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Global burden of cancer and associated risk factors in 204 countries and territories, 1980–2021: a systematic analysis for the GBD 2021

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Abstract

Background Cancer is the second most common cause of death globally. Therefore, it is imperative to investigate cancer incidence, mortality rates, and disability-adjusted life years (DALYs) to enhance preventive measures and healthcare resource allocation. This study aimed to assess cancer burden and associated risk factors in 204 countries and territories between 1980 and 2021.

Methods We selected data on cancer incidence and mortality rates and associated risk factors from the global burden of disease (GBD) study tool for 204 countries and territories from 1990 to 2021 and 1980 to 2021. We estimated the age-standardized incidence (ASIR) and age-standardized deaths (ASDR) of 34 cancer types categorized as level 3 causes based on the GBD hierarchy.

Results In 2021, cancer accounted for 14.57% (95% uncertainty interval: 13.65–15.28) of total deaths and 8.8% (7.99–9.67) of total DALYs in both sexes globally. ASIR and ASDR were 790.33 (694.43–893.01) and 116.49 (107.28–124.69), respectively. Additionally, females exhibited higher ASIR than males (923.44 versus 673.09), while males exhibited higher ASDR than females (145.69 versus 93.60). This indicates that policymakers should focus on the importance of gender equality in healthcare. Non-melanoma skin cancer exhibited the highest ASIR (74.10) in both sexes, while digestive cancers accounted for 39.29% of all cancer-related deaths, and Asia exhibited the heaviest cancer burden. In females, breast cancer exhibited the highest ASIR (46.40) and ASDR (14.55). In males, tracheal, bronchial, and lung cancer exhibited the highest ASIR (37.85) and ASDR (34.32), highlighting the urgent need for targeted tobacco control measures. Different cancers in various countries exhibit unique characteristics. Therefore, policymakers should formulate specific prevention and control strategies that reflect the cancer in their country. Tobacco was the primary level 2 risk factor for cancer DALYs in males. It accounted for 29.32% (25.32–33.14) of all cancer DALYs. Dietary risks, alcohol consumption, and air pollution accounted for 5.89% (2.01–10.73), 5.48% (4.83–6.11), and 4.30% (2.77–5.95) of male cancer DALYs, respectively. Therefore, policymakers should prioritize smoking regulation and other carcinogenic risks.

Conclusion Cancer is a significant public health concern globally. Understanding the common etiologies of different cancers is essential for developing effective control strategies and targeted interventions.

Keywords Cancer, Global, GBD, Incidence, Mortality

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Introduction

Cancer is the second leading cause of death globally, and the global cancer burden is expected to increase over the next two decades[1]. In 2022, there were approximately 20 million new cancer cases, including non-melanoma skin cancers (NMSC), and 9.7 million cancer-related deaths, including NMSC[2]. Efforts must encompass comprehensive assessments of cancer burden, including incidence and mortality rates and disability-adjusted life years (DALYs), particularly between developing and developed countries. The aging global population, combined with the prevalence of unhealthy lifestyles and environmental changes, has contributed to an increase in cancer incidence, particularly in low- and middle-income countries. Cancer epidemiological studies are essential for developing government health policies because they provide crucial data for identifying cancer risk factors, management at the population level, formulation of cancer screening policies, and allocation of resources for cancer prevention[3,4].

Although some cancer cases may be inevitable, governments can establish policies that can reduce population-level exposure to recognized cancer risk factors, including smoking, overweight, obesity, and infections. Epidemiological data and variations in cancer types differ across global regions. In 2022, Asia accounted for approximately 50% of all cancer cases (49.2%) and the highest cancer-related deaths (56.1%), while Europe accounted for approximately 25% of global cancer cases (22.4%) and 20.4% of cancer-related deaths[2]. In countries with higher human development index (HDI), lung, prostate, and colorectal cancers have the highest incidence among men, while in countries with lower HDI, prostate, lung, and lip and oral cavity cancers have the highest incidences[2]. A previous study reported that prostate cancer is the most common cancer among men in 40 sub-Saharan African countries. Women have a 14.1% risk of developing cancer by the age of 75 in Sub-Saharan Africa, with breast and cervical cancers accounting for 50% of this risk at 4.1% and 3.5%, respectively[5]. In 2020, the overall risk of cancer-related death among women in Africa was similar to the risks observed in women in Northern America and the wealthiest European countries[6]. Consequently, comprehensive assessments of cancer burden will provide valuable insights for improving the global cancer quality control management system. After the COVID-19 pandemic, patients with cancer seem to experience worsened symptoms and an increased risk of death than others[7]. Therefore, assessing the trend of cancer incidence and mortality rates after the pandemic is imperative for formulating cancer control strategies.

The Global Burden of Diseases (GBD), Injuries, and Risk Factors Study 2021 (GBD 2021) framework facilitates a standardized assessment of cancer burden across various locations and timeframes, focusing on cancer incidence, mortality, and DALYs. The GBD study categorizes age into 5-year intervals and considers the long-term impact of specific disorders globally across various countries and regions. GBD 2021 revealed the proportion of cancer burden attributed to modifiable risk factors and the temporal changes in these percentages[8]. Primary and secondary preventive measures should be implemented to reduce cancer incidence and mortality while enhancing patient survival rates. Compared to GBD 2019, GBD 2021, for the first time, estimated the onset of cancer mortality from 1980, providing more data for analyzing the dynamic changes of cancer. This study utilized data from GBD 2021 to estimate the incidence, mortality, and contribution of risk factors from 1990/1980 to 2021 in 204 countries and territories to inform policy development and improve cancer prevention initiatives.

Materials and methods

GBD source

This general framework for the GBD 2021 cancer estimation included all malignant cancers except for non-melanoma skin cancer (basal cell carcinoma and squamous cell carcinoma), benign and in situ cancer (intestinal, cervical, uterine, and other benign cancers), and myelodysplastic, myeloproliferative, and other hemopoietic cancers. According to the International Classification of Diseases (ICD), the different types of cancer are categorized into 34 categories. The cancer incidence data were collected from a single cancer registry, Nordic cancer registries, or a combined database of cancer registries, including cancer incidence in five continents, surveillance, epidemiology, and outcomes. This analysis depends on current epidemiological data and improved standardized methods. The data are accessible through the Global Health Data Exchange query tool (http://ghdx.healthdata.org/gbd-results-tool), categorized by region, gender, country, and risk factors. Additionally, GBD 2021 calculated essential statistics for 23 different age categories ranging from birth to ≥ 95 years, collectively covering males, females, and all genders. Data were collected for 204 countries and territories, categorized into 21 regions and seven super-regions. We selected neoplasm data on incidence, mortality, and associated risk factors from the GBD study tool for 204 countries and territories from 1990 to 2021 and 1980 to 2021. We estimated the age-standardized incidence rate (ASIR) and age-standardized death rate (ASDR) of 34 cancer types categorized as level 3 causes in the GBD hierarchy. For GBD 2021, incidence, prevalence, and disability were assessed for all cancers and benign cancer as classified in ICD-10 (C00–D49). Cancer incidence is directly derived from mortality estimates using mortality-to-incidence ratios (MIRs). The current GBD cancer mortality and MIR estimates are based on the methodology described in the latest GBD study, with additional information accessible elsewhere; a concise overview is provided below[9–11].

Estimates

The GBD 2021 collaborators modeled incidence and mortality estimates for male and female individuals across all age groups. The cause-of-death ensemble model was utilized to estimate cause-specific mortality for each combination of sex, age, location, and year. The GBD team developed the DisMod-MR software (version 2.1), a Bayesian meta-regression tool, to perform incidence estimations through an analytical cascade process. Before the modeling, data points and biases were adjusted by (1) disaggregating data that were not previously disaggregated by age and sex distribution and (2) applying a meta-regression—Bayesian, regularized, trimmed model to compare study designs and case definitions directly. Information regarding bias correction and other modifications implemented for each specific disorder is available in the GBD 2021 capstone report12. DALYs, a summary measure of overall health loss, were calculated by adding years of life lost (YLLs) and years lived with disability (YLDs) for each etiology. YLLs were calculated by multiplying the number of deaths associated with specific causes by the remaining life expectancy at the time of death, based on a standard life expectancy. The GBD 2021 database of mortality causes included data from various sources, including vital registration, verbal autopsy, cancer registries, police records, sibling histories, surveillance, and survey or census data collected since 1980. Accordingly, we estimated the burden of DALYs attributed to risk factors in 2021. The GBD comparative risk assessment (CRA) framework was employed to assess the exposure of risk factors associated with digestive diseases and their consequent disease burden. The CRA comprised seven primary interrelated methodological components. The effect size was initially estimated by quantifying the relative risk (RR) of the designated health outcome of exposure to the identified risk factor. The population-attributable fraction of YLL and YLDs was calculated for each risk factor by considering the distribution of exposures across different ages, genders, locations, and years and the RR associated with each level of exposure. The sociodemographic index (SDI) was used to demonstrate variations in cancer burden attributed to different levels of socioeconomic development. It was determined by factors including the total fertility rate in women below 25 years, income per capita distribution over time, and average education levels for individuals aged ≥ 15 years13. The index ranged from 0 (low SDI) to 100 (high SDI), classifying countries in 2021 into five groups based on quintiles: low, low-middle, middle, high-middle, and high SDI.

