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Global and regional burden of pancreatitis: epidemiological trends, risk factors, and projections to 2050 from the global burden of disease study 2021

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Abstract

Background Pancreatitis is a significant global health concern with rising incidence, complex management, and substantial mortality. This study aimed to assess global and regional trends in pancreatitis from 1990 to 2021 and project future trends to 2050 using data from the Global Burden of Disease (GBD) Study 2021.

Methods We analyzed GBD 2021 data to evaluate age-standardized incidence (ASIR), mortality (ASMR), and disability-adjusted life years (DALYs) rates of pancreatitis. Regional trends, gender disparities, and correlations with the Socio-demographic Index (SDI) were examined. Key risk factors, including alcohol consumption, smoking, and metabolic disorders such as hyperlipidemia, were extracted and evaluated. A Bayesian age-period-cohort model (BAPC) was used for future projections.

Results From 1990 to 2021, global pancreatitis cases increased from 1.73 million to 2.75 million, representing a rise of 59%. Despite this, ASIR decreased slightly from 37.62 to 32.81 per 100,000, a 12.8% reduction. Deaths rose from 68,490 to 122,416, an increase of 78.7%, while ASMR decreased from 1.69 to 1.45 per 100,000, a reduction of 14.2%. DALYs increased from 2.58 million to 4.10 million (59%). Significant regional variations were found, with Eastern Europe showing the highest ASIR, ASMR, and DALY rates. Projections indicate continued declines in ASIR, ASMR, and DALYs through 2050.

Conclusions While global age-standardized rates of pancreatitis have declined, significant regional and socio-economic disparities persist. Targeted prevention efforts, particularly in high-burden areas like Eastern Europe, and addressing modifiable risk factors such as alcohol use are crucial for reducing the future burden of pancreatitis.

Keywords Pancreatitis, Risk factors, Projections, Global burden of disease study

Introduction

Pancreatitis is an inflammatory condition of the pancreas that can arise from various causes and is categorized into two main types: acute pancreatitis (AP) and chronic pancreatitis (CP) [1]. Acute pancreatitis is characterized by severe abdominal pain, systemic inflammation, and the risk of multi-organ failure, necessitating intensive medical intervention [2, 3] When the inflammatory process becomes prolonged or recurrent, the disease may progress to chronic pancreatitis, marked

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by irreversible pancreatic damage [4, 5]. This chronic condition is associated with exocrine and endocrine insufficiency, leading to malnutrition, diabetes mellitus, and an elevated risk of pancreatic malignancy [6, 7]. The persistent inflammation and damage to the pancreas not only diminish the quality of life but also carry substantial morbidity and mortality risks if not properly managed.

The Global Burden of Disease (GBD) Study is a large, ongoing epidemiological effort led by the Institute for Health Metrics and Evaluation (IHME), designed to quantify mortality, morbidity, and risk factors for major diseases and injuries across 204 countries. The GBD 2021 update, which includes data on 369 diseases and injuries, offers an unprecedented opportunity to assess global and regional epidemiological trends over time, providing a valuable basis for understanding the changing burden of diseases like pancreatitis [8].

The global incidence of pancreatitis has shown an alarming upward trend over the past few decades [9], driven by factors such as gallstone disease, alcohol consumption, smoking, and metabolic disorders like hypertriglyceridemia [10–12]. In most Western countries, alcoholic pancreatitis has the highest incidence among all types of pancreatitis [13, 14]. In northern Europe, the incidence rate is 8.2 per 100,000, with an overall prevalence of 27.4 per 100,000 [15]. A meta-analysis by Samokhvalov et al. revealed the dose–response relationships between alcohol consumption and risk of pancreatitis. Additionally, consuming more than 40 g/day was found to significantly increase the risk of developing pancreatitis [16]. Alcoholic pancreatitis typically follows a chronic course but can also present as an acute episode when large quantities of alcohol are consumed in a short time. Understanding the current status and trends in the alcohol-related burden of pancreatitis is crucial for effective disease control and health promotion.

Understanding the epidemiological characteristics and temporal trends of pancreatitis is crucial for developing effective prevention and control strategies. To the best of our knowledge, this is the first study to utilize the updated GBD 2021 data for a comprehensive epidemiological analysis of pancreatitis. This study aims to fill this gap by providing a detailed analysis of global and regional trends in the incidence, mortality, and Disability-Adjusted Life Years (DALYs) associated with pancreatitis from 1990 to 2021. We also project future trends to 2050 using the Bayesian age-period-cohort model (BAPC) model. By examining the correlation between pancreatitis metrics and SDI, as well as exploring gender disparities and the impact of key risk factors, this study seeks to offer a comprehensive understanding of the evolving burden of pancreatitis. The findings are intended to serve as a scientific basis for enhancing global pancreatitis prevention and control measures, ultimately reducing the associated health and economic burdens.

Methods

Overview and data collection

The GBD 2021 study evaluated the incidence, mortality, and DALYs rates in 204 countries and territories from 1990 to 2021. This study is a global, continuous effort with annual updates, classified by age, sex, and SDI. Using the Global Health Data Exchange query tool (https://vizhub.healthdata.org/gbd-results/) developed by GBD collaborators, we collected standardized disease definitions, prevalence data, global risk factors, and additional relevant information for patients with pancreatitis. Previous reports have provided a comprehensive overview of the data extraction and modeling methods used in the GBD 2021 study [17, 18].

The GBD 2021 study employs the DisMod-MR 2.1 Bayesian meta-regression model to synthesize data from multiple sources, including cohorts, surveys, and hospital records. This model adjusts for biases and ensures consistency between incidence, prevalence, and mortality data. Covariates such as the SDI are included to account for regional differences, enabling robust regional and global estimates. Uncertainty intervals (UI) are calculated for all estimates to reflect data variability.

This study utilized publicly available, de-identified data from GBD 2021, eliminating the need for individual-level data. Consequently, the institutional review board of Peking Union Medical College Hospital waived the requirements for ethical approval and informed consent.

Sociodemographic index

The Socio-demographic Index (SDI) is a composite measure used to assess the health-related social and economic conditions of a region. It combines indicators such as income per capita, educational attainment, and fertility rates to provide a comprehensive overview of a region's socioeconomic status. The SDI values range from 0 to 1, with higher scores indicating greater socioeconomic development. In the GBD 2021 data, countries and territories are classified into five development levels based on their SDI scores: low (< 0.46), low-middle (0.46–0.60), middle (0.61–0.69), high-middle (0.70–0.81), and high (> 0.81).

Case definition

In this study, we analyzed the incidence of both acute pancreatitis and newly diagnosed cases of chronic pancreatitis using data from the Global Burden of Disease (GBD) Study 2021. The classification of pancreatitis follows the International Classification of Diseases tenth editions

(ICD-10). The ICD-10 provides specific codes for classifying pancreatitis. Acute pancreatitis is coded as K85, with subcategories ranging from K85.0 to K85.9 to specify different types and causes. Chronic pancreatitis is coded as K86.0, while K86.1 is used for other related conditions [8].

Statistical analysis

We used age-standardized incidence rates (ASIR), mortality rates (ASMR), and disability-adjusted life years rates (ASDR) to describe the global burden of pancreatitis. Temporal trends from 1990 to 2021 were analyzed using estimated annual percentage changes (EAPC), calculated through linear regression models [19]. An increasing ASR was determined when both the EAPC value and the lower limit of the 95% confidence interval were above zero. Conversely, a decreasing ASR was identified when both the EAPC value and the upper limit of the 95% confidence interval were below zero [20]. If neither condition was met, the ASR was considered stable over time. The relationship between these rates and the Sociodemographic Index (SDI) was assessed using Spearman's rank correlation coefficient. Additionally, a Bayesian age-period-cohort (BAPC) model was employed to project future trends of pancreatitis burden through 2050 [21, 22]. BAPC models offer a robust framework for making projections by employing Integrated Nested Laplace Approximations (INLA) for complete Bayesian inference [23]. All statistical analysis was performed using R software package (version 4.2.1). A two-sided p-value < 0.05 was considered statistically significant.

Results

Incidence and temporal trend

From 1990 to 2021, the global incidence of pancreatitis exhibited an increasing trend in the number of cases, rising from approximately 1.73 million cases in 1990 to 2.75 million in 2021. However, despite this rise in absolute numbers, the age-standardized rate per 100,000 population demonstrated a slight decline, from 37.62 in 1990 to 32.81 in 2021, indicating an overall decrease in the incidence rate when adjusted for population growth. The estimated annual percentage change (EAPC) during this period was -0.491% globally (Table 1).

Regional variations were observed with East Asia and Central Europe showing significant decreases in age-standardized rates, with EAPCs of -1.361% and -0.805%, respectively. Conversely, South Asia experienced a notable increase in both the number of cases and the age-standardized rate, reflected in an EAPC of 0.42%, highlighting a region-specific rise in pancreatitis incidence (Table 1). Figure 1A illustrates the geographical distribution of ASIR in 2021, with Eastern Europe recording the highest rate at 99.35 per 100,000 population, indicating a particularly high burden. High-income North America and Central Asia also had relatively high ASIRs, at 51.99 and 47.94 per 100,000 population, respectively. In contrast, Tropical Latin America exhibited the lowest ASIR, at 16.63 per 100,000 population. Additionally, the Sub-Saharan Africa region, including Central, Eastern, Southern, and Western Sub-Saharan Africa, showed relatively low ASIRs, ranging from 18.69 to 23.32 per 100,000 population. Notably, from 1990 to 2021, Eastern Europe consistently had the highest ASIR throughout these years, with rates significantly higher than other regions (Fig. 2A).

Further analysis illustrates the trends in ASIR across different SDI regions. Globally, the ASIR remained relatively stable until the early 2000s, after which it began to increase steadily. High SDI regions experienced a slight decline in ASIR around the early 2000s, followed by a gradual increase, indicating fluctuating but generally rising incidence rates. High-middle and middle SDI regions showed a similar trend, with ASIR stabilizing before gradually increasing. In contrast, low-middle and low SDI regions exhibited a steady rise in ASIR throughout the period, reflecting a growing burden of pancreatitis incidence in these lower-income regions. (Fig. 3A).

Death and temporal trend

Table 2 highlights global and regional trends in deaths attributed to pancreatitis from 1990 to 2021. Globally, the number of deaths increased from approximately 68,490 in 1990 to 122,416 in 2021. However, the age-standardized death rate per 100,000 population showed a slight decline from 1.69 in 1990 to 1.45 in 2021, with an estimated annual percentage change (EAPC) of -0.498%. Regionally, Eastern Europe reported the ASMR in 2021, at 5.60 per 100,000 population, reflecting a significant burden of mortality due to pancreatitis. Western Sub-Saharan Africa and Central Europe also had relatively high ASMRs, at 3.23 and 2.77 per 100,000 population, respectively. On the other hand, regions like Oceania and High-income Asia Pacific reported much lower ASMRs, at 0.62 and 0.47 per 100,000 population (Fig. 1B). While many regions show a general decline in ASMR from 1990 to 2021, Eastern Europe exhibits a distinctive upward trend, particularly between 2000 and 2021 (Fig. 2B).

