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# Global burden of benign prostatic hyperplasia in males aged 60–90 years from 1990 to 2019: results from the global burden of disease study 2019

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## Abstract

**Background** Benign prostatic hyperplasia (BPH) is a prevalent urological disease in elderly males. However, few studies have estimated the temporal and spatial distributions of the BPH burden in male adults aged 60 years and over at the global, national, and regional scales.

**Methods** Leveraging the Global Burden of Disease, Injuries, and Risk Factors Study, we estimated the global epidemiological trends in the prevalence, incidence, and disability-adjusted life-years (DALYs) of BPH in 204 countries and 21 regions and 5 sociodemographic index (SDI) regions in males aged 60 years and over between 1990 and 2019. The average annual percentage changes (AAPCs) in age-specific rates were estimated to quantify overall trends. We estimated the contribution of population aging and epidemiological alterations in disease burden via composition analysis.

**Results** Over the past three decades, the global prevalent cases, incident cases and DALYs of BPH have increased, ranging from 118.78 to 121.22%. The global number of prevalent BPH cases reached 79 million in people aged 60 years and older in 2019. The prevalence, incidence, and DALYs rates gradually increased, with AAPCs of 0.02, 0.02, and 0.01, respectively. Low-middle, middle, and low SDI regions experienced rapid increases in the number of prevalent cases of BPH. In 2019, China, India, and United States of America bore the largest burden of prevalent cases among people aged 60 years and over. The three regions with the highest prevalence rates of BPH were Eastern Europe, Central Latin America, and Andean Latin America. The increased prevalence was attributed to population growth (94.93%), epidemiological changes (3.45%), and aging (1.62%), globally.

**Conclusions** BPH is a global health issue that imposes substantial economic burdens on most countries, particularly males aged 60 years and over. Effective health decisions are imperative for BPH prevention and treatment.

**Keywords** Benign prostatic hyperplasia, Disability-adjusted life-years, Global disease burden, Incidence, Prevalence

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## Background

Benign prostatic hyperplasia (BPH) has become an emerging concern in male health with the aging population and changing lifestyle. BPH is characterized by an enlarged prostate that can cause symptoms linked to the bladder, urinary tract or kidney, such as partial or complete urethral blockage [1]. An enlarged prostate can hinder urinary output, leading to lower urinary tract symptoms (LUTS) [2–4]. In 2019, the age-standardized prevalence of BPH was 2480 (95% uncertainty interval [UI]: 1940–3090) per 100,000 people globally [5]. In the U.S., the direct expenditure attributed to treatment, excluding outpatient drugs, reached $1.1 billion in 2000 [6]. Given the profound social and medical implications of the BPH burden, further analysis of its long-term trend is imperative.

Aging is an important determinant of the development of BPH [7–9]. Globally, a meta-analysis including 30 epidemiological studies estimated an approximately 26% pooled prevalence of BPH in older men between 1990 and 2016 [10]. In China, a meta-analysis based on epidemiological surveys reported a pooled prevalence of 36.6% among men aged 40 years and older between 1989 and 2014 [11]. In addition to increasing the risk of acute urinary retention, BPH and LUTS significantly affect quality of life. A pilot study based on the International Prostatism Symptom Score (IPSS) revealed that older European men, coupled with LUTS and BPH, had an average score of 4.14 on items related to quality of life, indicating a worse condition [12]. This finding was supported by the American Urological Association Symptom Index [13]. Furthermore, BPH severity may lead to sleep disorders due to the occurrence of nocturia (frequently awakening to urinate at night). In a prior study, researchers reported that Nocturia-specific Quality of Life (N-QoL) scores were negatively associated with the frequency of nighttime voiding [14]. Older males also suffer from multiple chronic diseases, and these comorbidities increase the incidence risk and decrease the therapeutic effect of BPH. For example, among 547 patients who reported BPH, those who were diagnosed with depression had higher AUS-AI scores, and their odds of having moderate and even severe LUSTs were three times greater than those of those without depression in a longitudinal study [15]. Although a growing body of studies has elucidated the association between BPH and impaired quality of life, the current evidence remains heterogeneous due to contextual differences in various countries and regions. Therefore, a comprehensive analysis that compiles global metrics is warranted.

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) synthesizes global, national, and regional epidemiological data via a validated estimation framework, standardized procedure, and advanced analysis methods to identify epidemiological trends and conduct comparisons during specific periods stratified by cause, sex, age group and geographical location [16–18]. In this study, we aimed to estimate the number, prevalence, incidence, and disability-adjusted life years (DALYs) of BPH among older people aged between 60 and 90 years at the global, regional, and national scales via a GBD study from 1990 to 2019. We also assessed the proportions attributable to aging, population and epidemiological factors through a decomposition analysis.

