BMC Cancer

RESEARCH

Open Access

Global, regional, and national burdens of bladder cancer attributable to high fasting plasma glucose from 1990 to 2021, with future forecasts to 2050: a systematic analysis for the global burden of disease study 2021

Kaijian Lan[1†], Yuanfeng Zhang[1,2†], Yingxun Luo[1], Ting Hong[3], Xinyu Liu[3], Yangcheng Hu[1], Weiqiang Lin[1], Xuwei Hong[1,2*] and Yonghai Zhang[1*]

Abstract

Background The aim of this study was to characterize global, regional, and national burden in bladder cancer attributable to high fasting plasma glucose (HFPG) from 1990 to 2021 and future forecasts to 2050.

Methods The data were sourced from the Global Burden of Disease 2021 study. Deaths and disability-adjusted life years (DALYs) data were analyzed via age-standardized rates. The estimated annual percentage change was computed. Age-period-cohort analysis was employed to estimate the age, period, and cohort effects of bladder cancer attributable to HFPG. Moreover, bayesian age-period-cohort model was utilized to project the burden of bladder cancer attributable to HFPG to 2050.

Results The global deaths of bladder cancer attributable to HFPG increased from 6,092 cases in 1990 to 17,562 cases in 2021, while the age-standardized death rate rose from 0.176 per 100,000 people in 1990 to 0.213 per 100,000 people in 2021. The burden of bladder cancer attributable to HFPG rose in all socio-demographic index (SDI) regions. Singapore had lowest increase in age-standardized DALYs rate of bladder cancer attributable to HFPG from 1990 to 2021. The age group with the highest number of deaths was 80–84 age group, regardless of gender, with 805 females and 2,430 males. The burden of bladder cancer attributable to HFPG are generally on the rise from 2021 to 2050.

Conclusions The growing global burden of bladder cancer attributable to HFPG needs urgent health interventions, especially in high SDI regions.

Trial registration Not applicable.

†Kaijian Lan and Yuanfeng Zhang contributed equally to this work.

*Correspondence:
Xuwei Hong
hong_xuwei@sina.cn
Yonghai Zhang
zhang_yonghai@126.com

Full list of author information is available at the end of the article

© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

Keywords Bladder cancer, Global burden of disease, Age-period-cohort, High fasting plasma glucose, Bayesian age-period-cohort model

Introduction

Bladder cancer is one of the most common malignant tumors of the urinary system. According to Global Cancer Statistics 2022, there were 613,791 cases of bladder cancer worldwide, which was the ninth highest number of cancer incidence worldwide, and 220,349 deaths, which was the 13th highest number of cancer deaths worldwide [1]. Bladder cancer can occur at all ages, with the highest incidence rate among those aged 50 to 90 years and the incidence of bladder cancer in men was 3 to 4 times that in women [2]. Bladder cancer is associated with a variety of risk factors, such as smoking, alcohol consumption, high fasting plasma glucose (HFPG), and occupational exposures [3–7].

HFPG is an abnormal metabolic state that usually manifests as prediabetes and diabetic conditions. HFPG posed a huge burden globally. In 2019, the global disability-adjusted life years (DALYs) attributable to HFPG was 172.07 million with an age-standardized DALYs rate of 2,104.26 per 100,000 persons, and the burden is on an upward trend [8]. Numerous studies have shown that HFPG was associated with the risks of various diseases. Studies have found that there is a positive correlation between diabetes and the risk of bladder cancer [9]. A meta-analysis had pointed out that compared with non-diabetic patients, diabetic patients had significantly higher bladder cancer-specific mortality rate, higher risk of bladder cancer progression, and higher recurrence rate [10]. In 2019, there were a total of 22,823.33 deaths from bladder cancer attributable to HFPG, and the age-standardized deaths rate (ASDR) was 0.30 per 100,000 people [11].

Although previous literature had reported on bladder cancer attributable to HFPG, there is a lack of research on data from 1990 to 2021. Understanding the burden of bladder cancer attributable to HFPG at the global, regional, and national levels is beneficial for resource allocation and burden reduction. The Global Burden of Disease (GBD) Database is one of the most authoritative and comprehensive data platforms in the global public health field. It aims to quantify the health losses caused by diseases, injuries, and related risk factors worldwide, providing a scientific basis for health policy-making. Covering 204 countries and regions, it contains detailed data on 371 diseases and injuries. Therefore, the GBD Database can provide substantial data support for understanding the disease burden attributable to HFPG at the global, regional, and national levels from 1990 to 2021, which is conducive to the rational allocation of resources and alleviation of the burden of bladder cancer. This study assessed the burden of bladder cancer attributable to HFPG between 1990 and 2021 based on the latest data from the GBD 2021, providing a reference for the prevention and control of bladder cancer attributable to HFPG.

Materials and methods

Data source

The data on the burden of bladder cancer attributable to HFPG was sourced from the GBD 2021 database. The data were downloaded via the GBD Results Tool (https://ghdx.healthdata.org/gbd-results-tool) on March 31, 2025. The relevant scripts are provided in the Appendix. The data screening strategy is as follows: select bladder cancer for Cause; select Deaths and DALYs for Measure; select Number, Percent and Rate for Metric; select High fasting plasma glucose for Risk; set Location as Global; select each year from 1990 to 2021 for Year; select All ages for Age; and select Both, Male and Female for Sex. The data in this study mainly included deaths and DALYs of bladder cancer attributable to HFPG, and their age-standardized rates (ASR) were calculated. The analysis was stratified by sex, age, socio-demographic index (SDI), World Health Organization (WHO) regions, continents, World Bank regions, and GBD super regions. The age groups ranged from 25 to 95 + years old, with every 5 years old as an age group. The SDI regions were divided into high SDI regions, high-middle SDI regions, middle SDI regions, low-middle SDI regions, and low SDI regions. In this study, the negative bounds of the uncertainty interval (UI) were truncated to zero.

Relevant definitions

HFPG was defined as an exposure level exceeding the theoretical minimum risk exposure level (TMREL) of 4.8–5.4 mmol/L or 86.4–97.2 mg/dL. The TMREL was defined as the risk exposure level that maintains the disease risk at the lowest level at the population level [12].

Statistical methods

All statistical analyses and visualizations were performed using R software (version 4.4.3). Estimated annual percentage change (EAPC) is used to depict the long-term trend of the ASR of the bladder cancer attributable to HFPG [13]. The calculation formula of EAPC is $Y = \alpha + \beta X + e$, where Y represents the ln (ASR), X is the calendar year, α is the intercept, β is the slope, and e is the error term. $EAPC = 100 \times [\exp(\beta) - 1]$ and 95% confidence interval (CI) derived from a linear regression model. When both EAPC and the lower limit of 95% CI exceed 0, the trend is upward. When both EAPC

