# The Epidemiology and Trends in the Burden of Burns throughout the World

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# Abstract

### Background

Burns are a type of injuries, caused by unintentional exposure to substances of high temperature, including hot liquid, solid, and objects radiating heat energy, placing a high burden not only on patients' families but also on national healthcare systems globally. It is difficult for policymakers and clinicians to formulate targeted management strategies for burns because data on current epidemiological patterns worldwide are lacking.

### Methods

Data on burns were obtained from the Global Burden of Disease (GBD) 2019 Study. The incidence, disability-adjusted life years (DALYs), and deaths of burns in 204 countries and regions from 1990 to 2019 were calculated and stratified by sex, age, geographical location, and sociodemographic index (SDI). The estimated annual percentage change (EAPC) of incidence, DALYs, and deaths was calculated to evaluate the temporal trends. All analyses were performed using R software, version 4.1.1, with 2-sided P-values < .05 indicating a statistically significant difference.

### Results

A total of 8,378,122 new cases (95% UI, 10,363,109–6,531,887 cases) of burns were identified globally in 2019, which is almost evenly split between men and women, and most of the new cases were concentrated in the 10–19-year age group. Besides, burns account for 111292 deaths (95% UI, 132,392–88,188) globally in 2019, most of which were concentrated in those aged 1–4 years. The burden of burns measured in DALYs was 7,460,448.65 (95% UI, 9,478,717.81–5,794,505.89) in 2019, of which 67% and 33% could be attributed to YLLs and YLDs, respectively. The EAPC of incidence, DALYs, and deaths were negative, the age-standardized rate (ASR) of incidence, DALYs, and deaths were considered to be decreasing in most of the regions, and the EAPCs were negatively correlated with SDI levels, universal health coverage (UHC), and gross domestic product (GDP).

### Conclusion

Globally, the burden of burns was decreased gradually from 1990 to 2019 and was considered to be decreasing in most of the regions. And from the relationship of EAPCs with SDI levels, universal health coverage (UHC), and gross domestic product (GDP), it can be found that the ASRs of burns decreased as the economy developed and a country's healthcare system performance improved. These phenomena suggest that national healthcare systems need to increase funding for burns prevention and intervention strategies.


# Background

Burns are a type of injuries, caused by unintentional exposure to substances of high temperature, including hot liquid, solid, or gas such as cooking stoves, smoke, steam, drinks, machinery, appliances, tools, radiators, and objects radiating heat energy[1], placing a high burden not only on patients' families but also on national healthcare systems globally. Therefore, it is necessary to understand the latest spatial distribution and temporal trends of burns worldwide to establish more reasonable and effective prevention and treatment programs to improve patients' quality of life and reduce avoidable medical expenses.

The Global Burden of Disease (GBD) Study provides a systematic scientific assessment of epidemiological data related to disease and injury from multiple sources. The GBD 2019 Study provides the most up-to-date assessment of the descriptive epidemiology of a mutually exclusive and collectively exhaustive list of 369 diseases, along with 87 risk factors based on location, sex, age, and year for 204 countries and territories, from 1990 to 2019[1, 2].

To investigate the level, trends, and burden of burns at the national, regional, and global levels in order to provide a basis for optimizing strategies for the management of burns, we aimed to extract and analyze annual data on burns incidence, disability-adjusted life years (DALYs), as well as deaths by location, sex, and age from the GBD 2019 Study.

# Materials And Methods

We collected annual case data and age-standardized rates (ASRs) for burns incidence, deaths, DALYs from 1990 to 2019 from the Institute for Health Metrics and Evaluation using the Global Health Data Exchange (GHDx) online query tool (http://ghdx.healthdata.org/gbd-results-tool).

The detailed original data introduction and general analysis methods of the GBD 2019 study have been described in previous researches[1, 3, 4]. Briefly, the Cause of Death Ensemble Model (CODEm) was used to generate cause-specific mortality and years of life lost (YLLs) estimates, and DisMod-MR 2.1 was used to estimate disease burden (incidence, and years lived with disability (YLDs)). DALYs were calculated by adding the sum of YLDs to YLLs. The GBD methodology of attributes mortality to burns that was described in the previous studies[1, 5]. ASRs were calculated by adjusting for population size (per 100 000 population) and for age structure. We further calculated the estimated annual percentage change (EAPC) to describe the temporal trend in various age-standardized rates (ASRs) of burns burden and the detailed methods have been described in previous researches[6–9]. Occupational injuries are defined as the proportion of injuries in the working-age population attributable to occupational work, based on fatal injury rates in 17 economic activities[4].

The 95% uncertainty intervals (UIs) for every metric in the 2019 GBD study were calculated to reflect the certainty of the estimates, which were determined by the 25th and 975th values of the 1,000 values, after ordering them from smallest to largest[1, 4, 10]. We also calculated 95% confidence intervals (95%CIs) for the EAPCs[11]. Temporal trends in ASRs were recognized to be in an increasing trend when the EAPCs and the lower boundary of the 95% CI were positive; conversely, to be a decreasing trend when EAPCs and the upper boundary of the 95% CI were negative. Otherwise, the ASRs were considered to be stable[11, 12]. The

data were collected from 204 countries and territories and were divided into five regions according to their sociodemographic index (SDI) that was developed by GBD researchers and is a composite indicator constructed from measures of per capita income, average years of education, and total fertility rates. Geographically, the world was further classified into 45 regions.

For exploring the potential factors of changing trends, we also calculated the association between universal health coverage (UHC), gross domestic product (GDP) with EAPCs in burns burden.

# Data analysis

EAPCs were calculated on a regression line model. The natural logarithm of the regression line is fitted to ASR with the following formula, $y = \alpha + \beta x + \varepsilon$, where $y = \ln(ASR)$, and $x$ = calendar year. The EAPCs of ASRs and their 95% CI were calculated as $100 \times [\exp(\beta) - 1]$ with the linear regression model[9, 10]. The correlations of EAPCs with UHC in 2019, GDP in 2019, and SDI value using a Pearson correlation analysis[13]. All analyses were performed using R software, version 4.1.1, with 2-sided P-values < .05 indicating a statistically significant difference.

# Results

Incidence of burns Globally, a total of 8,378,122new cases (95% UI, 10,363,109–6,531,887 cases) of burns were identified in 2019, which is almost evenly split between men and women, and most of the new cases were concentrated in the 10–19-year age group (Table 1, Figure 1A). From 1990 to 2015, the number of incident cases fluctuates within a certain degree, but the number of incident cases sharply increased from 2016 (Table 1, Figure 1B). Females affected occupied about 87% of the increased cases that from 1990 to 2019 (Table 1). However, the age-standardized incidence rate (ASIR) was found to have decreased by an average of 0.7% per year in the same period (from 149.86 per 100,000 in 1990 to 117.51 per 100,000 in 2019) and the ASIR value of both genders is similar in 2019, besides incidence distribution by age can be seen in supplemental materials (Table 1, Supplemental Figure S1A, D, E). Among the SDI quintiles, countries with Middle SDI level has the highest incident cases than countries with other SDI levels, both in 1990 and 2019, and the number of incident cases increased in Low, Low-middle, Middle SDI levels from 1990 to 2019, whereas the number decreased in High and High-middle SDI levels (Table 1, Supplemental Figure S1B). However, the ASIR decreased for all SDI levels and countries with the High SDI level had the highest ASIR than in those with lower SDI levels, both in 1990 and 2019 (Figure 1C). The number of new cases was higher in females than in males in Low-middle, Low SDI levels than other SDI levels both in 1990 and 2019 (Figure 1D, Supplemental Figure S1B). The absolute number of burns cases increased in most of GDB regions. Asia had the most new cases in 2019 (3,913,524.80 [95% UI 4,959,607.51–2,946,199.45]), with a 19% increase relative to cases in 1990 (3,287,567.95 [95% UI, 4,165,597.49–2,473,836.69]), whereas Oceania had the fewest new cases in 2019 (27,510.31 [95% UI, 33,261.04–21,933.81]). The regions that had the most significantly increased and decreased numbers of new cases, respectively, were World Bank Lower Middle Income category (from 2,118,416.48 [95% UI, 2,646,959.73–1,626,255.73] to 2,827,973.07 [95% UI, 3,575,667.26–2,124,427.64]) and the Europe (from 1,982,378.87