Figure 3B highlights the disparities in pancreatitis-related mortality across different socio-economic contexts. Globally, the ASMR increased until around 2005 and then began to stabilize. High SDI regions experienced a peak in ASMR during the early 2000s, followed by a gradual decline, indicating improvements in healthcare. High-middle SDI regions also showed an initial rise with a subsequent decrease, although their mortality rates remained higher than in other regions. In contrast,

Table 1 Incidence of Pancreatitis Between 1990 and 2021 at the Global and Regional Level

	Number of cases, 1990			Age-standardised rate per 100 000 population, 1990			Number of cases, 2021		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Global	953728.393(820789.739-1116606.730)	774412.874(668135.142-890629.067)	1728141.267(1495095.633-1995752.186)	41.775(36.016-48.430)	33.232(28.820-38.100)	37.618(32.567-43.463)	1508972.109(1320033.356-1734259.892)	1238396.055(1094690.007-1399816.296)	2747368.165(2413877.627-3133076.307)
East Asia	221854.564(181985.268-266062.232)	155452.990(129302.510-181390.416)	377307.554(311765.766-447070.902)	40.582(34.027-47.991)	30.383(25.525-35.792)	35.647(30.118-41.713)	268832.114(229514.097-313386.904)	201819.837(172264.765-237796.181)	470651.951(403601.217-548056.070)
Southeast Asia	47355.307(39458.783-56715.222)	41932.558(35007.752-49477.173)	89287.865(74780.703-105802.841)	26.618(22.477-31.410)	22.646(19.119-26.463)	24.588(20.889-28.838)	97538.194(82521.926-115140.993)	81607.604(69806.214-95257.483)	179145.797(152379.515-209528.495)
Oceania	539.416(444.854-643.986)	414.870(348.352-488.325)	954.286(788.934-1129.487)	23.163(19.592-27.239)	19.934(16.985-23.226)	21.596(18.418-25.169)	1254.987(1044.862-1509.840)	969.945(807.438-1150.068)	2224.932(1853.028-2647.380)
Central Asia	14462.315(12259.100-17249.240)	12136.110(10422.333-14190.920)	26598.425(22701.580-31289.744)	53.599(45.910-62.723)	40.148(34.402-46.897)	46.735(40.240-54.171)	25825.419(21942.537-30539.640)	19896.565(16967.846-23556.192)	45721.984(39128.119-53162.162)
Central Europe	43196.340(37220.000-50126.767)	29837.083(25693.443-34588.066)	73033.423(63193.669-84733.043)	65.683(56.788-76.188)	39.363(34.154-45.333)	52.369(45.484-60.611)	42338.657(38654.775-46180.197)	28220.640(26008.101-30808.724)	70559.297(64882.720-76850.808)
Eastern Europe	124563.862(102237.809-154764.297)	113017.383(93722.983-138058.025)	237581.245(195712.649-287166.469)	108.802(90.707-132.809)	76.326(63.299-91.974)	92.768(76.885-111.190)	136499.246(113503.373-164181.824)	131893.149(109197.823-160576.947)	268392.396(223073.977-322225.519)
Western Europe	69405.542(61724.344-78305.587)	62801.996(55804.729-70156.659)	132207.538(118034.337-148291.961)	31.693(28.176-35.823)	23.898(21.275-26.686)	27.677(24.648-31.111)	106500.002(95976.726-117928.953)	92386.930(86161.055-99177.445)	198886.931(182278.433-215736.478)
Southern Latin America	4990.354(4389.784-5678.225)	9712.897(8413.467-11145.362)	14703.251(12880.969-16806.301)	22.356(19.680-25.448)	38.676(33.692-44.442)	30.915(27.194-35.230)	9550.852(8516.683-10823.559)	18030.283(15905.576-20570.268)	27581.135(24437.704-31491.165)
Australasia	3926.186(3359.988-4591.483)	3893.809(3326.847-4490.029)	7819.996(6696.350-9078.677)	36.707(31.596-42.609)	33.534(28.752-38.667)	34.964(30.140-40.375)	7002.179(6038.487-8146.475)	6556.508(5644.947-7610.057)	13558.687(11690.474-15749.447)
High-income Asia Pacific	41446.312(35278.040-48872.405)	24131.914(20294.800-28309.747)	65578.226(55887.643-76897.901)	43.828(37.463-51.016)	24.242(20.435-28.161)	33.762(28.761-39.227)	47484.321(41175.623-53934.985)	25652.966(22644.116-29148.850)	73137.287(64059.820-82718.503)
Central Latin America	25091.280(21298.260-29536.382)	22122.471(18914.073-25242.772)	47213.751(40374.693-54700.439)	40.603(34.964-47.266)	35.299(30.658-40.156)	37.853(32.669-43.622)	50898.027(44043.730-58867.687)	51459.359(45317.822-58563.031)	102357.387(89703.596-117032.991)
High-income North America	94771.164(83094.608-108014.921)	109148.298(95965.180-123480.499)	203919.462(179759.028-231497.769)	63.690(55.682-72.249)	63.521(55.971-71.860)	63.633(55.873-72.081)	128096.703(118452.193-138070.990)	136034.900(126090.478-146075.859)	264131.603(244465.602-283649.089)
Caribbean	4399.167(3729.043-5173.837)	4384.736(3737.205-5112.757)	8783.903(7430.357-10257.499)	29.769(25.497-34.844)	28.080(23.902-32.676)	28.884(24.691-33.697)	7258.897(6208.916-8558.051)	7332.379(6309.296-8539.335)	14591.275(12548.002-17048.942)
Andean Latin America	5309.519(4586.899-6075.193)	6566.250(5645.979-7677.176)	11875.769(10281.305-13776.217)	39.465(34.475-45.253)	44.690(38.864-51.333)	42.116(36.752-48.280)	11232.040(9957.424-12807.870)	13818.050(12251.652-15569.106)	25050.090(22198.106-28319.942)
Central Sub-Saharan Africa	3076.707(2512.661-3682.367)	3640.898(2981.617-4366.870)	6717.605(5510.879-8052.707)	17.863(15.162-20.966)	19.740(16.454-23.078)	18.838(15.807-21.996)	8065.738(6563.733-9555.270)	9356.315(7687.516-11091.775)	17422.053(14204.562-20644.902)
Eastern Sub-Saharan Africa	11274.507(9289.340-13367.664)	12541.198(10238.699-14975.008)	23815.704(19528.039-28410.993)	18.967(16.113-22.234)	20.274(17.124-23.738)	19.634(16.621-22.969)	26175.825(21495.304-31255.155)	31259.365(25544.419-37251.858)	57435.191(47011.538-68537.108)

Table 1 (continued)

	Number of cases, 1990			Age-standardised rate per 100 000 population, 1990			Number of cases, 2021		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Tropical Latin America	14616.365(12910.365-16734.718)	8059.516(7147.750-9090.387)	22675.881(20192.746-25696.611)	24.870(22.031-27.867)	13.218(11.761-14.862)	18.822(16.812-21.046)	24819.381(21779.100-28255.047)	17699.182(15697.860-19926.345)	42518.562(37418.510-48223.808)
North Africa and Middle East	33310.306(27715.729-39215.702)	29724.712(24800.232-34854.089)	63035.018(52688.395-74091.672)	27.799(23.813-32.343)	26.415(22.468-31.032)	27.084(23.183-31.503)	77988.850(66727.850-90548.439)	68227.061(58772.995-79269.543)	146215.912(125435.426-169956.206)
South Asia	172523.504(140633.764-207857.603)	104582.024(86428.343-124072.895)	277105.528(229053.682-331365.659)	37.473(31.140-44.616)	25.239(21.165-29.383)	31.644(26.295-37.445)	390691.035(320684.867-471617.319)	244038.409(204467.180-287510.686)	634729.444(528403.759-757199.574)
Southern Sub-Saharan Africa	3561.239(2977.260-4229.859)	4850.482(4037.019-5741.848)	8411.721(6969.620-9971.055)	19.560(16.657-22.868)	23.568(20.082-27.609)	21.741(18.562-25.524)	6453.555(5380.947-7672.552)	8978.098(7478.647-10603.036)	15431.653(12869.303-18278.529)
Western Sub-Saharan Africa	14054.437(11609.216-16615.215)	15460.678(12856.837-18309.429)	29515.115(24426.514-34804.903)	21.332(18.150-24.966)	23.839(20.101-27.816)	22.587(19.145-26.389)	34466.089(28437.506-40920.415)	43158.507(35645.167-51054.505)	77624.596(63947.167-91922.581)

Table 1 (continued)

	Age-standardised rate per 100 000 population, 2021			Estimated annual percentage change, 1990-2021
	Male	Female	Total	
Global	36.747(32.194-42.243)	28.822(25.378-32.548)	32.806(28.853-37.377)	-0.491[(-0.557-(-0.426)]
East Asia	28.415(24.444-33.147)	20.073(17.255-23.117)	24.302(20.983-28.080)	-1.361[(-1.714-(-1.008)]
Southeast Asia	26.951(22.896-31.602)	21.955(18.894-25.418)	24.439(20.954-28.446)	-0.037[(-0.051-(-0.023)]
Oceania	22.540(19.106-26.619)	19.380(16.499-22.645)	20.954(17.817-24.464)	-0.114[(-0.123-(-0.105)]
Central Asia	55.900(48.081-65.399)	40.223(34.599-46.797)	47.936(41.425-55.370)	0.063(0.033-0.094)
Central Europe	56.149(51.496-61.174)	30.554(28.289-33.137)	43.307(39.882-46.918)	-0.805[(-0.908-(-0.703)]
Eastern Europe	114.757(95.965-138.766)	83.400(69.628-99.855)	99.349(82.691-117.934)	0.189(-0.001-0.380)
Western Europe	35.556(31.999-39.822)	26.707(24.942-28.639)	31.081(28.494-34.141)	0.079(-0.041-0.198)
Southern Latin America	25.875(23.085-29.293)	44.722(39.263-50.763)	35.595(31.519-40.521)	0.057(-0.082-0.197)
Australasia	34.259(29.760-39.459)	31.543(27.230-36.604)	32.780(28.622-37.626)	-0.213[(-0.264-(-0.162)]
High-income Asia Pacific	39.220(34.349-44.565)	18.767(16.465-21.099)	29.155(25.569-32.940)	-0.431[(-0.483-(-0.380)]
Central Latin America	40.707(35.271-46.877)	37.782(33.270-42.828)	39.215(34.298-44.736)	0.053(0.017-0.089)
High-income North America	52.391(48.636-56.117)	51.742(48.066-55.324)	51.990(48.356-55.533)	-0.696[(-0.838-(-0.554)]
Caribbean	29.298(25.052-34.489)	27.681(23.636-32.252)	28.471(24.463-33.246)	-0.028[(-0.048-(-0.009)]
Andean Latin America	35.901(31.968-40.733)	41.746(37.036-47.105)	38.794(34.564-43.672)	-0.386[(-0.447-(-0.324)]
Central Sub-Saharan Africa	17.650(15.011-20.796)	19.606(16.549-22.823)	18.689(15.796-21.864)	-0.021[(-0.036-(-0.005)]
Eastern Sub-Saharan Africa	18.458(15.697-21.747)	20.905(17.607-24.515)	19.731(16.730-23.137)	-0.002(-0.024-0.021)
Tropical Latin America	20.556(18.085-23.240)	13.138(11.661-14.799)	16.628(14.701-18.834)	-0.273[(-0.360-(-0.187)]
North Africa and Middle East	26.981(23.523-30.883)	25.639(22.260-29.563)	26.339(22.915-30.071)	-0.033[(-0.058-(-0.007)]
South Asia	42.250(35.137-50.274)	27.484(23.141-31.903)	34.971(29.037-41.279)	0.420(0.365-0.474)
Southern Sub-Saharan Africa	18.865(16.064-22.108)	23.176(19.608-27.276)	21.215(18.090-24.894)	-0.124[(-0.167-(-0.081)]
Western Sub-Saharan Africa	21.707(18.503-25.422)	24.783(20.916-28.874)	23.322(19.814-27.201)	0.088(0.075-0.100)

middle, low-middle, and low SDI regions exhibited more stable ASMRs over the years, with the low SDI region showing a notable decline after 2010, highlighting gradual progress in reducing pancreatitis-related mortality in these lower-income regions.

