.67 (95% CI: 4.44 to 4.90). In contrast, the most marked decline was in Central Asia, with an EAPC of -7.67 (95% CI: -8.65 to -6.68). Regarding the Age-Standardized Incidence Rate (ASIR), Central Saharan Africa reported the highest at 17,483.1 per 100,000 population (95% UI: 11,494 to 24,305.9), while Western Europe had the lowest at 1 case per 100,000 population (95% UI: 0.8 to 1.3; Table 2). Figure S3B illustrates a significant negative correlation between the incidence of NTDs and SDI ($R = -0.76$, $P < 0.001$). Additionally, four regions, including Central and Western Saharan Africa, Oceania, and Eastern Saharan Africa, exhibited migraine prevalence rates surpassing the global average (3,062), whereas 17 regions, like Central Asia and Central Europe, reported lower rates.

In 2019, Benin recorded the highest incidence of NTDs among the 204 countries surveyed, with 20,785.3 cases per 100,000 population (95% UI: 14,113.6 to 28,428.4, Table S2, Fig. 3B). In stark contrast, Canada reported the lowest incidence, effectively zero cases per 100,000 (95% UI: 0 to 0.1, Table S2, Fig. 3B). From 1990 to 2019,

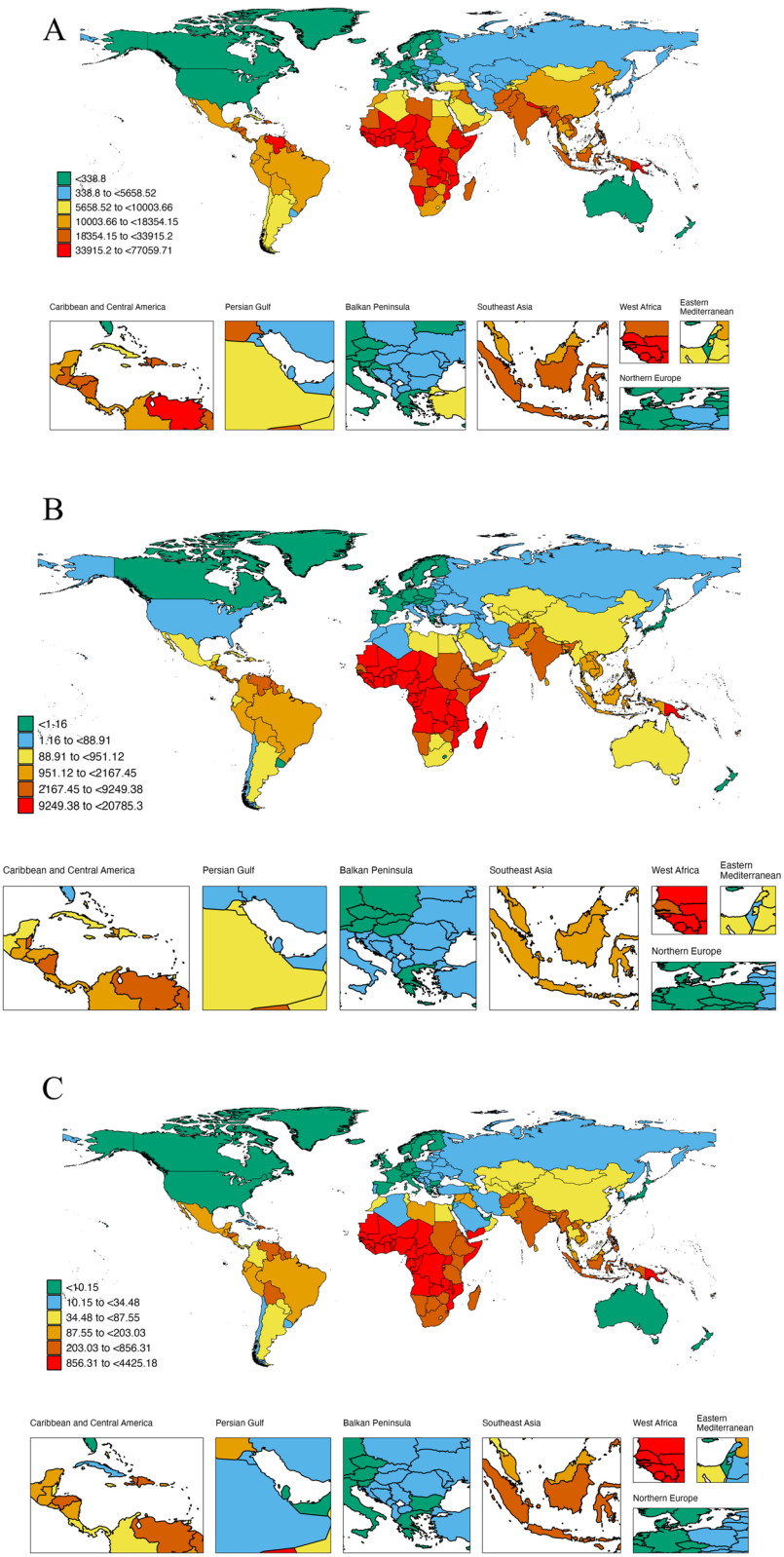

Fig. 3 The Global Disease Burden of NTDs for Both Sexes in 204 Countries and Territories. **A** Prevalence rate for NTDs. **B** Incidence rate for NTDs. **C** DALYs rate for NTDs