[95% UI, 2,411,800.64–1,585,062.86] to 1,492,624.00 [95% UI, 1,831,234.57–1,169,397.61]) Europe (Supplemental Figure S1I). As for the ASIR, Caribbean had the highest ASIR in 2019 (336.06 [95% UI, 414.72–267.46]), whereas Eastern Mediterranean Region had the lowest (57.43 [95% UI, 71.52–44.27]). The ASIRs decreased in most of the regions. The most greatestt reduction detected was in Tropical Latin America (from 286.29 [95% UI, 352.94–219.37] to 140.70 [95% UI, 175.49–107.88]), whereas the most significant increase was detected in East Asia (from 76.47 [95% UI, 96.95–57.12] to 85.93 [95% UI, 110.91–61.61]) (Supplemental Figure S1J). At the national level, the most highest number of cases were recorded in Mainland of China in 2019, which account for 12% of the new cases detected globally (overall, 1,079,670.14 [95% UI, 1,389,157.59–786,947.53]; males, 565,448.23 [95% UI, 728,230.85–417,357.69]; females, 514,221.91 [95% UI, 660,910.29–370,324.64]) (cases number peaked in those who were 30–34 years of age), followed by India (1,009,518.92 [95% UI, 1,295,202.13–742,769.05]), collectively accounting for 11% of all new cases, globally. Niue had the fewest new cases in 2019 (1.84 [95% UI, 2.39–1.35] cases). The most significant reduction detected was in Brazil (from 463,695.51 [95% UI, 583,046.27–350,241.35] to 290,004.98 [95% UI, 362,276.26–225,525.87]), whereas the most significant increase was detected in India (from 716858.75 [95% UI, 918,816.44–534,524.91] to 1,009,518.92 [95% UI, 1,295,202.13–742,769.05]), followed by Mainland of China where increased about 972398 cases (Figure 1E). Cuba had the highest ASIR in 2019 (overall, 460.33 [95% UI, 585.47–347.29]; males, 483.27 [95% UI, 615.59–364.71); females, 435.87 [95% UI, 555.02–326.68]), and the lowest ASIR was observed in Pakistan (overall, 35.50 [95% UI, 45.88–26.20]; males, 29.48 [95% UI, 38.07–21.69]; females, 41.90 [95% UI, 54.77–30.63]). The regions with the largest increase and decrease in the ASIR were Cuba and Estonia, respectively (Figure 1F). Furthermore, we visualized the number of cases in 2019 among 204 countries and territories by map (Figure 1G). Table 1 Incident Cases, Age-Standardized Incidence Rate (ASIR), and Temporal Trends for Burns From 1990 to 2019. No. (95% UI) No. (95% CI) 1990 2019 1990-2019 Variable Incident cases ASIR per 100000 Incident cases ASIR per 100000 EAPC Global 8378121.71 (10363108.53 to 6531886.66) 149.86 (183.52 to 118.10) 8955227.69 (11157666.34 to 6820977.02) 117.51 (146.66 to 88.79) -0.93 (-1.03 to -0.82) male 4444900.33 (5467109.97 to 3503352.17) 157.69 (191.85 to 125.36) 4520220.92 (5616794.50 to 3458623.54) 117.04 (145.43 to 89.04) -1.13 (-1.22 to -1.04) female 3933221.38 (4896272.45 to 3001685.66) 142.08 (174.96 to 109.68) 4435006.77 (5533943.36 to 3356767.64) 118.26 (148.07 to 88.71) -0.71 (-0.82 to -0.59) SDI High 1829400.67 (2233743.92 to 1449098.13) 231.04 (281.57 to 182.62) 1617342.41 (1998030.50 to 1242112.77) 182.79(229.19 to 137.78) -1.09 (-1.29 to -0.89) High-middle 2268203.43 (2791394.84 to 1767421.04) 193.43 (235.99 to 151.47) 1968714.13 (2446137.06 to1520777.66) 150.53(188.45 to 113.48) -0.97 (-1.07 to -0.87) Middle 2318376.08 (2925009.94 to 1758311.51) 122.15 (151.55 to 94.32) 2489842.35 (3119116.86 to 1867023.57) 108.16 (137.69 to 80.58 -0.32 (-0.43 to -0.21) Low-middle 1261052.24(1588226.97 to 958368.21) 100.76 (124.86 to 78.12) 1578840.04 (2007600.31 to 1180460.57) 84.85 (106.79 to 64.03) -0.69 (-0.79 to -0.58) Low 694078.23(876228.73 to 535540.88) 118.29 (145.79 to 92.60) 1291495.65 (1674261.60 to 947627.72) 101.20 (127.39 to 77.25) -0.66 (-0.76 to -0.57) Abbreviations, ASIR, age-standardized incidence rate; EAPC, estimated annual percentage change; SDI, sociodemographic index; UI, uncertainty interval; CI, Confidence interval. DALYs of burns The burden of burns measured in DALYs was 7,460,448.65 (95% UI, 9,478,717.81–5,794,505.89) in 2019, of which 67% and 33% could be attributed to

YLLs and YLDs, respectively. The burden decreased gradually from 1990 to 2019 (Table 2, Figure 2A). And the age-standardized DALYs rate (ASDAR) also decreased substantially from 1990 to 2019 (Table 2, Supplemental Figure S2A, B). The DALYs among females was higher than among males, and the ASDAR among females also was higher than among males in 2019, which is just the opposite in 1990 (Table 2, Figure 2 C, D, E, F). DALYs were high in the younger population and the highest DALYs were observed in the 1–4-year age group both in 2019 and 1990, besides DALYs rate distribution by age can be seen in supplemental materials (Figure S2 G). In addition, 10% of age-standardized DALYs attributable to occupational injuries for both sexes combined globally in 2019 (Figure 2 H). Among the SDI quintiles, DALYs were decreased in all SDI levels except Low SDI level in 2019 compared to those in 1990, and countries with the Middle SDI level had higher DALYs than countries with other SDI levels in 1990 and the Low-middle SDI level in 2019 (Table 2, Figure 2B). The ASDARs were significantly decreased in regions with all SDI levels, countries with the Low SDI level had higher DALYs than countries with other SDI levels both in 1990 and 2019 (Table 2, Supplemental Figure S2B). With regard to the sex ratios of DALYs and ASDARs among SDI levels, except for the low-middle SDI level, the DALYs and ASDAR were higher in males for all SDI levels in both 1990 and 2019 (Figure 2 C, D, E, F). The percentage of age-standardized DALYs attributable to alcohol use for both sexes combined is highest in High SDI level, to occupational injuries is in Low SDI level in 2019 (Figure 2 H). For most of the GBD regions, the absolute DALYs of burns was decreased, with the highest DALYs observed in 2019 is in Asia (3,735,101.26 [95%UI, 4,744,685.60–2,763,340.35]) and the lowest observed in Australasia (20,813.30 [95%UI, 30,776.21–13,842.51); meanwhile, Western Sub-Saharan Africa (from 471311.76 [95% UI, 648,837.12–311,274.77] to 670,821.92 [95% UI, 928,527.33–493,686.72]) and World Bank Upper Middle Income regions(from 3,309,575.83 [95% UI, 3,932,627.20–2,642,128.26] to 2,066,166.93 [95% UI, 2,697,166.96–1,644,020.10]) exhibited the most significant increase and decrease in numbers, respectively (Supplemental Figure S2E). As for the ASDAR of burns, for all except one GBD regions, namely Oceania, the rate decreased. The greatest ASDAR was observed in 2019 in the Oceania (472.12 [95%UI, 780.73–118.52]) and the lowest was in East Asia (48.28 [95%UI, 68.00–34.94). The most significant decrease in the ASDAR was detected in Central Asia (from 438.56 [95% UI, 493.45–393.52] to 196.25 [95% UI, 242.53–163.25]), whereas the most significant increase was detected in Oceania (from 419.79 [95% UI, 664.47–145.61] to 425.30 [95% UI, 687.13–118.75]) (Supplemental Figure S2F). For the assessment of changes at the national level, the highest DALYs, accounting for 11% of the value globally, was recorded in India in 2019 (overall, 1,577,243.30 [95% UI, 2,223,193.75–1,069,291.85]; males, (423,295.84 [95% UI, 528,849.46–321,148.61]); females, (28,036.17 [95% UI, 35,787.12–20,767.08])), followed by Mainland of China (1153947.45 [95% UI, 1778176.96–711833.97]). In India, the 6% of age-standardized DALYs result from occupational injuries and the DALYs reached a peak among those 20~24 years of age in 2019. The lowest DALYs were observed in Tokelau (0.92 [95%UI, 1.31–0.66). As for measures of the ASDAR, Papua New Guinea had the highest ASDAR in 2019 (overall, 497.21 [95% UI, 824.53–116.10]); males, (868.96 [95% UI, 1446.77–180.42]); females, (95.77 [95% UI, 165.90–40.06])). Italy had the lowest ASDAR in 2019 (26.83 [95% UI, 36.37–19.82]); males, (32.71 [95% UI, 44.24–24.16]); females, (21.13 [95% UI, 28.76–15.50]). The places that exhibited the most significantly increased and decreased DALY values, respectively, were Nigeria(from 204791.75 [95% UI, 305,529.32–128,433.17] to 278,416.67 [95% UI, 400,510.66–197,549.76]) and Mainland of China(from