Statistical analysis

Based on the GBD framework, 95% uncertainty intervals (UIs) for all estimates were calculated by averaging the data from 1,000 draws, with the lower and upper bounds of the 95% UIs established by the 25th and 975th ranked values among all 1,000 draws. R software (version 4.2.3) was used for data analysis. This study utilized data from the GBD study, which was approved by the Institutional Review Board of the University of Washington and is publicly accessible. The GBD study analyses adhered to the Guidelines for Accurate and Transparent Health Estimates Reporting13.

Results

The burden of cancers in the global

In 2021, cancer accounted for 14.57% (95% UI, 13.65–15.28) of total mortality and 8.8% (7.99–9.67) of total DALYs across both sexes globally. During the same period, the ASIR and ASDR were 790.33 (694.43–893.01) and 116.49 (107.28–124.69), respectively (Table 1). Figure 1 depicts the disparities in the incidence rates and proportion of cancer cases between males and females. In 2021, females exhibited a higher ASIR than males (923.44 versus 673.09), while males exhibited a higher ASDR than females (145.69 versus 93.60). In both sexes, non-melanoma skin cancer exhibited the highest ASIR (74.10), followed by tracheal, bronchial, and lung (TBL) cancer (26.43), colon and rectal cancer (25.61), breast cancer (24.56), prostate cancer (15.37), and stomach cancer (14.33). TBL cancer exhibited the highest ASDR (23.50), followed by colon and rectal cancer (12.40), stomach cancer (11.20), breast cancer (7.90), and esophageal cancer (6.25). In females, breast cancer exhibited the highest ASIR (46.40) and ASDR (14.55). In males, TBL cancer exhibited the highest ASIR (37.85) and ASDR (34.32). Digestive cancer accounted for 39.29% of all cancer-related deaths (Figure S1).

Age-related sex-specific patterns exhibited some variation. Between 1990 and 2021, females exhibited a higher cancer incidence and ASIR than males, and ASIR demonstrated a stable trend. Between 1980 and 2021, males exhibited a higher rate of cancer deaths and ASDR than females, and ASDR demonstrated a decreased trend. The ASDR of cancer decreased by approximately 24.81% in males and 24.47% in females in the past 40 years globally (Fig. 2). In 2021, breast cancer accounted for 5.28% of all cancer incidence and 15.29% of cancer-related deaths in

Table 1 The all age incidence/death cases and age-standardized incidence/death rate of both sexes neoplasms in global

	1990		2021		1980		2021	
Type of neoplasms	All age incidence cases No. (95% UI)	Age-standardized incidence rate per 100,000 (95% UI)	All age incidence cases No. (95% UI)	Age-standardized incidence rate per 100,000 (95% UI)	All age death cases No. (95% UI)	Age-standardized death rate per 100,000 (95% UI)	All age death cases No. (95% UI)	Age-standardized death rate per 100,000 (95% UI)
Neoplasms	34,774,679.41 (30,034,912.81,40,425,534.96)	758.26 (658.68,869.22)	66,479,607.27 (58,335,731.4,74,980,442.95)	790.33 (694.43,893.01)	4,796,347.41 (4,549,260.7,5,084,876.75)	153.52 (145.3,162.15)	9,888,413.46 (9,124,879.13,10,585,373.15)	116.49 (107.28,124.69)
Bladder cancer	260,141.8 (242,823.27,272,206.57)	6.9 (6.46,7.23)	540,309.73 (494,720.89,582,579.44)	6.35 (5.8,6.85)	98,391.26 (90,284.72,105,045.92)	3.59 (3.31,3.82)	221,888.32 (200,567.17,242,326.46)	2.68 (2.42,2.93)
Brain and central nervous system cancer	173,086.44 (147,452.47,194,951.22)	3.75 (3.21,4.21)	357,482.3 (310,456.68,407,432.57)	4.28 (3.71,4.88)	106,990.82 (89,747.36,126,261.59)	2.89 (2.45,3.35)	258,626.8 (222,185.21,296,133.94)	3.06 (2.62,3.5)
Breast cancer	875,657.23 (834,228.9,910,528.91)	21.38 (20.27,22.22)	2,121,564.32 (1,982,142.64,2,268,722.63)	24.56 (22.93,26.26)	281,432.61 (265,487.27,297,309.39)	9.08 (8.53,9.56)	674,199.41 (623,371.55,720,822.55)	7.9 (7.27,8.44)
Cervical cancer	409,548.49 (383,207.24,438,505.58)	9.25 (8.65,9.91)	667,426.4 (613,030.09,726,422.07)	7.79 (7.16,8.48)	199,543.83 (182,793.46,224,433.73)	5.96 (5.48,6.69)	296,667.24 (272,058.62,321,905.72)	3.44 (3.16,3.73)
Colon and rectum cancer	916,583.53 (866,238.31,951,894.97)	24.04 (22.54,25.01)	2,194,143.25 (2,001,271.82,2,359,390.09)	25.61 (23.32,27.52)	462,372.65 (420,618.76,499,011.02)	16.03 (14.7,17.27)	1,044,072.21 (950,187.61,1,120,169.34)	12.4 (11.24,13.31)
Esophageal cancer	354,730.82 (317,512.39,388,914.46)	8.86 (7.96,9.69)	576,529.28 (509,492.07,645,648.46)	6.65 (5.88,7.45)	299,718.68 (260,955.36,341,533.62)	9.5 (8.3,10.78)	538,601.91 (475,943.98,603,405.55)	6.25 (5.53,7)
Eye cancer	18,002.21 (14,772.09,21,233.11)	0.4 (0.33,0.47)	33,950.77 (26,532.91,39,857.27)	0.42 (0.33,0.5)	6656.88 (5145.73,7857.55)	0.18 (0.14,0.2)	10,432.79 (8013.52,12,230.91)	0.13 (0.1,0.16)
Gallbladder and biliary tract cancer	107,797.75 (96,890.17,117,511.81)	2.89 (2.59,3.15)	216,768.35 (181,887.99,245,237.6)	2.56 (2.16,2.89)	78,620.48 (69,424.31,87,848.72)	2.7 (2.4,2.99)	171,961.17 (142,351.85,194,238.42)	2.04 (1.7,2.29)
Hodgkin lymphoma	54,671.44 (45,648.57,59,832.16)	1.12 (0.93,1.23)	65,182.01 (53,167.43,77,142.98)	0.79 (0.64,0.94)	28,670.69 (21,558.13,32,505)	0.78 (0.6,0.89)	28,179.99 (20,895.4,35,652.96)	0.34 (0.25,0.43)
Kidney cancer	159,774.29 (154,831.25,163,926.28)	3.89 (3.75,3.99)	387,828.72 (365,359.71,406,635.25)	4.52 (4.26,4.75)	58,851.77 (56,258.4,61,270.66)	1.88 (1.81,1.95)	161,194.54 (150,317.57,169,348.28)	1.91 (1.78,2.01)
Larynx cancer	125,175.07 (118,981.12,131,639)	3.07 (2.92,3.23)	200,883.04 (186,941.11,216,097.56)	2.29 (2.13,2.47)	71,052.78 (65,958.77,77,167.26)	2.22 (2.06,2.4)	117,251.6 (109,354.57,125,952.42)	1.35 (1.26,1.45)
Leukemia	311,647.62 (278,619.9,343,177.37)	6.89 (6.22,7.49)	461,422.73 (397,547.9,504,397.01)	5.63 (4.83,6.17)	221,449.6 (190,958.64,255,967.69)	5.95 (5.26,6.7)	320,283.63 (274,969.49,349,049.9)	3.89 (3.34,4.25)