and the upper limit of 95% CI are below 0, the trend is downward. If 95% CI contains 0, the trend remains stable [14]. The age-period-cohort (APC) model were adopted to analyze and estimate the impacts of age, period, and cohort effects on the disease burden of bladder cancer attributable to HFPG. The age effect is considered a change caused by alterations in physiology, psychology, and social status resulting from aging. The cohort effect refers to the phenomenon where individuals born in the same calendar year, having long-term exposure to the same cultural, environmental, and social changes over time, may share similar disease risk levels—this is known as the cohort effect. The period effect denotes the occurrence of incidence or mortality changes during specific periods due to variations in natural conditions or social environments. The calculation formula of the APC model is $\ln(\lambda_{ij}) = \mu + \alpha_i + \beta_j + \gamma_k + Z_{ij}$, where λ_{ij} represents the death rate or DALYs rate for age group i in period j in this study; α_i denotes the age effect, β_j the period effect, and γ_k the cohort effect.In the APC model: Patients are divided into 15 age groups at 5-year intervals: 25–<29 years, 30–<34 years, 35–<39 years, 40–<44 years, 45–<49 years, 50–<54 years, 55–<59 years, 60–<64 years, 65–<69 years, 70–<74 years, 75–<79 years, 80–<84 years, 85–<89 years, 90–<94 years, and 95–<100 years; Periods are divided into 6 intervals at 5-year intervals: 1992–1996, 1997–2001, 2002–2006, 2007–2011, 2012–2016, and 2017–2021; Birth cohorts are calculated using the formula "birth cohort = period - age" and divided into 20 groups: 1897–1901, 1902–1906, 1907–1911, 1912–1916, 1917–1921, 1922–1926, 1927–1931, 1932–1936, 1937–1941, 1942–1946, 1947–1951, 1952–1956, 1957–1961, 1962–1966, 1967–1971, 1972–1976, 1977–1981, 1982–1986, 1987–1991, and 1992–1996. Among the periods, 2002–2006 serves as the reference period, and among the birth cohorts, 1942–1946 acts as the reference cohort. The bayesian age-period-cohort (BAPC) model predicted the burden of bladder cancer attributable to HFPG from 2022 to 2050. BAPC model treats all unknown parameters as random parameters with appropriate prior distributions, no longer relying on explicit parameter settings. Meanwhile, it can incorporate additional parameters for unstructured differences to address the issue of large data dispersion. Simultaneously, it uses the prior information of unknown parameters and sample data to estimate the posterior distribution, and infers unknown parameters based on the posterior distribution. The BAPC model is constructed based on the Integrated Nested Laplace Approximation (INLA) method. As an efficient Bayesian inference technique, INLA can quickly and accurately approximate the posterior distribution when dealing with complex hierarchical models, while avoiding common problems in Markov Chain Monte Carlo (MCMC) such as poor mixing and convergence. The calculation formula of the BAPC model is $\ln(\lambda_{ij}) = \mu + \alpha_i + \beta_j + \gamma_k + Z_{ij}$where Z_{ij} represents the unstructured variation parameter, and $Z_{ij} \sim N(0, k_z^{-1})$ [15].

Results

Global burden of bladder cancer attributable to HFPG

The global deaths of bladder cancer attributable to HFPG increased from 6,092 cases in 1990 (95% UI:0–13,812) to 17,562 cases in 2021 (95% UI: 0–39,857) while the ASDR rose from 0.18 (95% UI: 0.00–0.40) per 100,000 people in 1990 to 0.21 (95% UI: 0.00–0.48) per 100,000 people in 2021. The EAPC of bladder cancer attributable to HFPG ASDR from 1990 to 2021 was 0.65% (95% CI: 0.55 to 0.76) (Table 1 and Supplementary Fig. 1). In addition, the number of global DALYs for bladder cancer attributable to HFPG in 2021 reached 323,834 (95% UI: 0–734,867), corresponding to an age-standardized DALYs rate of 3.81 (95% UI: 0.00–8.64) per 100,000 people. The age-standardized DALYs rate increased relatively to 1990, with an EAPC of 0.48% (95% CI: 0.38 to 0.58) (Table 1 and Supplementary Fig. 1).

Regional burden of bladder cancer attributable to HFPG

At SDI levels, the ASDR and age-standardized DALYs rate for bladder cancer attributable to HFPG rose in all SDI regions from 1990 to 2021 (Table 1 and Supplementary Fig. 1). The high SDI region had highest ASDR [0.30 (95% UI: 0.00–0.67) per 100,000 people] and age-standardized DALYs rate [5.42 (95% UI: 0.00–12.10) per 100,000 people] for bladder cancer attributable to HFPG in 2021 while the lowest of those was found in middle SDI regions with rates of 0.14 (95% UI: 0.00–0.32) per 100,000 people, 2.56 (95% UI: 0.00–5.92) per 100,000 people, respectively. It is worth noting that the low-middle SDI regions also had lowest ASDR in 2021 [0.14 (95% UI: 0.00–0.33) per 100,000 people]. The regions had highest increase in ASDR and age-standardized DALYs rate of bladder cancer attributable to HFPG was low-middle SDI regions with EAPCs of 1.34% (95% CI: 1.25 to 1.42), 1.32% (95% CI: 1.23 to 1.40), respectively. The regions had lowest increase of ASDR and age-standardized DALYs rate of bladder cancer attributable to HFPG from 1990 to 2021 was middle SDI regions, with EAPCs of 0.26% (95% CI: 0.15 to 0.37), 0.22% (95% CI: 0.11 to 0.32), respectively. It is worth noting that high-middle SDI regions also had lowest increase of age-standardized DALYs rate [EAPC: 0.22% (95% CI: 0.05 to 0.39)] (Table 1 and Supplementary Fig. 1).

At World Bank regions levels, high income regions had highest ASDR [0.30 (95% UI: 0.00–0.71) per 100,000 people], age-standardized DALYs rate [4.88 (95% UI:0.00–11.52) per 100,000 people] for bladder cancer attributable to HFPG in 2021 and lowest increase in ASDR [EAPC:

Table 1 The global, regional burden of bladder cancer attributable to high fasting plasma glucose: death and DALYs, 1990–2021