## Methods

### Study data

The study data were collected and downloaded from the GBD 2019, which was integrated and published by the Institute for Health Metrics and Evaluation at the University of Washington, USA. The GBD 2019 offers rough estimates and 95% UI on cause-specific prevalence, incidence, and disability for 369 diseases and injuries, alongside 87 risk factors, in 204 countries and territories between 1990 and 2019 [19]. The GBD 2019 has been widely studied for its epidemiological description of and trends in diseases, prediction of cases, estimation of health loss and economic burden, and assessment of health disparities [20–22]. All the data can be found on the Global Health Data Exchange (GHDx) website.

The definition of BPH was based on the clinical diagnosis using the codes of the International Classification of Diseases (ICD) [23]. The ICD-9 codes used were 600, 600.0, 600.1, 600.2, 600.3 and 600.9, and the ICD-10 codes used were N40, N40.0, N40.1, N40.2, N40.3 and N40.9. The complications associated with BPH were not considered in this analysis because these diseases were mapped to other forms of GBD definitions, such as kidney stones. According to the GBD 2019 design, BPH incidence was estimated only for nonfatal health loss because fatal complications were grouped into other types of conditions and mortality attributed to these complications should not be recalculated. Because the WHO defines older people as those aged 60 years and over, we included people aged between 60 and 90 years [24]. The age stratification was divided into 5-year intervals starting from 60 years.

### Statistical analysis

We procured annual measures encompassing the numbers and rates of prevalence, incidence, and DALYs. Prevalence refers to the total number of cases of a disease in a population at a given time, whereas incidence refers to the number of new cases that develop in a specific period. DALYs measure the overall disease burden, expressed as the number of years lost due to ill health, disability, or early death. The detailed data processing and statistical modeling methods used were described

previously [19]. In brief, DisMod-MR V2.5 software and meta-regression-Bayesian, regularized, trimmed (MR-BRT) software were used to estimate the metrics. The UI was ascertained for each metric via posterior distributions after 1000 posterior draws, ranging from the 25th and 975th order values. However, we used the aggregated data rather than the original data to estimate the burden of diseases, increasing potential bias.

The sociodemographic index (SDI), a composite indicator used to assess social and population development in a country or region, is derived from parameters such as the fertility rate, education level, and per capita income. With a range from 0 to 1, higher SDI values denote superior socioeconomic development. Furthermore, the SDI is correlated with epidemiological patterns of disease and mortality [25]. The countries and regions included in the GBD 2019 study were generally categorized into five grades (high, high-middle, middle, low-middle, and low). In this study, we further examined the associations of BPHs with various SDI regions over time.

We employed joinpoint regression modeling to investigate alterations in BPH epidemiology trends at global, regional, and national scales [26]. This method can identify significant points where the slopes of trends change, and then the periods can be divided into multiple time intervals on the basis of the locations of the observed points. We then calculated the epidemiological trends for each time interval, represented via average annual percentage changes (AAPCs) and their 95% CIs [27]. The total asymptotic significance was ascertained via the Bonferroni correction and Monte Carlo permutation method, which was applied to 4499 datasets of random permutations. The AAPCs represent the magnitude of annual changes. Negative AAPCs denote a downward epidemiological trend, whereas positive AAPCs denote an upward epidemiological trend. In detail, AAPC is determined by first estimating the joinpoint model that best fits the data. The AAPC for any fixed interval is then computed as a weighted average of the slope coefficients from the joinpoint regression model, with the interval. Finally, this weighted average of the slope coefficients is transformed into an annual percent change. If $b_i$ represents the slope coefficient for the $i_{th}$ segment and $w_i$ denotes the length of each segment within the specified range of years, the following formula is applied:

$$APC_i = \{exp\,(b_i) - 1\} \times 100 \textbf{ and } AAPC = \left\{exp\left(\frac{\sum w_i b_i}{\sum w_i}\right) - 1\right\} \times 100$$

Decomposition analysis was used to quantify the contributions of three determinants (aging, population growth and epidemiological changes) to epidemiological metrics over specific periods. Epidemiological changes were characterized as modifications in age-adjusted and population-adjusted mortality and prevalence rates. We first used the decomposition methodology of Das Gupta to decompose, prevalence, incidence, and DALYs by population age structure, population growth, and epidemiologic changes. For example, the number of DALYs at each location was obtained from $DALY_{ay,py,ey} = \sum_{i=1}^{20} (a_{i,y} * p_y * e_{i,y})$, where $DALY_{ay,py,ey}$ represents DALYs based on the factors of age structure, population, and the DALYs rate for a specific year y; $a_{i,y}$ represents the proportion of the population for the age category $i$ of the different age categories in a given year $y$; $p_y$ represents the total population in a given year $y$; and $e_{i,y}$ represents the DALYs rate given age category $i$ in year $y$. The contribution of each factor to the change in DALYs from 1990 to 2019 was defined by the effect of factor changes while the other factors were held constant.

All the statistical analyses were completed via R version 4.2.1 and the joinpoint regression program (4.9.1.0).

