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ORIGINAL ARTICLE

Reversal of global health inequality in pancreatitis burden from 1990 to 2021: A cross-national GBD 2021 analysis with forecast to 2030

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Abstract: Pancreatitis is a rapidly expanding global non-communicable disease, marked by substantial disparities across populations. However, comprehensive long-term assessments of global health inequalities remain scarce. This study examined inequality in the pancreatitis burden from 1990 to 2021, identified principal determinants, and forecasted future trends across countries with varying Socio-demographic Index (SDI) levels. Using data from the Global Burden of Disease 2021, we assessed inequalities in the prevalence, incidence, and disability-adjusted life years of pancreatitis *via* the Slope Index of Inequality (SII) and Concentration Index (CI). Decomposition analysis was used to identify drivers of change, and a Bayesian age-period-cohort model projected trends to 2030. Between 1990 and 2019, the SII decreased from 13.83 to 8.61, signaling a reduction in absolute health inequality. Nevertheless, beginning in 2020, the SII turned negative, reaching –10.79 in 2021, indicating a structural reversal in disease burden distribution from high- to low-SDI countries. Concurrently, the CI declined from –0.04 to –0.10, suggesting worsening relative inequality. Decomposition revealed population growth and aging as primary drivers of the rising burden, while epidemiological improvements contributed minimally, particularly in low-SDI regions. Projections suggest that while global age-standardized rates may continue to decrease through 2030, the proportional burden in low-SDI countries is expected to rise steadily. The global socioeconomic distribution of pancreatitis burden is experiencing a profound shift, with inequalities increasingly concentrated in low-SDI areas. Driven by demographic trends, this shift underscores the necessity for targeted global strategies to mitigate disparities and bolster health system resilience.

***Keywords*:** global burden of disease, slope index of inequality, concentration index

Introduction

Pancreatitis is a sterile inflammatory disorder that now ranks among the most pressing global public-health challenges (*1*). In the Global Burden of Disease (GBD) framework, it is recorded as a single cause, yet clinically it encompasses two distinct syndromes: acute pancreatitis, a sudden inflammatory attack with high early mortality, and chronic pancreatitis, a progressive fibroinflammatory disease that causes long-term disability (*2-4*). Together, these conditions generated an estimated 2.7 million incident cases, 5.9 million prevalent cases, and 122,000 deaths worldwide in 2021 (*5*). Increasing evidence shows that this burden is distributed unevenly across geographic regions and socioeconomic strata, placing equity — not simple disease control — at the center of contemporary pancreatitis epidemiology and motivating the focused analysis of health inequalities.

Investigations into health inequalities are vital for both clinical medicine and public health (*6*). Such analyses underscore disparities in disease burden among socioeconomic groups, facilitating the identification of vulnerable populations and guiding targeted interventions and resource distribution (*7,8*). The GBD database delivers critical datasets for evaluating disease burden (*9,10*). Previous research has predominantly examined the pancreatitis burden at global, regional, and national scales, typically relying on cross-sectional data on incidence, mortality, and disability-adjusted life years (DALYs), with limited methodological diversity (*5,11*). Although these studies offer valuable insights, they frequently lack a dedicated analysis of health inequalities and seldom investigate their temporal trends.

This study utilized data from GBD 2021 to systematically evaluate shifts in the pancreatitis burden across countries and regions from 1990 to 2021, with particular emphasis on the temporal dynamics of health inequalities and their socioeconomic and public health determinants. Additionally, the study projected the global and regional burden of pancreatitis through 2030, intending to support evidence-based public health policies and resource distribution strategies.

Materials and Methods

Data sources

Data for this study were retrieved from the Global Health Data Exchange *via* its official website (*https://vizhub.healthdata.org/gbd-results/*). All data used in this study were directly extracted from the latest GBD 2021 database. Pancreatitis was classified following the International Classification of Diseases, Tenth Revision, using codes K85.0–K85.9, K86.0, and K86.1. To comprehensively evaluate the disease burden, key indicators, namely prevalence, incidence, and DALYs, were included. All indicators underwent age-standardization to facilitate comparability across populations. Data were stratified further by geographic region, Socio-demographic Index (SDI), age group, and sex to provide a comprehensive evaluation of the pancreatitis burden across diverse population subgroups. Because the GBD database comprises publicly available, anonymized data, no ethical approval was required. All methods conformed to the GBD 2021 modeling protocol and adhered to the Guidelines for Accurate and Transparent Health Estimates Reporting (*12*), thereby ensuring methodological rigor and transparency.

Statistical analysis

The estimated annual percentage change (EAPC) was applied to evaluate temporal trends in age-standardized rates (ASRs) (*13*). EAPCs and their 95% confidence intervals (CIs) were calculated using linear regression models. A positive EAPC whose lower CI bound exceeds zero signifies an upward trend, whereas a negative EAPC whose upper CI bound is below zero indicates a downward trend. All disease burden metrics were presented as point estimates with corresponding 95% uncertainty intervals (UIs), derived from 1,000 random draws from the posterior distribution. The 2.5th and 97.5th percentiles served as the lower and upper bounds, respectively, to convey the credibility of the estimates.

Temporal trends in pancreatitis burden indicators and ASRs from 1990 to 2021 were analyzed both globally and across SDI regions. Joinpoint regression analysis (version 5.3.0) was used to identify statistically significant shifts in trend directions (*14*), and annual percentage changes were calculated for each segment. Furthermore, age- and sex-specific differences in the disease burden were evaluated. To explore regional disparities, a Bayesian meta-regression-based linear mixed-effects model was applied to assess associations between burden indicators and national SDI levels (*10*).

To elucidate the factors driving changes in disease burden, the Das Gupta decomposition method was utilized to separate total variations into three components: population growth, aging, and epidemiological shifts (*15,16*). This approach quantifies each factor's relative contribution.

Crude DALY rates served as the metric for evaluating health inequalities associated with pancreatitis. Disparities among countries and regions were measured *via* the slope index of inequality (SII) and the concentration index (CI) (*17,18*). The SII was determined by regressing DALY rates on country-level SDI, thereby quantifying absolute inequality across nations. The CI was derived from fitting a Lorenz curve to the cumulative share of DALYs against the cumulative population share. CI values range from –1 to 1, with negative values representing higher burden in low-SDI regions and positive values in high-SDI regions. Finally, a Bayesian age-period-cohort (BAPC) model (*19*) was employed to forecast future trends in the global and regional pancreatitis burden through 2030, drawing on historical data from 1990 to 2021. All analyses were performed in R software (version 4.4.1), considering p-values < 0.05 to be statistically significant.

Results

Temporal trends in the global burden of pancreatitis

From 1990 to 2021, the absolute global burden of pancreatitis exhibited a consistent rise. The prevalent cases increased from 4.15 million to 5.90 million, incident cases from 1.73 million to 2.75 million, and DALYs from 2.58 million to 4.10 million, which corresponded to rises of 42.17%, 58.96%, and 58.91%, respectively. Conversely, the ASRs declined: the age-standardized prevalence rate (ASPR) decreased from 93.74 to 68.99 per 100,000 (EAPC = –1.09); the age-standardized incidence rate (ASIR) dropped from 37.62 to 32.81 per 100,000 (EAPC = –0.49); and the age-standardized disability-adjusted life years rate (ASDR) fell from 57.39 to 48.43 per 100,000 (EAPC = –0.61) (Tables 1-3, Figures 1-2).