DALYs and temporal trend

Globally, the total DALYs increased substantially, from approximately 2.58 million in 1990 to about 4.10 million in 2021. However, the age-standardized rates showed a slight decline, from 57.393 per 100,000 population in 1990 to 48.425 per 100,000 in 2021, with an estimated annual percentage change of -0.609%. Regional variations were observed with East Asia and Andean Latin America showing significant decreases in age-standardized rates, with EAPCs of -1.584% and -1.497%, respectively. Conversely, Eastern Europe experienced a notable increase in both the number of cases and the age-standardized rate, reflected in an EAPC of 1.410% (Table 3).

The 2021 global distribution map of ASDR for pancreatitis illustrates significant regional variations in the burden of the disease. The highest rates, depicted in dark red, are concentrated in Eastern Europe, Central Asia, and parts of Sub-Saharan Africa, indicating a substantial health burden in these regions with rates ranging from 119.9 to 260.8 per 100,000 population. In contrast, much of North America, parts of Western Europe, Australia, and East Asia show lower DALY rates, with regions like East Asia and Oceania depicted in blue shades, indicating rates as low as 11.049 to 25.56 per 100,000 population (Fig. 1C). The temporal trend reveals a significant increase in ASDR in Eastern Europe and Central Asia, where the rates are the highest among all regions analyzed from 1990 to 2021. This upward trend is particularly stark when contrasted with the overall global decline in ASDR (Fig. 2C).

The ASDR for pancreatitis from 1990 to 2021 also reveal distinct patterns across different SDI levels (Fig. 3C). Globally, there was an initial increase until the early 2000s, followed by a gradual decline. High and high-middle SDI regions exhibited significant peaks around 2005, with subsequent declines, reflecting improved disease management. In contrast, middle and low-middle SDI regions showed a steady increase in DALY rates, indicating a growing burden. Low SDI regions maintained the lowest rates overall, with a relatively stable trend and slight decline after 2005.

Correlation of pancreatitis metrics with Socio-demographic Index (SDI) from 1990 to 2021

From 1990 to 2021, the ASIR ($r=0.5408$, $p<0.001$), ASMR ($r=-0.0764$, $p=0.043$), and ASDR ($r=-0.1276$, $p<0.001$) for pancreatitis showed significant correlations with the SDI, with ASIR being positively correlated and the other metrics exhibiting negative correlations (Figs. 4A-C).

Gender disparities in ASIR, ASMR, and ASDR across age groups

We also present a comparative analysis of ASIR, ASMR, and ASDR across various global regions, disaggregated by gender. The ASIR is shown to be higher in males than in females in nearly all regions, with Eastern Europe displaying the most pronounced difference (Fig. 5A). Figure 5B highlights the ASMR, where a similar pattern emerges. Males have notably higher mortality rates than females, particularly in Eastern Europe, which exhibits the highest ASMR among all regions. Figure 5C presents the ASDR, again demonstrating that males are disproportionately affected. Eastern Europe stands out with the highest ASDR, underscoring the severe DALYs burden especially among males. Overall, the data reveal significant gender disparities, with males consistently exhibiting higher rates across all three metrics compared to females.

For incidence rates, males peak in the 35–39 year age group, while females have a slightly later peak in the 55–59 year age group (Fig. 6A). Mortality rates for males peak between 55–59 years, whereas females have a later peak between 70–74 years (Fig. 6B). The burden of disease as measured by DALYs peaks for males between 45–49 years, while females peak later between 65–69 years (Fig. 6C).

Proportion of deaths attributable to risk factors

The global and regional proportions of deaths attributable to a major risk factor—alcohol use—were analyzed. Globally, 15.22% of deaths are attributed to alcohol use. We also revealed significant regional variation, with the highest proportions observed in Central Europe (26.37%), Eastern Europe (24.13%), and Western Europe (24.55%). In contrast, regions such as North Africa and the Middle East (1.37%) and Oceania (5.3%) show the lowest proportions of alcohol-related deaths (Figs. 7).

Projecting disease burden

Our study demonstrated a consistent downward trend in ASIR, ASMR, and ASDR for pancreatitis from 1990 to 2020. Projections for the future suggest that this declining trend is likely to continue through 2050, although with increasing uncertainty as time progresses (Figs. 8A-C).

Discussion

This study provides a comprehensive overview of the global and regional epidemiological trends of pancreatitis over the past three decades, utilizing data from the GBD

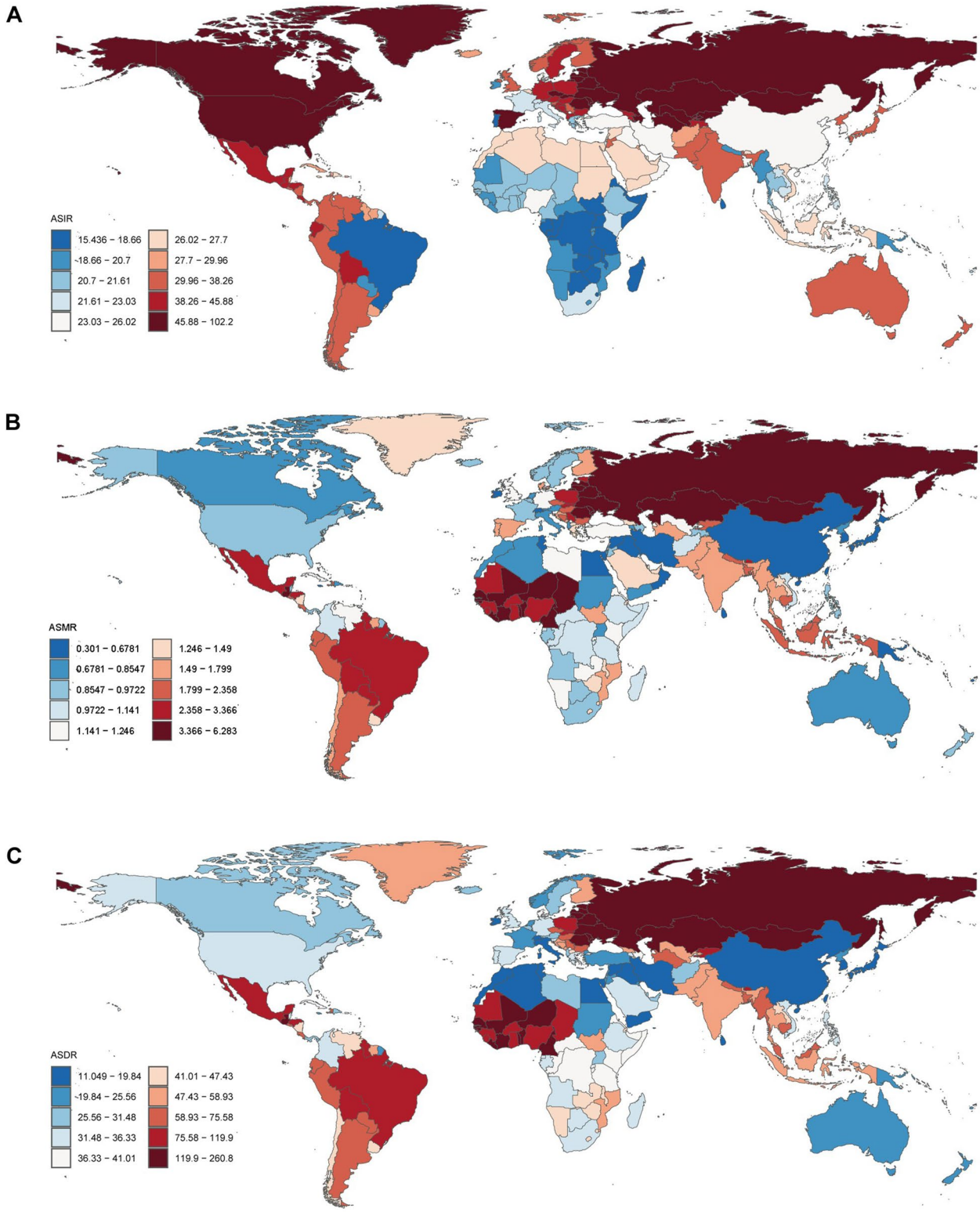

Fig. 1 Global maps showing the age-standardized incidence rate (ASIR), mortality rate (ASMR), and disability-adjusted life year rate (ASDR) of pancreatitis in 2021: (**A**) ASIR, (**B**) ASMR, and (**C**) ASDR