## Results

### Global prevalence of BPH

In 2019, the global prevalent cases of BPH in patients aged≥60 years was estimated to be 79,309,174 (95% UI: 61,181,380 to 100,520,944), which represented an increase of 119.01% since 1990. The number of prevalent cases across the SDI regions was 13,632,697 (95% UI: 10,998,556 to 16,806,334) in the high SDI region, 21,905,268 (95% UI: 16,972,535 to 27,614,632) in the high-middle SDI region, 25,432,808 (95% UI: 19,361,477 to 32,726,746) in the middle SDI region, 14,598,225 (95% UI: 10,963,470 to 19,018,350) in the low-middle region, and 3,698,996 (95% UI: 2,724,222 to 4876579) in the low region, with the highest increase observed in the low-middle region at 162.37% from 1990. The three GBD regions with the highest numbers of prevalent cases of BPH in patients aged 60 years and older were East Asia, South Asia, and Western Europe; Andean Latin America, South Asia, and Central Latin America presented the greatest increases in new cases since 1990 (Table 1). At the national and territorial levels, the patterns of prevalent cases were diverse among patients aged 60 years and older. The three countries or territories with the highest prevalent numbers were China, India, and United States of American (Fig. 1A and Table S1).

In 2019, the global prevalence rate of BPH in patients aged 60 years and older was 16,781 (95% UI: 12,946 to 21,269) per 100,000 population. The regions with low-middle SDIs had the highest prevalence of BPH (19,094.72 95% UI: 14,340.40 to 24876.32). In addition, the three GBD regions with the highest prevalence rates of BPH in patients aged≥60 years were Andean Latin America, Central Latin America, and Eastern Europe

**Table 1** Prevalence of benign prostatic hyperplasia between 1990 and 2019 at the global and regional level

| Location | Prevalence | | | | | |
|---|---|---|---|---|---|---|
| | Cases (*n*), 1990 | Prevalence (per 100000 population), 1990 | Cases (*n*), 2019 | Prevalence (per 100000 population), 2019 | Cases change (%) | AAPC (1990–2019) |
| Global | 36,212,682 (27488577 to 47055403) | 16720.65 (12692.43 to 21727.11) | 79,309,174 (61181380 to 100520944) | 16,781 (12946 to 21269.72) | 119.01 (109.75 to 128.93) | 0.02 (0 to 0.03) |
| SDI | | | | | | |
| High | 7,183,792 (5616783 to 9085333) | 12808.01 (10014.18 to 16198.27) | 13,632,697 (10998556 to 16806334) | 12590.11 (10157.42 to 15521.04) | 89.77 (81.90 to 99.03) | -0.06 (-0.08 to -0.04) |
| High Middle | 11,740,733 (9003051 to 15174472) | 20953.22 (16067.38 to 27081.27) | 21,905,268 (16972535 to 27614632) | 18836.99 (14595.19 to 23746.64) | 86.57 (78.22 to 95.70) | -0.37 (-0.42 to -0.33) |
| Middle | 10,199,013 (7590371 to 13419906) | 17995.16 (13392.47 to 23678.11) | 25,432,808 (19361477 to 32726746) | 17731.93 (13498.96 to 22817.31) | 149.36 (136.48 to 165.51) | -0.04 (-0.08 to -0.01) |
| Low Middle | 5563934.963 (4082887.419 to 7411069.014) | 16328.79 (11982.27 to 21749.67) | 14,598,225 (10963470 to 19018350) | 19094.72 (14340.40 to 24876.32) | 162.37 (145.53 to 179.75) | 0.55 (0.51 to 0.58) |
| Low | 1,504,515 (1091518 to 2039000) | 11072.04 (8032.71 to 15005.43) | 3,698,996 (2724222 to 4876579) | 13250.83 (9758.92 to 17469.26) | 145.86 (130.93 to 161.41) | 0.63 (0.57 to 0.68) |
| Region | | | | | | |
| Andean Latin America | 250,350 (184050 to 329752) | 22108.60 (16253.58 to 29120.62) | 807,886 (597317 to 1036301) | 25301.33 (18706.74 to 32454.80) | 222.70 (198.41 to 258.11) | 0.34 (0.1 to 0.58) |
| Australasia | 195,662 (144163 to 259543) | 14321.91 (10552.37 to 18997.86) | 426,434 (317690 to 564196) | 14546.15 (10836.75 to 19245.37) | 117.94 (101.91 to 136.95) | -0.25 (-0.29 to -0.21) |
| Caribbean | 291,929 (212765 to 386937) | 19120.18 (13935.28 to 25342.82) | 569,670 (414344 to 758989) | 19512.15 (14191.97 to 25996.63) | 95.14 (87.07 to 103.95) | 0.1 (-0.05 to 0.26) |
| Central Asia | 317,261 (235679 to 421850) | 14999.27 (11142.30 to 19943.98) | 546,078 (410251 to 715875) | 15530.79 (11667.80 to 20359.91) | 72.12 (64.95 to 80.36) | 0.28 (0.22 to 0.34) |
| Central Europe | 1,827,192 (1441742 to 2278218) | 22915.73 (18081.62 to 28572.27) | 2,561,792 (2083691 to 3105134) | 20983.34 (17067.28 to 25433.79) | 40.20 (32.69 to 48.13) | -0.39 (-0.47 to -0.32) |
| Central Latin America | 1,317,379 (1045481 to 1626592) | 28843.52 (22890.43 to 35613.63) | 3,743,620 (3001939 to 4617137) | 28941.68 (23207.79 to 35694.78) | 184.17 (176.78 to 193.57) | 0.01 (-0.04 to 0.06) |
| Central Sub-Saharan Africa | 83,005 (58281 to 115317) | 7022.43 (4930.65 to 9756.03) | 165,884 (116653 to 227610) | 6849.00 (4816.39 to 9397.57) | 99.85 (88.16 to 113.82) | -0.04 (-0.06 to -0.02) |
| East Asia | 8,081,445 (5836629 to 11075535) | 16209.56 (11706.97 to 22215.03) | 19,362,414 (14586323 to 25211406) | 15282.80 (11513.02 to 19899.42) | 139.59 (118.81 to 164.79) | -0.19 (-0.23 to -0.15) |
| Eastern Europe | 4,744,425 (3652456 to 6037311) | 40035.66 (30821.12 to 50945.64) | 7,064,759 (5481387 to 8860607) | 42171.49 (32719.91 to 52891.40) | 48.91 (42.12 to 56.16) | 0.04 (-0.06 to 0.14) |
| Eastern Sub-Saharan Africa | 315,098 (225179 to 430348) | 7511.74 (5368.13 to 10259.24) | 620,305 (444180 to 846879) | 7490.82 (5363.93 to 10226.94) | 96.86 (91.81 to 102.71) | -0.03 (-0.06 to 0) |
| High-income Asia Pacific | 919,930 (680470 to 1228991) | 8626.47 (6380.98 to 11524.63) | 2,133,654 (1596339 to 2805318) | 8648.91 (6470.87 to 11371.54) | 131.93 (117.97 to 147.44) | -0.45 (-0.55 to -0.36) |
| High-income North America | 2,058,861 (1638609 to 2594036) | 10731.83 (8541.26to 13521.43) | 4,061,952 (3500759 to 4758862) | 10964.92 (9450.02 to 12846.17) | 97.29 (78.01 to 123.64) | 0.21 (0.15 to 0.27) |
| North Africa and Middle East | 606,923 (436443 to 843896) | 6114.34 (4396.87 to 8501.67) | 1,545,594 (1111371 to 2102573) | 6305.04 (4533.68 to 8577.15) | 154.66 (146.67 to 162.64) | 0.05 (0.04 to 0.06) |