location	1990		2021		EAPC (95% CI)
	Number (95% UI)	ASR (95% UI)	Number (95% UI)	ASR (95% UI)	
Deaths					
Global	6092(0–13812)	0.18(0.00–0.40)	17,562(0–39857)	0.21(0.00–0.48)	0.65(0.55to0.76)
SDI					
High-middle SDI	1882(0–4259)	0.21(0.00–0.47)	4611(0–10340)	0.23(0.00–0.52)	0.40(0.22to0.59)
High SDI	2551(0–5697)	0.22(0.00–0.50)	7224(0–16187)	0.30(0.00–0.67)	1.06(0.95to1.16)
Low-middle SDI	445(0–979)	0.09(0.00–0.21)	1773(0–4039)	0.14(0.00–0.33)	1.34(1.25to1.42)
Low SDI	187(0–426)	0.11(0.00–0.26)	600(0–1357)	0.16(0.00–0.35)	0.92(0.83to1.02)
Middle SDI	1016(0–2328)	0.13(0.00–0.29)	3326(0–7758)	0.14(0.00–0.32)	0.26(0.15to0.37)
World Bank region					
High Income	416(0–950)	0.26(0.00–0.59)	923(0–2212)	0.30(0.00–0.71)	0.62(0.51to0.72)
Middle Income	438(0–982)	0.09(0.00–0.21)	1854(0–4165)	0.14(0.00–0.32)	1.14(1.02to1.25)
Low Income	53(0–120)	0.08(0.00–0.18)	201(0–496)	0.11(0.00–0.26)	0.78(0.59to0.97)
Continents					
Africa	272(0–622)	0.13(0.00–0.29)	942(0–2216)	0.19(0.00–0.45)	1.35(1.28to1.41)
America	1124(0–2468)	0.19(0.00–0.41)	3957(0–8881)	0.29(0.00–0.64)	1.69(1.45to1.93)
Asia	2141(0–4789)	0.14(0.00–0.31)	6927(0–15520)	0.15(0.00–0.34)	0.25(0.10to0.40)
Europe	2534(0–5828)	0.24(0.00–0.55)	5686(0–12892)	0.32(0.00–0.72)	0.90(0.83to0.97)
WHO regions					
African Region	180(0–411)	0.11(0.00–0.26)	586(0–1360)	0.16(0.00–0.36)	1.12(1.07to1.16)
Eastern Mediterranean Region	318(0–711)	0.22(0.00–0.50)	1314(0–3018)	0.38(0.00–0.88)	1.85(1.74to1.96)
European Region	2562(0–5886)	0.23(0.00–0.54)	5788(0–13144)	0.31(0.00–0.71)	0.92(0.85to0.99)
Region of the Americas	1124(0–2468)	0.19(0.00–0.41)	3957(0–8881)	0.29(0.00–0.64)	1.69(1.45to1.93)
South-East Asia Region	387(0–884)	0.07(0.00–0.17)	1690(0–3886)	0.11(0.00–0.26)	1.02(0.89to1.15)
Western Pacific Region	1476(0–3318)	0.16(0.00–0.37)	4059(0–9045)	0.15(0.00–0.33)	−0.34(−0.53to-0.15)
GBD regions					
Andean Latin America	12(0–26)	0.06(0.00–0.15)	66(0–155)	0.12(0.00–0.28)	2.08(1.96to2.21)
Australasia	42(0–91)	0.17(0.00–0.38)	111(0–240)	0.18(0.00–0.39)	0.20(0.12to0.27)
Caribbean	57(0–132)	0.24(0.00–0.55)	149(0–348)	0.27(0.00–0.64)	0.71(0.57to0.84)
Central Asia	29(0–64)	0.06(0.00–0.14)	96(0–226)	0.14(0.00–0.32)	2.61(2.41to2.81)
Central Europe	364(0–816)	0.25(0.00–0.56)	1193(0–2697)	0.49(0.00–1.11)	2.17(2.05to2.28)
Central Latin America	91(0–210)	0.13(0.00–0.30)	310(0–728)	0.13(0.00–0.31)	−0.12(−0.24to-0.01)
Central Sub-Saharan Africa	26(0–57)	0.18(0.00–0.40)	81(0–186)	0.21(0.00–0.50)	0.57(0.39to0.75)
East Asia	1120(0–2560)	0.17(0.00–0.39)	2803(0–6323)	0.14(0.00–0.31)	−0.67(−0.93to-0.42)
Eastern Europe	257(0–577)	0.09(0.00–0.21)	536(0–1212)	0.15(0.00–0.33)	1.42(1.15to1.69)
Eastern Sub-Saharan Africa	55(0–133)	0.11(0.00–0.27)	166(0–396)	0.14(0.00–0.32)	0.61(0.53to0.69)
High-income Asia Pacific	302(0–656)	0.16(0.00–0.36)	1099(0–2367)	0.17(0.00–0.37)	0.03(−0.07to0.14)
High-income North America	759(0–1650)	0.20(0.00–0.44)	2769(0–6236)	0.39(0.00–0.87)	2.47(2.13to2.81)
North Africa and Middle East	275(0–617)	0.21(0.00–0.47)	1233(0–2794)	0.34(0.00–0.78)	1.76(1.65to1.86)
Oceania	2(0–5)	0.10(0.00–0.24)	8(0–19)	0.14(0.00–0.32)	1.11(1.05to1.17)
South Asia	397(0–884)	0.09(0.00–0.20)	1714(0–3847)	0.14(0.00–0.30)	1.03(0.89to1.17)
Southeast Asia	147(0–350)	0.08(0.00–0.18)	604(0–1458)	0.12(0.00–0.28)	1.11(1.05to1.17)
Southern Latin America	95(0–203)	0.21(0.00–0.45)	227(0–513)	0.25(0.00–0.56)	0.69(0.59to0.78)
Southern Sub-Saharan Africa	32(0–76)	0.15(0.00–0.35)	104(0–255)	0.22(0.00–0.53)	1.48(1.21to1.75)
Tropical Latin America	121(0–282)	0.16(0.00–0.37)	463(0–1047)	0.19(0.00–0.42)	0.90(0.81to1.00)
Western Europe	1855(0–4278)	0.30(0.00–0.68)	3645(0–8308)	0.32(0.00–0.74)	0.25(0.20to0.30)
Western Sub-Saharan Africa	53(0–119)	0.08(0.00–0.18)	186(0–424)	0.13(0.00–0.29)	1.63(1.53to1.73)
DALYs					
Global	122,939(0–278962)	3.29(0.00–7.44)	323,834(0–734867)	3.81(0.00–8.64)	0.48(0.38to0.58)
SDI					
High-middle SDI	38,843(0–88092)	4.03(0.00–9.14)	85,856(0–195002)	4.29(0.00–9.73)	0.22(0.05to0.39)
High SDI	48,408(0–108716)	4.25(0.00–9.54)	122,018(0–272619)	5.42(0.00–12.10)	0.88(0.77to1.00)
Low-middle SDI	9633(0–21078)	1.76(0.00–3.88)	36,931(0–83808)	2.74(0.00–6.24)	1.32(1.23to1.40)

Table 1 (continued)