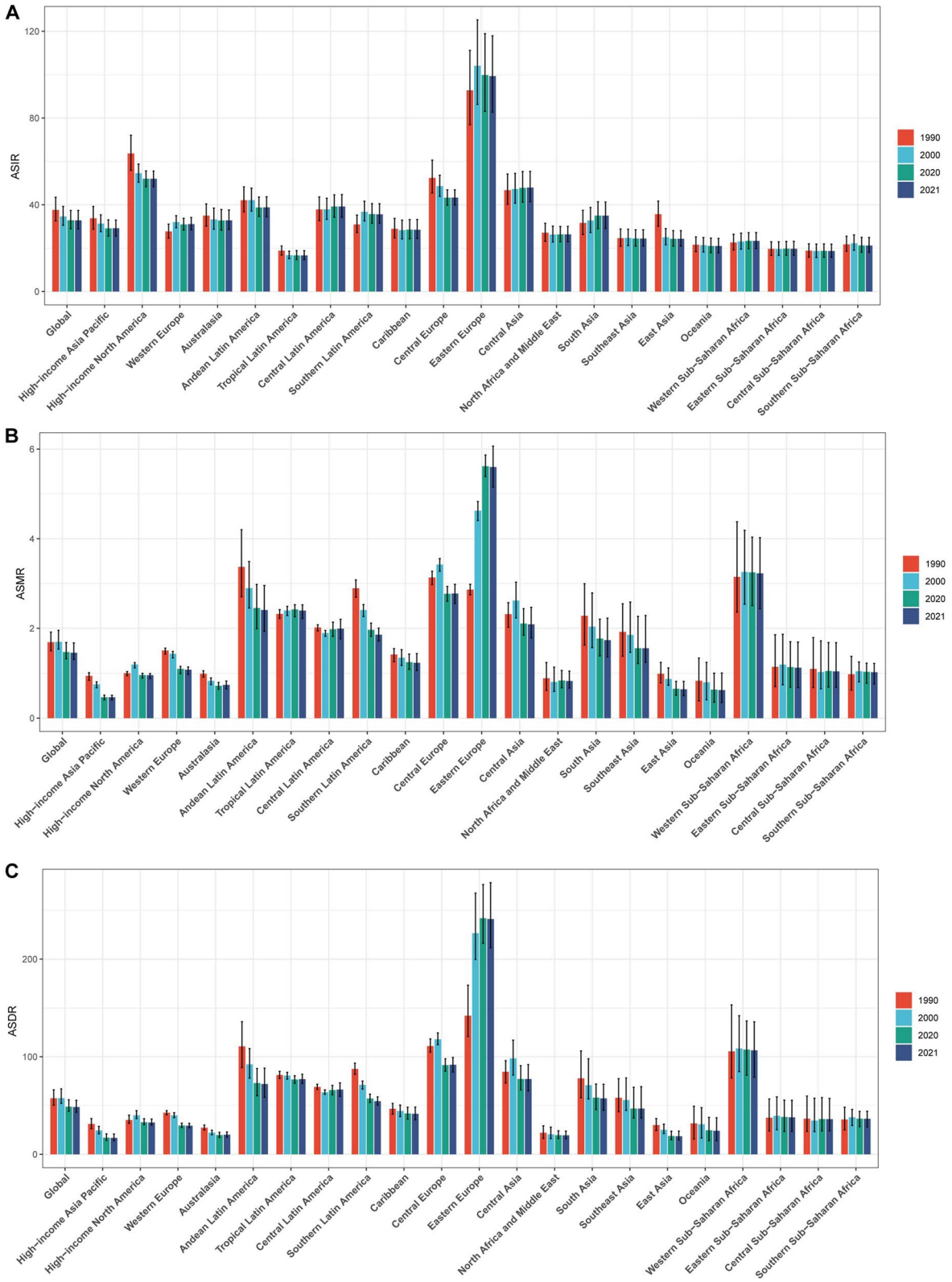

Fig. 2 Trends in age-standardized rates of pancreatitis across global regions from 1990 to 2021. **A** Age-standardized incidence rate (ASIR), **B** Age-standardized mortality rate (ASMR), and (**C**) Age-standardized disability-adjusted life year rate (ASDR)

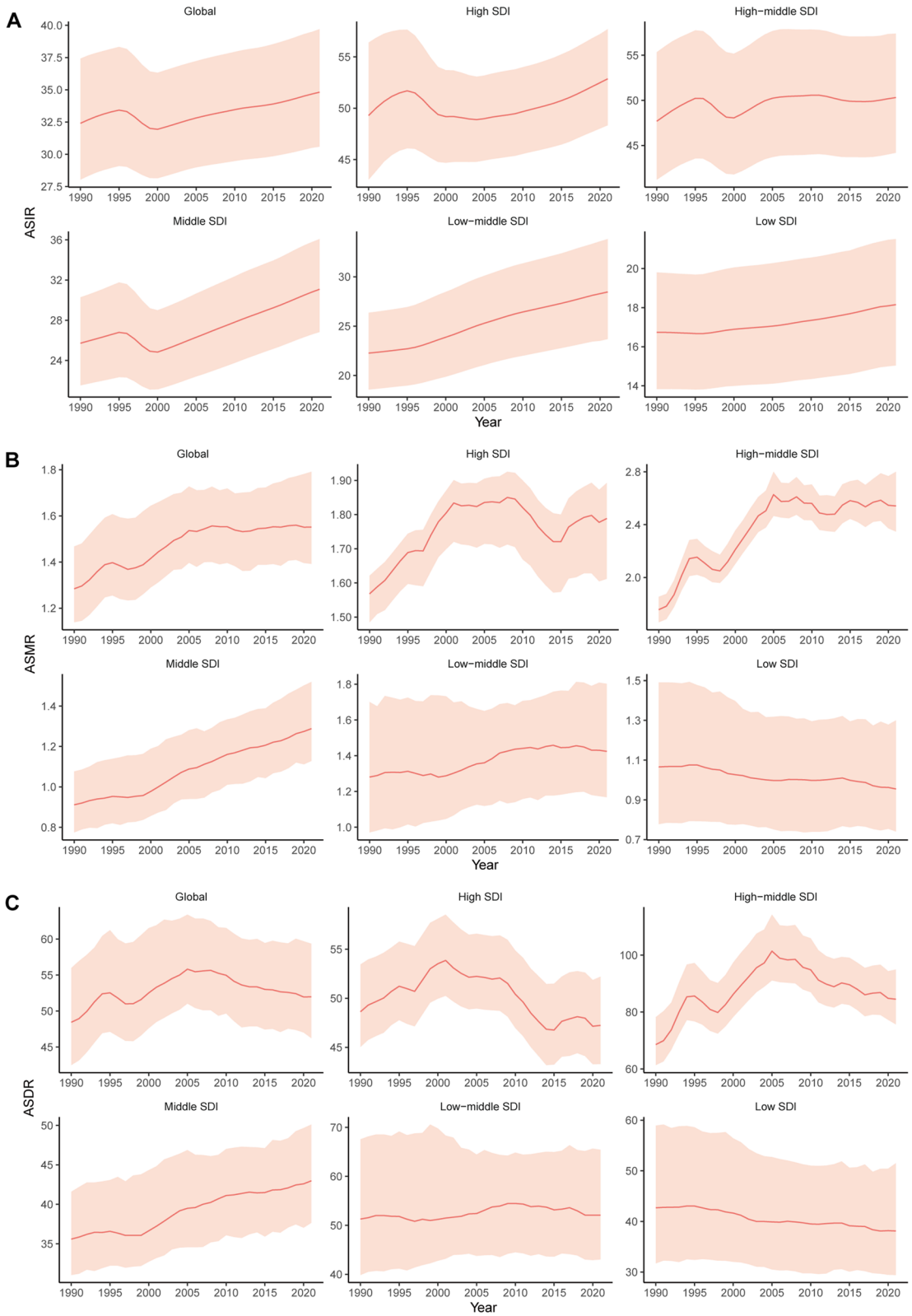

Fig. 3 Trends in age-standardized rates of pancreatitis from 1990 to 2021 across different Socio-demographic Index (SDI) levels. **A** Age-standardized incidence rate (ASIR), **B** Age-standardized mortality rate (ASMR), and (**C**) Age-standardized disability-adjusted life year rate (ASDR)

Table 2 Deaths of pancreatitis between 1990 and 2021 at the Global and Regional Level

	Number of cases, 1990			Age-standardised rate per 100 000 population, 1990			Number of cases, 2021		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Global	42717.178(36180.568-51284.217)	25772.724(21239.763-30924.056)	68489.903(60748.392-78272.377)	2.171(1.842-2.595)	1.225(1.015-1.474)	1.690(1.496-1.916)	77052.596(66085.809-90319.257)	45363.374(38255.041-57289.923)	122415.970(109847.625-141361.823)
Central Asia	679.601(576.599-783.523)	455.487(394.985-509.795)	1135.088(996.226-1258.017)	3.052(2.542-3.521)	1.644(1.418-1.854)	2.315(2.023-2.570)	1162.377(962.376-1406.610)	619.771(529.510-727.685)	1782.148(1511.118-2115.585)
Oceania	23.440(10.183-40.446)	8.724(3.251-13.691)	32.164(14.861-51.878)	1.090(0.464-1.872)	0.548(0.221-0.851)	0.834(0.386-1.333)	44.906(21.439-75.909)	14.653(7.471-24.340)	59.559(32.549-95.754)
High-income Asia Pacific	1112.673(980.068-1201.247)	666.101(573.883-728.349)	1778.774(1606.698-1907.351)	1.324(1.181-1.422)	0.618(0.531-0.676)	0.942(0.845-1.013)	1307.597(1166.899-1449.864)	1022.965(731.881-1208.787)	2330.563(1921.896-2588.776)
Southeast Asia	3620.751(2441.394-5176.963)	1508.931(880.310-2255.747)	5129.681(3764.679-6900.084)	2.646(1.762-3.800)	1.241(0.684-1.854)	1.921(1.377-2.548)	7154.459(5498.976-11188.224)	2708.334(2016.737-4630.182)	9862.794(7806.106-14769.998)
East Asia	4296.321(3160.444-5817.190)	3894.159(2379.712-5380.357)	8190.481(6497.012-10045.450)	1.062(0.774-1.438)	0.924(0.560-1.279)	0.989(0.785-1.243)	7619.029(5367.107-10650.941)	5123.599(3420.742-7415.579)	12742.628(9802.787-16475.674)
Australasia	126.944(117.965-136.319)	99.919(90.030-108.961)	226.864(209.573-241.402)	1.271(1.183-1.361)	0.748(0.676-0.812)	0.991(0.916-1.055)	224.002(198.110-251.739)	187.948(153.063-212.860)	411.949(361.252-460.555)
Caribbean	229.885(201.774-267.629)	149.161(127.995-177.480)	379.046(336.741-417.578)	1.750(1.538-2.035)	1.094(0.943-1.295)	1.415(1.261-1.547)	394.379(327.887-480.442)	261.513(215.102-314.658)	655.892(564.495-763.528)
Eastern Europe	4541.296(4320.686-4770.708)	3041.450(2909.185-3164.698)	7582.746(7276.177-7899.473)	4.100(3.898-4.311)	1.827(1.751-1.897)	2.863(2.747-2.982)	10688.229(9636.331-11771.336)	6274.687(5618.940-6944.566)	16962.916(15639.359-18331.990)
Tropical Latin America	1691.433(1629.445-1755.202)	734.253(693.723-778.092)	2425.686(2338.423-2523.032)	3.259(3.131-3.376)	1.449(1.360-1.544)	2.321(2.220-2.416)	3769.846(3502.597-4015.797)	2345.879(2094.012-2525.557)	6115.725(5685.926-6443.792)
Western Sub-Saharan Africa	2359.247(1564.867-3893.553)	779.930(445.533-1201.567)	3139.177(2323.355-4482.629)	4.466(3.029-7.200)	1.765(0.994-2.701)	3.147(2.360-4.379)	5847.565(4181.803-7850.877)	1979.162(1039.195-2619.336)	7826.727(5746.057-9946.071)
High-income North America	1881.474(1809.510-1941.194)	1577.939(1421.913-1665.344)	3459.413(3252.228-3597.289)	1.288(1.234-1.329)	0.763(0.699-0.800)	1.003(0.945-1.041)	3234.762(3045.113-3347.598)	2590.241(2235.954-2772.899)	5825.003(5293.154-6103.707)
Central Europe	2690.436(2536.745-2851.192)	1760.781(1641.289-1872.869)	4451.216(4241.709-4647.420)	4.144(3.904-4.386)	2.163(2.013-2.299)	3.134(2.977-3.274)	3394.119(3098.089-3684.896)	2060.758(1850.832-2278.751)	5454.877(5021.994-5850.869)
Andean Latin America	453.983(357.190-565.980)	337.976(243.905-466.550)	791.959(634.193-984.479)	3.905(3.070-4.902)	2.846(2.065-4.070)	3.368(2.702-4.200)	842.473(649.614-1081.993)	607.207(466.886-803.792)	1449.680(1164.659-1778.485)
Eastern Sub-Saharan Africa	857.465(512.111-1368.683)	113.410(60.142-202.136)	970.874(608.424-1521.021)	2.022(1.164-3.353)	0.298(0.145-0.556)	1.142(0.705-1.855)	2077.734(1188.166-3201.048)	279.294(144.979-456.087)	2357.027(1418.141-3486.716)
Central Sub-Saharan Africa	259.181(152.165-446.891)	24.857(12.347-45.587)	284.038(174.875-476.208)	2.087(1.222-3.473)	0.210(0.106-0.418)	1.097(0.680-1.793)	659.284(416.823-1101.423)	67.566(38.441-132.434)	726.850(474.723-1178.149)
Western Europe	4470.978(4298.486-4629.775)	3898.894(3562.146-4109.235)	8369.871(7901.467-8677.607)	1.984(1.904-2.055)	1.093(1.009-1.148)	1.504(1.424-1.557)	5603.472(5172.083-5880.890)	4842.733(3926.115-5348.264)	10446.205(9087.032-11153.718)
Central Latin America	1261.759(1212.601-1311.189)	721.111(686.409-755.056)	1982.870(1910.382-2039.912)	2.550(2.447-2.653)	1.514(1.431-1.592)	2.018(1.940-2.079)	2998.424(2634.407-3389.864)	2040.504(1775.883-2299.902)	5038.928(4471.316-5572.677)
South Asia	10559.366(7077.872-15047.165)	4696.404(3097.476-7189.450)	15255.770(11193.820-20916.703)	2.870(1.865-4.034)	1.623(1.034-2.476)	2.277(1.622-2.994)	17129.464(11722.264-22385.788)	9854.511(6440.415-15396.763)	26983.976(21209.690-34535.738)
Southern Latin America	772.055(712.680-831.427)	557.813(509.472-601.195)	1329.869(1242.409-1414.303)	3.714(3.428-4.002)	2.194(2.010-2.360)	2.891(2.696-3.080)	898.580(823.713-979.152)	696.746(627.646-758.396)	1595.326(1470.702-1722.463)
North Africa and Middle East	576.288(395.102-891.636)	688.556(391.271-1052.393)	1264.844(919.955-1762.607)	0.775(0.511-1.236)	0.992(0.557-1.564)	0.890(0.619-1.243)	1480.822(1123.712-1979.645)	1646.278(1093.383-2326.661)	3127.100(2546.289-3942.006)
Southern Sub-Saharan Africa	252.603(159.745-371.035)	56.869(30.304-79.735)	309.472(202.892-432.508)	1.727(1.047-2.619)	0.363(0.185-0.510)	0.978(0.625-1.375)	521.074(372.322-661.176)	139.025(80.869-175.082)	660.099(486.340-804.298)