1,204,419.61 [95% UI, 1,493,528.50–862,545.83] to 687,955.14 [95% UI, 973,860.45–494,849.21]) (Supplemental Figure S2G), whereas, for the ASIR, the locations were, respectively, Lesotho (from 272.21 [95% UI, 375.43–198.26] to 336.32 [95% UI, 442.86–246.06]) and Haiti(from 827.26 [95% UI, 1,258.22–324.99] to 385.90 [95% UI, 525.93–210.16]) (Supplemental Figure S2H) Table 2. DALYs, Age-Standardized DALYs Rates and Temporal Trends for Burns From 1990 to 2019. No. (95% UI) No. (95% CI) 1990 2019 1990–2019 Variable DALYs ASDAR per 100,000 people DALYs ASDAR per 100,000 people EAPC Global 9240519.41 (11508751.20 to 6971954.76) 169.85 (209.27 to 129.91) 7460448.65 (9478717.81 to 5794505.89) 96.60 (123.05 to 75.03) -2.13 (-2.21 to -2.06) Male 4862036.55 (5672841.93 to 3630820.92) 179.26 (209.21 to 138.91) 3706456.40 (4597302.42 to 2900689.35) 95.91 (119.10 to 75.01) -2.33 (-2.43 to -2.24) Female 4378482.86 (6087956.08 to 2430157.83) 160.84 (219.06 to 93.48) 3753992.25 (4897043.09 to 2820247.72) 97.63 (127.98 to 73.02) -1.92 (-1.99 to -1.84) SDI High 1008484.65 (1271676.70 to 822574.10) 121.48 (150.14 to 101.06) 785070.61 (1104553.70 to 577164.47) 64.90 (89.23 to 48.56) -2.36 (-2.56 to -2.17) High-middle 1777696.50 (2060491.85 to 1525910.33) 157.37 (182.22 to 135.25) 1273402.10 (1646553.63 to 1031688.77) 79.11 (100.63 to 64.33) -2.86 (-3.16 to -2.55) Middle 2688458.99 (3355364.82 to 2001006.36) 154.13 (189.75 to 116.77) 1859086.98 (2429347.02 to 1385859.19) 76.87 (100.44 to 57.21) -2.55 (-2.63 to -2.47) Low-middle 2280046.88 (3095008.34 to 1474160.34) 187.95 (246.34 to 128.19) 1855910.26 (2276397.59 to 1435536.98) 107.04 (130.59 to 83.44) -2.06 (-2.12 to -2.01) Low 1477894.50 (2012908.16 to 949450.00) 237.17 (306.75 to 168.86) 1678780.87 (2162104.10 to 1268530.73) 149.99 (188.57 to 114.86) -1.58 (-1.60 to -1.55) Abbreviations, DALYs, disability-adjusted life years; ASDAR, age-standardized DALYs rate; EAPC, estimated annual percentage change; SDI, sociodemographic index; UI, uncertainty interval; CI, Confidence interval Mortality of burns A total of 111292.39 deaths (95% UI, 132,392.34–88,188.86) associated with burns were identified globally in 2019, most of which were concentrated in those aged 1–4 years (Figure3A). The number of deaths increased from 1990 to 1994, then begins to decline with slightly fluctuates, especially in males (Figure3B, Table 3). The age-standardized deaths rate (ASDR) of burns gradually decreased from 2019 to 1990 (Table 3, Supplemental Figure S3A, B), and the ASDR and the number of deaths were higher in males than in females, both in 1990 and 2019(Figure3D, Table 3, Supplemental Figure S3E, F). 7.3% of age-standardized deaths attributable to occupational injuries for both genders globally in 2019, besides deaths rate distribution by age can be seen in supplemental materials (Figure5F, Supplemental Figure S3D). Deaths were lower among all SDI quantiles except Low SDI level in 2019 than in 1990, and countries with the Middle SDI level had the highest numbers of deaths compared with countries with other SDI levels in 1990, Low-middle SDI level in 2019 (Figure5C, Table 3). The ASDR increased in all SDI levels, and countries with the Low SDI level had higher ASDR than countries with other SDI levels both in 1990 and 2019 (Supplemental Figure S3B, Table 3). In terms of sex, except for the Low-middle SDI level, the number of deaths was higher in males than females not only in 2019 but also in 1990, surprisingly, the ASDR values distributed mode the same with the distribution of deaths among genders. (Figure5D, E, Table 3, Supplemental Figure S3E, F). The percentage of age-standardized deaths attributable to Alcohol use for both sexes combined is highest in High-middle SDI level, to occupational injuries is in Low SDI level in 2019 (Figure5D). For GDB regions, the numbers of deaths decreased in most of the GBD regions, with the most significant decrease detected in World Bank Upper-Middle Income area (from 44,295.11 [95% UI,

51,049.62–36,096.24] to 32,500.09 [95% UI, 36,865.88–27,061.87]) and Australasia has the lowest deaths in 2019(131.83 [95% UI, 141.72-119.11]), where also has the lowest ASDR in 2019 (0.32 [95% UI, 0.34-0.29]). Asia has the highest death cases in 2019 (57202.37 [95% UI, 70564.74-41804.00]), the most significant increase from 1990 to 2019 was detected in Commonwealth Middle Income area (32,612.48 [95% UI, 45,344.34-19,592.70] to 38,255.11[95% UI, 50,950.82-26,466.17]) (Supplemental Figure S3G). Except for in one GDB region, namely Oceania, the ASDR of burns decreased, where has the highest ASDR in 2019 and has the most significant increased ASDR value among 45 GBD regions (from 6.24 [95% UI, 3.10–1.65] to 6.34 [95% UI, 10.61-1.17]). The most significant decrease in ASDR was detected in Central Asia (from 5.66 [95% UI, 6.03–5.37] to 2.64 [95% UI, 3.10–2.28]) (Supplemental Figure S3H). At the national level, the highest number of deaths was recorded in India in 2019 (25,876.39 [95% UI, 37,389.59–16,992.26]), an increase of 12% from 1990 (23,031.84 [95% UI, 33,464.85–12,259.04]). The deaths number of India increased the most globally, accounting for about 23% of global deaths in 2019, 27% and 73% of which occurred in males and females, respectively. This was followed by deaths in the Mainland of China (11,095.91 [95% UI, 14,085.43–7,938.48]), 63% and 37% of which occurred in males and females, respectively. In India, 4.8% of age-standardized deaths result from occupational injuries, and deaths peaked in those 20–24 years of age in 2019. The most significant decrease in the number of deaths was detected in Mainland of China (from 17,289.45 [95% UI, 21,015.43–12,545.78] to 11,095.91 [95% UI, 14,085.43–7,938.48]) (Supplemental Figure S3I), Tokelau has the lowest death number and almost reach zero (0.01 [95% UI, 0.02-0.01]) in 2019. Lesotho had the highest ASDR (7.75 [95% UI, 10.45–5.63]), whereas Singapore had the lowest (0.19 [95% UI, 0.20–0.17]) in 2019. The most significant increase in the ASDR was detected in Lesotho (from 6.19 [95% UI, 8.82–4.38] to 7.75 [95% UI, 10.45–5.63]), whereas the most significant decrease was detected in Armenia (from 7.38 [95% UI, 7.91–6.89] to 1.28 [95% UI, 1.49–1.09]) (Supplemental Figure S3J). Furthermore, we visualized the number of deaths in 2019 among 204 countries and territories by map (Figure 3G). Table 3 Deaths Cases, Age-Standardized Deaths Rates, and Temporal Trends for Burns From 1990 to 2019. No. (95% UI) No. (95% UI) 1990 2019 1990-2019 Variable Deaths cases ASDR per 100000 people Deaths cases ASDR per 100000 people EAPC Global 123213.46 (151399.41 to 95472.73) 2.51 (3.00 to 2.01) 111292.39 (132392.34 to 88188.86) 1.44 (1.72 to 1.14) -2.16 (-2.30 to -2.02) male 66454.79 (74334.55 to 49765.66) 2.84 (3.14 to 2.21) 56854.07 (67315.99 to 44072.37) 1.53 (1.81 to 1.19) -2.36 (-2.55 to -2.18) female 56758.67 (78772.85 to 29388.76) 2.23 (3.01 to 1.23) 54438.32 (69985.43 to 39110.13) 1.37 (1.78 to 0.98) -1.93 (-2.02 to -1.83) SDI High 13818.45 (14266.95 to 13273.62) 1.57 (1.63 to 1.51) 10257.90 (11035.41 to 9298.42) 0.68 (0.74 to 0.62) -3.04 (-3.17 to -2.91) High-middle 25586.04 (27776.91 to 23374.97) 2.40 (2.60 to 2.19) 21486.04 (23804.92 to 18615.42) 1.23 (1.37 to 1.06) -2.89 (-3.39 to -2.40) Middle 34836.88 (43397.49 to 25141.73) 2.38 (2.89 to 1.82) 27772.69 (34978.77 to 20017.38) 1.22 (1.53 to 0.89) -2.47 (-2.53 to -2.42) Low-middle 29736.85 (40630.72 to 18605.80 2.96 (3.88 to 2.02) 28424.96 (34569.40 to 21859.46) 1.84 (2.20 to 1.44) -1.80 (-1.86 to -1.74) Low 19145.18 (26000.12 to 12568.06) 4.04 (5.10 to 2.95) 23254.21 (30275.53 to 17019.13) 2.81 (3.55 to 2.08) -1.26 (-1.29 to -1.23) Abbreviations: ASDR, age-standardized deaths rate; EAPC, estimated annual percentage change; SDI, sociodemographic index; UI, uncertainty interval; CI, Confidence interval. Temporal Trends of burns We analyzed the temporal trends in burns incidence, DALYs, and deaths at the national, regional, and global levels from 1990 to 2019. Incidence, DALYs, and deaths of