**Table 1** (continued)

| Location | Prevalence | | | | | |
|---|---|---|---|---|---|---|
| | Cases (*n*), 1990 | Prevalence (per 100000 population), 1990 | Cases (*n*), 2019 | Prevalence (per 100000 population), 2019 | Cases change (%) | AAPC (1990–2019) |
| Oceania | 32,006 (23413to 42624) | 19078.18 (13956.05 to 25407.48) | 77,478 (57004 to 101946) | 20334.46 (14960.94 to 26756.08) | 142.07 (128.48 to 153.38) | 0.14 (0.08 to 0.2) |
| South Asia | 5,666,708 (4117578 to 7631409) | 17299.27 (12570.10to 23297.08) | 17,883,801 (13339769 to 23336352) | 21903.75 (16338.30 to 28581.93) | 215.59 (187.14 to 244.77) | 0.82 (0.75 to 0.9) |
| Southeast Asia | 3,402,663 (2568042 to 4434639) | 25488.47 (19236.54 to 33218.74) | 7,195,067 (5446068 to 9264945) | 22397.44 (16953.00 to 28840.73) | 111.45 (103.33 to 122.39) | -0.23 (-0.24 to -0.21) |
| Southern Latin America | 204,565 (147611 to 278181) | 8010.68 (5780.37 to 10893.44) | 373,971 (269617 to 508663) | 8130.09 (5861.43 to 11058.26) | 82.81 (70.95 to 96.67) | -0.11 (-0.19 to -0.03) |
| Southern Sub-Saharan Africa | 151,652 (109271 to 205714) | 11201.56 (8071.13 to 15194.69) | 306,500 (221177 to 412638) | 11440.41 (8255.67 to 15402.12) | 102.10 (95.78 to 108.64) | 0.09 (0.07 to 0.1) |
| Tropical Latin America | 608,075 (479802to 759778) | 12316.41 (9718.28 to 15389.13) | 1,553,954 (1245102 to 1920589) | 11798.69 (9453.67 to 14582.43) | 155.55 (147.27 to 164.26) | -0.2 (-0.25 to -0.14) |
| Western Europe | 4,778,183 (3717229to 6038189) | 15471.83 (12036.44 to 19551.75) | 7,613,313 (6002225 to 9532830) | 15142.18 (11937.87 to 18959.92) | 59.33 (54.01 to 64.70) | -0.24 (-0.3 to -0.18) |
| Western Sub-Saharan Africa | 359,370 (257836to 493751) | 7140.57 (5123.13 to 9810.68) | 695,047 (501028 to 947136) | 7211.37 (5198.35 to 9826.89) | 93.41 (89.74 to 98.09) | -0.03 (-0.05 to -0.01) |