Age and sex distribution characteristics

In 2021, the numbers of prevalent cases, incident cases, and total DALYs linked to pancreatitis rose with advancing age, peaking among middle-aged and older adults before declining (Figure 3A). Males consistently demonstrated higher prevalence, incidence, and DALY rates than females, especially in the 30–59 age group. This gender disparity attenuated among individuals aged 70 years and older (Figure 3B).

Regional variations in disease burden

In 2021, considerable regional variation in the pancreatitis burden was observed across GBD regions and countries (Tables 1-3, Figures 4-6). Eastern Europe, Central Asia, and South Asia experienced the highest burdens, with DALYs rising significantly since 1990. In Eastern Europe, DALYs increased from 371,000 to 675,000, and ASDR rose from 141.99 to 240.99 per 100,000 (EAPC = +1.41), positioning it as one of the few regions globally with an upward age-standardized trend. In contrast, High-income Asia Pacific, East Asia, and Western Europe showed declining trends in age-standardized metrics. For instance, in High-income Asia Pacific, ASDR decreased from 31.00 to 16.87 per 100,000 (EAPC = –2.19), marking one of the fastest declines globally. Similarly, ASDR in East Asia dropped from 29.96 to 18.53 per 100,000 (EAPC = –1.58), accompanied by simultaneous declines in prevalence and incidence.

Decomposition analysis of changes in disease burden

The changes in crude pancreatitis rates from 1990 to 2021 were decomposed into three contributing factors: population growth, aging, and epidemiological shifts. For prevalence, population growth contributed 139.03%, aging accounted for 51.08%, and epidemiological changes contributed –90.11%. For incidence, contributions were 160.46% from population growth, –20.14% from aging, and –40.32% from epidemiological shifts. For DALYs, the contributions were 104.90% from population growth, 31.70% from aging, and –36.60% from epidemiological shifts. The relative influence of these factors differed across SDI levels. In general, population growth was the primary driver in low- and middle-SDI countries, whereas aging played a dominant role in high-SDI countries. The direction and magnitude of epidemiological shifts varied across SDI groups (Figure 7).

Evolution of global health inequality and the reversal phenomenon

SII monitoring showed a reduction in absolute income-related health inequality across SDI levels from 1990 to 2019, with the SII for crude DALY rates falling from 13.83 to 8.61 (Figures 8, A and B). However, beginning in 2020, the SII became negative (–3.62) for the first time and decreased further to –10.79 in 2021. The CI for DALYs decreased from –0.04 in 1990 to –0.10 in 2021, with the curve further diverging from the equality line (Figure 8C).

Forecast of future burden trends

Projections suggest that global ASPR, ASIR, and ASDR will continue to decrease through 2030 (Figure 9). In high-SDI countries, the burden is anticipated to plateau or decline, while low-SDI countries will bear an increasing proportion of the global pancreatitis burden (Supplemental Figures S1-2, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=103*).

Discussion

This study employs data from GBD 2021 to provide a comprehensive assessment of global trends in pancreatitis burden and related health inequalities from 1990 to 2021. Despite the decline in ASRs, the absolute burden has risen, reinforcing the growing impact of pancreatitis on global public health. The burden remained unequally distributed by sex, age, and region, reflecting enduring structural disparities. Further analysis revealed that population growth and aging were the main drivers of the rising burden, while improvements in epidemiological factors played a mitigating role. Notably, health inequalities exhibited minimal improvement over time. Although absolute inequality decreased in earlier years, relative inequality progressively worsened. Since 2020, a noticeable reversal has occurred, with the burden shifting from high- to low-SDI countries, revealing socioeconomic reconcentration rather than an actual reduction in inequality. This shift highlights the entrenched and worsening nature of global health disparities. Projections suggest that although global ASRs for pancreatitis may decline by 2030, low-SDI countries are projected to experience an increasing burden, which may exacerbate global health inequalities.

Previous GBD 2019 and 2021 studies documented persistent declines in age-standardized prevalence, incidence, and mortality of pancreatitis, while global numbers of prevalent cases, incident cases, and DALYs continued to increase, demonstrating the coexistence of declining rates and a rising absolute burden (*5,11*). Building on these findings, this study applied decomposition analysis to prevalence, incidence, and DALYs, quantifying the relative contributions of population growth, aging, and epidemiological shifts. Results indicated that population growth was the dominant contributor across all indicators, particularly in low- and middle-SDI countries. The effect of aging was complex: it increased prevalence and DALYs due to cumulative chronic health loss in older populations, but reduced incidence, possibly due to under-diagnosis

Table 1. Prevalence and ASPR of pancreatitis in 1990 and 2021 and the temporal trends from 1990 to 2021

Location	1990		2021		1990–2021
	Case No. (95% UI)	ASPR per 100,000 (95% UI)	Case No. (95% UI)	ASPR per 100,000 (95% UI)	EAPC in ASPR (95% CI)
Global	4148305 (3042449, 5639570)	93.74 (68.31, 127.08)	5900340 (4376043, 7838798)	68.99 (51.26, 91.29)	-1.09 (-1.15, -1.03)
High-income Asia Pacific	216094 (148598, 313085)	107.98 (74.37, 154.71)	240270 (177415, 313839)	84.25 (64.14, 108.02)	-0.49 (-0.68, -0.31)
Central Asia	105928 (78148, 144548)	193.68 (141.31, 266.08)	186359 (134695, 258449)	198.86 (144.92, 273.25)	0.08 (0.04, 0.11)
Southeast Asia	123476 (84869, 170333)	37 (25.01, 51.82)	287206 (192642, 402947)	39.91 (26.9, 55.44)	0.25 (0.23, 0.27)
East Asia	361290 (245281, 520967)	34.98 (23.56, 50.5)	505641 (356676, 718544)	24.18 (17.35, 33.34)	-1.32 (-1.79, -0.85)
Central Europe	192379 (136913, 270027)	133.34 (96.33, 188.43)	184625 (145053, 230736)	104.53 (83.68, 129.15)	-1.14 (-1.39, -0.89)
Eastern Europe	1888989 (1348790, 2635807)	707.46 (513.99,976.18)	2147275 (1499103, 2992643)	723.28 (525.24, 1003.43)	0.05 (-0.22, 0.33)
North Africa and Middle East	111863 (78197, 154573)	45.32 (31.5,62.3)	263146 (182720, 364679)	44.81 (31, 61.22)	0 (-0.01, 0)
Australasia	12120 (8577, 16490)	53.75 (37.93, 72.68)	21627 (15189, 29521)	49.71 (35.16, 67.52)	-0.15 (-0.2, -0.1)
Western Europe	221151 (164445, 287229)	45.17 (33.89, 58.53)	331644 (259348, 421579)	49.29 (38.81, 61.86)	-0.14 (-0.29, 0.01)
Andean Latin America	8412 (6246, 11053)	33.19 (24.1, 44.41)	19602 (14213, 26689)	31.21 (22.53, 42.63)	-0.1 (-0.15, -0.05)
Caribbean	14957 (10260, 20509)	51.99 (35.62, 71.95)	27788 (19017, 38350)	53.07 (36.3, 73.15)	0.07 (0.06, 0.09)
High-income North America	346881 (247220, 464413)	108.24 (77.51, 145.27)	445425 (326587, 576416)	81.39 (61.13, 103.26)	-1.16 (-1.36, -0.96)
Western Sub-Saharan Africa	41826 (28558, 56669)	32.69 (22.23, 45.18)	109504 (75059, 149631)	33.71 (22.97, 46.39)	0.08 (0.07, 0.09)
South Asia	298616 (204350, 409182)	36.34 (24.47, 49.96)	660317 (448007, 909405)	37.77 (25.59, 51.79)	0.13 (0.12, 0.15)
Oceania	1251 (869, 1760)	30.35 (20.77, 43.6)	3047 (2064, 4420)	30.49 (20.77, 44.6)	0.04 (0.02, 0.07)
Central Sub-Saharan Africa	9000 (5882, 12530)	25.45 (16.68, 35.45)	23789 (15500, 32985)	25.74 (17.04, 35.48)	0.12 (0.09, 0.15)
Central Latin America	46998 (34874, 62015)	42.44 (30.96, 57.41)	102106 (75647, 134285)	39.39 (29.26, 51.92)	-0.19 (-0.27, -0.11)
Southern Latin America	28350 (21090, 38077)	59.88 (44.51, 80.81)	41516 (33443, 50036)	52.44 (42.36, 63.15)	-0.46 (-0.52, -0.4)
Tropical Latin America	66583 (51914, 82135)	61.25 (47.91, 75.93)	181046 (141234, 225320)	69.9 (54.71, 86.42)	0.45 (0.33, 0.56)
Eastern Sub-Saharan Africa	36153 (24284, 49099)	30.35 (20.34, 41.73)	88832 (60066, 122019)	31.02 (21.02, 42.9)	0.06 (0.04, 0.08)
Southern Sub-Saharan Africa	15990 (11037, 21844)	42.03 (28.78, 57.73)	29575 (20182, 41037)	40.75 (27.66, 55.94)	-0.2 (-0.24, -0.15)