Table 1 (continued)

	1990		2021		1980		2021	
Lip and oral cavity cancer	174,077.49 (167,404.23,181,621.61)	4.27 (4.1,4.45)	421,577.11 (389,878.79,449,782.06)	4.88 (4.52,5.2)	75,530.83 (70,956.24,81,724.77)	2.4 (2.26,2.58)	208,379.43 (191,287.97,224,162.08)	2.42 (2.23,2.6)
Liver cancer	244,689.36 (224,795.5,268,548.98)	5.9 (5.43,6.48)	529,202.46 (480,339.46,593,849.1)	6.15 (5.58,6.9)	203,098.32 (170,622.75,235,838.89)	6.17 (5.21,7.18)	483,875.13 (440,400.32,540,177.12)	5.65 (5.13,6.3)
Malignant neoplasm of bone and articular cartilage	46,583.02 (42,150.54,54,215.43)	0.97 (0.89,1.13)	91,375.06 (73,780.37,102,469.66)	1.11 (0.9,1.25)	32,403.82 (29,160.57,37,214.64)	0.9 (0.82,1.02)	66,114.26 (53,305.43,74,466.88)	0.79 (0.64,0.89)
Malignant skin melanoma	124,319.84 (119,603.87,127,610.46)	2.98 (2.87,3.06)	303,104.61 (281,717.64,318,904.82)	3.56 (3.31,3.75)	24,355.42 (22,280.52,26,020.01)	0.78 (0.72,0.84)	61,549.73 (54,852.45,66,265.02)	0.73 (0.65,0.79)
Mesothelioma	16,493.16 (15,324.92,17,783.42)	0.42 (0.39,0.46)	31,907.89 (29,643.13,34,115.3)	0.37 (0.35,0.4)	12,539.91 (11,012.23,14,190.21)	0.42 (0.37,0.47)	29,618.93 (27,424.48,31,764.63)	0.35 (0.32,0.38)
Multiple myeloma	55,710.1 (52,022.49,59,687.84)	1.47 (1.37,1.57)	148,754.63 (131,780.43,162,049.23)	1.74 (1.54,1.89)	34,293.34 (31,638.59,37,181.27)	1.18 (1.08,1.27)	116,359.63 (103,078.62,128,470.57)	1.37 (1.22,1.52)
Nasopharynx cancer	76,255.83 (68,714.02,83,570.23)	1.74 (1.56,1.9)	118,877.91 (104,836.07,135,884.37)	1.38 (1.22,1.58)	52,474.42 (44,689.83,58,899.82)	1.52 (1.29,1.7)	75,358.67 (67,515.37,83,706.34)	0.87 (0.78,0.97)
Neuroblastoma and other peripheral nervous cell tumors	5854.22 (4516.81,7643.14)	0.11 (0.08,0.14)	10,867.4 (8279.04,13,556.99)	0.15 (0.11,0.18)	2120.99 (1823.15,2582.12)	0.05 (0.04,0.06)	5193.81 (4294.57,5932.3)	0.07 (0.06,0.08)
Non-Hodgkin lymphoma	255,667.85 (242,749.28,272,800.89)	6.08 (5.76,6.48)	604,554.14 (558,229.23,648,746.23)	7.14 (6.58,7.66)	108,989.52 (99,370.61,119,491.07)	3.26 (2.99,3.57)	267,061.2 (246,094.69,288,695.72)	3.19 (2.93,3.44)
Non-melanoma skin cancer	1,661,643.97 (1,430,711.62,1,901,240.26)	45.04 (39.4,50.96)	6,336,846.1 (5,744,729.38,6,896,046.6)	74.1 (67.32,80.69)	17,366.52 (15,706.47,19,334.37)	0.67 (0.61,0.74)	56,913.23 (48,761.35,63,037.42)	0.69 (0.59,0.77)
Other malignant neoplasms	205,977.17 (184,968.46,222,043.27)	4.86 (4.38,5.22)	422,295.02 (380,537.15,462,634.87)	5 (4.51,5.49)	120,758.75 (105,957.87,135,933.28)	3.65 (3.25,4.05)	222,208.37 (199,406.3,240,746.74)	2.65 (2.38,2.88)
Other neoplasms	24,715,051.69 (19,991,541.93,30,340,404.66)	505.41 (405.88,613.11)	42,913,361.9 (34,917,159.4,51,701,423.42)	515.17 (420.89,620.55)	13,822.9 (10,893.04,19,748.47)	0.55 (0.44,0.78)	55,179.07 (46,760.97,64,295.48)	0.68 (0.58,0.79)

Table 1 (continued)

	1990		2021		1980		2021	
Other pharynx cancer	64,528.86 (60,828.8,68,919.74)	1.55 (1.46,1.66)	169,819.52 (159,847.12,179,704.19)	1.93 (1.82,2.05)	33,228.64 (30,125.39,37,133.35)	1.01 (0.92,1.13)	98,435.11 (91,566.81,105,484.9)	1.13 (1.05,1.21)
Ovarian cancer	159,095.96 (145,708.88,174,055.01)	3.82 (3.51,4.15)	298,876 (270,729.82,324,501.02)	3.48 (3.15,3.78)	79,959.04 (73,868.7,88,950.3)	2.55 (2.36,2.82)	185,608.68 (167,961.98,201,012.67)	2.16 (1.95,2.34)
Pancreatic cancer	207,905.23 (196,649.42,217,778.46)	5.47 (5.16,5.73)	508,532.7 (462,090.89,547,207.62)	5.96 (5.39,6.42)	163,598.9 (152,946.45,177,770.67)	5.51 (5.13,5.96)	505,752.16 (461,224.42,543,899.41)	5.95 (5.4,6.41)
Prostate cancer	506,405.2 (480,851.38,524,697.41)	13.69 (12.96,14.19)	1,324,382.9 (1,217,320.93,1,400,222.17)	15.37 (14.13,16.25)	149,768.11 (136,473.64,159,297.28)	5.85 (5.35,6.22)	432,463.33 (381,872.79,463,645.28)	5.26 (4.65,5.64)
Soft tissue and other extraos-seous sarcomas	54,630.92 (46,757.16,63,999.62)	1.21 (1.04,1.39)	96,200.96 (83,423.51,116,184.87)	1.16 (1,1.41)	27,390.17 (22,977.09,32,412.8)	0.77 (0.65,0.91)	50,203.14 (43,232,61,280.38)	0.6 (0.52,0.74)
Stomach cancer	980,899.43 (891,306.83,1,072,236.02)	24.76 (22.58,27)	1,230,232.61 (1,052,350.05,1,409,969.66)	14.33 (12.23,16.41)	827,903.85 (741,976.9,906,091.23)	26.76 (24.14,29.14)	954,373.6 (821,750.81,1,089,576.58)	11.2 (9.62,12.73)
Testicular cancer	38,833.49 (37,572.49,40,260.79)	0.75 (0.72,0.77)	91,507.38 (87,965.92,95,709.72)	1.12 (1.08,1.18)	6974.76 (6569.3,7482)	0.19 (0.17,0.2)	11,388.3 (10,770.7,12,055.62)	0.14 (0.13,0.15)
Thyroid cancer	89,885.45 (84,681.27,96,998.78)	2.06 (1.95,2.22)	249,538.02 (223,290.35,274,638.17)	2.91 (2.61,3.21)	17,886.88 (16,590.56,19,653.55)	0.59 (0.55,0.64)	44,798.54 (39,924.73,48,541)	0.53 (0.47,0.57)
Tracheal, bronchus, and lung cancer	1,132,063.62 (1,075,370.86,1,186,163.37)	28.54 (27.06,29.91)	2,280,688.22 (2,063,251.87,2,509,739.73)	26.43 (23.9,29.07)	828,845.54 (774,601.52,899,552.37)	26.36 (24.6,28.55)	2,016,547.44 (1,820,497.67,2,218,371.89)	23.5 (21.22,25.85)
Uterine cancer	191,290.85 (175,002.55,201,941.37)	4.72 (4.32,4.97)	473,613.85 (429,915.57,513,666.88)	5.41 (4.9,5.87)	49,284.71 (43,664.51,54,165.33)	1.63 (1.46,1.78)	97,672.08 (86,515.79,108,061.54)	1.14 (1.01,1.26)
Abbre-viation: UI: uncer-tainty interval								