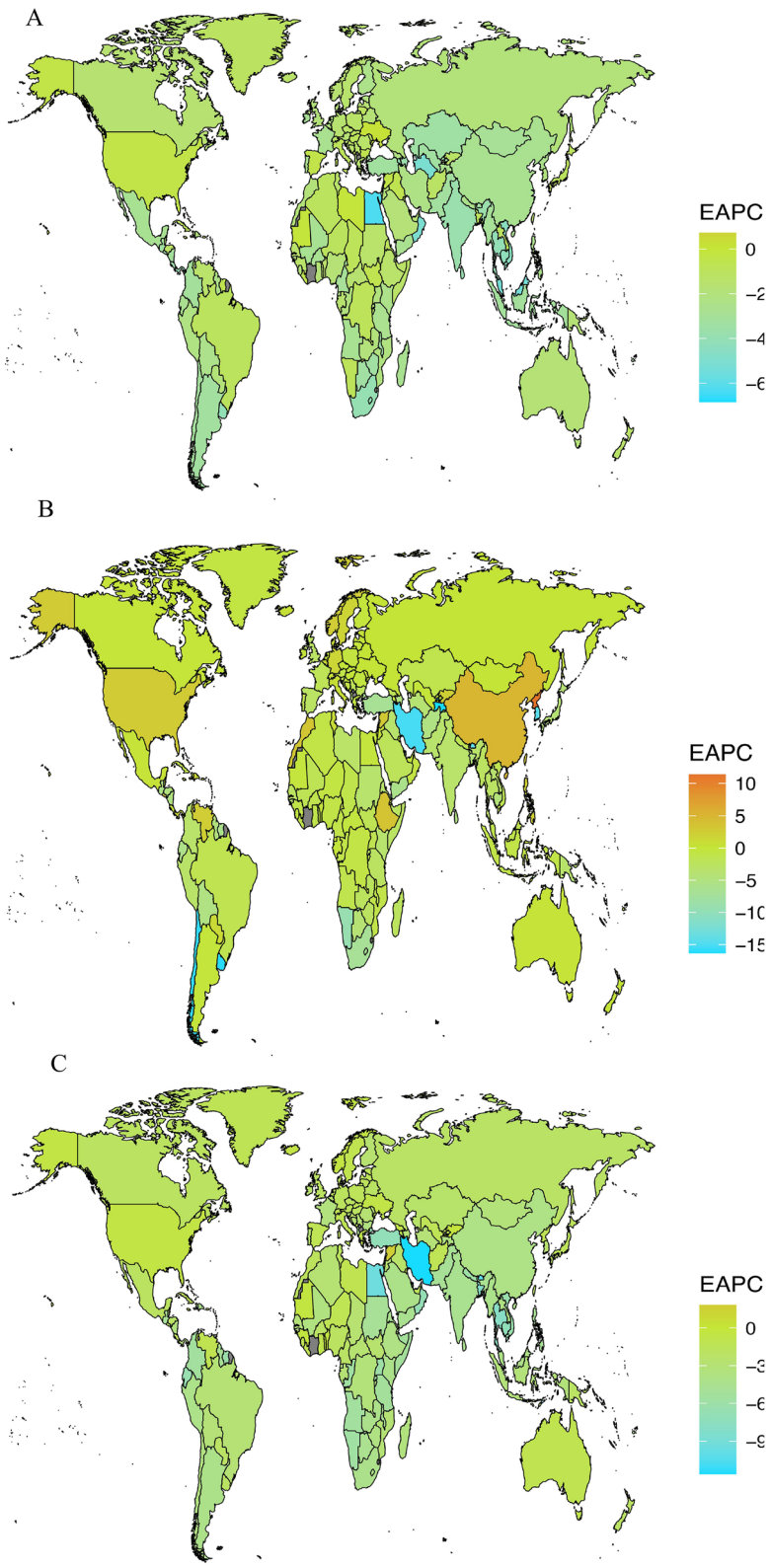

Fig. 4 The Global Disease Burden of NTDs for Both Sexes in 204 Countries and Territories. **A** EAPC for NTDs prevalence. **B** EAPC for NTDs incidence. **C** EAPC for NTDs DALYs

the Democratic People's Republic of Korea observed the most significant increase in NTD incidence (EAPC: 11.18; 95% CI: 0.56 to 22.92, Table S2, Fig. 4B), while Tajikistan experienced the largest decrease (EAPC: -16.31; 95% CI: -18.45 to -14.11, Table S2, Fig. 4B).