ASPR: age-standardized prevalence rate, CI: confidence interval, EAPC: estimated annual percentage changes, UI: uncertainty interval.

Table 2. Incidence and ASIR of pancreatitis in 1990 and 2021 and the temporal trends from 1990 to 2021

Location	1990		2021		1990–2021
	Case No. (95% UI)	ASPR per 100,000 (95% UI)	Case No. (95% UI)	ASPR per 100,000 (95% UI)	EAPC in ASPR (95% CI)
Global	1728141 (1495096, 1995752)	37.62 (32.57, 43.46)	2747368 (2413878, 3133076)	32.81 (28.85, 37.38)	-0.49 (-0.55, -0.43)
High-income Asia Pacific	65578 (55888, 76898)	33.76 (28.76, 39.23)	73137 (64060, 82719)	29.16 (25.57, 32.94)	-0.43 (-0.48, -0.38)
Central Asia	26598 (22702, 31290)	46.74 (40.24, 54.17)	45722 (39128, 53162)	47.94 (41.43, 55.37)	0.06 (0.03, 0.09)
Southeast Asia	89288 (74781, 105803)	24.59 (20.89, 28.84)	179146 (152380, 209528)	24.44 (20.95, 28.45)	-0.04 (-0.05, -0.02)
East Asia	377308 (311766, 447071)	35.65 (30.12, 41.71)	470652 (403601, 548056)	24.3 (20.98, 28.08)	-1.36 (-1.7, -1.02)
Central Europe	73033 (63194, 84733)	52.37 (45.48, 60.61)	70559 (64883, 76851)	43.31 (39.88, 46.92)	-0.81 (-0.9, -0.71)
Eastern Europe	237581 (195713, 287166)	92.77 (76.88, 111.19)	268392 (223074, 322226)	99.35 (82.69, 117.93)	0.19 (0.01, 0.37)
North Africa and Middle East	63035 (52688,74092)	27.08 (23.18,31.5)	146216 (125435,169956)	26.34 (22.92,30.07)	-0.03 (-0.05, -0.02)
Australasia	7820 (6696, 9079)	34.96 (30.14, 40.38)	13559 (11690, 15749)	32.78 (28.62, 37.63)	-0.21 (-0.26, -0.16)
Western Europe	132208 (118034, 148292)	27.68 (24.65, 31.11)	198887 (182278, 215736)	31.08 (28.49, 34.14)	0.08 (-0.04, 0.19)
Andean Latin America	11876 (10281, 13776)	42.12 (36.75, 48.28)	25050 (22198, 28320)	38.79 (34.56, 43.67)	-0.39 (-0.45, -0.33)
Caribbean	8784 (7430, 10257)	28.88 (24.69, 33.7)	14591 (12548, 17049)	28.47 (24.46, 33.25)	-0.03 (-0.05, -0.01)
High-income North America	203919 (179759, 231498)	63.63 (55.87, 72.08)	264132 (244466, 283649)	51.99 (48.36, 55.53)	-0.7 (-0.83, -0.56)
Western Sub-Saharan Africa	29515 (24427, 34805)	22.59 (19.15, 26.39)	77625 (63947, 91923)	23.32 (19.81, 27.2)	0.09 (0.08, 0.1)
South Asia	277106 (229054, 331366)	31.64 (26.29, 37.45)	634729 (528404, 757200)	34.97 (29.04, 41.28)	0.42 (0.38, 0.46)
Oceania	954 (789, 1129)	21.6 (18.42,2 5.17)	2225 (1853, 2647)	20.95 (17.82, 24.46)	-0.11 (-0.12, -0.11)
Central Sub-Saharan Africa	6718 (5511, 8053)	18.84 (15.81, 22)	17422 (14205, 20645)	18.69 (15.8, 21.86)	-0.02 (-0.04, -0.01)
Central Latin America	47214 (40375, 54700)	37.85 (32.67, 43.62)	102357 (89704, 117033)	39.22 (34.3, 44.74)	0.05 (0.02, 0.09)
Southern Latin America	14703 (12881, 16806)	30.92 (27.19, 35.23)	27581 (24438, 31491)	35.59 (31.52, 40.52)	0.06 (-0.08, 0.19)
Tropical Latin America	22676 (20193, 25697)	18.82 (16.81, 21.05)	42519 (37419, 48224)	16.63 (14.7, 18.83)	-0.27 (-0.36, -0.19)
Eastern Sub-Saharan Africa	23816 (19528, 28411)	19.63 (16.62, 22.97)	57435 (47012, 68537)	19.73 (16.73, 23.14)	0 (-0.02, 0.02)
Southern Sub-Saharan Africa	8412 (6970, 9971)	21.74 (18.56, 25.52)	15432 (12869, 18279)	21.22 (18.09, 24.89)	-0.12 (-0.17, -0.08)

ASPR: age-standardized prevalence rate, CI: confidence interval, EAPC: estimated annual percentage changes, UI: uncertainty interval.

Table 3. DALYs and ASDR of pancreatitis in 1990 and 2019 and the temporal trends from 1990 to 2021