Estimated New Cases

Males			Females		
Other neoplasms	14265486.1	52.71%	Other neoplasms	28647875.8	72.68%
Non-melanoma skin cancer	3696317.6	13.66%	Non-melanoma skin cancer	2640528.5	6.70%
Tracheal, bronchus, and lung cancer	1501980.5	5.55%	Breast cancer	2082737.0	5.28%
Prostate cancer	1324382.9	4.89%	Colon and rectum cancer	930680.9	2.36%
Colon and rectum cancer	1263462.4	4.67%	Tracheal, bronchus, and lung cancer	778707.7	1.98%
Stomach cancer	832920.9	3.08%	Cervical cancer	667426.4	1.69%
Esophageal cancer	428387.1	1.58%	Uterine cancer	473613.9	1.20%
Bladder cancer	417706.0	1.54%	Stomach cancer	397311.7	1.01%
Liver cancer	364354.5	1.35%	Ovarian cancer	298876.0	0.76%
Non-Hodgkin lymphoma	359141.7	1.33%	Non-Hodgkin lymphoma	245412.5	0.62%
Pancreatic cancer	273617.1	1.01%	Pancreatic cancer	234915.6	0.60%
Lip and oral cavity cancer	272917.0	1.01%	Other malignant neoplasms	211225.8	0.54%
Leukemia	263712.4	0.97%	Leukemia	197710.3	0.50%
Kidney cancer	252589.2	0.93%	Brain and central nervous system cancer	167352.7	0.42%
Other malignant neoplasms	211069.2	0.78%	Thyroid cancer	167236.6	0.42%
Brain and central nervous system cancer	190129.6	0.70%	Liver cancer	164847.9	0.42%
Larynx cancer	171788.6	0.63%	Lip and oral cavity cancer	148660.1	0.38%
Malignant skin melanoma	161315.9	0.60%	Esophageal cancer	148142.2	0.38%
Other pharynx cancer	137066.1	0.51%	Malignant skin melanoma	141788.7	0.36%
Gallbladder and biliary tract cancer	100783.6	0.37%	Kidney cancer	135239.5	0.34%
Testicular cancer	91507.4	0.34%	Bladder cancer	122603.8	0.31%
Nasopharynx cancer	86483.0	0.32%	Gallbladder and biliary tract cancer	115984.8	0.29%
Multiple myeloma	82454.0	0.30%	Multiple myeloma	66300.6	0.17%
Thyroid cancer	82301.4	0.30%	Soft tissue and other extraosseous sarcomas	43853.0	0.11%
Malignant neoplasm of bone and articular cartilage	54693.3	0.20%	Malignant neoplasm of bone and articular cartilage	36681.8	0.09%
Soft tissue and other extraosseous sarcomas	52347.9	0.19%	Other pharynx cancer	32753.4	0.08%
Breast cancer	38827.3	0.14%	Nasopharynx cancer	32394.9	0.08%
Hodgkin lymphoma	38619.0	0.14%	Larynx cancer	29094.4	0.07%
Mesothelioma	23184.2	0.09%	Hodgkin lymphoma	26563.1	0.07%
Eye cancer	17230.0	0.06%	Eye cancer	16720.8	0.04%
Neuroblastoma and other peripheral nervous cell tumors	6293.0	0.02%	Mesothelioma	8723.7	0.02%
All Sites	**27063068.7**	**100%**	Neuroblastoma and other peripheral nervous cell tumors	4574.4	0.01%
			All Sites	**39416538.5**	**100%**

Fig. 1 Differences in incidence rate and proportion of cancer cases among males and females

females. Prostate cancer accounted for 4.89% of all cancer incidence and 7.72% of cancer-related deaths in males. The ASIR of breast cancer in females was 46.40 (43.26–49.56), and the ASDR was 14.54 (13.45–15.56). The ASIR of prostate cancer in males was 34.05 (31.27–36.00), and the ASDR was 12.63 (11.16–13.55). From 1990 to 2021, the percentage change in ASIR was 0.04% (0.01–0.07), while the percentage change in ASIR was –0.02% (–0.04, 0) from 2019 to 2021. The percentage change in ASDR decreased from 1990 to 2021 and from 2019 to 2021 (Table S1). In 2021, the incidence rates were highest among women aged 60 to 64 years and men aged 65–69 years. Before the age of 55–59, the incidence rate in females was higher than that in males, while from age 65 to 69, the incidence rate in males was higher than that in females (Fig. 3A). Cancer incidence is increasing among younger individuals, particularly among women under the age of 50. The death rate was highest among individuals aged 70–74 years for males and females, and before the age of 40–44, the death rate in females was higher than that in males (Fig. 3B).

Burden of cancers in countries

Across the 21 GBD regions, high-income North America exhibited the highest observed ASIR: 3138.73 (2786.29–3519.73), followed by Central Europe: 1308.53 (1147.64–1501.09) and high-income Asia Pacific: 1253.28 (1092.47–1,462.55) (Figure S2). Eastern Sub-Saharan Africa exhibited the lowest observed ASIR: 268.54 (238.04–300.85), followed by Western and Central Sub-Saharan Africa. Central Europe exhibited the highest observed ASDR: 157.77 (146.33–167.79), followed by Southern Sub-Saharan Africa: (144.19 (132.84–154.13) and East Asia: 137.08 (115.32–162.11). Furthermore, South Asia exhibited the lowest observed ASDR: 74.73 (68.77–81.23), followed by Western Sub-Saharan Africa: 89.08 (72.14–103.40), and North Africa and the Middle East: 90.11 (80.96–99.52) (Figure S3). From 1990 to 2021, Southern Sub-Saharan Africa exhibited the largest percentage increase in the rates of cancer deaths: 22% (11%–35%), while Australasia exhibited the biggest percentage decline in the rates of cancer deaths (–30%, –34% to –27%) (Table S1).

In 2021, the ASIR exhibited variations globally. Across the 204 countries, the United States of America exhibited the highest ASIR: 3,304.9 (2941.64–3699.14), followed by Canada: 1,758.48 (1470.8–2062.1) and Greenland: 1,751.13 (1468.51–2039.7). Meanwhile, Burundi exhibited the lowest observed ASIR: 243.71 (206.6–285.36), followed by Madagascar: 243.88 (207.76–281.58) and Kenya: 251.15 (218.01–287.69) (Figs. 4A and S4). Mongolia exhibited the highest observed ASDR: 214.81 (188.01, 243.86), followed by Monaco: 207.69 (173.54–245.45) and Zimbabwe: 201.33 (162.95–246.3). Furthermore, Oman