DALYs

As per Table S3, Western Saharan Africa accounted for the highest number of migraine-related DALYs, registering 4,119,446.1 (95% UI: 2,502,037 to 6,363,543), while Australasia reported the lowest at 356.8 (95% UI: 127 to 779.7). The highest DALY rate per 100,000 population was in Western Saharan Africa at 2,299.5 (95% UI: 1,396.6 to 3,552.1), compared to the lowest in Western Europe at 2.9 (95% UI: 1.8 to 4.5). Notably, the DALY rate in regions like Central, Eastern, and Western Sub-Saharan Africa, and Oceania surpassed the global average of 364.8. Conversely, 17 regions, including South and East Asia, reported DALY rates lower than the global average (detailed in Table 3). Moreover, a distinct negative correlation was found between migraine-related DALY and SDI, as depicted in Figure S3C ($R = -0.74$, $P < 0.001$).

In 2019, Liberia, Sierra Leone, and Cote d'Ivoire had the highest age-standardized DALY rates for NTDs among 204 countries, with rates of 4,425.2, 3,387.1, and 3,153.2 per 100,000 people, respectively (Table S3, Fig. 3C). In contrast, Belgium, France, and Ireland reported the lowest rates, at 0.6, 0.6, and 0.8 per 100,000, respectively (Table S3). Between 1990 and 2019, the Syrian Arab Republic, Northern Mariana Islands, and Nauru saw the most notable increases in age-standardized DALY rates (EAPCs: 1.82, 1.41, and 1.19, respectively). Conversely, Iran, Bhutan, and Egypt experienced the most substantial decreases in these rates (EAPCs: -11.61, -10.19, and -9.4, respectively, Table S3 and Fig. 4C).

Future burden of TDs

Figure S4 delineates the forecasted trajectory of NTD prevalence worldwide, indicating an overarching downward trend in the global burden of these disorders. Notably, regions with a lower Socio-Demographic Index (SDI) have exhibited a significant decline in prevalence, surpassing other regions and the global mean, yet they continue to report prevalence rates exceeding the global average. In contrast, high SDI regions have maintained a consistently lower prevalence of NTDs, with relatively minor fluctuations observed over time. A gender disparity is also evident, with women exhibiting higher prevalence rates compared to men (Figure S4). Projections suggest a continued decrease in NTD prevalence through to 2040, reflecting ongoing global health efforts and advancements.

Discussion

This study provides a comprehensive analysis of the global, regional, and national epidemiology and burden of NTDs among youths and young adults aged 15–39 years from 1990 to 2019. Several key findings emerge:

The global prevalence of NTDs decreased by 29% between 1990 and 2019, from 713.5 million to 552 million cases. However, the incidence increased by 17% over the same period, from 77 to 91 million new cases annually. These divergent trends likely reflect ongoing control efforts which have reduced overall prevalence, alongside persistently high rates of new infections in tropical regions with poor access to preventive measures.

This study suggests that males exhibited a higher disease burden across most metrics. The age-standardized prevalence, incidence, and DALYsrates were consistently higher in males compared to females globally. This likely relates to differential occupational and behavioral exposures. Males often engage in higher-risk activities like outdoor labor, travel, and certain cultural practices that elevate infection risk [17–19]. Targeted interventions for at-risk males could yield substantial dividends. Further speaking, youths and young adults shoulder the greatest burden, accounting for over 60% of new NTD cases in 2019. Both the absolute number of cases and age-standardized incidence rates peaked between ages 15–24 years. Younger populations also contributed the most DALYs, reflecting the productivity losses when NTDs afflict those in their prime productive years. Control efforts focused on adolescents and young adults may be especially impactful given their role in transmission and the long-term sequelae if untreated [20, 21].

Interestingly, NTD prevalence, incidence, and DALYs demonstrated an inverse relationship with country development level across socioeconomic strata. Low and low-middle SDI regions consistently reported the highest burdens. The age-standardized prevalence in low SDI areas was over 30 times higher than in high SDI regions in 2019 (38,841 vs 1,152 per 100,000). This likely reflects closer proximity to zoonotic reservoirs in resource-limited tropical areas as well as inadequate water, sanitation, and vector control infrastructure—critical determinants of NTD propagation [22–24]. It further spotlights the links between poverty and NTDs. The declines in prevalence and DALYs outpaced falls in incidence globally. From 1990 to 2019, age-standardized prevalence and DALYs decreased annually by 2.04% and 2.29% respectively, while incidence diminished by just 0.43% per year. This divergent pattern suggests that increased diagnosis and treatment improved disease control and averted long-term impairments, but ongoing transmission continues to sustain incident cases

[25]. Reinforcing preventive measures alongside therapeutic coverage will be key to accelerating declines.