Location	1990		2021		1990–2021
	DALYs No. (95% UI)	ASPR per 100,000 (95% UI)	DALYs No. (95% UI)	ASPR per 100,000 (95% UI)	EAPC in ASPR (95% CI)
Global	2583402 (2265738, 2985509)	57.39 (50.34, 66.07)	4101154 (3647631, 4684283)	48.43 (43.07, 55.35)	-0.61 (-0.73, -0.49)
High-income Asia Pacific	61138 (51955, 72205)	31 (26.33, 36.66)	56035 (46991, 67531)	16.87 (13.99, 20.8)	-2.19 (-2.33, -2.05)
Central Asia	45577 (39446, 51891)	84.58 (72.98, 96.02)	72819 (61133, 87133)	77.14 (64.95, 91.96)	-0.77 (-1.04, -0.5)
Southeast Asia	189737 (142679, 256438)	57.92 (43.51, 77.54)	332855 (262388, 492344)	46.9 (37.21, 69.3)	-0.79 (-0.84, -0.73)
East Asia	307618 (251065, 375431)	29.96 (24.31, 36.61)	364563 (288981, 468429)	18.53 (14.77, 23.88)	-1.58 (-1.64, -1.53)
Central Europe	157124 (148011, 167599)	110.93 (104.63, 118.22)	156970 (143758, 169208)	91.75 (84.24, 99.2)	-0.93 (-1.14, -0.72)
Eastern Europe	370859 (314475, 452709)	141.99 (120.6, 173.32)	675000 (591617, 781577)	240.99 (211.6, 278.4)	1.41 (0.87, 1.95)
North Africa and Middle East	42821 (32610, 55536)	22.04 (16.3, 29.27)	94244 (76404, 115152)	19.47 (15.96, 23.84)	-0.28 (-0.31, -0.25)
Australasia	6215 (5690, 6814)	27.28 (24.98, 30)	9425 (8240, 10729)	20.07 (17.49, 22.94)	-0.86 (-1.09, -0.64)
Western Europe	215416 (204742, 226425)	42.56 (40.5, 44.78)	223172 (203349, 239445)	29.35 (27.27, 31.8)	-1.23 (-1.31, -1.16)
Andean Latin America	31019 (25114,38243)	110.59 (88.97,135.81)	45852 (36993,56198)	72.01 (58.39,88.31)	-1.5 (-1.61,-1.39)
Caribbean	13699 (12061, 15362)	46.6 (41.15, 52.26)	21590 (18438, 25131)	41.55 (35.44, 48.38)	-0.27 (-0.36, -0.17)
High-income North America	114419 (102882, 130220)	35.2 (31.63, 40.18)	169758 (154651, 189505)	32.64 (29.9, 36.14)	-0.36 (-0.57, -0.15)
Western Sub-Saharan Africa	120091 (88444, 177064)	105.45 (78.25, 153.13)	309900 (229727, 399293)	106.59 (79.03, 135.71)	0.05 (0, 0.1)
South Asia	621817 (470132, 853167)	77.9 (58.09, 105.99)	991510 (780478, 1238906)	57.3 (45.14, 71.84)	-0.89 (-0.97, -0.81)
Oceania	1504 (747, 2371)	31.7 (15.77, 49.26)	2729 (1571, 4237)	24.16 (13.85, 37.52)	-1.02 (-1.1, -0.94)
Central Sub-Saharan Africa	11986 (7752, 19871)	36.57 (23.56, 59.8)	31686 (20957, 51190)	35.98 (24.09, 57.3)	0.05 (-0.05, 0.15)
Central Latin America	81333 (78107, 84575)	69.09 (66.37, 71.83)	173650 (155450, 192013)	66.28 (59.33, 73.21)	-0.15 (-0.32, 0.01)
Southern Latin America	41196 (38641, 44061)	87.43 (81.94, 93.41)	44257 (41033, 47795)	54.4 (50.55,58.84)	-1.22 (-1.42, -1.02)
Tropical Latin America	97559 (93262, 102039)	81.32 (77.77,85.06)	199347 (187796, 212703)	76.98 (72.49, 82.14)	0.06 (-0.13, 0.24)
Eastern Sub-Saharan Africa	39130 (25451, 58303)	37.45 (23.93,56.74)	99334 (61289, 143914)	37.88 (23.34, 55.32)	0.05 (-0.01, 0.1)
Southern Sub-Saharan Africa	13147 (9380, 17495)	35.73 (25.15, 48.28)	26458 (20649, 32801)	36.35 (28.1, 44.2)	0.19 (-0.03, 0.41)

ASDR: age-standardized DALY rate, CI: confidence interval, DALYs: disability-adjusted life years, EAPC: estimated annual percentage changes, UI: uncertainty interval.

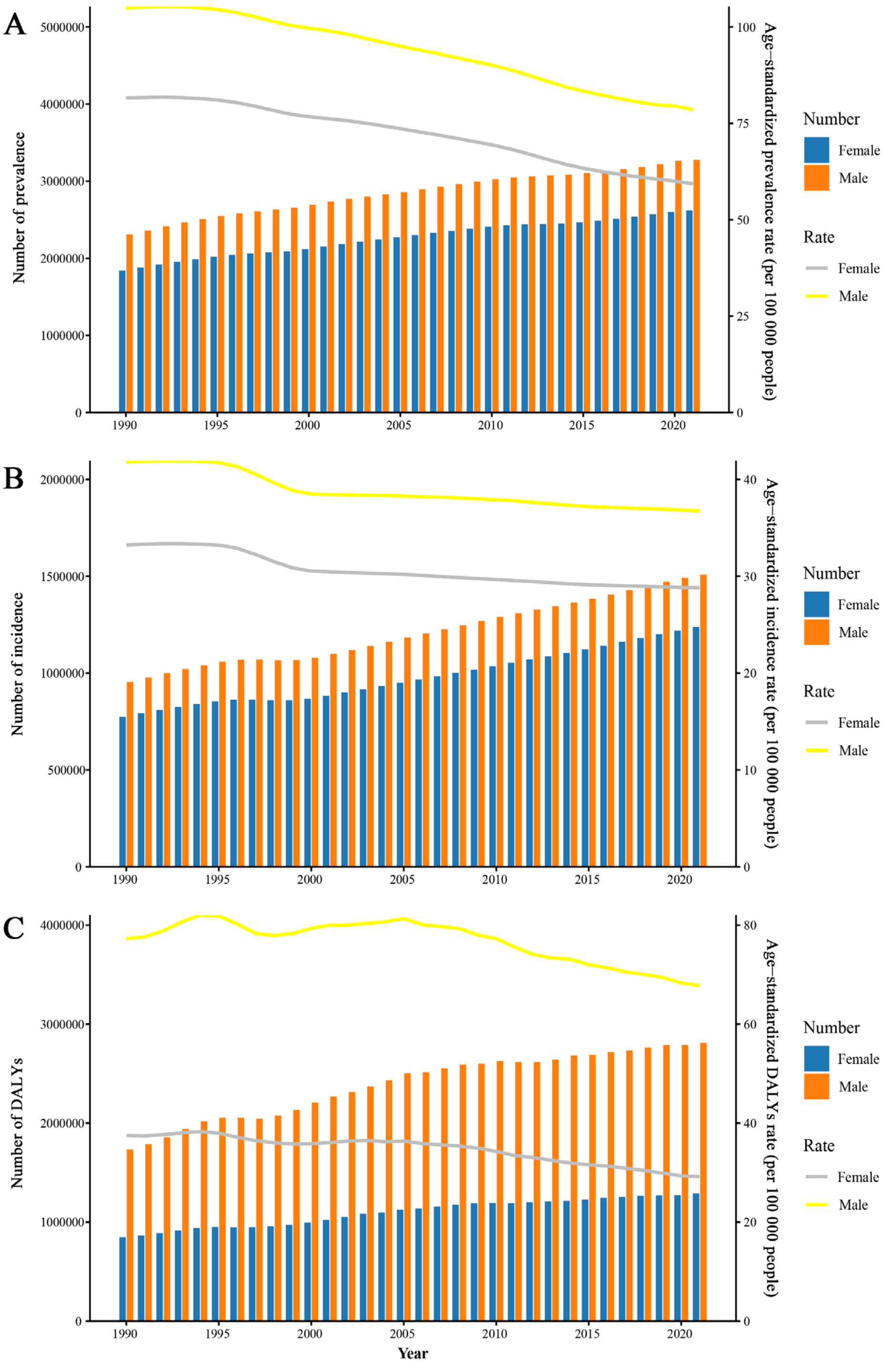

Figure 1. Global trends in pancreatitis prevalence, incidence, and DALYs, 1990–2021, shown as absolute numbers and age-standardized rates. DALYs: disability-adjusted life years.

of acute episodes in older adults, caused by delays or atypical symptoms. Epidemiological shifts generally had a beneficial effect, especially in high- and upper-middle-SDI countries, while only marginal improvements were observed in low-SDI regions, emphasizing inequities in prevention and control capabilities.