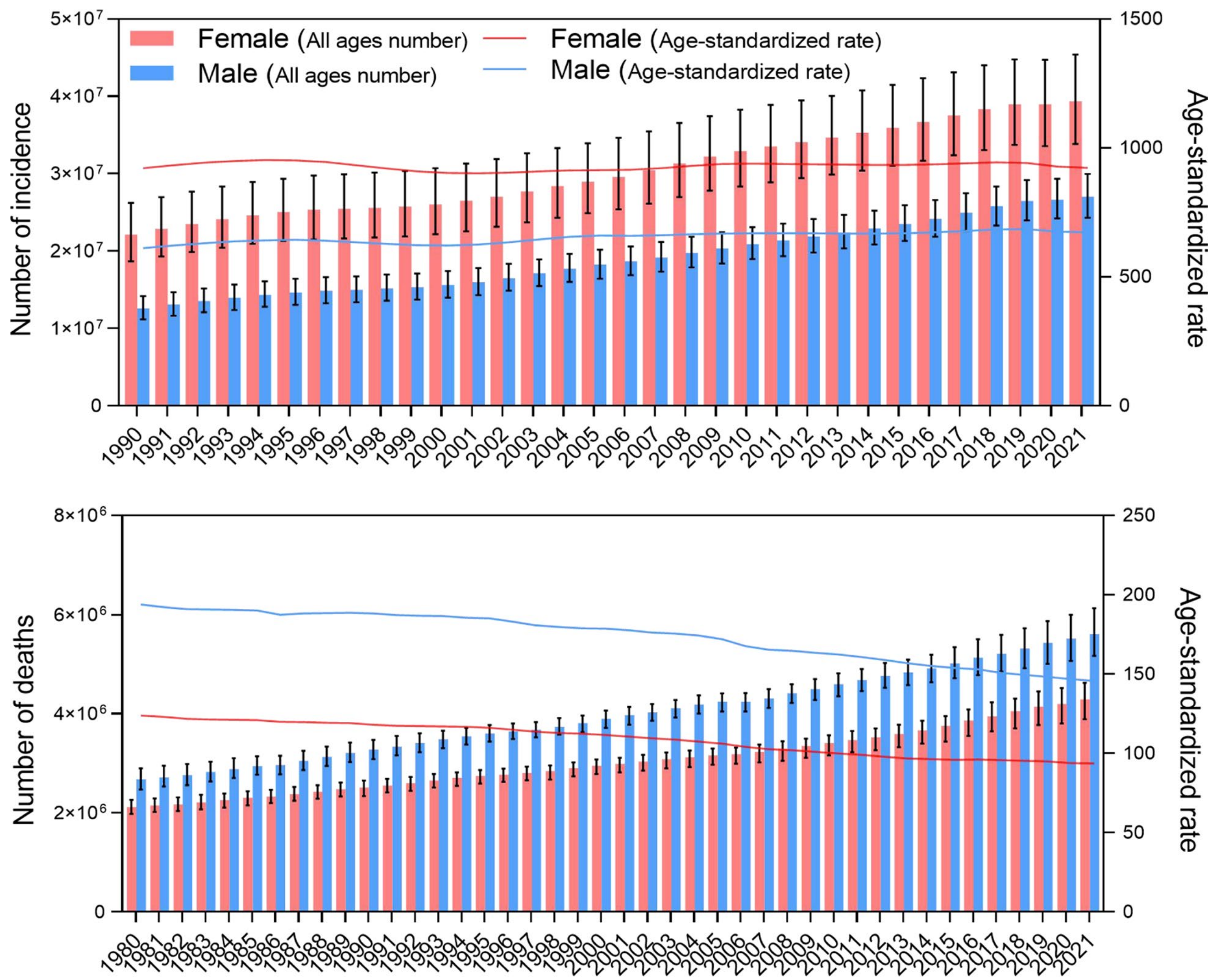

Fig. 2 Trends in cancer rates and age-standardized changes globally. Up. The rate of cancer incidence and age-standardized changes from 1990 to 2021; below, the rate of cancer deaths and age-standardized changes from 1980 to 2021

exhibited the lowest observed ASDR: 44.21 (36.51–52.81), followed by the Maldives: 47.86 (39.57–56.19) and Algeria: 51.51 (43.01–61.21) (Figs. 4B and S5). Between 1990 and 2021, the United States of America exhibited the largest percentage increase in cancer incidence: 88% (78%–97%), while Burundi exhibited the biggest percentage decline in cancer incidence (–15%, –26% to –1%). Additionally, between 1990 and 2021, Lesotho (80%, 32% to 140%) exhibited the largest percentage increase in cancer-related deaths, while Kazakhstan (–50%, –56% to –44%) exhibited the biggest percentage decline in cancer-related deaths (Table S2).

SDI and *cancer* burden

In 2021, the high SDI quintile exhibited the highest ASIR: 1671.46 (95% UI: 1484.99–1875.02) and ASDR 123.22 (95% UI: 113.06–128.96), while the low SDI exhibited the lowest ASIR: 336.09 (95% UI: 288.48–385.96) and ASDR: 90.64 (95% UI: 79.86–102.00). Figure 5 depicts the changes in age-standardized incidence and death rates across five SDIs from 1990/1980 to 2021. The findings suggest a significant increase of ASIR and ASDR in high-SDI and high-middle SDI regions. However, low, middle, and low-middle SDIs exhibited a stable trend in ASIR and ASDR. Based on the changes in age-standardized death rates by region, the high-income North Pacific exhibited an increase in ASIR among the four regions with the highest SDI. The ASIR increased gradually as the SDI increased until it reached approximately 0.65, after which it increased significantly. However, the United States of America experienced unexpectedly high ASIR based on SDI levels (Figure S6). The ASDR value in the region level decreased as the SDI increased to approximately 0.34. Subsequently, it increased until it reached

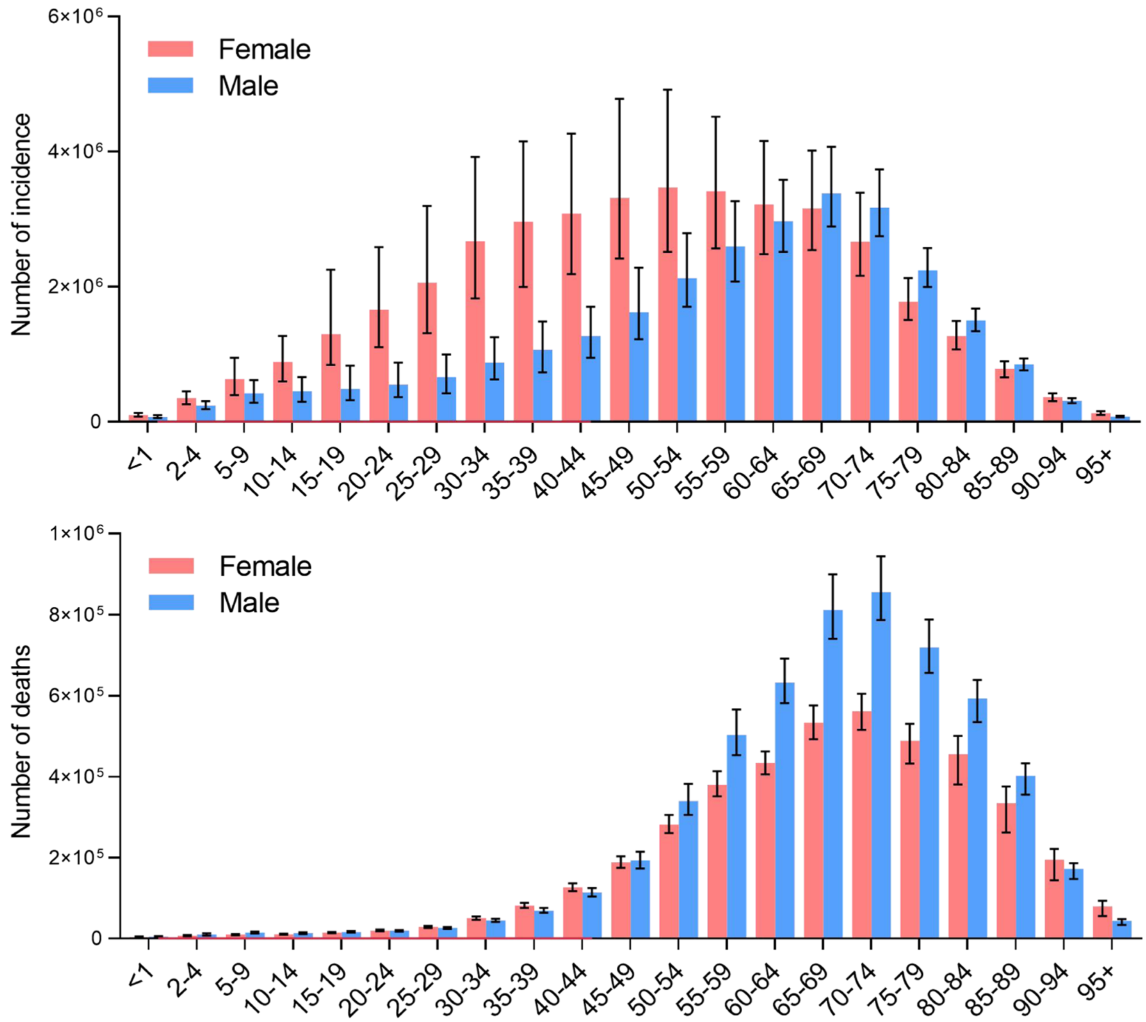

Fig. 3 Cancer count of different age groups and sexes globally. Up. Rate of cancer incidence by age groups from 1990 to 2021; below, rate of cancer deaths by age groups from 1980 to 2021

approximately 0.75, after which it decreased significantly (Figure S7).