burns cline to decrease at the global level and all SDI level. Meanwhile, the EAPC of incidence and deaths are all higher in High SDI level, the EAPC of DALYs a higher in High-middle SDI level. In the 45 GBD regions, except four regions, namely East Asia, Western Pacific Region, East Asia & Pacific – WB, Oceania, the EAPC of incidence were negative (Figure 4A); except one region, namely Oceania, the EAPC of DALYs and deaths were negative, suggesting that the incidence, DALYs and deaths of burns was decreasing over time in most of the GBD regions (Supplemental Figure S4A, B). At the national level, most of EAPCs were negative, the highest positive EAPCs of incidence, DALYs, and deaths were observed in Cuba, Lesotho, and Lesotho, respectively; whereas the highest negative EAPCs of incidence, DALYs and deaths were observed in Mauritius, Taiwan (Province of China) and Armenia, respectively (Figure 4B, C, D). Furthermore, we visualized the EAPCs of incidence, DALYs, and deaths in 2019 among 204 countries and territories by map (Figure 4E, Supplemental Figure S4C, D). Relationship of EAPC of burns incidence, DALYs, and death with SDI, UHC, and GDP. We analyzed the correlation between the 2019 SDI and EAPCs in burns incidence, DALYs, and deaths. SDI was negatively correlated with all EAPCs (incidence, R = − 0.029, p = 0.68; DALYs, R = − 0.16, p = 0.026; deaths, R = −0.49, p = 0.00000000000016), indicating that incidence, DALYs, and deaths of burns declined with increasing SDI values. SDI values also negatively and significantly correlated with the EAPC of DALYs and deaths, meaning that the SDI value had an impact on temporal trends related to DALYs and deaths of burns (Figure 5A, B, C). The UHC index provides a summary measure on a scale of 0 to 100 that facilitates a comparison of the number of individuals receiving the health services they need.7 To better understand the distribution of burns based on healthcare system performances of countries, we examined the relationship between EAPCs in burns incidence, DALYs, and deaths with the UHC index by Pearson correlation analysis. The SDI was negatively correlated with all EAPC measurements (incidence, R = − 0.055, p = 0.43; DALYs, R = − 0.16, p = 0.027; deaths, R = − 0.5, p = 0.000000000000025). These results suggest that the UHC index has a vital impact on temporal trends related to DALYs and deaths of burns (Figure 5D, E, F). Spending on healthcare varied within and across income groups and geographical regions, and which is expected to rise.8 We examined the relationship between EAPCs in burns incidence, DALYs, and deaths with GDP by Pearson correlation analysis. GDP was negatively correlated with all EAPC measurements (incidence, R = − 0.05, p = 0.48; DALYs, R = − 0.04, p = 0.57; deaths, R = − 0.37, p = 0.000000041). These results suggest that GDP has a vital impact on the temporal trend of deaths (Figure 5G, H, Supplemental Figure S5).

# Discussion

Burn injuries are under-appreciated trauma that is an important cause of morbidity and mortality in many parts of the world[14-16]. To our knowledge, this study is the first to comprehensively analyze international burns trends in 204 countries and territories from 1990 to 2019. The study improved our understanding of the global prevalence and burden of burns.

From our study, we can see from the EAPC of prevalence that burns will continuously decrease, but the number of new cases in each year exhibited a significant increasing tendency that will result in a persistent healthcare burden on each country, especially those with lower SDI levels[17]. The DALYs of burns reached a low level in 2019, 67% and 33% of which could be attributed to YLLs and YLDs, respectively. Although

the YLLs decreased and the YLDs increased from 1990 to 2019, their ASR values decreased, and their EAPCs suggest that their rates will continue to decrease. However, the numbers would not decline rapidly in just a few years, and the YLDs were more concentrated in countries with the High-SDI level and the YLLs concentrated at the Low SDI level. In addition, 10% of age-standardized DALYs attributable to occupational injuries for both sexes combined globally in 2019

We observed that burns were responsible for 111,292 deaths in 2019 at the global level, and the number of deaths will increase and become more prevalent in countries with the Low SDI level, whereas the ASDR will decrease. Besides, 7.3% of age-standardized deaths were attributable to occupational injuries for both genders globally in 2019. We also found that burns were more prevalent in younger age groups globally in 2019, especially among males, and the deaths and burden of burns measured in DALYs were higher in the 1–4-year age group and incidence was higher in those aged 10–14 years, possibly because children have low ability to avoiding risks, unable to verbalize their needs, have different airway anatomy than adults, resulting in a higher incidence of upper airway obstruction due to edema and are prone to the development of hypothermia[18-20].

The highest ASIR in 2019 occurred in Cuba, followed by Azerbaijan. This finding highlights the substantial societal burden and disease management challenges that burns continue to pose. Notably, the most distinct increase in the ASIR occurred in Grenada, raising potential concerns for the government of that country. In contrast, a substantial decrease in the ASIR occurred in Estonia, suggesting successful prevention and healthcare policies. Thus, the policies of Estonia warrant further study and could be used as a reference point for establishing new policies elsewhere. In addition, we obtained the estimated 2019 to 2100 years population number of India, UHC in 2019, and GDP in 2019 and we subsequently analyzed the future population numbers among three age groups with a higher burden of burn in India in 2019 and evaluated the correlation of EAPCs with UHC and GDP in 2019 (Figure 6) [21, 22]. The results showed that according to the population numbers of specific age groups with a higher burden of burn all of the epidemiological indices will decline by year in India. By calculating EAPCs and the correlation of EAPCs with UHC in 2019 and GDP in 2019, we observed that the ASRs were decreasing in most of the nations, and EAPCs were negatively correlated with SDI levels, UHC, and GDP. These phenomena suggest that the ASRs of burns decreased as the economy developed and the countries' healthcare system performance improved.