The study further revealed significant disparities across demographic and geographic groups, reflecting entrenched structural inequities. Males consistently demonstrated higher prevalence, incidence, and DALY rates than females, with the largest differences observed in individuals aged 30–59 years. The burden also increased with age, with middle-aged and older adults shouldering the largest proportion of health losses. This dual sensitivity to sex and age may be attributed to gender-specific risk factors (*e.g.*, alcohol use, smoking, obesity) (*20*), occupational exposures (*21*), and heightened physiological vulnerability in older adults (*22*). Geographically, DALYs continued to increase in low-SDI regions, including Eastern Europe, Central Asia,

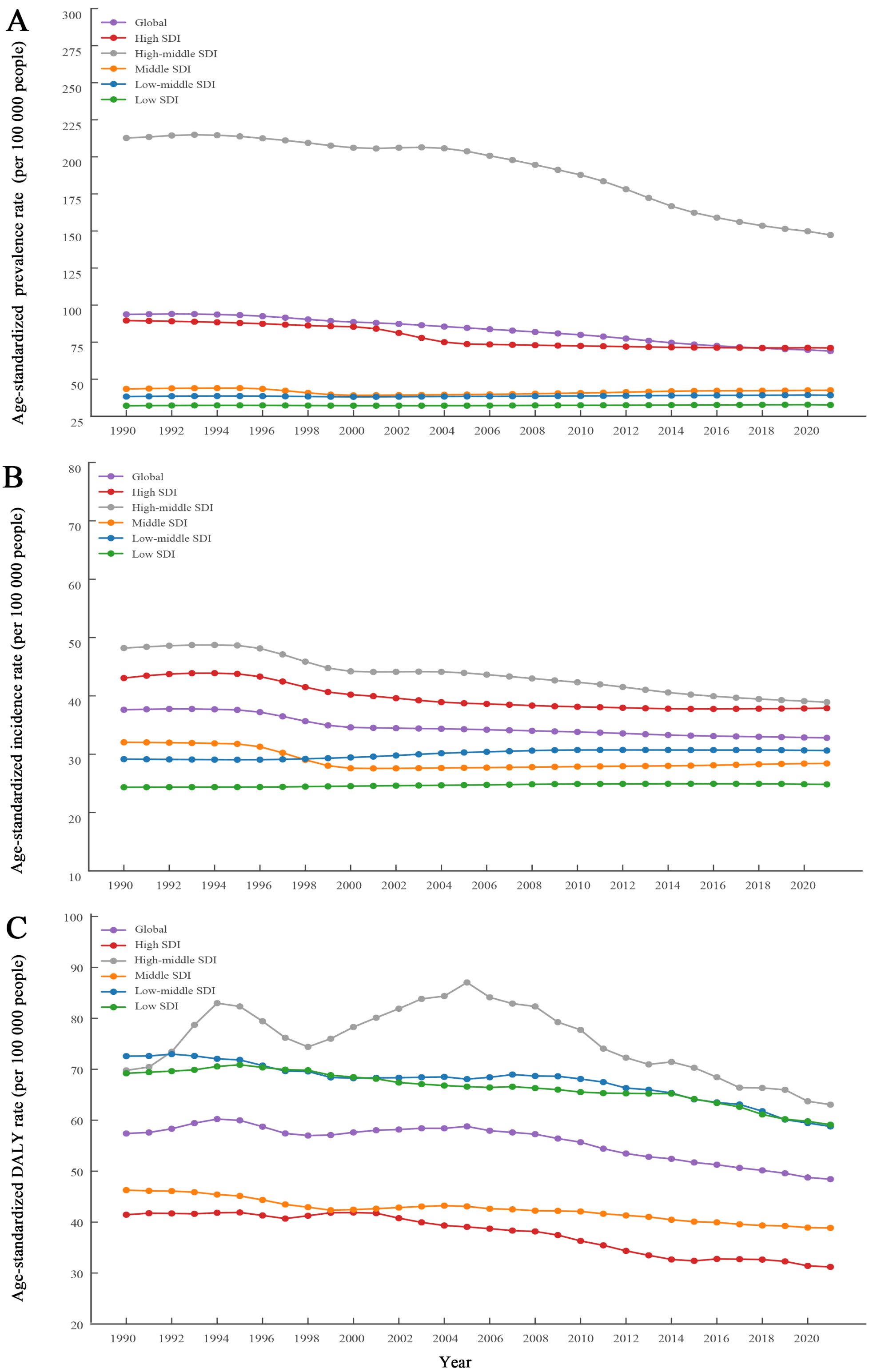

Figure 2. Trends in age-standardized prevalence, incidence, and DALY rates of pancreatitis globally and by SDI region, 1990–2021. DALYs: disability-adjusted life years; SDI: Socio-demographic Index.

and South Asia. In opposition, high-SDI regions, such as High-income Asia Pacific, East Asia, and Western Europe, consistently demonstrated declines in ASRs. These findings align with previous GBD reports (*5*). The persistence of intersecting inequalities illustrates the importance of identifying high-risk populations and strategically allocating resources to ensure equitable and effective prevention.

While stratified analyses by region and SDI level revealed distinct geographic and developmental patterns, descriptive comparisons alone fail to fully capture the complexity of global health inequality. To evaluate the