Burden of *cancer* attributable to risk factors

In 2021, 4.06 million (95% UI: 3.46–4.75) global cancer-related deaths were caused by all estimated risk factors, representing 41.07% (35.24–46.64) of all cancer-related deaths for both sexes. Risk factors caused 2.56 million (95% UI: 2.20–2.99) cancer-related deaths in males and 1.50 million (95% UI: 1.16–1.83) in females, accounting for 45.65% (40.72–50.77) of all male cancer-related deaths and 35.08% (27.38–42.23) of all female cancer-related deaths. The global overall cancer DALYs attributed to estimated risk factors were 100.30 million (95% UI: 86.19–116.72) for both sexes, representing 39.59% (34.18–44.88) of all cancer DALYs. Males accounted for 62.09 million (95% UI: 53.92–72.60) cancer DALYs due to risk factors, representing 43.81% (29.81–46.07) of all cancer DALYs, while females accounted for an estimated 38.21 million (95% UI: 32.8–43.1) cancer DALYs attributable to risk factors, representing 34.21% (27.05–40.69) of all cancer DALYs in females. Global geographical pattern variations were observed for cancer age-standardized DALY rates caused by environmental and occupational, behavioral, and metabolic risks across different regions. Higher age-standardized DALY rates were observed in central Europe within these level 1 risk factor categories (Figure S8).

Tobacco was the primary level 2 risk factor for cancer DALYs in males, contributing to 29.32% (25.32–33.14) of all cancer DALYs, followed by dietary risks, alcohol use, and air pollution, which accounted for 5.89% (2.01–10.73), 5.48% (4.83–6.11), and 4.30% (2.77–5.95) of male cancer DALYs in 2021, respectively. Additionally, unsafe

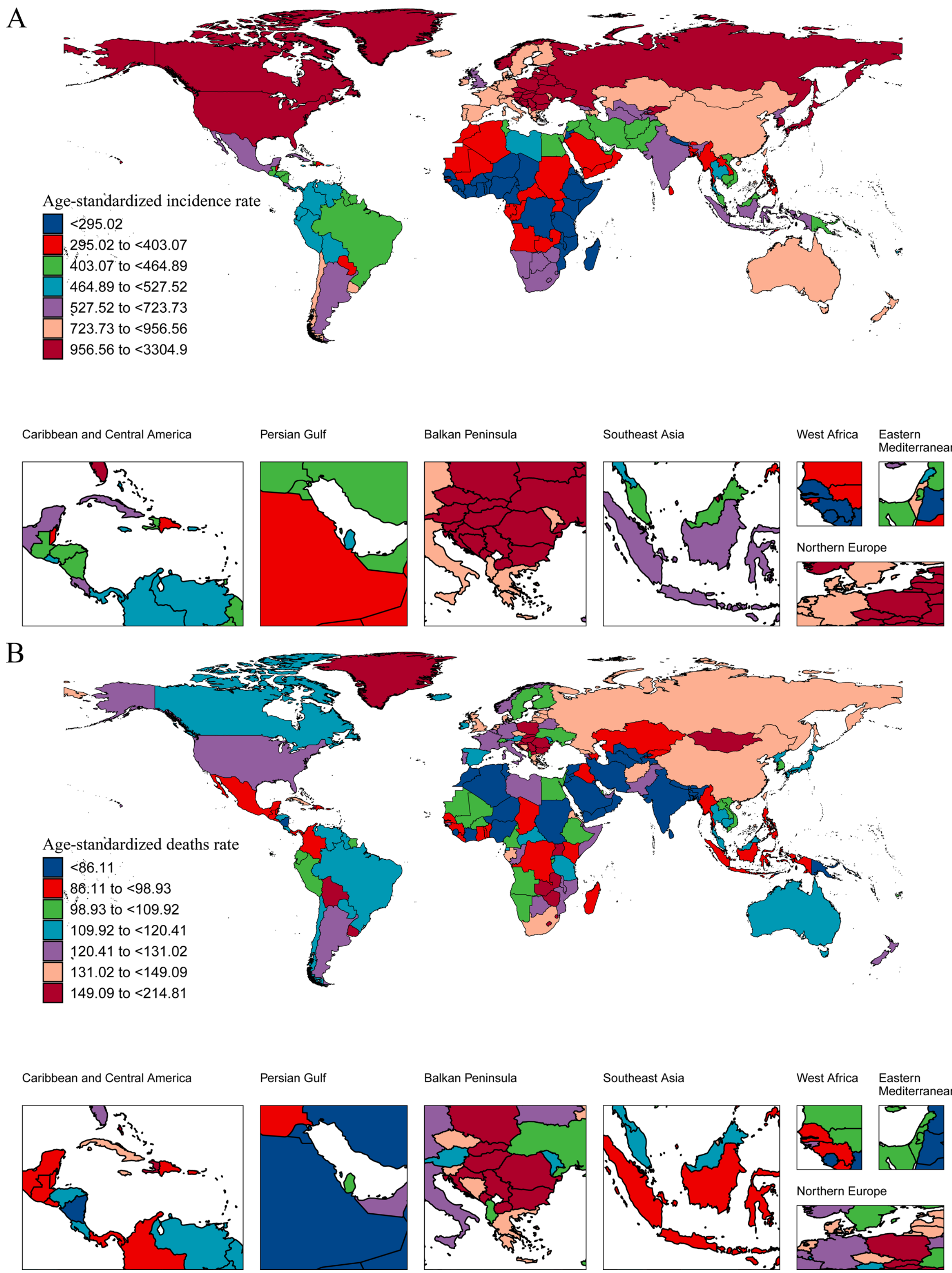

Fig. 4 ASIR and deaths rate in 204 countries and territories in 2021. A. Age-standardized incidence rate; B. Age-standardized death rate

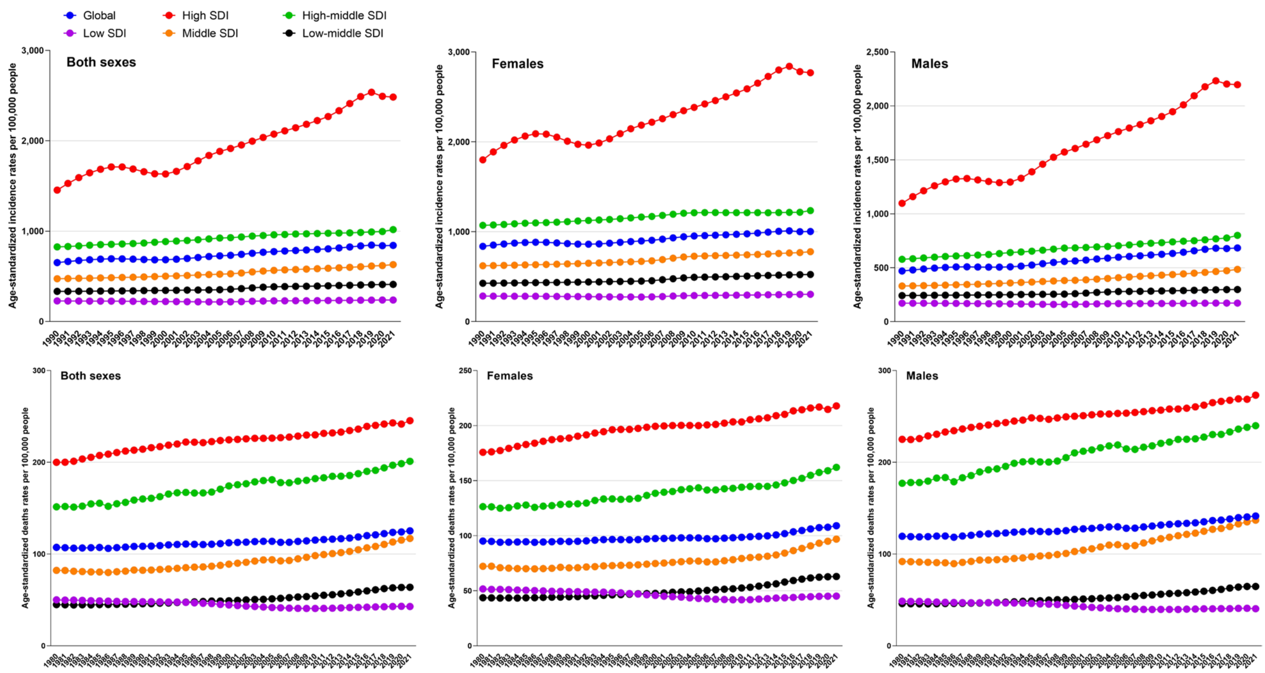

Fig. 5 ASIR and death rate change trends in females and males among global and sociodemographic indexes

sex was the primary level 2 risk factor for females based on cancer DALYs. It comprised 8.88% (8.40–9.49) of all female cancer DALYs, followed by tobacco: 8.09% (6.12–10.05), dietary risks 7.21% (1.96–12.92), and high BMI 4.72% (1.86–7.59) (Figure S9).