Note. Data in parentheses are 95% uncertainty intervals for cases and prevalence, and 95% CIs for AAPCs. SDI: sociodemographic index, UI: uncertainty interval. AAPC: average annual percentage change

(Table 1). During the period from 1990 to 2019, the AAPCs in people aged 60 years and older were 0.02 (95% CI: 0.00 to 0.72), indicating that the overall change in prevalence showed an increasing trend globally (Table 1; Fig. 2A).

In the decomposition analysis, the increasing prevalent number of BPH was attributed primarily to population growth (94.93%), aging (1.62%), and epidemiological changes (3.45%). Among the SDI regions, the high-middle SDI region reported the highest contribution from population growth (117.88%), whereas the low-middle SDI region had the lowest contribution (79.31%). Aging contributed the most to the middle SDI region (4.45%) and the least to the low SDI region (1.92%). The proportion of prevalent number attributed to epidemiological changes was highest in the low SDI region (18.78%), and the lowest proportion was detected in the high-middle SDI region (-23.85%) (Fig. 3A).

In the sensitivity analysis for prevalence in different aga groups, the 75–79 years age group had the highest prevalent rate, with 24324.8 per 100,000 population (Fig. 4A).

### Global incidence of BPH

At the global level, the number of incident cases of BPH in patients aged 60 years and older was estimated to be 8,357,953 (95% UI: 6,126,619 to 11,303,565), representing an increase of 121.22% from 1990 (Table 2). The highest number of incident cases was 2,862,907 (95% UI: 2,089,644 to 3,866,897) in the region with middle SDI, whereas the lowest number was 1,268,882 (95% UI: 948,649 to 1,685,017) in the region with high SDI. The high-middle region exhibited the most pronounced growth, increasing by 158.37%. The top three GBD regions for incident cases were East Asia (2.5 million cases), South Asia (1.8 million cases) and Southeast Asia (767 thousand cases). A rapid increase of 217.48% was reported in South Asia (Table 2). At the national or territorial scale, China, India, and United States of American ranked as the top three countries for incident cases of BPH in patients aged 60 years and older in 2019 (Fig. 1B and Table S2).

Globally, the incidence rate of BPH was 1768.50 (95% UI: 1296.36 to 2391.78) per 100,000 population, with a large epidemiological change of 121.22% in people aged 60 years and older. An increasing overall trend was observed since AAPCs exceeded 0 (0.02, 95% CI: 0.00 to 0.03) among older people in 2019 globally. The highest incidence of BPH was 1988.75 (95% UI: 1456.56 to 2680.07) in the high-middle region, with a decreasing trend between 1990 and 2019 (AAPCs: -0.37, 95% CI: -0.42 to -0.33) (Table 2; Fig. 2B). The top three GBD regions for the incidence of BPH in 2019 were Eastern Europe, Central Latin America and Oceania for patients aged 60 years and older (Table 2).