location	1990		2021		EAPC (95% CI)
	Number (95% UI)	ASR (95% UI)	Number (95% UI)	ASR (95% UI)	
Low SDI	4026(0–9149)	2.08(0.00–4.72)	12,495(0–27885)	2.84(0.00–6.38)	0.87(0.78to0.96)
Middle SDI	21,831(0–49278)	2.35(0.00–5.35)	66,008(0–153005)	2.56(0.00–5.92)	0.22(0.11to0.32)
World Bank region					
High Income	7566(0–17400)	4.74(0.00–10.90)	14,386(0–34167)	4.88(0.00–11.52)	0.22(0.13to0.31)
Middle Income	9403(0–20933)	1.73(0.00–3.88)	38,250(0–84419)	2.63(0.00–5.86)	1.15(1.04to1.26)
Low Income	1036(0–2327)	1.37(0.00–3.07)	3883(0–9462)	1.88(0.00–4.63)	0.85(0.71to1.00)
Continents					
Africa	5788(0–13141)	2.34(0.00–5.36)	19,982(0–47163)	3.55(0.00–8.33)	1.34(1.28to1.41)
America	22,442(0–49355)	3.67(0.00–8.07)	72,607(0–162282)	5.27(0.00–11.78)	1.42(1.19to1.66)
Asia	45,419(0–100781)	2.52(0.00–5.62)	131,497(0–296256)	2.70(0.00–6.09)	0.14(0.00to0.27)
Europe	48,901(0–111484)	4.58(0.00–10.44)	98,831(0–225319)	5.84(0.00–13.36)	0.76(0.69to0.84)
WHO regions					
African Region	3664(0–8253)	1.93(0.00–4.45)	12,089(0–27862)	2.79(0.00–6.47)	1.20(1.16to1.24)
Eastern Mediterranean Region	6907(0–15483)	4.23(0.00–9.50)	28,248(0–64480)	7.15(0.00–16.44)	1.76(1.65to1.86)
European Region	49,482(0–112658)	4.48(0.00–10.21)	100,842(0–230336)	5.74(0.00–13.13)	0.77(0.69to0.85)
Region of the Americas	22,442(0–49355)	3.67(0.00–8.07)	72,607(0–162282)	5.27(0.00–11.78)	1.42(1.19to1.66)
South-East Asia Region	8423(0–19087)	1.38(0.00–3.15)	34,071(0–76968)	2.02(0.00–4.60)	0.92(0.78to1.06)
Western Pacific Region	31,082(0–70316)	2.99(0.00–6.74)	72,998(0–166330)	2.58(0.00–5.89)	−0.48(−0.66to-0.31)
GBD regions					
Andean Latin America	218(0–491)	1.17(0.00–2.64)	1172(0–2677)	2.06(0.00–4.72)	1.92(1.81to2.04)
Australasia	798(0–1733)	3.32(0.00–7.23)	1813(0–3885)	3.17(0.00–6.77)	−0.10(−0.17to-0.03)
Caribbean	1048(0–2421)	4.17(0.00–9.63)	2734(0–6482)	5.06(0.00–12.01)	0.86(0.73to0.99)
Central Asia	676(0–1516)	1.45(0.00–3.27)	2145(0–5048)	2.78(0.00–6.55)	2.17(1.96to2.39)
Central Europe	7636(0–17062)	5.03(0.00–11.28)	22,485(0–50619)	9.58(0.00–21.51)	2.06(1.94to2.18)
Central Latin America	1835(0–4157)	2.40(0.00–5.46)	6121(0–14239)	2.50(0.00–5.84)	−0.06(−0.18to0.07)
Central Sub-Saharan Africa	603(0–1312)	3.26(0.00–7.18)	1869(0–4215)	4.03(0.00–9.21)	0.68(0.50to0.85)
East Asia	24,575(0–56559)	3.15(0.00–7.21)	54,205(0–122479)	2.53(0.00–5.70)	−0.73(−0.95to-0.50)
Eastern Europe	5728(0–12859)	2.00(0.00–4.49)	11,025(0–24698)	3.03(0.00–6.79)	1.17(0.88to1.46)
Eastern Sub-Saharan Africa	1115(0–2656)	1.85(0.00–4.48)	3302(0–7887)	2.39(0.00–5.73)	0.64(0.54to0.73)
High-income Asia Pacific	5565(0–12108)	2.87(0.00–6.24)	15,779(0–33863)	2.84(0.00–6.14)	−0.15(−0.28to-0.03)
High-income North America	15,181(0–33009)	4.18(0.00–9.07)	50,008(0–111020)	7.21(0.00–15.94)	2.09(1.75to2.44)
North Africa and Middle East	6010(0–13284)	3.96(0.00–8.84)	26,119(0–59855)	6.40(0.00–14.63)	1.66(1.55to1.77)
Oceania	56(0–128)	2.11(0.00–4.92)	202(0–464)	2.90(0.00–6.71)	1.20(1.13to1.27)
South Asia	8627(0–19035)	1.72(0.00–3.82)	35,248(0–78874)	2.54(0.00–5.74)	1.01(0.87to1.14)
Southeast Asia	2945(0–6889)	1.36(0.00–3.21)	11,919(0–28651)	2.03(0.00–4.92)	1.12(1.06to1.17)
Southern Latin America	1881(0–4020)	4.06(0.00–8.66)	4152(0–9312)	4.63(0.00–10.36)	0.58(0.48to0.68)
Southern Sub-Saharan Africa	616(0–1474)	2.55(0.00–6.12)	2212(0–5424)	4.12(0.00–10.15)	1.82(1.54to2.11)
Tropical Latin America	2505(0–5749)	2.97(0.00–6.86)	8894(0–20464)	3.51(0.00–8.08)	0.82(0.74to0.91)
Western Europe	34,255(0–78704)	5.63(0.00–12.89)	58,645(0–135177)	5.73(0.00–13.18)	0.03(−0.03to0.09)
Western Sub-Saharan Africa	1066(0–2392)	1.39(0.00–3.12)	3784(0–8642)	2.28(0.00–5.22)	1.65(1.55to1.76)

In this study, the negative bounds of the UI were truncated to zero

DALYs Disability-adjusted life years, *SDI* Social demographic index, *ASR* Age-standardized rate, *UI* Uncertainty interval, *CI* Confidence interval

0.62% (95% CI: 0.51 to 0.72)], age-standardized DALYs rate [EAPC: 0.22% (95% CI: 0.11 to 0.32)] from 1990 to 2021. The highest increase of those was found in middle income regions with EAPCs of 1.14% (95% CI: 1.02 to 1.25), 1.15% (95% CI: 1.04 to 1.26), respectively (Table 1). Of note, the low income regions had lowest ASDR [0.11 (95% UI: 0.00–0.26) per 100,000 people] and age-standardized DALYs rate [1.88 (95% UI: 0.00–4.63) per 100,000 people] in 2021 (Table 1).

All continents showed an increasing trend of burden of bladder cancer attributable to HFPG from 1990 to 2021. Among four continents, Europe had highest ASDR, age-standardized DALYs rate for bladder cancer attributable to HFPG in 2021, with rates of 0.32 (95% UI: 0.00–0.72) per 100,000 people, 5.84 (95% UI: 0.00–13.36) per 100,000 people, respectively (Table 1). Asia had lowest of those with rates of 0.15 (95% UI: 0.00–0.34) per 100,000 people, 2.70 (95% UI: 0.00–6.09) per 100,000 people,

respectively. Beyond that, Asia also had lowest increase in ASDR [EAPC: 0.25% (95% CI: 0.10 to 0.40)] and age-standardized DALYs rate [EAPC: 0.14% (95% CI: 0.00 to 0.27)] for bladder cancer attributable to HFPG from 1990 to 2021. The highest increase of those was found in America. At WHO regions levels, Eastern Mediterranean region reached highest increase ASDR [EAPC: 1.85% (95% CI: 1.74 to 1.96)], age-standardized DALYs rate [EAPC: 1.76% (95% CI: 1.65 to 1.86)] and Western Pacific region reached lowest increase ASDR [EAPC: −0.34% (95% CI: −0.53 to −0.15)] and age-standardized DALYs rate [EAPC: −0.48% (95% CI: −0.66 to −0.31)] of bladder cancer attributable to HFPG from 1990 to 2021 (Table 1). At GBD super regions, Central Asia had highest increase in ASDR [EAPC: 2.61% (95% CI: 2.41 to 2.81)] and age-standardized DALYs rate [EAPC: 2.17% (95% CI: 1.96 to 2.39)] of bladder cancer attributable to HFPG from 1990 to 2021. At the same time, East Asia had lowest increase of those, with EAPCs of −0.67% (95% CI: −0.93 to −0.42), −0.73% (95% CI: −0.95 to −0.50), respectively (Table 1).