Table 2 (continued)

	Age-standardised rate per 100 000 population, 2021			Estimated annual percentage change, 1990-2021
	Male	Female	Total	
Global	1.929(1.662-2.255)	0.992(0.834-1.253)	1.452(1.303-1.674)	-0.498[(-0.619-(-0.378)]
Central Asia	2.848(2.390-3.392)	1.395(1.195-1.641)	2.087(1.782-2.468)	-0.799[(-1.071-(-0.527)]
Oceania	0.850(0.408-1.451)	0.382(0.195-0.632)	0.624(0.347-1.008)	-1.037[(-1.096-(-0.979)]
High-income Asia Pacific	0.678(0.616-0.756)	0.268(0.212-0.315)	0.466(0.405-0.511)	-2.650[(-2.804-(-2.495)]
Southeast Asia	2.281(1.765-3.575)	0.877(0.652-1.497)	1.555(1.244-2.284)	-0.791[(-0.864-(-0.718)]
East Asia	0.843(0.601-1.155)	0.477(0.319-0.691)	0.644(0.500-0.820)	-1.374[(-1.482-(-1.265)]
Australasia	0.922(0.816-1.033)	0.569(0.477-0.638)	0.742(0.654-0.829)	-0.804(-1.054-(-0.554)
Caribbean	1.575(1.312-1.917)	0.910(0.744-1.101)	1.234(1.062-1.435)	-0.332(-0.460-(-0.203)
Eastern Europe	8.368(7.534-9.220)	3.193(2.862-3.550)	5.599(5.151-6.066)	1.932(1.412-2.455)
Tropical Latin America	3.201(2.978-3.403)	1.670(1.494-1.797)	2.394(2.220-2.523)	0.424(0.215-0.633)
Western Sub-Saharan Africa	4.763(3.418-6.314)	1.854(0.979-2.441)	3.226(2.435-4.024)	0.103(0.059-0.146)
High-income North America	1.205(1.142-1.246)	0.725(0.648-0.764)	0.958(0.885-0.996)	-0.275(-0.568-0.018)
Central Europe	4.025(3.677-4.360)	1.595(1.447-1.754)	2.774(2.553-2.983)	-0.653[(-0.894-(-0.412)]
Andean Latin America	2.890(2.237-3.714)	1.947(1.494-2.573)	2.406(1.930-2.956)	-1.121[(-1.225-(-1.017)]
Eastern Sub-Saharan Africa	2.043(1.165-3.223)	0.304(0.156-0.517)	1.125(0.683-1.692)	-0.046(-0.110-0.019)
Central Sub-Saharan Africa	2.053(1.317-3.376)	0.219(0.124-0.449)	1.043(0.688-1.679)	-0.083(-0.189-0.024)
Western Europe	1.414(1.324-1.481)	0.769(0.652-0.833)	1.080(0.975-1.141)	-1.064[(-1.150-(-0.978)]
Central Latin America	2.515(2.210-2.839)	1.517(1.320-1.708)	1.991(1.767-2.200)	-0.011(-0.155-0.133)
South Asia	2.171(1.491-2.858)	1.301(0.857-2.026)	1.735(1.359-2.226)	-0.717[(-0.859-(-0.574)]
Southern Latin America	2.375(2.175-2.586)	1.410(1.287-1.529)	1.856(1.716-2.003)	-1.092[(-1.280-(-0.904)]
North Africa and Middle East	0.734(0.553-1.006)	0.916(0.603-1.277)	0.828(0.668-1.048)	0.000(-0.097-0.097)
Southern Sub-Saharan Africa	1.769(1.232-2.199)	0.430(0.247-0.536)	1.026(0.763-1.219)	0.315(0.112-0.517)

Table 3 DALYs of pancreatitis between 1990 and 2021 at the global and regional Level

	Number of cases, 1990			Age-standardised rate per 100 000 population, 1990			Number of cases, 2021		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Global	1735243.678(1468008.794-2083565.684)	848158.020(699236.627-1022957.562)	2583401.698(2265737.751-2985509.046)	77.253(65.283-92.183)	37.479(30.903-45.134)	57.393(50.340-66.067)	2811263.234(2455169.498-3288191.542)	1289890.732(1083719.810-1600080.192)	4101153.966(3647630.928-4684282.659)
East Asia	173614.091(131632.749-225664.253)	134003.975(84134.903-180896.339)	307618.066(251064.577-375431.444)	33.112(24.898-43.663)	26.682(16.822-36.276)	29.965(24.307-36.606)	232821.511(170595.601-317524.849)	131741.824(90244.779-189429.370)	364563.335(288980.531-468429.225)
Central Europe	106055.139(99257.498-113680.679)	51069.049(47515.924-55154.954)	157124.188(148010.726-167599.040)	157.858(147.741-168.882)	65.307(60.822-70.781)	110.934(104.626-118.220)	111118.067(101434.247-120518.440)	45851.771(41138.756-50678.133)	156969.837(143758.176-169207.603)
Central Latin America	53775.288(51439.407-56088.851)	27557.703(26000.846-29229.239)	81332.991(78107.415-84574.628)	92.545(88.612-96.477)	46.831(44.366-49.696)	69.088(66.369-71.830)	110926.089(98359.174-124353.191)	62724.210(54866.051-71124.055)	173650.299(155449.621-192013.162)
Oceania	1096.693(498.840-1851.705)	407.024(174.610-622.013)	1503.717(746.580-2371.344)	44.320(20.412-74.269)	18.105(7.883-27.091)	31.698(15.773-49.262)	2069.841(1043.999-3361.228)	659.264(368.179-1008.347)	2729.105(1571.067-4236.672)
Tropical Latin America	71498.295(68596.617-74463.039)	26061.147(24605.599-27822.245)	97559.442(93261.615-102039.125)	120.446(115.418-125.855)	44.309(41.722-47.417)	81.315(77.772-85.065)	132917.330(124099.326-141755.608)	66429.984(61224.580-71820.037)	199347.315(187796.216-212703.162)
High-income North America	66445.786(61167.302-74108.246)	47972.772(41643.543-56036.902)	114418.558(102881.920-130219.944)	44.444(40.858-49.587)	26.841(23.394-31.635)	35.200(31.632-40.185)	100901.127(93718.161-110110.652)	68856.778(60128.902-79030.690)	169757.905(154651.476-189505.176)
High-income Asia Pacific	42974.053(35919.774-50753.806)	18163.890(15246.875-21776.942)	61137.943(51954.640-72205.276)	45.816(38.473-53.723)	17.357(14.504-20.922)	31.004(26.331-36.664)	38366.055(32291.201-46724.986)	17669.270(14044.440-21218.696)	56035.325(46990.665-67531.058)
Central Asia	29637.144(25309.699-33743.871)	15939.417(13550.383-18639.146)	45576.561(39445.788-51890.926)	116.555(99.026-133.152)	54.750(46.375-64.056)	84.579(72.978-96.023)	50127.287(41945.765-60585.369)	22692.082(18501.894-27760.443)	72819.370(61133.279-87132.566)
South-east Asia	144879.841(101652.460-206821.577)	44856.691(29422.965-65462.359)	189736.532(142679.474-256437.807)	87.675(60.323-124.403)	29.725(18.444-43.375)	57.922(43.513-77.537)	262602.007(201604.476-400394.807)	70253.069(53461.309-118649.763)	332855.077(262388.476-492343.615)
Eastern Europe	236594.501(204814.524-285326.782)	134264.363(108116.709-171985.667)	370858.864(314474.802-452708.657)	203.928(176.557-245.688)	86.528(70.242-109.644)	141.992(120.598-173.320)	459040.871(402083.477-527794.413)	215958.725(179958.830-262969.326)	674999.596(591616.765-781577.207)
Eastern Sub-Saharan Africa	34016.956(21094.338-52531.444)	5113.046(3236.421-8281.983)	39130.002(25451.131-58303.382)	65.906(40.060-103.535)	9.906(5.924-15.798)	37.450(23.927-56.737)	86814.782(50449.282-129897.358)	12519.580(7582.243-18338.745)	99334.362(61288.689-143914.410)
Caribbean	8723.908(7541.819-10136.843)	4975.369(4114.512-5991.228)	13699.277(12061.399-15362.018)	60.955(52.947-70.735)	32.884(27.550-39.492)	46.595(41.153-52.255)	13871.132(11477.169-17025.996)	7718.538(6237.059-9888.399)	21589.669(18437.617-25130.896)
Southern Latin America	24648.215(22804.918-26785.795)	16547.513(15209.430-17874.850)	41195.728(38641.152-44061.272)	112.180(103.866-121.797)	65.459(60.151-70.745)	87.429(81.936-93.413)	26328.818(24233.895-28591.154)	17928.034(16370.404-19430.564)	44256.851(41033.217-47795.393)
Australasia	3817.067(3500.823-4203.264)	2397.478(2157.671-2682.202)	6214.545(5689.955-6814.294)	35.819(32.917-39.365)	19.305(17.318-21.733)	27.281(24.976-29.999)	5717.960(4969.566-6519.409)	3707.127(3128.809-4248.810)	9425.087(8239.654-10729.202)