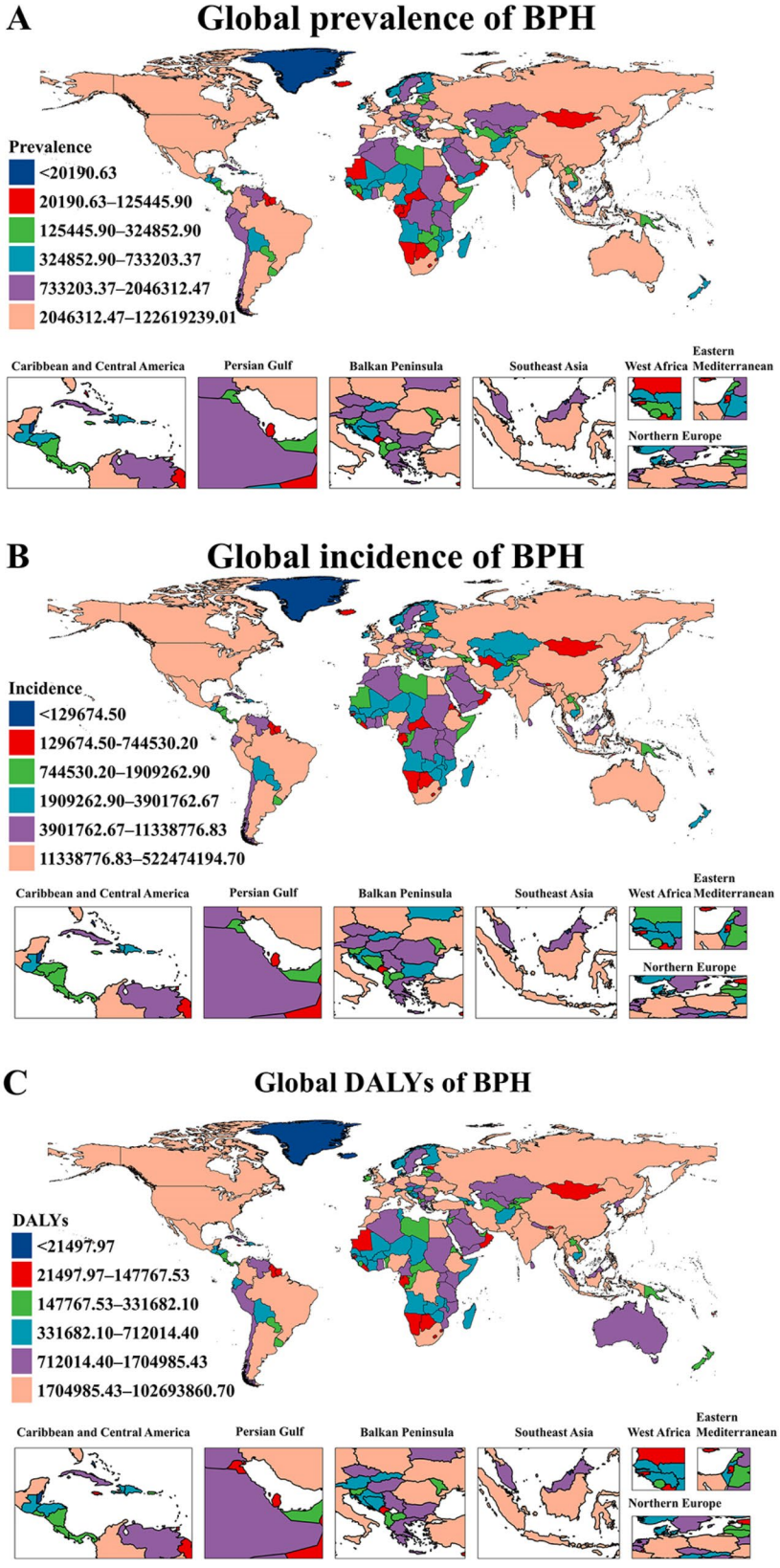


**Fig. 1** Global map of 2019 prevalence, incidence, and DALYs of BPH from 1990 to 2019. The 2019 prevalence **(A)**, incidence **(B)**, and DALYs **(C)** in older adults aged 60–89 years from 1990 to 2019 were shown, respectively. BPH: benign prostatic hyperplasia

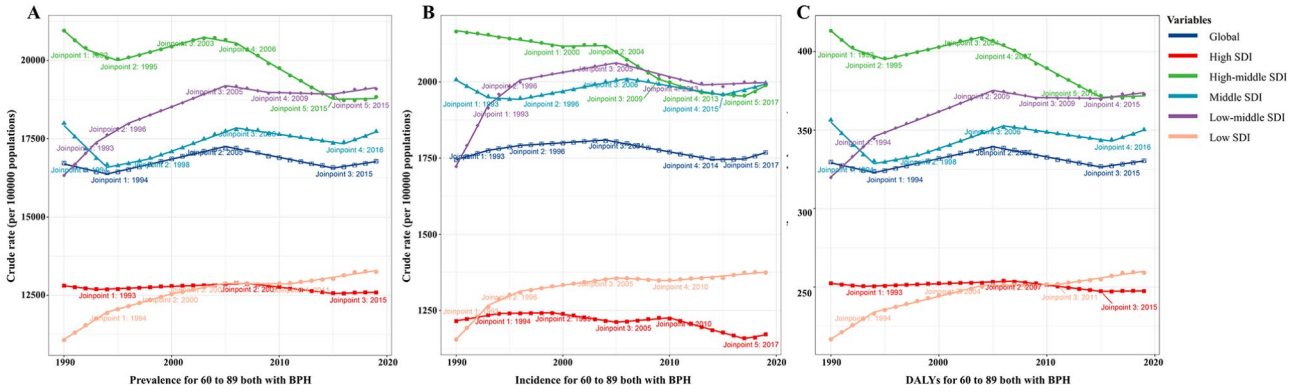


**Fig. 2** Joinpoint regression analysis of global BPH. The prevalence **(A)**, incidence **(B)**, and DALYs **(C)** in older adults aged 60–89 years from 1990 to 2019 were described, respectively. BPH: benign prostatic hyperplasia