# Limitations

This study suffers from the general limitations of GBD studies. First, the accuracy of GBD estimation depends largely on the quality and quantity of data used since there are under-reporting and under-diagnosis during burns registration. Second, death certification accuracy has international variability and the co-morbidities that are often associated with burns can add further ambiguity when identifying the true cause of death. Third, the data could not be explored further to extract information related to severity, and treatments, as such information was not provided in the GHDx. Therefore, we could not generate a detailed etiological understanding of global changes in burns patterns. Lastly, due to the observational nature of

this analysis, there are likely to be a number of unmeasured confounding factors not discussed and causal statements about the trends observed cannot be made.

## Conclusions

Globally, the number of incident cases fluctuates within a certain degree, but the number of incident cases sharply increased from 2016, whereas the burden measured in DALYs was decreased gradually from 1990 to 2019 and the number of deaths increased from 1990 to 1994, then begins to decline with slightly fluctuates. In addition, from the EAPCs of burns in incidence, DALYs, and deaths, we found that the burden of burns was considered to be decreasing in most of the regions, and from the relationship of EAPCs with SDI levels, universal health coverage (UHC), and gross domestic product (GDP), the ASRs of burns decreased as the economy developed and a country's healthcare system performance improved. These phenomena suggest that national healthcare systems need to increase funding for burns prevention and intervention strategies.

## Declarations

# Ethics approval and consent to participate

Ethics approval was exempted by the Ethics Committee of Ruijin Hospital, Shanghai JiaoTong University School of Medicine because the GBD 2019 study is a publicly available database and all data were anonymous. All methods were performed in accordance with the relevant guidelines and regulations.

# Consent for publication

Not applicable

# Availability of data and materials

The datasets generated and/or analyzed during the current study are available in the GBD 2019 repository, which is freely available on http://ghdx.healthdata.org/gbd-results-tool.

# Competing interests

The authors declare that they have no competing interests

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# Authors' contributions

AY, JZ analyzed and visualized the data. AY, SLL was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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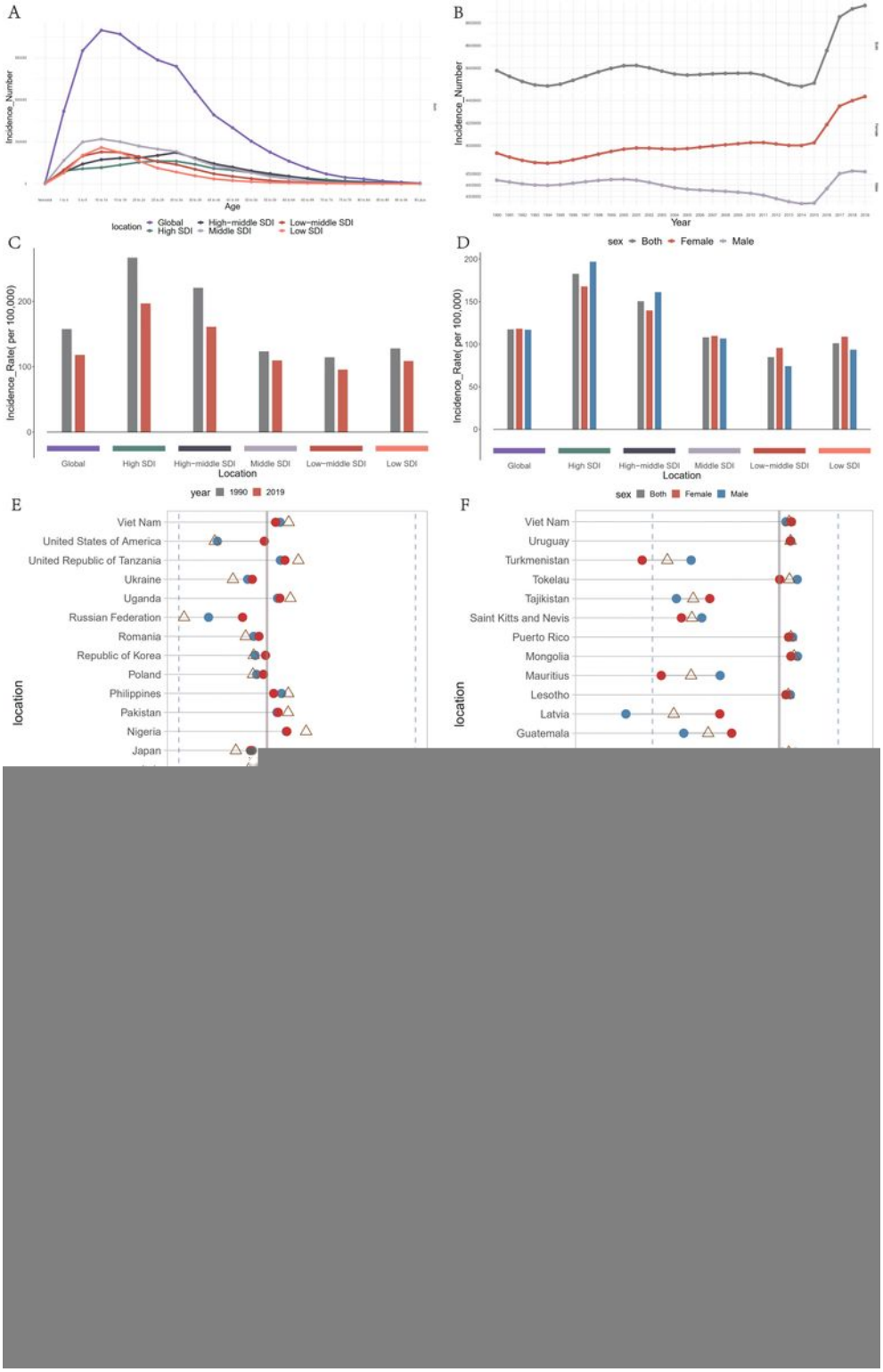
## References

1. *Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019.* Lancet (London, England), 2020. **396**(10258): p. 1204-1222.
2. *Five insights from the Global Burden of Disease Study 2019.* Lancet (London, England), 2020. **396**(10258): p. 1135-1159.
3. Fitzmaurice, C., et al., *Global, Regional, and National Cancer Incidence, Mortality, Years of Life Lost, Years Lived With Disability, and Disability-Adjusted Life-Years for 29 Cancer Groups, 1990 to 2017: A Systematic Analysis for the Global Burden of Disease Study*. JAMA oncology, 2019. **5**(12): p. 1749–1768.
4. *Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019.* Lancet (London, England), 2020. **396**(10258): p. 1223-1249.
5. Goodall, R., et al., *Trends in Decubitus Ulcer Disease Burden in European Union 15+ Countries, from 1990 to 2017.* Plastic and reconstructive surgery. Global open, 2020. **8**(11): p. e3252.
6. Gao, S., et al., *Declining rates of hepatocellular carcinoma in urban Shanghai: incidence trends in 1976-2005*. European journal of epidemiology, 2012. **27**(1): p. 39–46.
7. Trends *and risk factors of mortality and disability adjusted life years for chronic respiratory diseases from 1990 to 2017: systematic analysis for the Global Burden of Disease Study 2017*. BMJ (Clinical research ed.), 2020. **370**: p. m3150.
8. Yang, X., et al., *Temporal trends of the lung cancer mortality attributable to smoking from 1990 to 2017: A global, regional and national analysis*. Lung cancer (Amsterdam, Netherlands), 2021. **152**: p. 49–57.
9. Liu, Z., et al., *The trends in incidence of primary liver cancer caused by specific etiologies: Results from the Global Burden of Disease Study 2016 and implications for liver cancer prevention*. Journal of hepatology, 2019. **70**(4): p. 674–683.
10. Yang, X., et al., *Global, regional and national burden of anxiety disorders from 1990 to 2019: results from the Global Burden of Disease Study 2019*. Epidemiol Psychiatr Sci, 2021. **30**: p. e36.
11. Yang, X., et al., *Global, regional, and national burden of blindness and vision loss due to common eye diseases along with its attributable risk factors from 1990 to 2019: a systematic analysis from the*

*global burden of disease study 2019*. Aging (Albany NY), 2021. **13**(15): p. 19614–19642.