Table 3 (continued)

	Number of cases, 1990			Age-standardised rate per 100 000 population, 1990			Number of cases, 2021		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
North Africa and Middle East	21656.625(15639.381-30765.653)	21164.408(14238.947-30938.985)	42821.034(32610.215-55535.802)	21.051(14.832-30.533)	22.886(14.855-33.820)	22.036(16.301-29.269)	50393.730(39414.033-65408.135)	43850.008(31890.625-57903.955)	94243.738(76403.529-115152.090)
Central Sub-Saharan Africa	10742.908(6559.365-18275.380)	1242.964(697.007-2045.968)	11985.871(7751.725-19870.738)	68.569(41.160-115.472)	7.466(4.227-12.512)	36.569(23.563-59.797)	28421.932(18033.592-47865.506)	3263.579(2068.103-5236.458)	31685.511(20957.199-51189.563)
South Asia	446131.261(312101.028-640800.339)	175685.332(119091.728-272277.892)	621816.594(470132.388-853166.560)	104.030(71.337-147.360)	49.251(33.124-73.853)	77.905(58.091-105.991)	664423.717(468569.808-850914.461)	327086.092(216969.657-499402.242)	991509.809(780478.422-1238906.421)
Western Sub-Saharan Africa	96317.867(63046.242-159939.643)	23772.973(13948.771-36888.968)	120090.840(88444.486-177063.862)	156.426(103.535-258.156)	49.507(29.037-76.341)	105.450(78.247-153.132)	246209.540(177280.076-336113.203)	63690.241(34685.770-83483.974)	309899.781(229727.463-399293.046)
Western Europe	133635.406(127184.222-140870.788)	81780.299(75678.937-87124.599)	215415.705(204741.547-226424.534)	59.364(56.546-62.537)	26.922(25.128-28.819)	42.555(40.498-44.782)	138134.136(128502.798-147567.785)	85037.447(73424.091-92686.910)	223171.583(203349.365-239445.061)
Andean Latin America	18132.318(14448.623-22399.809)	12886.297(9022.619-17454.169)	31018.615(25113.974-38242.967)	132.404(104.676-163.988)	89.468(63.959-122.662)	110.593(88.966-135.811)	28458.280(21935.603-36379.262)	17393.851(13205.522-23011.473)	45852.130(36993.098-56197.760)
Southern Sub-Saharan Africa	10850.313(7266.979-15114.558)	2296.312(1536.223-3087.997)	13146.625(9380.405-17494.659)	62.572(40.780-89.441)	12.287(8.127-16.588)	35.725(25.149-48.283)	21599.022(15957.293-27575.698)	4859.259(3196.321-6233.907)	26458.281(20649.362-32801.130)

Table 3 (continued)

	Age-standardised rate per 100 000 population, 2021			Estimated annual percentage change, 1990-2021
	Male	Female	Total	
Global	67.825(59.273-79.396)	29.184(24.412-36.180)	48.425(43.071-55.347)	-0.609[(-0.733-(-0.485)]
East Asia	24.397(17.928-33.333)	12.821(8.771-18.267)	18.530(14.765-23.877)	-1.584[(-1.643-(-1.526)]
Central Europe	141.089(129.208-152.996)	43.302(38.830-48.080)	91.751(84.243-99.201)	-0.930[(-1.146-(-0.713)]
Central Latin America	88.711(78.592-99.395)	45.787(40.074-51.838)	66.281(59.334-73.211)	-0.153(-0.326-0.021)
Oceania	34.903(17.626-56.532)	13.026(7.199-20.369)	24.162(13.854-37.522)	-1.017[(-1.099-(-0.935)]
Tropical Latin America	108.078(100.863-115.171)	48.472(44.706-52.393)	76.984(72.487-82.141)	0.055(-0.134-0.244)
High-income North America	41.430(38.630-45.105)	24.202(21.402-27.814)	32.642(29.903-36.141)	-0.361[(-0.578-(-0.144)]
High-income Asia Pacific	25.351(21.080-31.290)	8.517(6.892-10.683)	16.874(13.989-20.805)	-2.191[(-2.336-(-2.046)]
Central Asia	109.040(91.176-131.388)	47.040(38.576-57.333)	77.136(64.951-91.960)	-0.773[(-1.054-(-0.492)]
Southeast Asia	74.284(57.087-112.910)	20.452(15.502-34.530)	46.901(37.209-69.304)	-0.788[(-0.846-(-0.729)]
Eastern Europe	365.710(322.449-422.578)	127.987(107.175-155.486)	240.990(211.597-278.397)	1.410(0.845-1.977)
Eastern Sub-Saharan Africa	67.921(39.442-103.496)	9.948(5.810-14.991)	37.881(23.337-55.315)	0.045(-0.015-0.106)
Caribbean	55.298(45.766-68.057)	28.428(22.832-36.678)	41.551(35.440-48.382)	-0.266[(-0.363-(-0.169)]
Southern Latin America	69.712(64.141-75.788)	40.736(37.332-44.214)	54.401(50.549-58.843)	-1.221[(-1.433-(-1.008)]
Australasia	26.216(22.809-29.913)	14.196(12.126-16.484)	20.073(17.494-22.936)	-0.864[(-1.099-(-0.628)]
North Africa and Middle East	19.302(15.147-25.100)	19.455(13.916-26.290)	19.470(15.963-23.836)	-0.280[(-0.327-(-0.233)]
Central Sub-Saharan Africa	67.385(43.141-111.715)	7.637(4.869-13.221)	35.979(24.090-57.303)	0.052(-0.053-0.157)
South Asia	75.330(53.172-96.680)	39.020(25.987-59.814)	57.300(45.143-71.838)	-0.891[(-1.010-(-0.773)]
Western Sub-Saharan Africa	167.897(121.897-225.932)	51.181(27.776-66.728)	106.593(79.032-135.712)	0.048(-0.003-0.099)
Western Europe	40.636(37.906-43.583)	18.492(16.578-20.353)	29.351(27.268-31.803)	-1.231[(-1.309-(-1.152)]
Andean Latin America	90.897(70.233-115.869)	53.877(40.953-71.139)	72.010(58.385-88.307)	-1.497[(-1.612-(-1.382)]
Southern Sub-Saharan Africa	62.670(46.080-78.505)	13.348(8.642-17.028)	36.351(28.096-44.202)	0.190(-0.043-0.424)

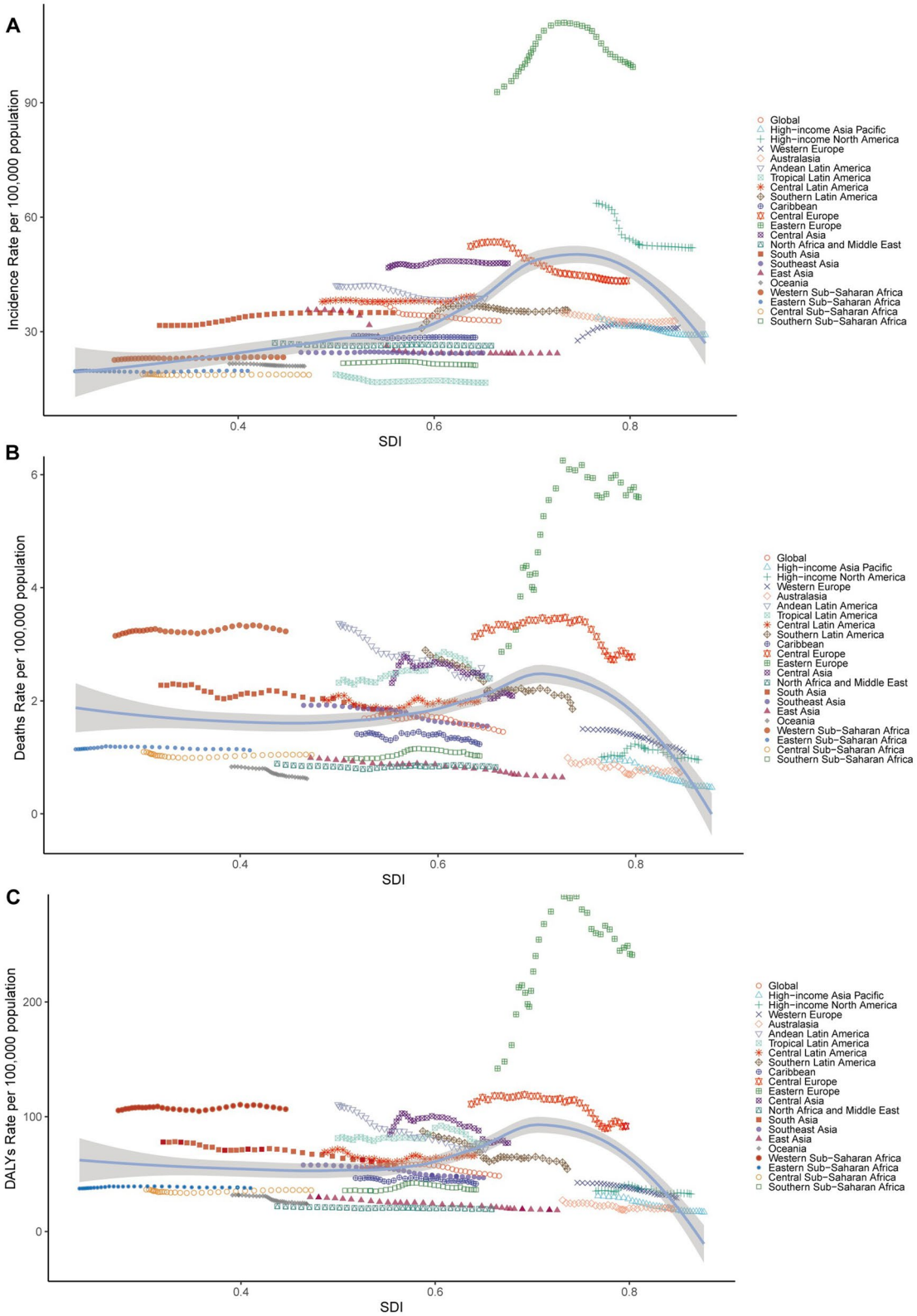

Fig. 4 Relationship between the socio-demographic index (SDI) and pancreatitis burden in terms of (**A**) age-standardized incidence rate (ASIR), (**B**) age-standardized mortality rate (ASMR), and (**C**) age-standardized disability-adjusted life year rate (ASDR) in 2021. Each point represents a region with trends showing the correlation between SDI and the respective rates