National burden of bladder cancer attributable to HFPG

Among 204 countries and territories, the burden of bladder cancer attributable to HFPG from 1990 to 2021 was on an upward trend in most countries. Lebanon exhibited highest ASDR and age-standardized DALYs rate in 2021, with rates of 0.89 (95% UI: 0.00–2.07) per 100,000 people, 15.94(95% UI: 0.00–37.03) per 100,000 people, respectively. Albania had lowest of those, with rates of 0.02 (95% UI: 0.00–0.04) per 100,000 people, 0.29 (95% UI: 0.00–0.68) per 100,000 people, respectively (Supplementary Table S1, Supplementary Fig. 2, and Supplementary Fig. 3). Cabo Verde experienced the highest increase in ADSR [EAPC: 7.07% (95% CI: 5.55 to 8.61)] and age-standardized DALYs rate [EAPC: 7.45% (95% CI: 5.92 to 8.99)] of bladder cancer attributable to HFPG from 1990 to 2021. Cyprus had lowest increase in ASDR, with an EAPC of −1.80% (95% CI: −1.91 to −1.69). In addition to this, Singapore had lowest increase in age-standardized DALYs rate, with an EAPC of −1.70% (95% CI: −1.94 to −1.47) (Supplementary Table S1, Supplementary Fig. 2, and Supplementary Fig. 3).

Burden of bladder cancer attributable to HFPG based on sex and age

Supplementary Fig. 4 demonstrated the burden of bladder cancer attributable to HFPG based on sex and age in 2021. The age group with the highest number of deaths was 80–84 age group, regardless of sex, with 805 females and 2,430 males. In terms of the number of DLAYs, irrespective of gender, the highest number was found in the 70–74 age group, with 12,491 for females and 46,967 for males. When stratified by SDI, both males and females had the highest death and DALYs in the high SDI regions (Supplementary Fig. 5).

Attribution of HFPG

Figure 1 showed the attribution of HFPG to bladder cancer. Among the risk factors of bladder cancer, HFPG shared at 7.9% of deaths in globally. The proportion of bladder cancer attributable to HFPG varied significantly across different SDI levels. High SDI regions had the highest share at 8.9%, followed by low-middle SDI regions at 8.3%, middle SDI regions at 7.2%, high-middle SDI regions at 7.2%, and low SDI regions at 6.4%. Regarding DALYs of bladder cancer, HFPG shared at 7.4% of DALYs in globally. Among SDI regions, high SDI regions recorded the highest share, at 8.6%, while low SDI regions had the lowest, standing at 5.5%.

APC modeling for bladder cancer attributable to HFPG

After adjusting for period and cohort effects, the death rate of bladder cancer attributable to HFPG first increased and then decreased with age. It rose from

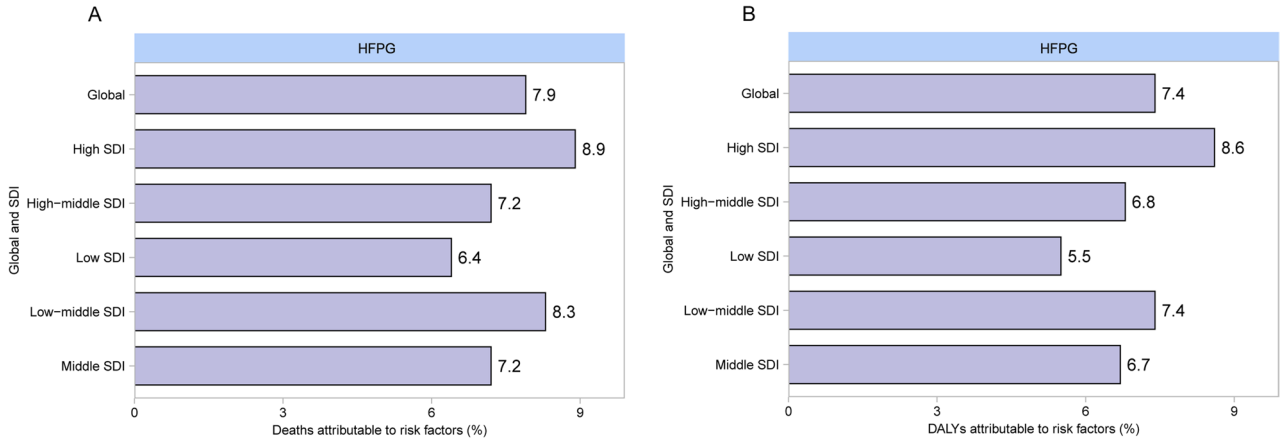


Fig. 1 Proportion of bladder cancer attributable to HFPG deaths and DALYs in 2021. **A** Deaths. **B** DALYs. HFPG: high fasting plasma glucose; DALYs: disability-adjusted life years

0.0004 (95% CI: 0.0002–0.0007) at 27.5 years old to 7.415 (95% CI: 7.097–7.747) at 92.5 years old, and then gradually declined. The DALY rate showed a similar trend, increasing from 0.023 (95% CI: 0.020–0.027) at 27.5 years old to 67.360 (95% CI: 66.048 68.698) at 92.5 years old, and then began to decrease gradually. After adjusting for age and cohort effects, the period rate ratio (RR) of the deaths rate of bladder cancer attributable to HFPG showed an overall increasing trend. Taking 2002–2006 as the reference (RR = 1), the period RR was the lowest in 1992–1996 (RR = 0.969, 95% CI: 0.928–1.012). Meanwhile, the period RR of the DALY rate of bladder cancer attributable to HFPG also showed an overall increasing trend. Taking 2002–2006 as the reference (RR = 1), the period RR was the lowest in 1992–1996 (RR = 0.950, 95% CI: 0.939 – 0.862). With the passage of birth years, the cohort RR of the deaths rate of bladder cancer attributable to HFPG showed a trend of increasing first and then fluctuating. Taking 1942–1946 as the reference (RR = 1), the cohort RR of the death rate of bladder cancer attributable to HFPG was the lowest in 1897–1901 (RR = 0.565, 95% CI: 0.425–0.752); and the cohort RR was the highest in 1932–1936 (RR = 1.024, 95% CI: 0.993–1.057). The cohort RR of the DALY rate of bladder cancer attributable to HFPG showed a similar trend. Taking 1942–1946 as the reference (RR = 1), the cohort RR of the DALY rate of bladder cancer attributable to HFPG was the lowest in 1897–1901 (RR = 0.566, 95% CI: 0.485–0.659); and the cohort RR was the highest in 1987–1991 (RR = 1.055, 95% CI: 0.906–1.229) (Fig. 2).

Future forecasts for the burden of bladder cancer attributable to HFPG

From Fig. 3, it can be seen that there is an increasing trend in the burden of bladder cancer attributable to HFPG regardless of gender. Age-standardized DALYs rate is projected to increase from 1.78 per 100,000 people in 2021 to 2.59 per 100,000 people (95% UI: 0.00–5.20.00.20) in 2050 in female population. In male population, age-standardized DALYs rate will be 7.49 per 100,000 people (95% UI: 0.36–14.62) in 2050, which is nearly three times that of females. ASDR for male is projected to increase from 0.32 per 100,000 people in 2021 to 0.38 per 100,000 people (95% UI: 0.00–0.79.00.79) in 2050. For female, ASDR will increase to 0.16 per 100,000 people (95% UI: 0.00–0.34.00.34), and the male ASDR is more than twice that of females.