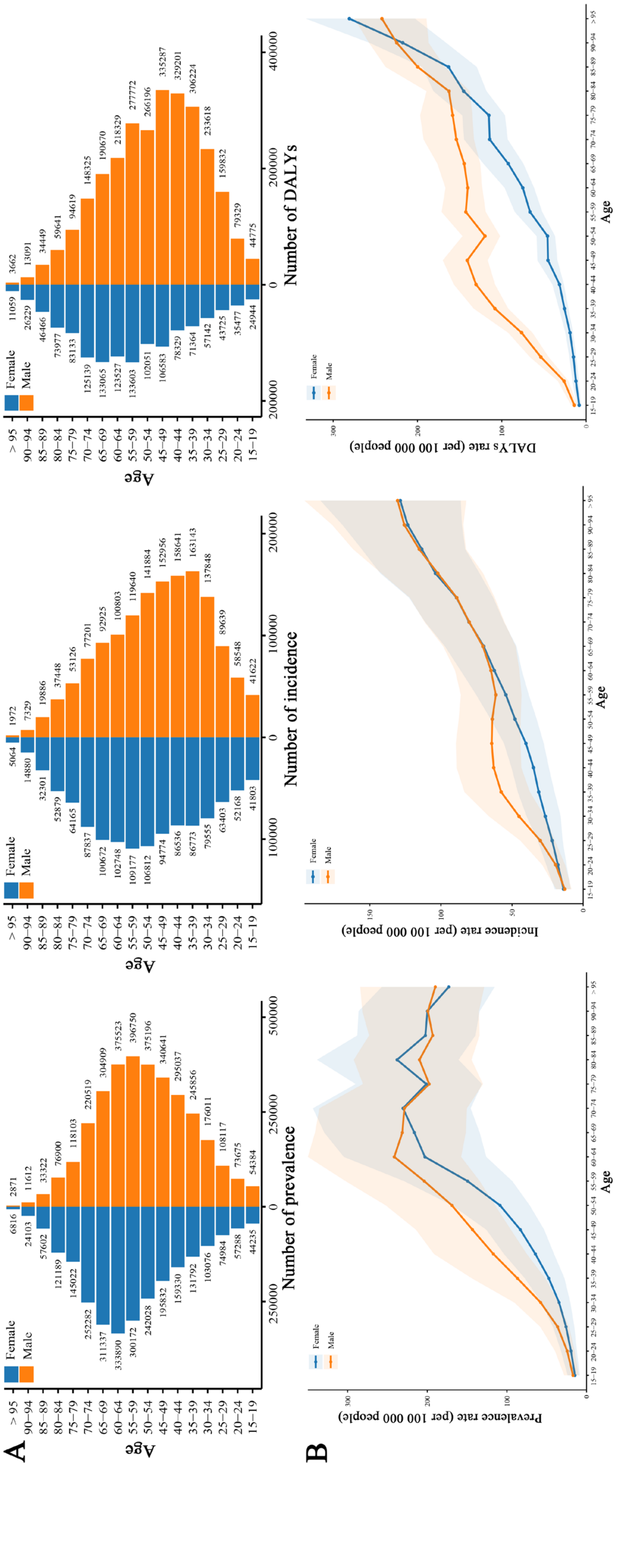

Figure 3. Age and sex distribution characteristics of pancreatitis burden in 2021. DALYs: disability-adjusted life years.

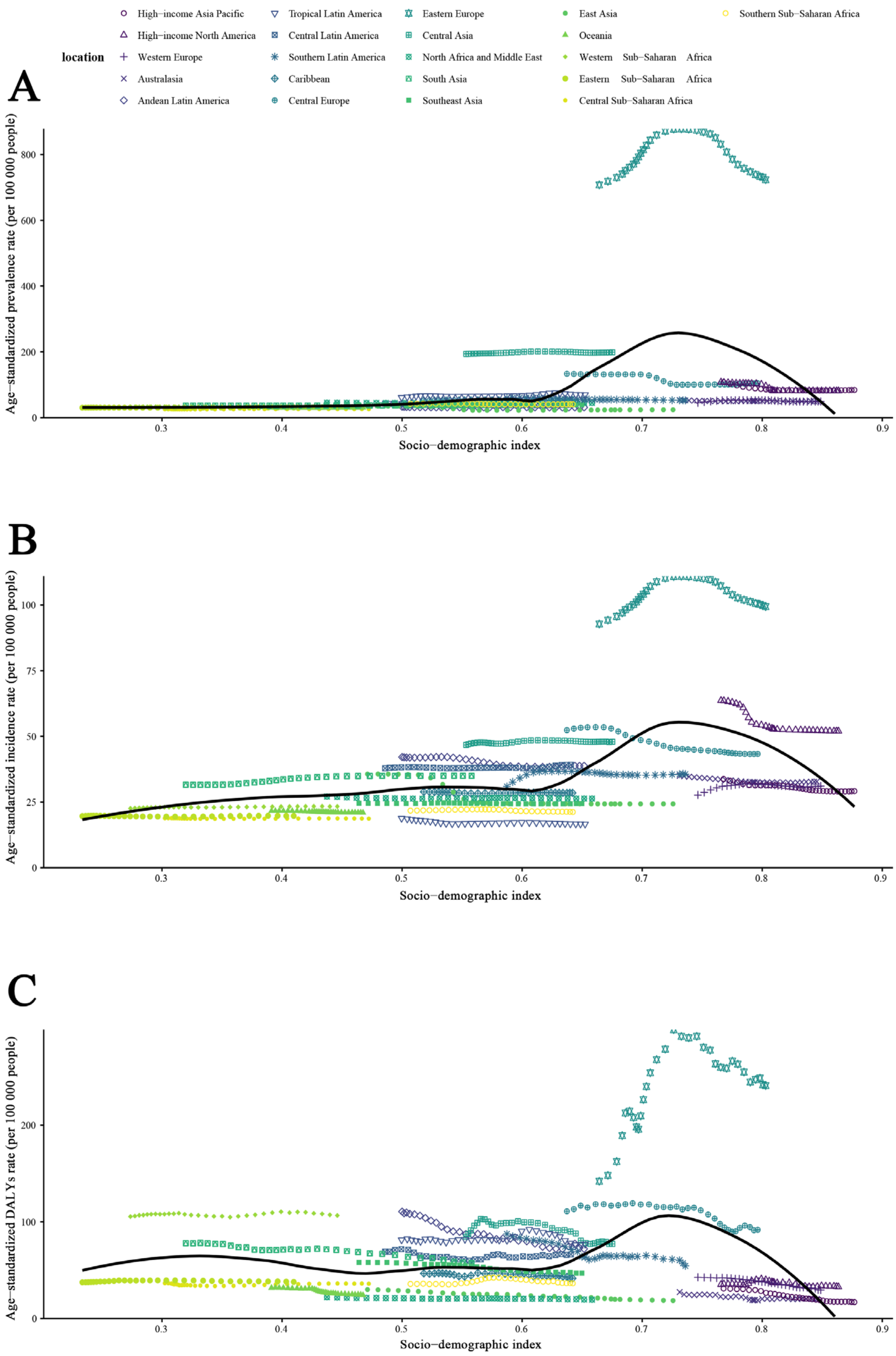

Figure 4. Changes in age-standardized prevalence, incidence, and DALY rates of pancreatitis across SDI regions. DALYs: disability-adjusted life years; SDI: Socio-demographic Index.

distribution of disease burden across socioeconomic contexts, this study employed the SII and CI (*17,18*). From 1990 to 2019, the SII decreased from 13.83 to 8.61, indicating reduced absolute disparities between high- and low-SDI countries, although the burden continued to be concentrated in more developed regions. However, in 2020, the SII shifted to a negative value of –3.62 and further dropped to –10.79 in 2021, signaling a structural shift of burden toward low-SDI countries. This shift coincided with the COVID-19 pandemic, which may have amplified low-SDI countries' vulnerability through overwhelmed health systems, disrupted chronic disease services, diverted public health resources, and reduced healthcare access, ultimately intensifying the concentration of non-communicable disease burdens such as pancreatitis (*23,24*). Despite the shift in burden epicenter, absolute health inequality has not meaningfully improved over time. Simultaneously, the CI dropped from –0.04 in 1990 to –0.10 in 2021, signifying a growing concentration of burden in low-SDI countries and worsening relative inequality driven by uneven structural resource allocation. Taken together, the