Discussion

This study provided a comprehensive overview of the global cancer burden and demonstrated significant trends and disparities in cancer incidence and mortality across genders, age groups, and geographical regions. The ASDR for cancer decreased by approximately 24.81% in males and 24.47% in females globally in the past 40 years. In 2021, digestive cancer accounted for 39.29% of all cancer-related deaths; thus, interventions aimed at promoting healthy diets and early screening for early signs of these cancers could potentially alleviate their burden. Significantly, TBL cancer exhibited the highest cancer burden, emphasizing the urgent need for targeted tobacco control measures. We demonstrated the significant impact of cancer on global health and highlighted the need for targeted interventions to alleviate this burden.

Data from 2021 reveal that cancers accounted for a significant percentage of global total deaths (14.57%) and DALYs (8.8%), indicating their critical role as an essential contributor to the GDB. The observed ASIR of 790.33 per 100,000 individuals and ASDR of 116.49 per 100,000 individuals signify the ubiquitous nature of cancer as a public health issue. Although the ASIR for females exceeded that of males, the ASDR was higher among males, indicating an increasing incidence of cancer among women while mortality is disproportionately high among men. This gender disparity illustrates variations in risk factors, including smoking and alcohol consumption, which are more common among men, and gender-specific cancers, including breast cancer in women and prostate cancer in men. Globally, the incidence of female breast cancer is continuously increasing in regions including North America, Australasia, and Africa, indicating the impact of social and economic development on the disease. Factors including age, sex, estrogen levels, family history, an unhealthy lifestyle, and gene mutations can all increase the risk of developing breast cancer[14]. The 5-year relative survival rates for breast cancer exhibit significant disparity between developed and developing countries. The rates exceed 90% in North America and Japan but fall below 40% in African countries such as Algeria[15]. Breast cancer is preventable, and developed countries have sufficient medical resources, including annual mammography screenings or daily chemopreventative drugs, to mitigate the risk of the disease. The strategy for breast cancer prevention involves enhancing primary prevention measures, including the avoidance of alcohol and excess dietary fat consumption, adoption of a healthy lifestyle, timely childbirth, and breastfeeding. Breast and prostate cancer are generally hormone-dependent and exhibit significant biological similarities. The high prevalence of breast cancer in females significantly affects the overall female ASIR and ASDR. This highlights the importance of breast cancer prevention, early detection, and treatment strategies in reducing the female cancer burden. Although prostate cancer is not the primary cause of cancer deaths among males, it significantly affects the male ASDR. Enhanced treatment options and screening strategies for prostate cancer may contribute to a decrease in male cancer mortality rates. Since the mid-2000s, the incidence rates of female breast cancer have gradually increased by approximately 0.5% annually, which can be partially attributed to the continuing decline in fertility rates and the increase in excess body weight[16]. The rapidly growing population and the significant number of men reaching the age of ≥ 65 contribute to a higher ASIR of prostate cancer[17]. The incidence rates of prostate cancer are highest in developed countries where there is increased awareness of the disease and widespread use of prostate-specific antigen tests for screening[18]. Although breast and prostate cancers significantly influence the overall gender disparities in cancer incidence and mortality, these disparities cannot be ascribed to these two cancers. Additional research and customized strategies are required to address the broader issue of gender disparities in cancer.

The variation in the cancer types across regions is affected by the unique environmental characteristics, dietary habits, and lifestyles specific to each area. Our study revealed that South Asia exhibited the highest incidence and mortality rates for lip and oral cavity cancer. The risk factors include unhealthy lifestyle habits (betel quid consumption), poor oral hygiene, exposure to ultraviolet radiation, and limited medical resources[19]. Enhancing the quality of health education for residents, improving their oral hygiene awareness and living habits, and investing in and constructing medical resources are essential to reducing lip and mouth cancer incidence and mortality rates. Additionally, the highest incidence and mortality rates of liver cancer are predominantly concentrated in the Asia Pacific and sub–Saharan Africa, primarily attributable to hepatitis B virus (HBV) and hepatitis C virus (HCV) infections. Liver cancer in China and Western Sub-Saharan Africa is caused mainly by chronic HBV infection, while in South Korea and Japan, HCV infection is the primary causative factor for liver cancer[20]. Despite the ongoing increase in cancer cases, there has been a significant decline in the ASR of liver cancer in specific regions over the past few decades. The reduction in ASR is primarily attributable to the effective control of HBV infection through vaccination initiatives. Metabolic syndrome, obesity, and NAFLD are increasing and may collectively emerge as the leading cause of liver cancer[21]. Consequently, it is recommended that different countries re-evaluate their prevention strategies. The ASIR of malignant skin melanoma in New Zealand and Australasia exceeded the global average due to the proximity of Oceania to the ozone hole over the Antarctic, leading to increased UV exposure in the region. Meanwhile, the warm climate and favorable conditions for outdoor activities in the equatorial regions allow individuals to wear minimal clothing and experience increased exposure to UV radiation, thereby increasing the risk of skin cancer consistent with this geographical trend[22]. As a result, enhancing public awareness and attention to malignant melanoma is essential to mitigating its incidence risk. Public health policies must be tailored to specific environmental factors, dietary habits, and lifestyles in different regions.

TBL cancer was the most common and primary cause of death across all cancer types, particularly in East Asia and Central Europe. The global morbidity and mortality rates of TBL cancer in males were 2.2 times and 2.4 times higher than that in females, respectively, primarily attributed to the higher rate of smoking among males. Greenland and Monaco have the highest ASIR and ASDR observed in TBL. Smoking was identified as the primary risk factor contributing to the incidence of lung cancer in men, although air pollution and occupational exposure play a significant role. Smoking patterns were identified as the primary factor contributing to the incidence of lung cancer in women[23]. A previous study reported that indoor air pollution from cooking and heating significantly contributes to lung cancer incidence, particularly in East Asia, where female smokers are uncommon[24]. Over time, lung cancer rates decreased among male smokers in Europe, while the rates increased among women who smoke[25]. Hence, initiatives to reduce both smoking prevalence and secondhand smoke exposure are essential. Regular screening with low-dose computed tomography of the chest resulted in a significant decrease in lung cancer mortality among heavy smokers, including nonsmokers[26]. A comprehensive strategy for prevention is required; this includes enhancing tobacco control measures, reducing air pollution, and promoting healthy diets and lifestyles. Implementing comprehensive smoke-free policies, augmenting public awareness campaigns, and providing smoking cessation services can effectively reduce tobacco consumption and its detrimental health effects[27,28].

This study has some limitations. First, due to the extensive and complex nature of the data, caution should be exercised when interpreting the TBL cancer burden. Second, establishing a correlation between the COVID-19 pandemic and cancer incidence and mortality rates was difficult and thus resulted in erroneous data. Third, GBD estimates were based on covariates and modeling parameters in cases where data were unavailable, potentially leading to overestimating or underestimating the cancer burden.

Conclusion

Cancer is a major global public health concern. The ASDR of cancer has decreased globally between 1980 and 2021. However, breast, tracheal, bronchial, and lung cancers are the most significant cancer burden globally. Various regions and countries may have distinct risk factors for specific cancer types. Understanding the common etiologies of various cancers is essential for formulating effective control strategies and targeted interventions consistent with local characteristics and environments.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13045-024-01640-8.

Additional file1 Figure S1. Differences in the death rate and proportion of cancer cases among males and females.

Additional file2 Figure S2. Heatmap of ASIR of different cancer types in 21 regions in 2021.

Additional file3 Figure S3. Heatmap of age-standardized death rate of different cancer types in 21 regions in 2021.

Additional file4 Figure S4. Heatmap of ASIR of different cancer types in 204 countries in 2021.

Additional file5 Figure S5. Heatmap of the age-standardized death rate of different cancer types in 204 countries in 2021.

Additional file6 Figure S6. Age-standardized incidence rates across 21 GBD regions and 204 countries by the sociodemographic index for both sexes combined, 1990 to 2021. A. 21 GBD regions; B. 204 countries.

Additional file7 Figure S7. Age-standardized death rates across 21 GBD regions and 204 countries by sociodemographic index for both sexes, 1990–2021. A. 21 GBD regions; B. 204 countries.