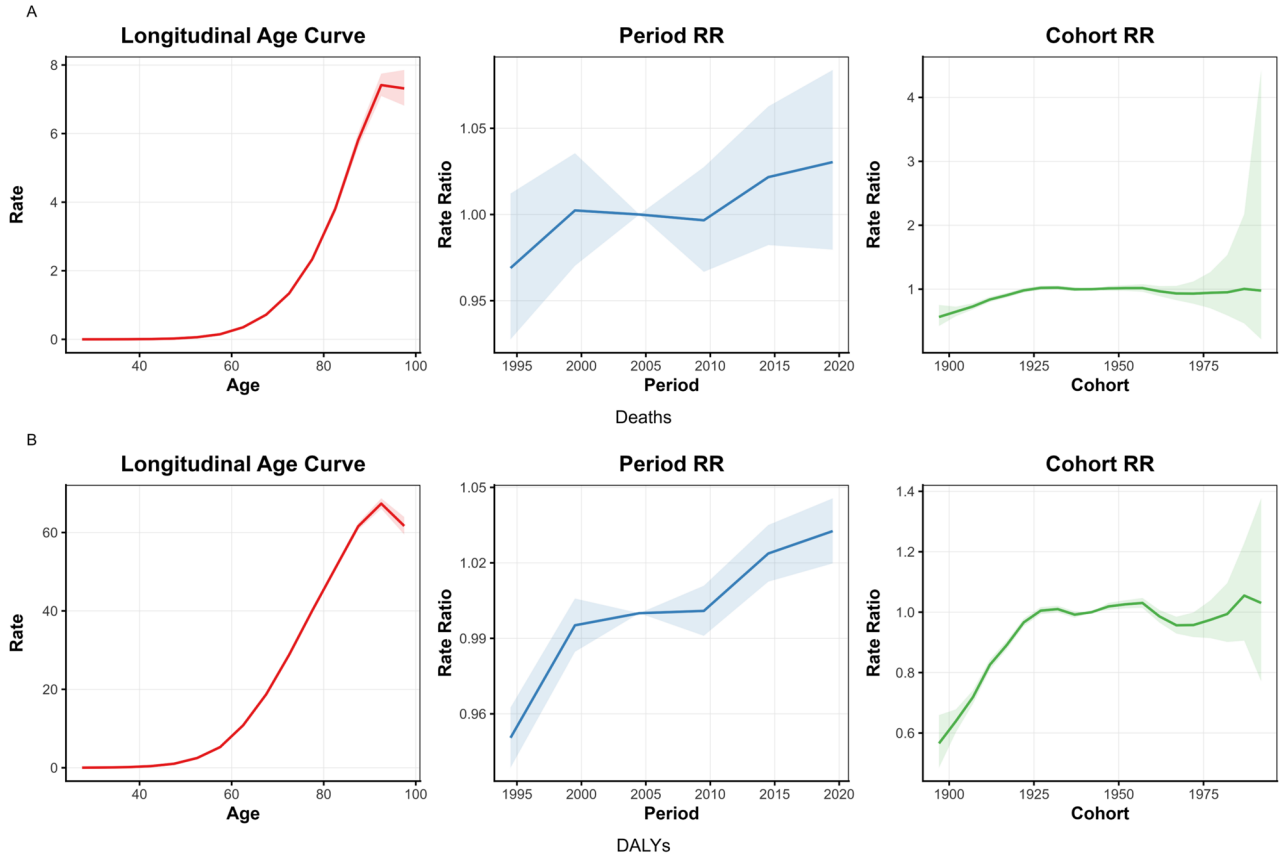


Fig. 2 Age, period and cohort effects on bladder cancer attributable to HFPG deaths and DALYs during 1990–2021. **A** Deaths. **B** DALYs. HFPG: high fasting plasma glucose; DALYs: disability-adjusted life years

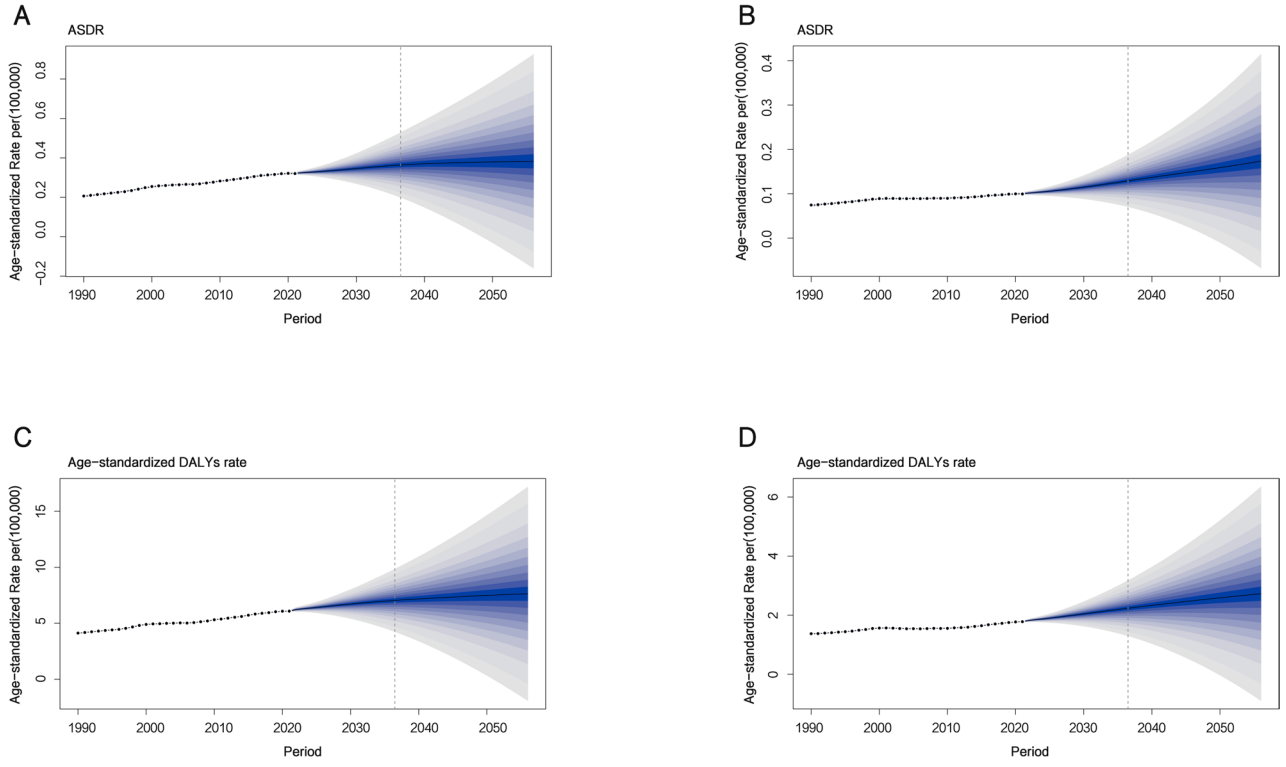


Fig. 3 Future projections of the global burden of bladder cancer attributable to HFPG by sex. **A** Male deaths. **B** Female deaths. **C** Male DALYs. **D** Female DALYs. HFPG: high fasting plasma glucose; DALYs: disability-adjusted life years

Discussion

This study evaluated the global, regional, and national levels and trends in burden of bladder cancer attributable to HFPG from 1990 to 2021. Although the disease burden of bladder cancer has shown a downward trend over the past three decades, this study found that the burden of bladder cancer attributable to HFPG was on the rise from 1990 to 2021 and the burden of bladder cancer attributable to HFPG keep rising to 2050. Our results suggested the need to pay attention to blood glucose levels in bladder cancer patients.