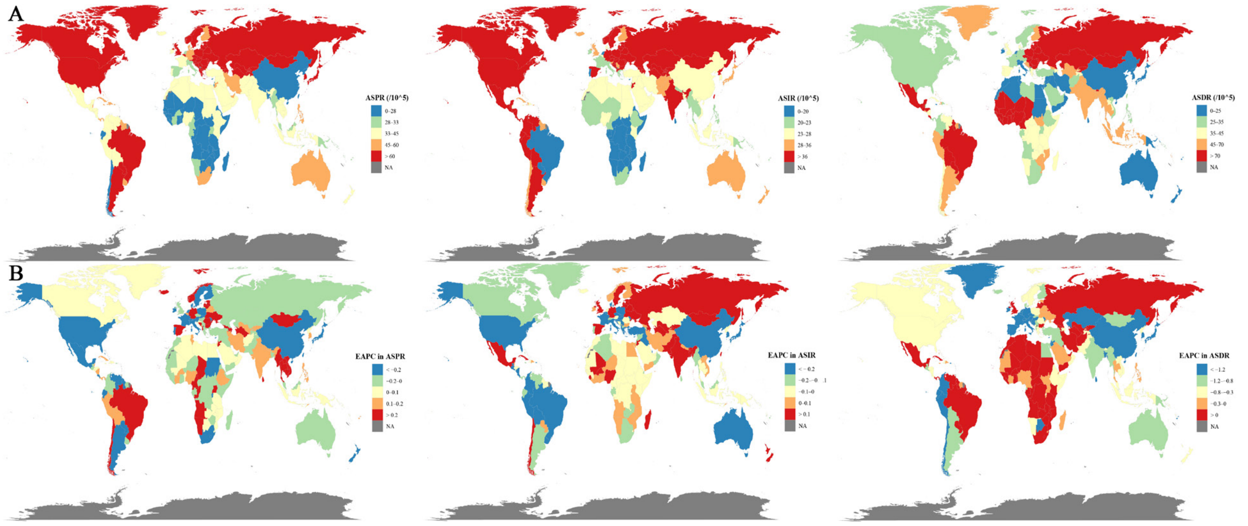

Figure 5. Global pancreatitis burden in 204 Countries and Territories: (A) age-standardized prevalence rate (ASPR), age-standardized incidence rate (ASIR), and age-standardized DALY rate (ASDR) in 2021; **(B)** EAPC of ASPR, ASIR, and ASDR from 1990 to 2021. DALYs: disability-adjusted life years; EAPC: estimated annual percentage changes.

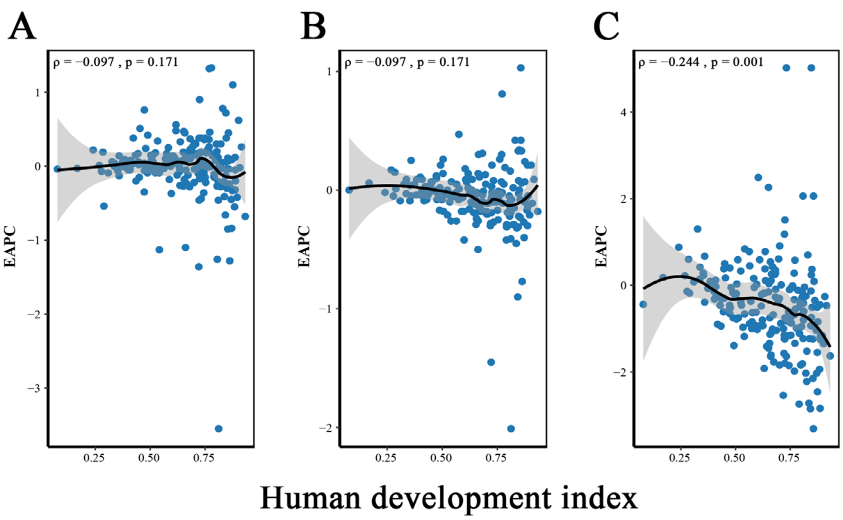

Figure 6. Global pancreatitis burden across 204 countries and territories by human development index in 2021.

SII and CI analyses reveal a shift in pancreatitis burden from development-level–driven inequality to structural reconcentration, a shift exacerbated by the COVID-19 pandemic.

Based on the identified reversal of global pancreatitis burden toward low-SDI countries and the emergence of entrenched structural inequalities, this study applied a BAPC model to project future trends. The projections suggest that while the global age-standardized burden of pancreatitis is expected to decrease by 2030, low-SDI countries will shoulder an increasing share, shifting the epicenter toward more socioeconomically disadvantaged regions and exacerbating existing inequalities. This trend suggests that inequality is not only a current concern but may persist in more systemic and less visible forms. These findings highlight the urgent need for global public health strategies to go beyond conventional disease control and address structural challenges, particularly by strengthening primary healthcare in low-SDI countries and improving chronic disease management and screening programs (*25*). Synchronously, global resource allocation should prioritize high-burden regions and vulnerable populations, enabling more targeted and equitable interventions (*26*). Strengthening international cooperation and institutional support, while integrating structural equity into global health agendas, is crucial to mitigate the shifting burden of chronic diseases and reduce global health disparities.

Several limitations should be acknowledged. First, the GBD database does not differentiate between acute and chronic pancreatitis, limiting the ability to assess their distinct etiologies and burden characteristics. Second, the reliance on national-level data restricts subnational analyses and reduces spatial resolution for

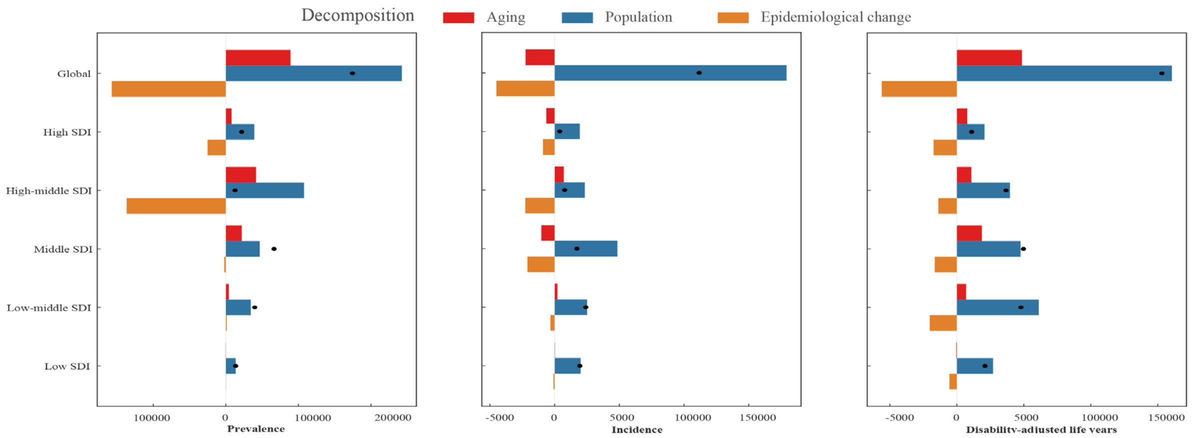

Figure 7. Decomposition analysis of pancreatitis indicators from 1990 to 2021. The black dot represents the overall change value of population growth, aging, and epidemiological change.