We found that sub-Saharan Africa witnessed dramatic reductions across most metrics over the past 30 years, likely reflecting the impacts of integrated mass drug administration (MDA) programs [26]. Prevalence in Southern sub-Saharan Africa declined by 3.67% annually from 1990–2019. However, the region still shoulders the highest residual burden, with Central and Western sub-Saharan Africa reporting the highest age-standardized prevalence and incidence rates globally in 2019. Sustained investments in strengthening local health systems will be vital to consolidate and advance the gains achieved to date [27, 28]. Among 204 nations, Liberia, Benin and Sierra Leone registered the highest NTD prevalence, incidence and DALYs respectively in 2019—spotlighting the disproportionate disease toll in West Africa. The Democratic Republic of Congo, South Sudan, Central African Republic, Guinea, Ivory Coast, and Cameroon rounded out the leading countries by various metrics. Many nations with the lowest SDI consistently ranked among the most afflicted, affirming the link between NTDs and development [29].

Collectively, these findings underscore both ongoing needs and measurable progress. The residual burden of over half a billion cases globally motivates the recent launch of the WHO's 2021–2030 NTD roadmap targeting 90% reduction in impact and transmission by 2030 [30]. Our projections suggest that, although premised on optimistic assumptions, this target may be attainable given the trajectories observed from 1990–2019. However, contextual changes like population growth, urbanization, climate change, and ecological disruptions could imperil recent gains [31].

Moreover, aggregate global metrics mask considerable heterogeneity across and within regions. National estimates revealed over 75-fold differences in prevalence and 100-fold variances in age-standardized DALY rates across the 204 nations analyzed. Such disparities highlight needs for precision targeting and social progress in the most afflicted areas. Our granular quantitation of trends by age, sex and SDI strata provides an evidence base for tailored policymaking.

Potential study limitations

Some limitations should be considered when interpreting our findings. Given the paucity of surveillance data in many afflicted areas, modeling techniques were employed which may underestimate or overestimate true disease burden [32]. Improved epidemiological tracking and diagnostics would strengthen future iterations. Our analysis also excluded four NTDs which could not be reliably measured, slightly underestimating the total burden. Lastly, we employed restrictive assumptions when projecting future trajectories which may overstate the likely declines without sustained interventions.

Conclusions

In conclusion, NTDs imposed over half a billion incident cases and 10.8 million DALYs lost globally in 2019—exerting an immense toll rivaling major infectious and non-communicable diseases. Encouraging declines in prevalence and disability burdens over the past three decades spotlight the potential to accelerate progress through evidence-based allocation of resources. However, ongoing transmission, regional disparities and the youth disease peak motivate targeted strategies focused on adolescent and young adult males in resource-limited nations. Furthermore, contextual threats ranging from population pressures to climate change could imperil recent gains without vigilance. Nevertheless, our projections provide grounds for cautious optimism that a 90% reduction in impact may be feasible with political commitment and precision public health policies informed by timely, granular data.These strategies will also benefit international travelers and migrants and reduce the spread of such neglected tropical diseases.

Abbreviations

NTDs	Neglected Tropical Diseases
DALYs	Disability-Adjusted Life Years
GBD	Global Burden of Disease
SDI	Socio-Demographic Index
EAPC	Estimated Annual Percentage Changes
ASR	Age-Standardized Rate
ASIR	Age-Standardized Incidence Rate
ASPR	Age-Standardized Prevalence Rate
CI	Confidence Interval
UI	Uncertainty Intervals

Supplementary Information

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Supplementary Material 1.

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Author's contributions

Jia-jie Lv contributed to the conceptualization, methodology, investigation, and writing of the original draft. Xin-yu Li was involved in the investigation, data curation, formal analysis, and review and editing of the manuscript. Cheng-hao Yang, as the corresponding author, made significant contributions to the conceptualization, methodology, formal analysis, supervision, writing of the original draft, review and editing of the manuscript, and project administration. Yi-chi Zhang participated in the investigation, formal analysis, and review and editing of the manuscript. Xuhui Wang provided supervision, reviewed and edited the manuscript, and offered overall project guidance. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials
The datasets generated and analysed during the current study are available in the GBD repository, https://vizhub.healthdata.org/gbd-results/.

Declarations

Ethics approval and consent to participate
Our study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. For the usage of deidentified data in GBD study, a waiver of informed consent has been approved by the University of Washington Institutional Review Board.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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