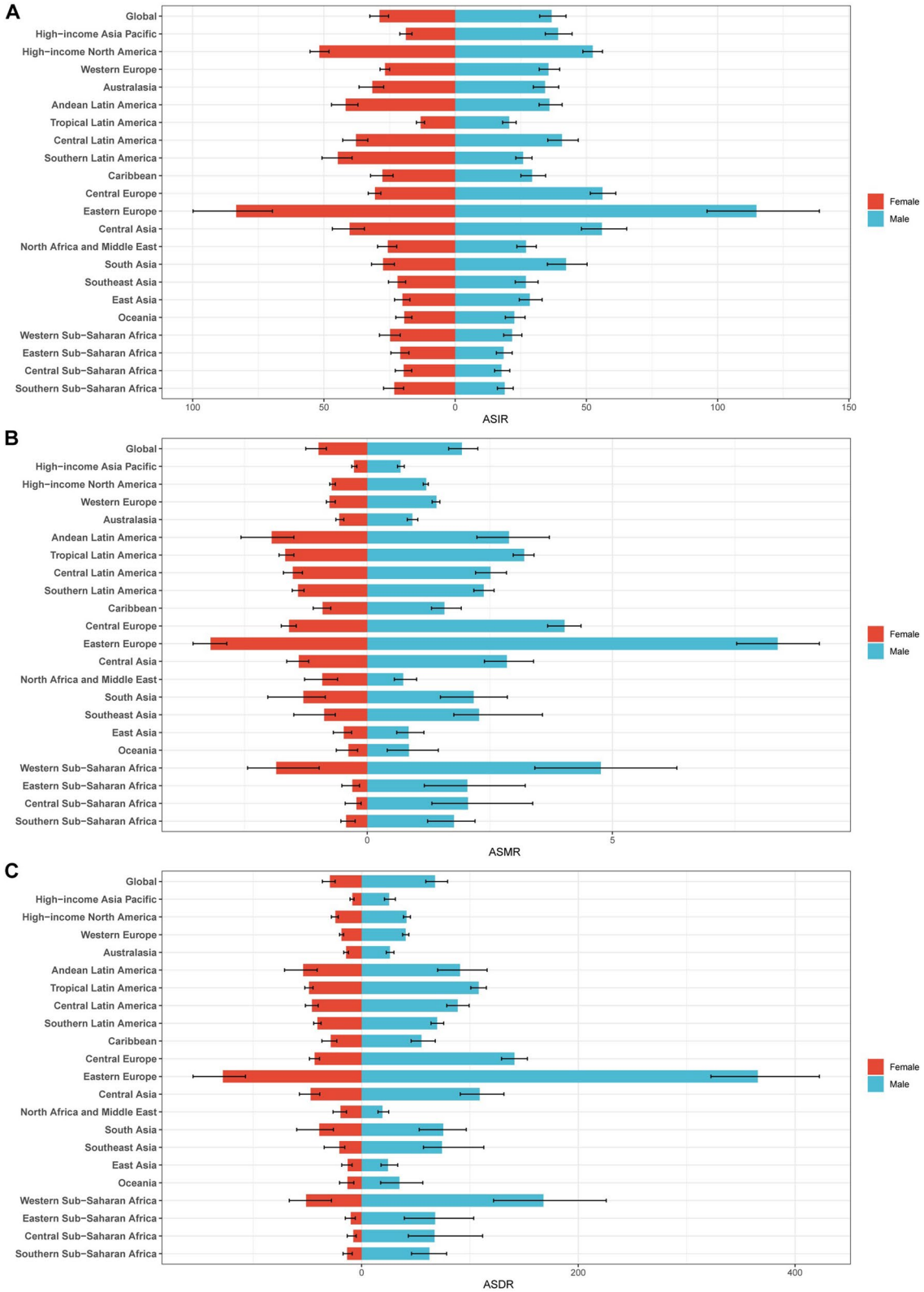

Fig. 5 Gender disparities in the global and regional burden of pancreatitis in 2021. **A** Age-standardized incidence rate (ASIR), **B** Age-standardized mortality rate (ASMR), and (**C**) Age-standardized disability-adjusted life year rate (ASDR) by sex across various regions

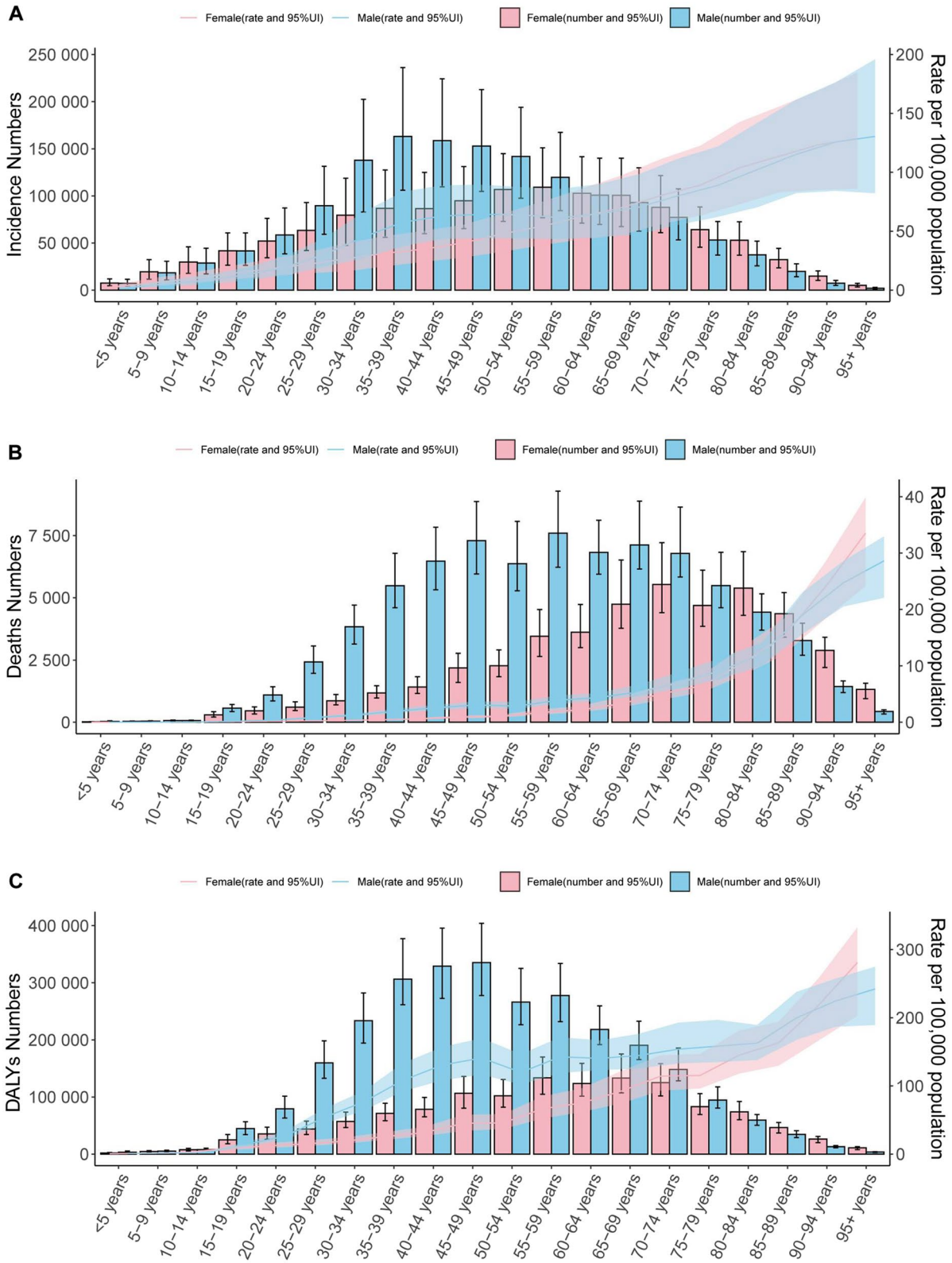

Fig. 6 Age and sex distribution of pancreatitis burden in 2021. **A** Incidence numbers and rates per 100,000 population, **B** Death numbers and rates, and (**C**) DALYs numbers and rates by age groups for males and females. Pink bars represent female data, blue bars represent male data, and lines with shaded areas show the rates per 100,000 population with 95% uncertainty intervals (UI)

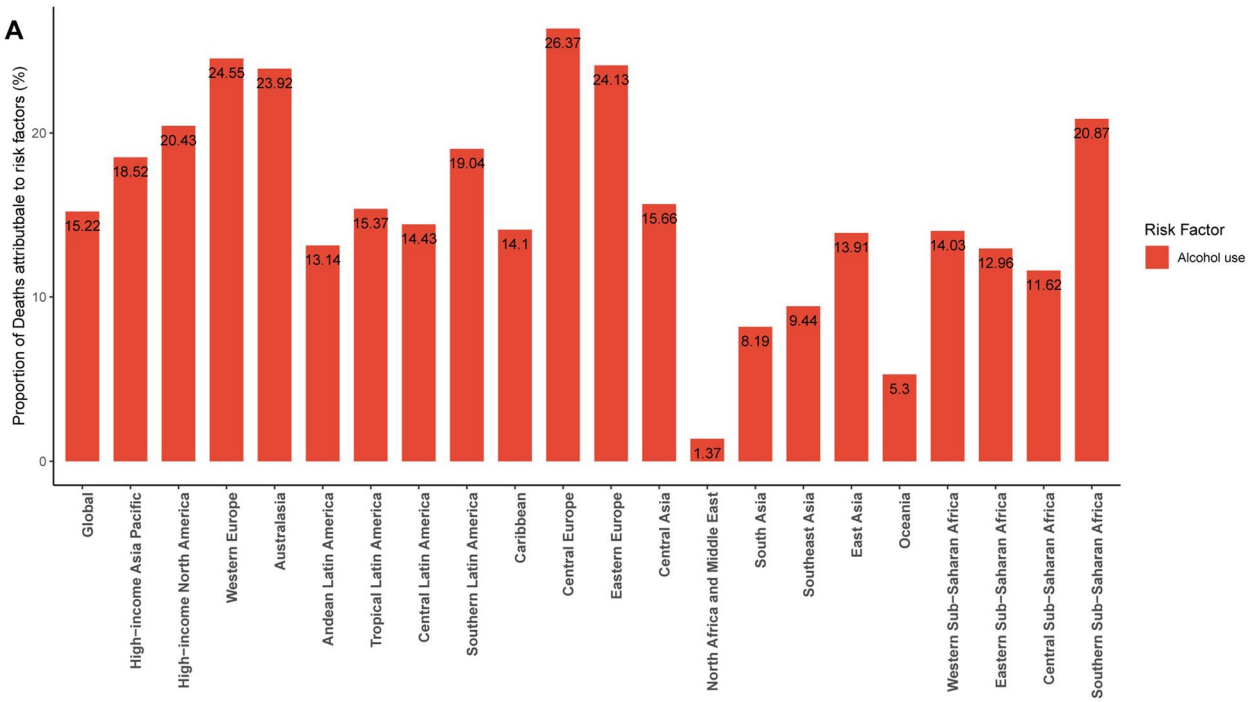

Fig. 7 Proportion of pancreatitis-related deaths attributable to alcohol use by region in 2021

Study 2021. Our findings indicate a substantial increase in the absolute number of pancreatitis cases and deaths from 1990 to 2021, yet age-standardized incidence, mortality, and DALYs rates have demonstrated a slight overall decline. These trends suggest that while pancreatitis continues to impose a significant global health burden, advancements in prevention, diagnosis, and management have likely contributed to improving outcomes over time.