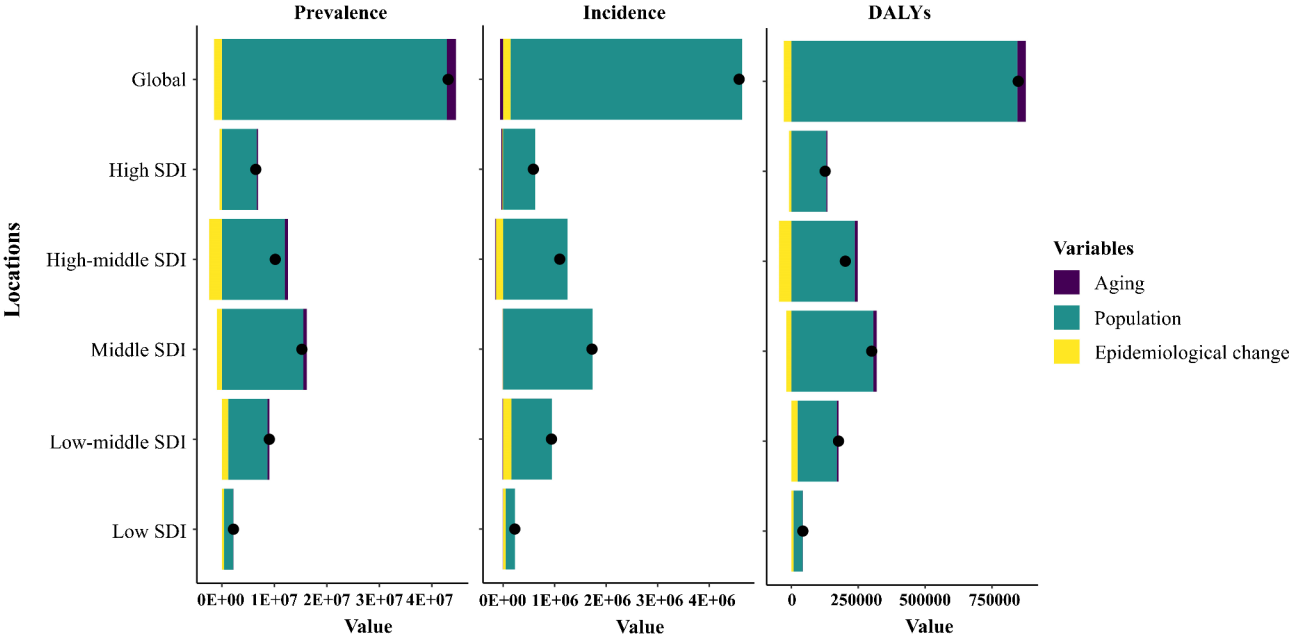


**Fig. 3** Decomposition analysis of global and SDI-specific BPH. The prevalence, incidence and DALYs in older adults aged 60–89 years from 1990 to 2019 were shown in this plot. SDI: sociodemographic index. BPH: benign prostatic hyperplasia

From 1990 to 2019, 98.14% of incident cases of BPH globally was attributable to population growth, -1.29% attributable to age, and 3.14% attributable to epidemiological changes. Like the pattern of prevalence, the incidence of BPH attributed to population growth among people aged 60 and over has increased to 113.68% in the high-middle SDI region at most, as opposed to the low-middle SDI region, with the lowest proportion of 83.9%. Aging contributor was linked to decreased BPH incidence during the study period, with the greatest decrease in the high-SDI region (-3.72%). The largest proportion of epidemiological changes increased to 21.61% in the low-SDI region and decreased to -12.33% in the high-middle-SDI region (Fig. 3B).

In the sensitivity analysis for incidence in different age groups, the age group of 65–69 years had the highest prevalent rate, with 2289.45 per 100,000 population (Fig. 4B).

### Global DALYs of BPH

Globally, BPH resulted in approximately 1,561,886 DALYs among people aged 60 years and over in 2019, representing an increase of 118.78%. The middle SDI region had the highest numbers of DALYs of BPH at 502,355 (95% UI: 295,820 to 761,702), whereas the low SDI region reported the lowest at 72,338 (95% UI: 41,955 to 111,020). A significant surge of 161.73% was observed in the low-middle SDI region. The middle SDI region accounted for the highest number of DALYs, whereas the low SDI region reported the lowest number of DALYs among individuals aged 60 and above. A similar rapid increase of 161.73% was noted in the proportion within