Additional file8 Figure S8. Global map of age-standardized DALY rate for risk-attributable cancer burden, both sexes, 2021. A. Environmental and occupational risks. B. Behavioral risks. C. Metabolic risks.

Additional file9 Figure S9. Cancer deaths and DALYs are attributable to 11 level 2 risk factors globally in 2021.

Additional file10 (DOCX 22 KB)

Additional file11 (DOCX 76 KB)

Author contributions

W.Z.H. designed and analyzed the research study; X.F.N. collected the data; W.Z.H. and L.R. wrote and revised the manuscript. All authors have read and approved the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Lin rong acting as the submission's guarantor responsibility for the integrity of the work as a whole, from inception to published article. All authors approved the final version of the manuscript.

Conflict of interest

The authors declare no competing interests.

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References

1. Global Burden of Disease 2019 Cancer Collaboration; Kocarnik JM, Compton K, et al. Cancer Incidence, Mortality, Years of Life Lost, Years Lived With Disability, and Disability-Adjusted Life Years for 29 Cancer Groups From 2010 to 2019: A Systematic Analysis for the Global Burden of Disease Study 2019. JAMA Oncol. 2022 Mar 1;8(3):420–444.
2. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, Jemal A. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2024;74(3):229–63.
3. Fan KM, Rimal J, Zhang P, Johnson NW. Stark differences in cancer epidemiological data between GLOBOCAN and GBD: Emphasis on oral cancer and wider implications. EClinicalMedicine. 2022;6(54): 101673.
4. Qiu H, Cao S, Xu R. Cancer incidence, mortality, and burden in China: a time-trend analysis and comparison with the United States and United Kingdom based on the global epidemiological data released in 2020. Cancer Commun (Lond). 2021;41(10):1037–48.
5. Bray F, Parkin DM; African Cancer Registry Network. Cancer in sub-Saharan Africa in 2020: a review of current estimates of the national burden, data gaps, and future needs. Lancet Oncol. 2022 Jun;23(6):719–728.
6. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin. 2021;71(3):209–49.
7. Barrios CH, Werutsky G, Mohar A, Ferrigno AS, Müller BG, Bychkovsky BL, Castro ECJ, Uribe CJ, Villarreal-Garza C, Soto-Perez-de-Celis E, Gutiérrez-Delgado F, Kim JS, Ismael J, Delgado L, Santini LA, Teich N, Chavez PC, Liedke PER, Exman P, Barroso-Sousa R, Stefani SD, Cáceres SAB, Rebelatto TF, Pastrana T, Chavarri-Guerra Y, Vargas Y, Cazap E. Cancer control in Latin America and the Caribbean: recent advances and opportunities to move forward. Lancet Oncol. 2021;22(11):e474–87.
8. GBD 2021 Risk Factors Collaborators. Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet. 2024 May 18;403(10440):2162–2203.
9. Kieling C, Buchweitz C, Caye A, Silvani J, Ameis SH, Brunoni AR, Cost KT, Courtney DB, Georgiades K, Merikangas KR, Henderson JL, Polanczyk GV, Rohde LA, Salum GA, Szatmari P. Worldwide prevalence and disability from mental disorders across childhood and adolescence: evidence from the global burden of disease study. JAMA Psychiat. 2024;31: e235051.
10. GBD 2021 Other Musculoskeletal Disorders Collaborators. Global, regional, and national burden of other musculoskeletal disorders, 1990–2020, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. Lancet Rheumatol. 2023 Oct 23;5(11):e670-e682.

11. GBD Spinal Cord Injuries Collaborators. Global, regional, and national burden of spinal cord injury, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol. 2023;22(11):1026–47.
12. GBD 2021 Neck Pain Collaborators. Global, regional, and national burden of neck pain, 1990–2020, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. Lancet Rheumatol. 2024 Mar;6(3):e142-e155.
13. GBD 2021 Diseases and Injuries Collaborators. Global incidence, prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet. 2024 May 18;403(10440):2133–2161.
14. Sun YS, Zhao Z, Yang ZN, Xu F, Lu HJ, Zhu ZY, Shi W, Jiang J, Yao PP, Zhu HP. Risk Factors and Preventions of Breast Cancer. Int J Biol Sci. 2017;13(11):1387–97.
15. Guha A, Fradley MG, Dent SF, Weintraub NL, Lustberg MB, Alonso A, Addison D. Incidence, risk factors, and mortality of atrial fibrillation in breast cancer: a SEER-Medicare analysis. Eur Heart J. 2022;43(4):300–12.
16. Pfeiffer RM, Webb-Vargas Y, Wheeler W, Gail MH. Proportion of US trends in breast cancer incidence attributable to long-term changes in risk factor distributions. Cancer Epidemiol Biomarkers Prev. 2018;27:1214–22.
17. Sekhoacha M, Riet K, Motloung P, Gumenku L, Adegoke A, Mashele S. Prostate cancer review: genetics, diagnosis, treatment options, and alternative approaches. Molecules. 2022;27(17):5730.
18. Haas GP, Delongchamps N, Brawley OW, Wang CY, de la Roza G. The worldwide epidemiology of prostate cancer: perspectives from autopsy studies. Can J Urol. 2008;15(1):3866–71.
19. Gupta B, Johnson NW. Systematic review and meta-analysis of association of smokeless tobacco and of betel quid without tobacco with incidence of oral cancer in South Asia and the Pacific. PLoS ONE. 2014;9(11): e113385.
20. Younossi ZM, Wong G, Anstee QM, Henry L. The global burden of liver disease. Clin Gastroenterol Hepatol. 2023;21(8):1978–91.
21. Sarin SK, Kumar M, Eslam M, George J, Al Mahtab M, Akbar SMF, Jia J, Tian Q, Aggarwal R, Muljono DH, Omata M, Ooka Y, Han KH, Lee HW, Jafri W, Butt AS, Chong CH, Lim SG, Pwu RF, Chen DS. Liver diseases in the Asia-Pacific region: a Lancet Gastroenterology & Hepatology Commission. Lancet Gastroenterol Hepatol. 2020 Feb;5(2):167–228. https://doi.org/10.1016/S2468-1253(19)30342-5. Epub 2019 Dec 15. Erratum in: Lancet Gastroenterol Hepatol. 2020 Mar;5(3):e2.
22. Qureshi AA, Laden F, Colditz GA, Hunter DJ. Geographic variation and risk of skin cancer in US women. Differences between melanoma, squamous cell carcinoma, and basal cell carcinoma. Arch Intern Med. 2008 Mar 10;168(5):501–7.
23. Deng Y, Zhao P, Zhou L, Xiang D, Hu J, Liu Y, Ruan J, Ye X, Zheng Y, Yao J, Zhai Z, Wang S, Yang S, Wu Y, Li N, Xu P, Zhang D, Kang H, Lyu J, Dai Z. Epidemiological trends of tracheal, bronchus, and lung cancer at the global, regional, and national levels: a population-based study. J Hematol Oncol. 2020;13(1):98.
24. Li M, Vierkötter A, Schikowski T, Hüls A, Ding A, Matsui MS, Deng B, Ma C, Ren A, Zhang J, Tan J, Yang Y, Jin L, Krutmann J, Li Z, Wang S. Epidemiological evidence that indoor air pollution from cooking with solid fuels accelerates skin aging in Chinese women. J Dermatol Sci. 2015;79(2):148–54.
25. Malvezzi M, Bertuccio P, Rosso T, Rota M, Levi F, La Vecchia C, Negri E. European cancer mortality predictions for the year 2015: does lung cancer have the highest death rate in EU women? Ann Oncol. 2015;26(4):779–86.
26. Luo YH, Chiu CH, Scott Kuo CH, Chou TY, Yeh YC, Hsu HS, Yen SH, Wu YH, Yang JC, Liao BC, Hsia TC, Chen YM. Lung Cancer in Republic of China. J Thorac Oncol. 2021;16(4):519–27.
27. Freeman B, Mamallapalli J, Bian T, Ballas K, Lynch A, Scala A, Huo Z, Fredenburg KM, Bruijnzeel AW, Baglole CJ, Lu J, Salloum RG, Malaty J, Xing C. Opportunities and challenges of kava in lung cancer prevention. Int J Mol Sci. 2023;24(11):9539.
28. Brody H. Lung cancer. Nature. 2014;513(7517):S1.

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