A notable finding of this study is the pronounced regional disparities in pancreatitis burden. Eastern Europe consistently exhibited the highest ASIR, ASMR, and ASDR rates, emphasizing the need for targeted public health interventions. Similarly, Roberts et al. reported that the incidence of acute pancreatitis in 17 European countries varied between 4.6 and 100 per 100,000 population, with the highest rates observed in Eastern Europe [24]. This region's high burden may be attributed to the elevated prevalence of alcohol consumption [24], which accounted for a substantial proportion of pancreatitis-related deaths. In contrast, regions like Tropical Latin America and parts of Sub-Saharan Africa exhibited relatively low rates, possibly reflecting differing etiological factors. Additionally, limited healthcare access and diagnostic capabilities in these resource-constrained regions can lead to underdiagnosis or misdiagnosis of pancreatitis, resulting in lower reported rates [25, 26].

Our study highlights significant socioeconomic and gender disparities in pancreatitis burden. ASIR was positively correlated with the SDI, indicating a higher burden in more socioeconomically developed regions. In contrast, mortality and DALY rates showed negative correlations with SDI, suggesting better healthcare access and management in higher SDI regions, leading to improved survival outcomes despite higher incidence. Gender disparities were also prominent, with males consistently exhibiting higher ASIR, ASMR, and ASDR than females across all regions and age groups. These findings align with the known higher prevalence of pancreatitis risk factors such as alcohol use and smoking among males [27, 28], underscoring the importance of gender-specific prevention strategies.

Alcohol use remains a leading modifiable risk factor for pancreatitis, accounting for over 15% of global deaths. Alcohol induces pancreatitis through several mechanisms: it directly damages pancreatic cells through toxic metabolites such as acetaldehyde, increases intracellular calcium levels, and activates proteases, which lead to cellular damage [29, 30]. Additionally, alcohol disrupts normal pancreatic secretions, leading to the formation of protein-rich plugs that obstruct ducts, resulting in self-digestion of pancreatic tissue [31]. Alcohol also induces oxidative stress by generating reactive oxygen species (ROS), further exacerbating pancreatic cell injury [32, 33]. This proportion was even higher in European regions, highlighting the critical role of alcohol control policies in mitigating the disease burden. Beyond alcohol,

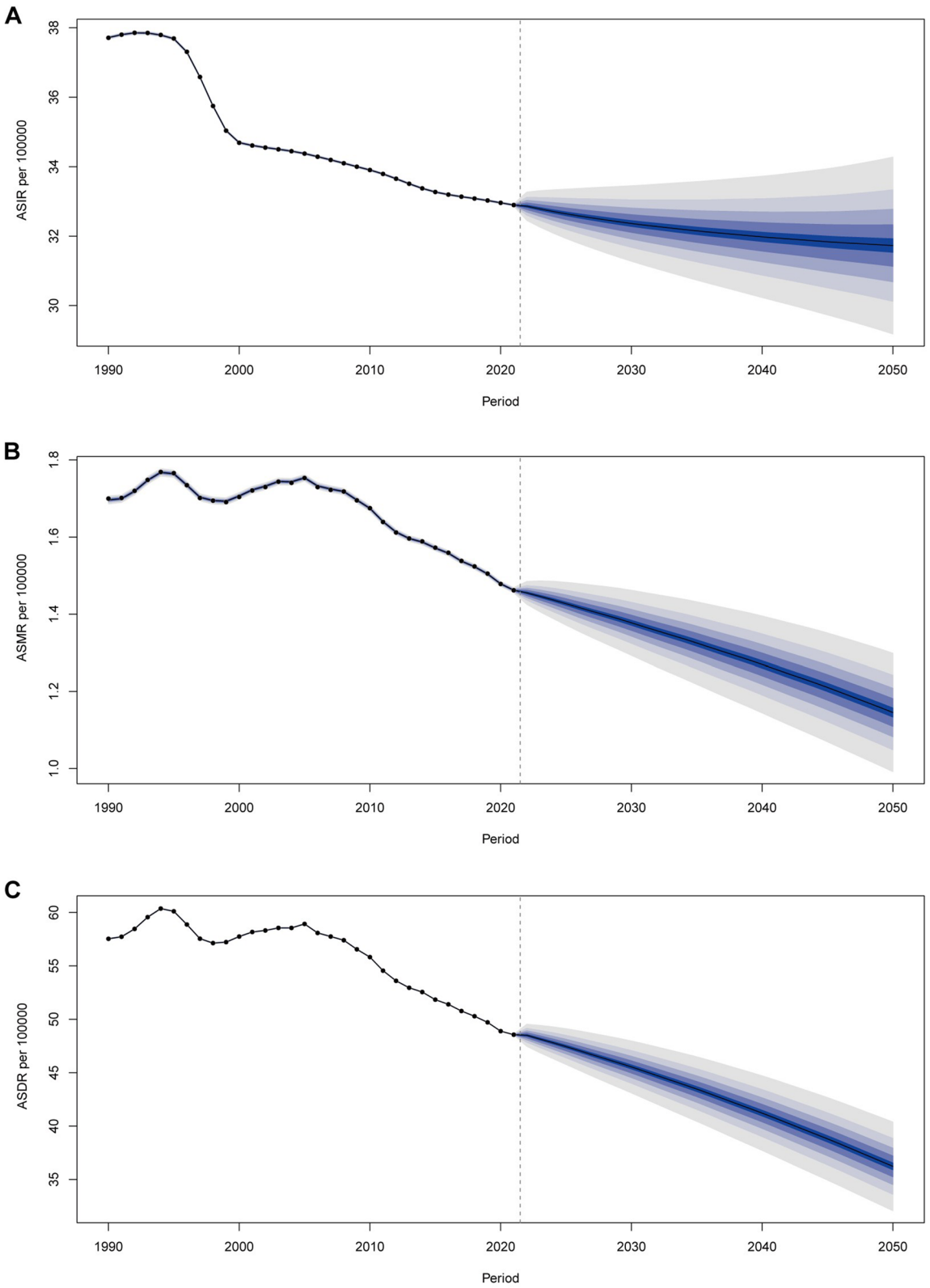

Fig. 8 Historical trends and future projections of pancreatitis burden from 1990 to 2050. **A** Age-standardized incidence rate (ASIR), **B** Age-standardized mortality rate (ASMR), and (**C**) Age-standardized disability-adjusted life year rate (ASDR) per 100,000 population

other significant contributors include gallstone disease, smoking, and metabolic disorders such as hypertriglyceridemia [2]. Addressing these risk factors through public health initiatives and targeted interventions could substantially reduce pancreatitis incidence and improve patient outcomes globally.

Our BAPC model projects a continued decline in ASIR, ASMR, and ASDR through 2050, reflecting ongoing improvements in disease management and preventive measures. However, the increasing absolute numbers of cases and deaths due to population growth and aging highlight the need for sustained efforts to enhance pancreatitis care [34]. Specifically, regions with a high burden, such as Eastern Europe, might benefit from focused strategies that address regional risk profiles, improve healthcare access, and promote early intervention.

This study is the first to utilize the latest GBD 2021 database to analyze temporal trends in pancreatitis, providing valuable insights into the evolving burden of pancreatitis and serves as a scientific basis for enhancing global prevention and control measures. However, several limitations must be acknowledged. This study has several limitations. First, the data used were sourced from the Global Burden of Disease Study, which relies on national health records that may vary in accuracy and completeness across different regions. This could result in underreporting or misclassification, particularly in low-resource settings. Second, The GBD study does not differentiate between acute and chronic pancreatitis in its data collection and modeling. Although separate ICD-10 codes exist for acute (K85) and chronic (K86) pancreatitis, the GBD aggregates data for these conditions, making it difficult to distinguish between primary acute pancreatitis and acute exacerbations of chronic pancreatitis. Third, as our analysis is based on population-level data, we were unable to include individual patient data such as detailed clinical information, comorbidities, or treatment outcomes. Additionally, the projections made to 2050 are based on historical trends and may not account for future changes in healthcare policies, emerging interventions, or unforeseen risk factors. Finally, while major risk factors such as alcohol consumption and smoking were considered, other potential risk factors or regional variations may not have been fully captured due to data constraints. Overcoming these limitations will enable the development of more accurate and impactful strategies to address pancreatitis on a global scale.

Conclusion

Despite improvements in disease management, the global burden of pancreatitis continues to rise in absolute numbers, with significant regional and gender disparities. Our study, utilizing GBD 2021 data, highlights the need for targeted prevention and control strategies, particularly in high-burden regions such as Eastern Europe. Furthermore, projections to 2050 underscore the importance of sustained public health efforts to mitigate future increases in pancreatitis-related morbidity and mortality. By addressing key modifiable risk factors and improving healthcare access, we can better manage and reduce the global impact of pancreatitis.

Abbreviations

ASIR	Age-Standardized Incidence Rate
ASMR	Age-Standardized Mortality Rate
ASDR	Age-standardized disability-adjusted life year rate
DALYs	Disability-Adjusted Life Years
GBD	Global Burden of Disease
SDI	Socio-Demographic Index
EAPC	Estimated Annual Percentage Change
BAPC	Bayesian Age-Period-Cohort Model
INLA	Integrated Nested Laplace Approximations
UI	Uncertainty Interval

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Authors' contributions

LTY collected the data, performed statistical analysis, and drafted the original manuscript. QC, ZBB, LZR, ZYT all made important revisions to this manuscript. WWB and LC designed this study and revised the manuscript. All authors read and approved the final version of the manuscript.

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Data availability

The datasets used during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This was a retrospective, observational cohort study; therefore, the requirement for informed consent was waived by the Peking Union Medical College Hospital in China.

Consent for publication

Not Applicable.

Competing Interests

The authors declare no competing interests.

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