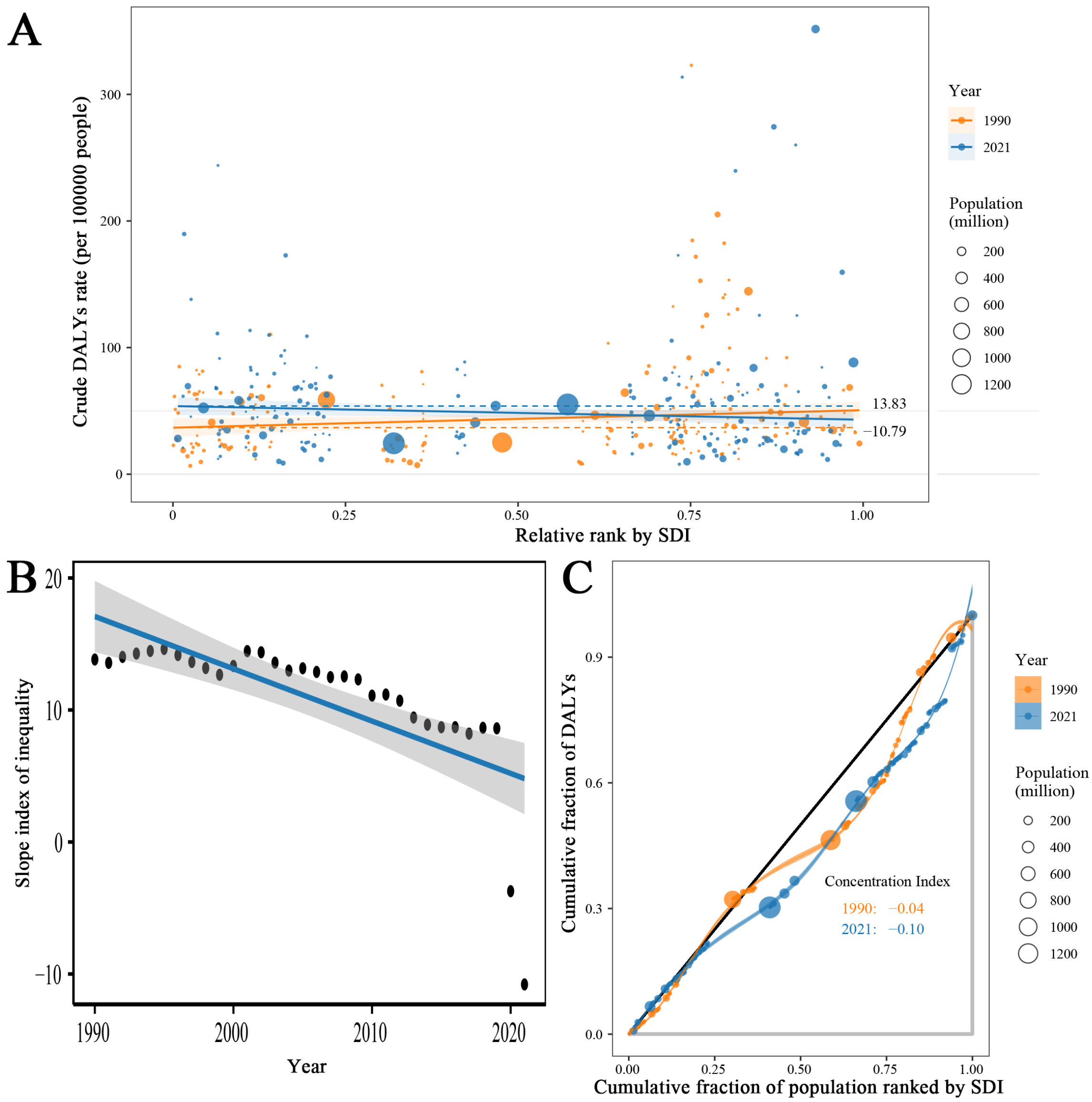

Figure 8. Trends in income-related health inequality in pancreatitis burden: slope index of inequality and concentration index analysis. DALYs: disability-adjusted life years.

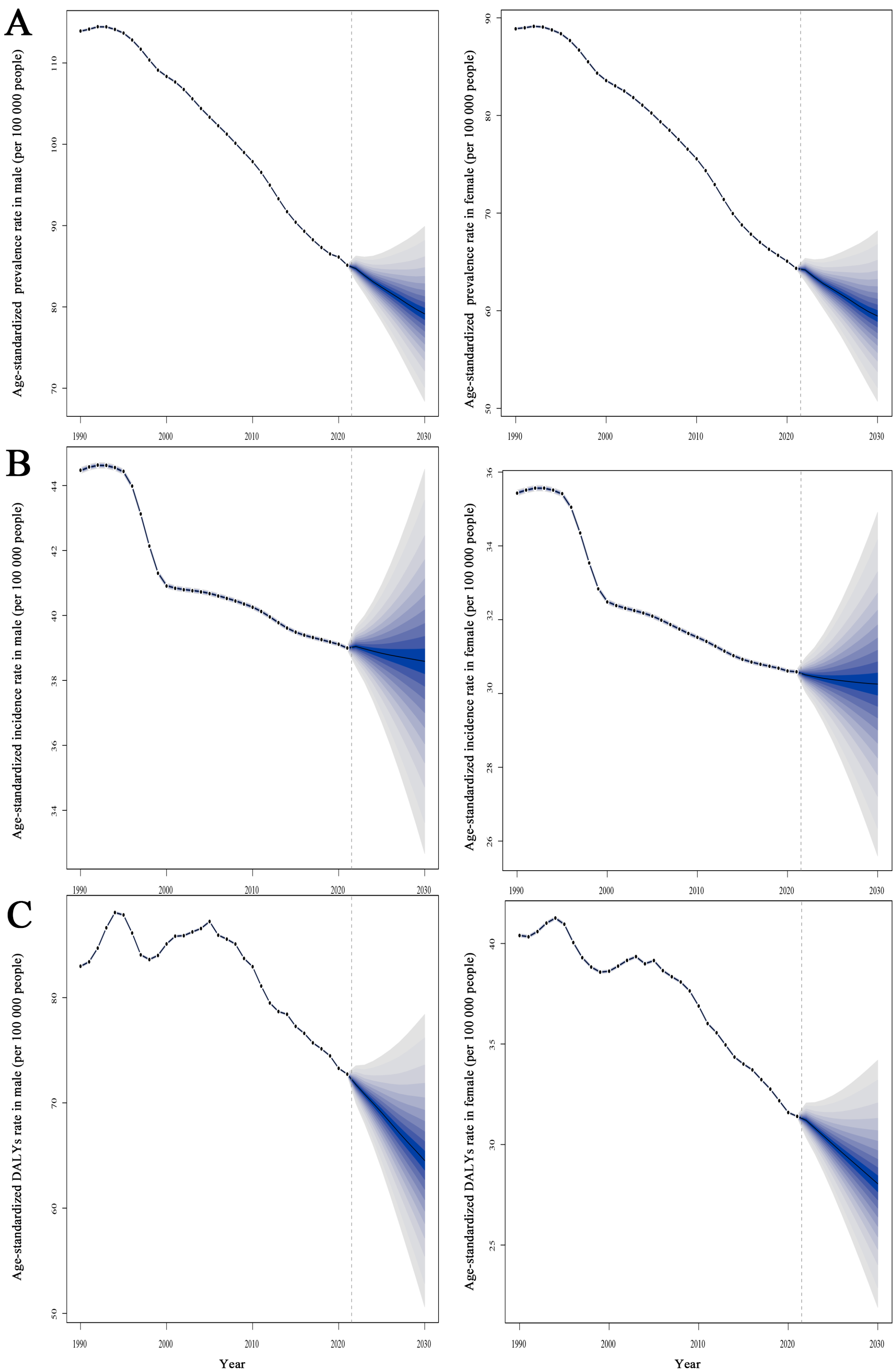

Figure 9. Projected number of new cases for all pancreatitis in 2030 according to the SDI. DALYs: disability-adjusted life years; SDI: Socio-demographic Index.

health policy planning. Third, the GBD database has limited primary data coverage in some economically disadvantaged regions. In such settings, model-based estimates may underestimate the true disease burden. Fourth, GBD data are mainly obtained from secondary sources and are not linked to clinical datasets, limiting insights into patient-level outcomes. Finally, although UIs are reported, regional variability may affect the stability and comparability of trend estimates.

In conclusion, this study provides a comprehensive assessment of the global evolution of the pancreatitis burden from 1990 to 2021, focusing on temporal trends, geographic disparities, and structural inequalities. Through decomposition analysis, we quantified the relative contributions of population growth, aging, and epidemiological changes, identifying the key drivers of the increasing global burden. Notably, the combined use of the SII and the CI showed a socioeconomic reversal in burden distribution, with the epicenter shifting from high- to low-SDI countries. This transition signals deepening structural entrenchment and worsening global health inequities. Forecasts based on the BAPC model indicate that this trend is likely to persist and may even intensify by 2030. These findings emphasize the urgent need to realign global health policies toward low-SDI countries by improving basic healthcare and implementing equity-focused interventions to alleviate the widening gaps in pancreatitis burden.

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