12. Zhai, Z., et al., *Assessment of Global Trends in the Diagnosis of Mesothelioma From 1990 to 2017*. JAMA network open, 2021. **4**(8): p. e2120360.
13. Cai, W., et al., *Trends Analysis of Non-Hodgkin Lymphoma at the National, Regional, and Global Level, 1990-2019: Results From the Global Burden of Disease Study 2019*. Front Med (Lausanne), 2021. **8**: p. 738693.
14. Finnerty, C.C., et al., *Hypertrophic scarring: the greatest unmet challenge after burn injury*. Lancet, 2016. **388**(10052): p. 1427–1436.
15. Greenhalgh, D.G., *Management of Burns*. N Engl J Med, 2019. **380**(24): p. 2349–2359.
16. Jeschke, M.G., et al., *Burn injury*. Nat Rev Dis Primers, 2020. **6**(1): p. 11.
17. Forjuoh, S.N., *Burns in low- and middle-income countries: a review of available literature on descriptive epidemiology, risk factors, treatment, and prevention*. Burns, 2006. **32**(5): p. 529–37.
18. Palmieri, T.L., *Pediatric Burn Resuscitation*. Crit Care Clin, 2016. **32**(4): p. 547–59.
19. Jeschke, M.G. and D.N. Herndon, *Burns in children: standard and new treatments*. Lancet (London, England), 2014. **383**(9923): p. 1168–1178.
20. Loos, M.H.J., et al., *Incidence and characteristics of non-accidental burns in children: A systematic review*. Burns, 2020. **46**(6): p. 1243–1253.
21. *Measuring universal health coverage based on an index of effective coverage of health services in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019.* Lancet (London, England), 2020. **396**(10258): p. 1250-1284.
22. *Global age-sex-specific fertility, mortality, healthy life expectancy (HALE), and population estimates in 204 countries and territories, 1950-2019: a comprehensive demographic analysis for the Global Burden of Disease Study 2019.* Lancet, 2020. **396**(10258): p. 1160-1203.

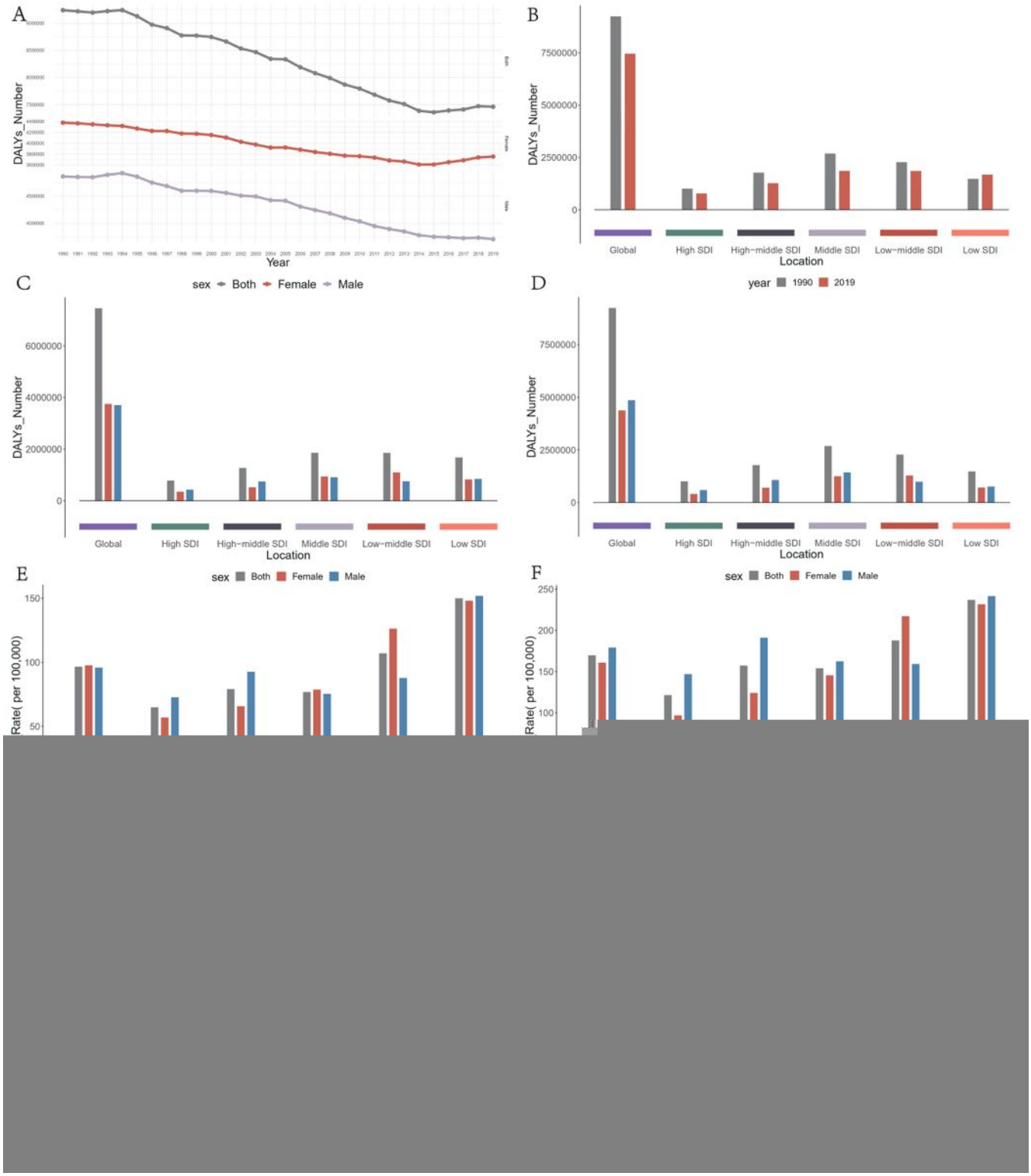
# Figures




## Figure 1

**Incidence of burns.** A, distribution of new cases among different age categories in 2019. B, the global changing trend in the number of new cases by sex from 1990 to 2019. C, a comparison of the ASIR between 1990 and 2019 at global and different SDI levels. D, a comparison of the ASIR by sex in 2019 at global and different SDI levels. E, the top increased or decreased in the number of new cases by sex in 2019 compared with 1990 among 204 countries and territories. F, the top increased or decreased in ASIR

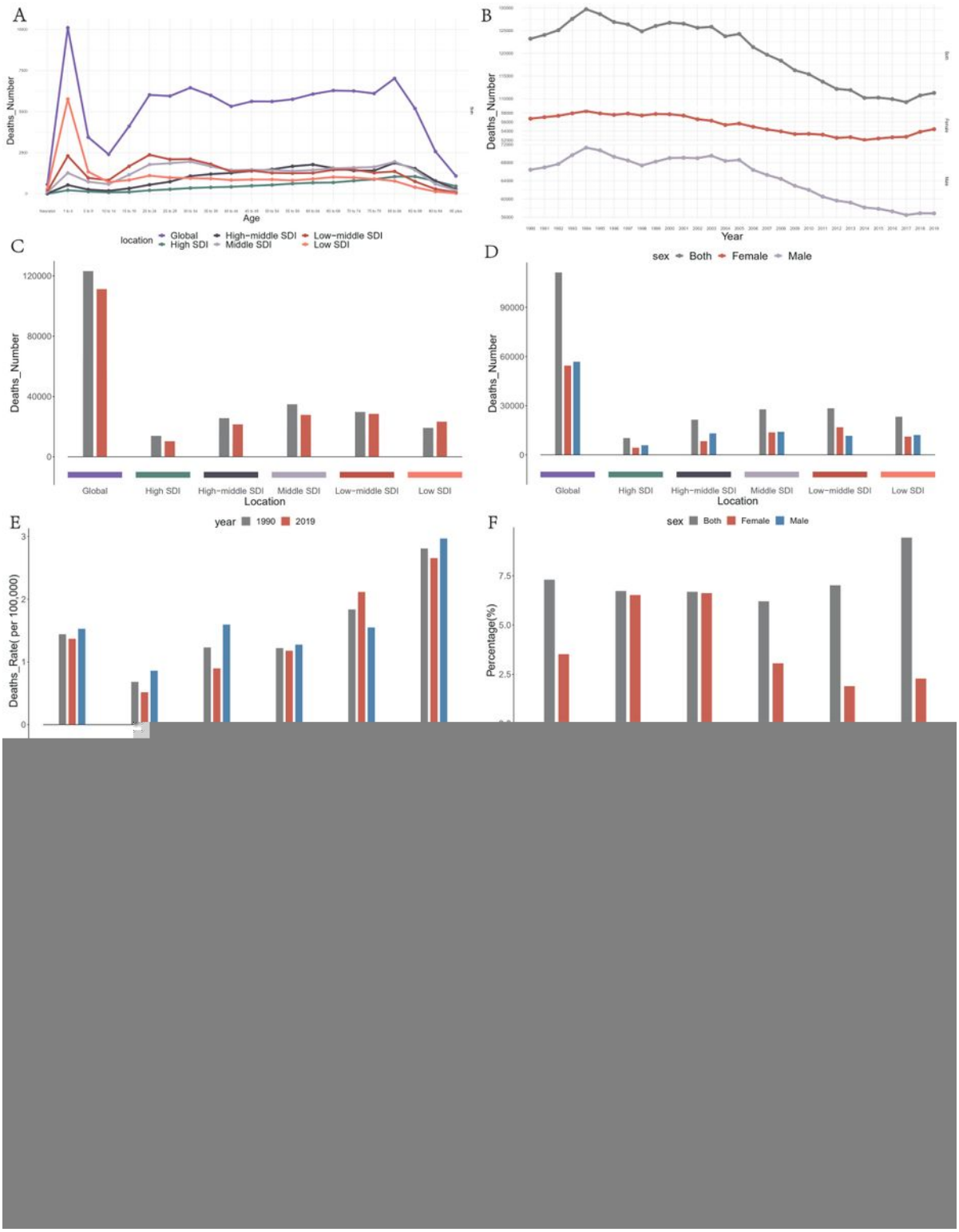
by sex in 2019 compared with 1990 among 204 countries and territories. G, the map of new cases in 2019 among 204 countries and territories. ASIR, age-standardized incidence rate; SDI, sociodemographic index.