Some studies have reported the potential mechanisms between HFPG and the risk of bladder cancer. HFPG leads to a marked increase in blood glucose. Enhanced glucose uptake by cancer cells is a clear marker of cancer cells, and high blood glucose can provide a high glucose fuel source for rapidly proliferating cancer cells [16]. HFPG also can increase the level of insulin-like growth factor-1 (IGF-1) through insulin resistance, and the role of IGF-1 in organisms is to promote the proliferation and differentiation of tumor cells and inhibit apoptosis, thus inducing bladder cancer [17]. In addition, antidiabetic drugs are also associated with the risk of bladder cancer. The results of a meta-analysis showed that sodium-glucose cotransporter 2 inhibitors may increase the risk of developing bladder cancer [18]. None of these findings fully explain the association between development of bladder cancer and HFPG or diabetes status. Given the global rise in the burden of bladder cancer attributable to HFPG, there is a need for further research into how HFPG, diabetes status, and antidiabetic medications may play a role in the development of bladder cancer.

In this study, it was found that the burden of bladder cancer attributable to HFPG in male was significantly higher than that in female. The burden in the male population was higher than that in the female population among the total bladder cancer population [2]. Apart from this, among the total population, there were 17.7 million more men than women worldwide who suffered from diabetes, and men were usually diagnosed with diabetes at a younger age and with a lower body fat percentage compared to women [19]. Smoking is one of the risk factors for bladder cancer, and is more prevalent in the male population [20]. Harmful substances in tobacco may damage the mucous membrane of the bladder, while metabolic abnormalities caused by HFPG may weaken the body's ability to repair itself, thus promoting the development of bladder cancer [21]. In addition to this, similar results were found in the elderly population in this study, and the situation was more pronounced. These above results suggested that more attention should be paid to the blood glucose levels in the bladders of elderly men.

The burden of bladder cancer attributable to HFPG varies across different regions and countries. In our study, it

was found that the burden of bladder cancer attributable to HFPG reached the highest level in high SDI regions, high income regions, and Europe. The study revealed that diabetic patients in economically developed regions have a higher risk of developing bladder cancer [22]. In high-income countries, people have shifted from occupations involving physical activity to sedentary jobs, which has led to an increase in the prevalence of obesity [23, 24]. This, in turn, has raised the risk of elevated blood sugar levels, as well as the incidence and death of bladder cancer [25, 26]. Advances in medical technology have made it easier for cancers to be detected in high income regions, and also for patients in those low income regions to be missed [27]. Therefore, the importance of physical activity should be emphasized, and targeted and effective intervention measures should be established in countries with different economic levels to alleviate the heavy burden caused by HFPG.

For the APC model, overall, the death rates and DALYs rates of bladder cancer attributable to HFPG showed first increased and then decreased with age. There is no doubt that aging plays a role in this, leading to a decline in overall physical functions and immune capabilities [28]. Regarding the downward trend observed after 92.5 years of age, we hypothesized that it may be related to the "survival effect"—among individuals aged 92.5 years and above, some high-risk groups have already died from bladder cancer or other chronic diseases. As a result, the overall risk of the remaining population is relatively reduced, leading to a slight decline in the disease burden. However, the burden still remains at a high level. In the period effect, the period RRs of both death rates and DALYs rates showed an upward trend. This phenomenon is closely associated with the continuous increase in the number of people with HFPG and improvements in diagnosis and reporting. Studies have shown that in 2021, the number of deaths from type 2 diabetes mellitus surged by 154.3%, with ASDR of 19.0 per 100,000 population, and the age-standardized DALYs rate increased by 202.2% [29]. Additionally, the coverage of cancer registration systems, pathological diagnosis technologies, and electronic health records has significantly improved. This has enabled more cases, especially early-stage ones, to be detected and included in statistics, which is reflected as an upward trend in death rates and DALYs rates in the GBD study [30].

Although this study was the first to analyze the global burden of bladder cancer attributable to HFPG from 1990 to 2021 and predict the burden trend up to 2050, it has certain limitations. Firstly, the GBD database relies on a diverse range of data sources from all over the world, encompassing hospital records, death registrations, population censuses, health surveys, and academic research. Nevertheless, the accessibility and quality of the data vary significantly across different countries and regions. Secondly, due to the inability to identify asymptomatic bladder cancer patients or those who refuse to seek medical treatment through patient databases, the burden may be underestimated. Finally, given that bladder cancer has multiple risk factors and due to the limitations of the GBD database, this study, which explored the association of bladder cancer attributable to HFPG, is unable to control for other potential risk factors.

Conclusions

This study strikingly emphasized the substantial and increasing burden of bladder cancer attributable to HFPG globally. The burden of bladder cancer attributable to HFPG rose in all SDI regions from 1990 to 2021. Europe had highest burden for bladder cancer attributable to HFPG in 2021.The burden of bladder cancer attributable to HFPG was higher in the elderly population. In light of these findings, it is essential to enhance ongoing investments in research and prevention efforts targeting bladder cancer attributable to HFPG.

Abbreviations

APC	Age-period-cohort
ASDR	Age-standardized deaths rate
ASR	Age-standardized rates
BAPC	Bayesian age-period-cohort
CI	Confidence interval
DALYs	Disability-adjusted life years
EAPC	Estimated annual percentage change
GBD	Global Burden of Disease
HFPG	High fasting plasma glucose
IGF-1	Insulin-like growth factor-1
INLA	Integrated Nested Laplace Approximation
MCMC	Markov Chain Monte Carlo
RR	Rate ratio
SDI	Socio-demographic index
TMREL	Theoretical minimum risk exposure level
UI	Uncertainty interval
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12885-025-15359-3.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

Supplementary Material 5.

Supplementary Material 6.

Acknowledgements

The authors appreciate the works by the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2021collaborators.

Authors' contributions

KJL was involved in writing–original draft, writing–review & editing, and formal analysis. YFZ contributed to writing–original draft, writing–review &

editing, and data curation. YXL took on writing–review & editing, investigation, and methodology. TH handled writing–review & editing and visualization. XYL was responsible for writing–review & editing and woftware. YCH participated in writing–review & editing and resources. WQL carried out writing–review & editing and supervision. XWH engaged in writing–review & editing and conceptualization. YHZ took charge of Writing–review & editing, Funding acquisition, and Project administration.All authors read and approved the final manuscript.

Funding
This study was funded by the National Natural Science Foundation of China (Grant No.82372685), Research Project of Guangdong Provincial Administration of Traditional Chinese Medicine (Grant No.20262049), Guangdong Basic and Applied Basic Research Foundation (Grant No.2023A1515220184, 2023A1515220213), Science and Technology Planning Projects of Guangdong Province (Grant No. STKJ202209068).