## Figure 2

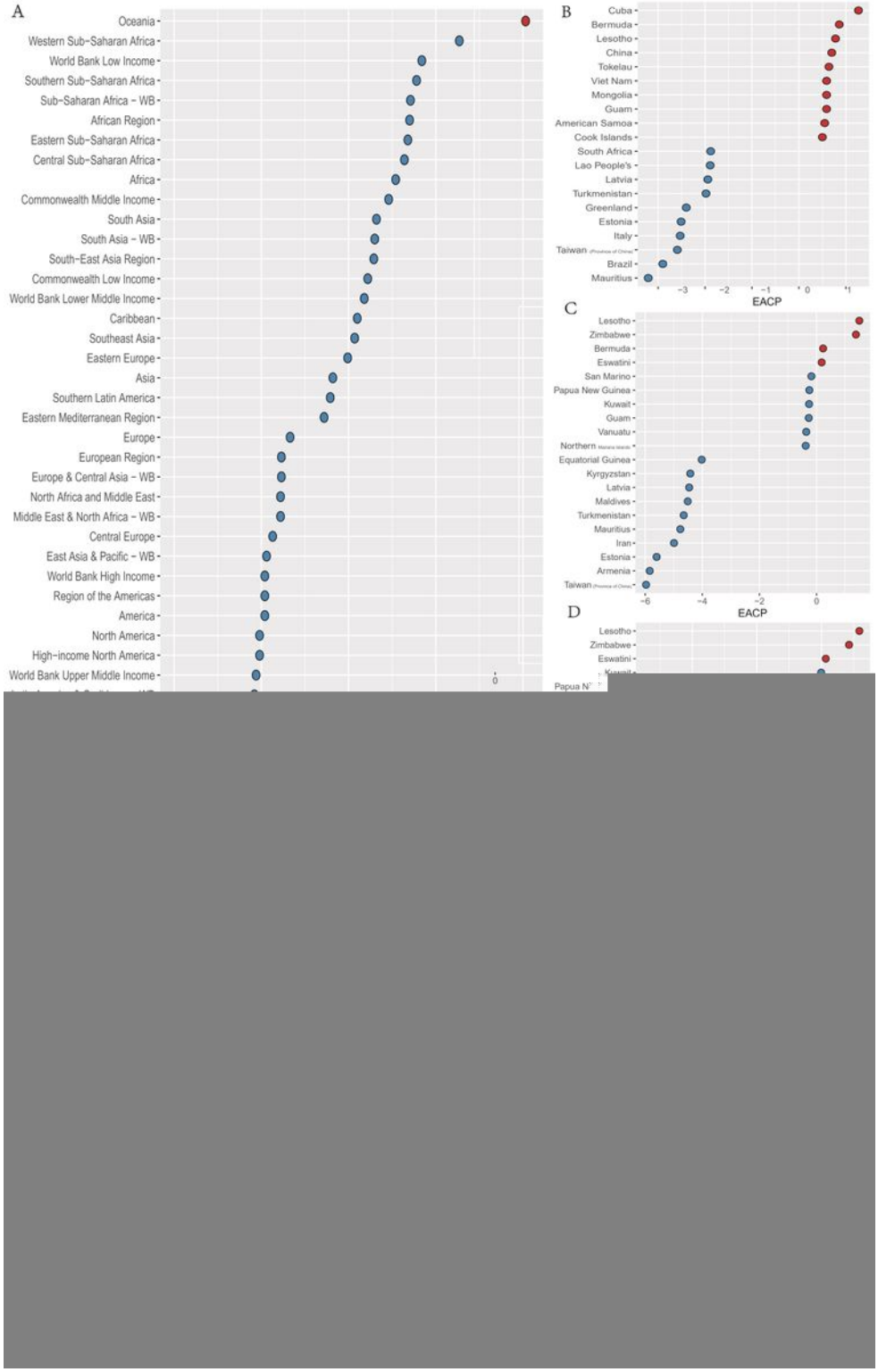
**DALYs of burns.** A, the global changing trend in DALYs by sex from 1990 to 2019. B, a comparison of the DALYs between 1990 and 2019 at global and different SDI levels. C, a comparison of the DALYs by sex at global and different SDI levels in 2019. D, a comparison of the DALYs by sex at global and different SDI

levels in 1990. E, a comparison of the ASDAR by sex at global and different SDI levels in 2019. F, a comparison of the ASDAR by sex at global and different SDI levels in 2019. G, distribution of DALYs among different age categories in 2019. H, the percentage of DALYs attributable to top risk factors for both sexes combined at global and different SDI levels in 2019. DALYs, disability-adjusted life years; ASDAR, age-standardized DALYs rate; SDI, sociodemographic index.



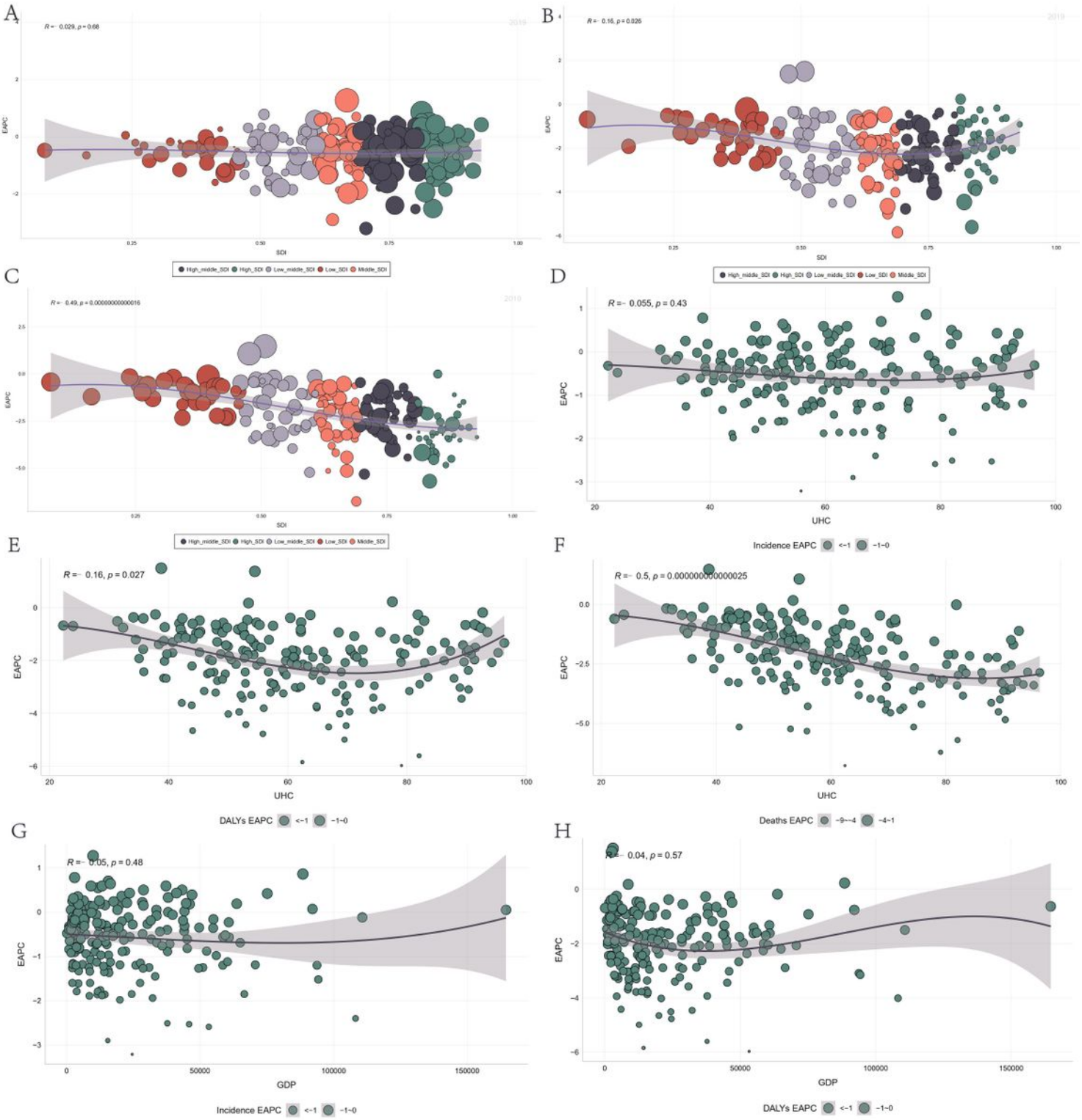
## Figure 3

**Mortality of burns.** A, distribution of death cases among different age categories in 2019. B, the global changing trend in the number of death cases by sex from 1990 to 2019. C, a comparison of the number of death cases between 1990 and 2019 at global and different SDI levels. D, a comparison of the number of death cases by sex at global and different SDI levels in 2019. E, a comparison of the ASDR by sex at global and different SDI levels in 2019. F, Percentage of deaths attributable to top risk factors for both sexes combined at global and different SDI levels in 2019. G, the map of ASDR in 2019 among 204 countries and territories. ASDR, age-standardized death rate; SDI, sociodemographic index




## Figure 4

**Temporal Trends of burns.** A, the EAPC of death in 45 GBD regions. B, the top positive and negative EAPC of incidence among 204 countries and territories. C, the top positive and negative EAPC of DALYs among 204 countries and territories. D, the top positive and negative EAPC of Deaths among 204 countries and territories. E, the map of Incidence EAPC in 2019 among 204 countries and territories. GBD, Global Burden of Disease; EAPC, estimated annual percentage change.




## Figure 5

**Relationship of EAPCs in burns incidence, DALYs, and death with SDI, UHC, and GDP.** A, correlation analysis of the EAPC of ASIR with SDI. B, correlation analysis of the EAPC of ASDAR with SDI. C, correlation analysis of the EAPC of ASDR with SDI. D, correlation analysis of the EAPC of ASIR with UHC. E, correlation analysis of the EAPC of ASDAR with UHC. F, correlation analysis of the EAPC of ASDR with

UHC. G, correlation analysis of the EAPC of ASIR with GDP. I, correlation analysis of the EAPC of ASDAR with GDP. EAPC, estimated annual percentage change; DALYs, disability-adjusted life years; SDI, sociodemographic index; UHC, universal health coverage; GDP, gross domestic product; ASIR, age-standardized incidence rate; ASDAR, age-standardized DALYs rate; ASPR, age-standardized prevalence rate.

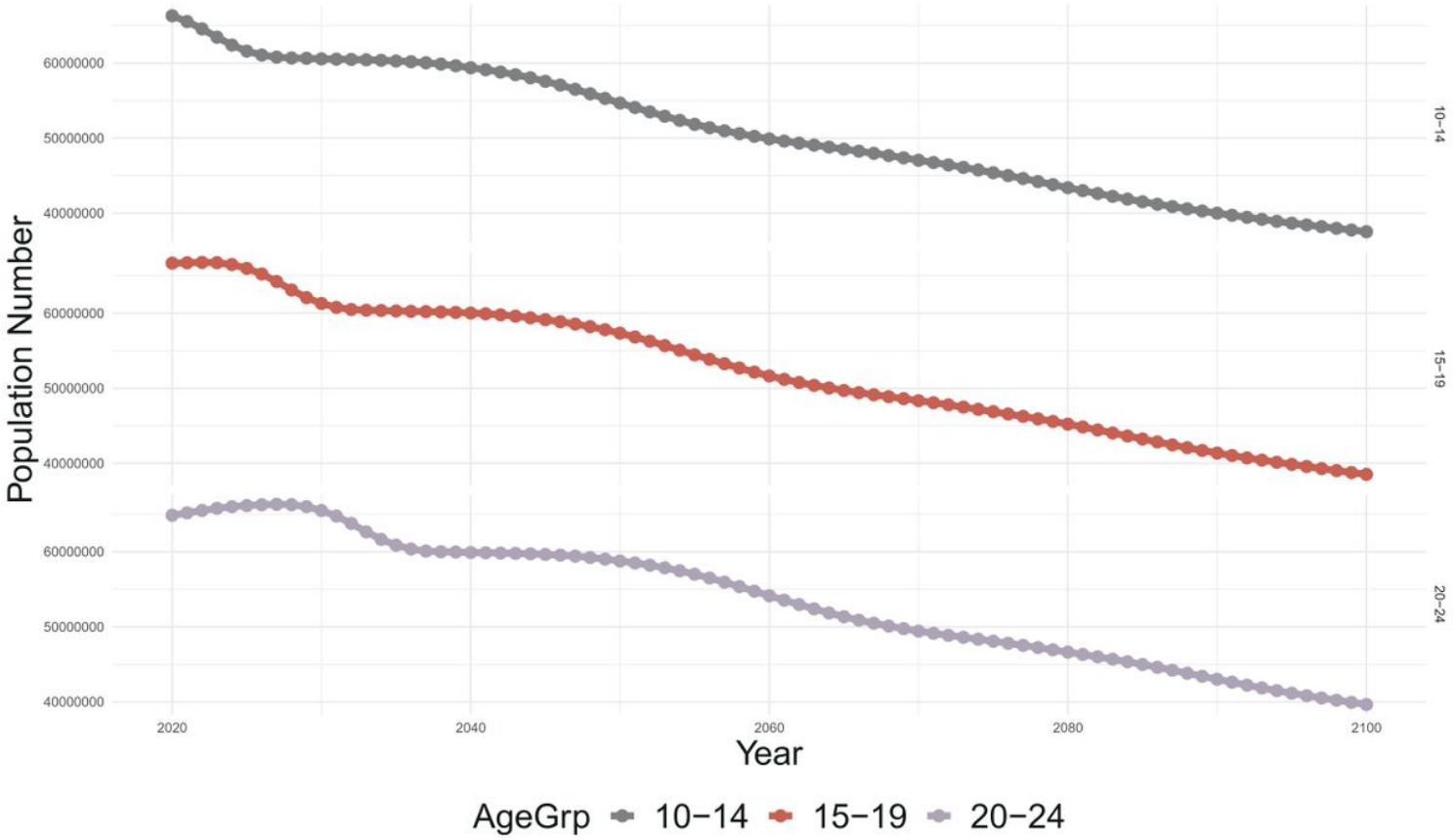



**Figure 6**

**Future population numbers of the three age groups.** AgeGrp, age group.

# Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementalFigureS1.Incidenceofburns.pdf
- SupplementalFigureS2.DALYsofburns.pdf
- SupplementalFigureS3.Mortalityofburns.pdf
- SupplementalFigureS4.TemporalTrendsofburns.pdf
- SupplementalFigureS5.RelationshipofEAPCsinburnsincidenceDALYsanddeathwithSDIUHCandGDP.pdf