Data availability
The datasets generated and/or analysed during the current study are available in the GBD database, https:/ghdx.healthdata.org/gbd-results-tool.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Urology, Shantou Central Hospital, Shantou, Guangdong 515031, China
[2]Shantou Key Laboratory of Basic and Translational Research of Malignant Tumor, Shantou, Guangdong 515031, China
[3]Clinical Medical Research Center, Shantou Central Hospital, Shantou, Guangdong 515031, China

Received: 29 August 2025 / Accepted: 15 November 2025
Published online: 04 December 2025

References

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. Cancer J Clin. 2024;74(3):229–63.
2. Zi H, Liu MY, Luo LS, Huang Q, Luo PC, Luan HH, et al. Global burden of benign prostatic hyperplasia, urinary tract infections, urolithiasis, bladder cancer, kidney cancer, and prostate cancer from 1990 to 2021. Military Med Res. 2024;11(1):64.
3. Zhao X, Wang Y, Liang C. Cigarette smoking and risk of bladder cancer: a dose-response meta-analysis. Int Urol Nephrol. 2022;54(6):1169–85.
4. van Hensbergen M, van Osch FHM, Jochems S, James ND, Wallace DMA, Wesselius A, et al. Fluid intake and clinicopathological characteristics of bladder cancer: the West Midlands bladder cancer prognosis programme. Eur J Cancer Prevention: Official J Eur Cancer Prev Organisation (ECP). 2020;29(2):110–8.
5. Seyyedsalehi MS, Bonetti M, Shah D, DeStefano V, Boffetta P. Occupational benzene exposure and risk of kidney and bladder cancers: a systematic review and meta-analysis. Eur J Cancer Prevention: Official J Eur Cancer Prev Organisation (ECP). 2025;34(3):205–13.
6. Yan B, Li X, Peng M, Zuo Y, Wang Y, Liu P, et al. The YTHDC1/GLUT3/RNF183 axis forms a positive feedback loop that modulates glucose metabolism and bladder cancer progression. Exp Mol Med. 2023;55(6):1145–58.
7. Jubber I, Ong S, Bukavina L, Black PC, Compérat E, Kamat AM, et al. Epidemiology of bladder cancer in 2023: A systematic review of risk factors. Eur Urol. 2023;84(2):176–90.
8. Liang R, Feng X, Shi D, Yang M, Yu L, Liu W, et al. The global burden of disease attributable to high fasting plasma glucose in 204 countries and territories, 1990–2019: an updated analysis for the Global Burden of Disease Study 2019. Diabetes Metab Res Rev. 2022;38(8):e3572.
9. Ko SH, Han KD, Yun JS, Chung S, Koh ES. Impact of obesity and diabetes on the incidence of kidney and bladder cancers: a nationwide cohort study. Eur J Endocrinol. 2019;181(5):489–98.
10. Lu Y, Tao J. Diabetes mellitus and obesity as risk factors for bladder cancer prognosis: a systematic review and meta-analysis. Front Endocrinol. 2021;12:699732.
11. Wu Y, Deng Y, Dai Z, Ma Y, Lyu L, Lei C, et al. Estimates of bladder cancer burden attributable to high fasting plasma glucose: findings of the Global Burden of Disease Study 2019. Cancer Med. 2023;12(15):16469–81.
12. Tondro Anamag F, Noori M, Nejadghaderi SA, Sullman MJM, Grieger JA, Kolahi AA, et al. Burden of cancers attributable to high fasting plasma glucose in the middle East and North Africa region, 1990–2019. Cancer Med. 2023;12(8):10031–44.
13. Ying J, Lan X, Zhou H, Li H, Sheng W, Huang J. Global, regional, and national burdens of chronic kidney disease attributable to high body mass index from 1990 to 2021, with future forecasts up to 2050: a systematic analysis for the global burden of disease study 2021. Front Public Health. 2025;13:1612300.
14. Cen J, Wang Q, Cheng L, Gao Q, Wang H, Sun F. Global, regional, and national burden and trends of migraine among women of childbearing age from 1990 to 2021: insights from the global burden of disease study 2021. J Headache Pain. 2024;25(1):96.
15. Nie Y, Wang N, Huang M, Li Y, Lu Y, Li H, et al. Global burden of disease from high-sodium diets, 1990–2021: analysis of GBD 2021 data. Front Nutr. 2025;12:1617644.
16. Yazdanparast S, Benvidi A, Abbasi S, Sabbagh SK. Monitoring the mechanism of anti-cancer agents to inhibit colorectal cancer cell proliferation: enzymatic biosensing of glucose combined with molecular docking. Enzyme Microb Technol. 2021;148:109804.
17. Friedrich N, Thuesen B, Jørgensen T, Juul A, Spielhagen C, Wallaschofksi H, et al. The association between IGF-I and insulin resistance: a general population study in Danish adults. Diabetes Care. 2012;35(4):768–73.
18. Søndergaard CS, Esquivel PN, Dalamaga M, Magkos F. Use of antihyperglycemic drugs and risk of cancer in patients with diabetes. Curr Oncol Rep. 2023;25(1):29–40.
19. Kautzky-Willer A, Leutner M, Harreiter J. Sex differences in type 2 diabetes. Diabetologia. 2023;66(6):986–1002.
20. Sell V, Ettala O, Perez IM, Järvinen R, Pekkarinen T, Vaarala M, et al. Awareness of smoking as a risk factor in bladder cancer: results from the Prospective FinnBladder 9 Trial. Eur Urol Focus. 2022;8(5):1246–52.
21. Jin F, Thaiparambil J, Donepudi SR, Vantaku V, Piyarathna DWB, Maity S, et al. Tobacco-specific carcinogens induce hypermethylation, DNA adducts, and DNA damage in bladder cancer. Cancer prevention research (Philadelphia, Pa). 2017;10(10):588–97.
22. Tseng CH. Diabetes and risk of bladder cancer: a study using the National Health Insurance database in Taiwan. Diabetologia. 2011;54(8):2009–15.
23. Eyjólfsdóttir HS, Agahi N, Fritzell J, Lennartsson C. Physical functioning as a predictor of retirement: has its importance changed over a thirty-year period in Sweden? Eur J Ageing. 2022;19(4):1417–28.
24. Pettit-Mee RJ, Ready ST, Padilla J, Kanaley JA. Leg fidgeting during prolonged sitting improves postprandial glycemic control in people with obesity. Obes (Silver Spring Md). 2021;29(7):1146–54.
25. Alobaid DS, Alansare AB. Associations of mentally active versus passive sedentary behavior with overweight/obesity in adults: role of patterns and sex. Healthcare. 2025;13(4):361.
26. Koelker M, Alkhatib K, Briggs L, Labban M, Meyer CP, Conwright D CM, et al. Impact of exercise on physical health status in bladder cancer patients. Can Urol Association J = J De l'Association Des Urologues Du Can. 2023;17(1):E8–14.
27. Hasan S, Lazarev S, Garg M, Mehta K, Press RH, Chhabra A, et al. Racial inequity and other social disparities in the diagnosis and management of bladder cancer. Cancer Med. 2023;12(1):640–50.
28. Yu W, Yu Y, Sun S, Lu C, Zhai J, Lei Y, et al. Immune alterations with aging: mechanisms and intervention strategies. Nutrients. 2024;16(22):3830.
29. Collaborator GD. Global, regional, and National burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the global burden of disease study 2021. Lancet (London England). 2023;402(10397):203–34.
30. Safiri S, Kolahi AA, Naghavi M. Global, regional and National burden of bladder cancer and its attributable risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019. BMJ Glob Health. 2021;6(11):e004128.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.