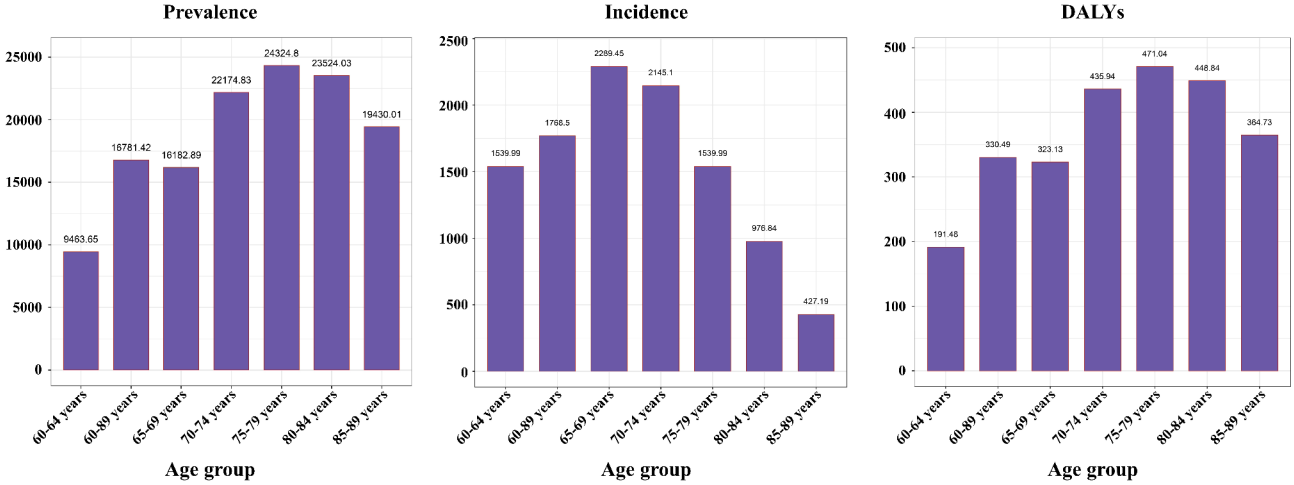


**Fig. 4** The prevalence, incidence, and DALYs of BPH across different age groups in 2019. The prevalence **(A)**, incidence **(B)**, and DALYs **(C)** in older adults with 60–64 years, 60–89 years, 65–69 years, 70–74 years, 75–79 years, 80–84 years and 85–89 years in 2019 were described, respectively. BPH: benign prostatic hyperplasia

the low-middle SDI region. The regions of East Asia, South Asia, and Western Europe had the greatest number of DALYs in 2019, with a dramatic increase of 221.70% detected in Andean Latin America (Table 3). Across countries and territories, China, India, and United States of American ranked among the top three total number of DALYs of BPH among older people aged 60 year and older in 2019 (Fig. 1C and Table S3).

Globally, the DALYs rate increased by approximately 329.64 to 330.49 per 100,000 population from 1990 to 2019 among patients aged 60 years and older. The overall trend over time increased, with an AAPC value of 0.01 (95% CI: 0.00 to 0.03). In 2019, the low-middle SDI region reported the highest number of DALYs, at approximately 373.05 per 100,000 population, whereas the high SDI region presented the lowest rate of DAYLs, at approximately 247.39 per 100,000 population (Fig. 2C). In 2019, Andean Latin America, Central Latin America, and Eastern Europe were the regions with the highest DALYs rate of BPH among individuals aged 60 years and over (Table 2).

During 1990 and 2019, the number of DALYs of BPH globally included epidemiological changes of -3.35%, an age of 3.76%, and population growth of 99.59%. Among the five SDI regions, the largest proportion of aging, population, and epidemiology contributors was 5.59% in the high-middle SDI region, 103.21% in the high SDI region, and 18.91% in the low SDI region, respectively (Fig. 3C).

In the sensitivity analysis for DALYs rate in different age groups, the 75–79 years age group had the highest prevalent rate, with 471.04 per 100,000 population (Fig. 4C).

## Discussion

In the spatial and temporal GBD analysis among people aged 60 years and over, we found significant increasing trends in the number of incident and prevalent cases, as well as DALYs of BPH between 1990 and 2019, which is consistent with studies showing that the histological situation of BPH continues to rise with age [6, 28, 29]. Overall, the number of prevalent cases increased by 119.01% from 1990 to 2019. We also observed increasing prevalence rates in high-middle, middle, and low-middle regions among older people aged 60 years and over. Specifically, the highest metrics, including prevalence, incidence, and DALYs, were found in China, India, and United States of America, in that order. The two largest regions contributing to the rates of prevalence, incidence, and DALYs were East Asia and South Asia. These findings inform the ongoing debate on health decisions regarding BPH among older people.

Our findings suggested that the burden of BPH was highest in older people, especially those aged 60 and over, which was consistent with the findings of previous surveys. A meta-analysis including 25 countries reported that the lifetime prevalence of BPH was 26.2%, and the age-specific prevalence increased with age [10]. Global epidemiological estimates further substantiated this evidence, indicating that adult males aged 65–74 years bore the maximum absolute burden of BPH. Additionally, the highest age-specific prevalence was observed among individuals aged between 75 and 79 years [5]. In addition, these global estimates were supported by community studies from different countries, such as Britain and the U.S. [30, 31], indicating that older male people were associated with a high risk of BPH and that this condition can even be aggravated as LUTS. Our analysis revealed that incident rates, prevalence rates and DALYs rates

**Table 2** Incidence of benign prostatic hyperplasia between 1990 and 2019 at the global and regional level

| Location | Incidence | | | | | |
|---|---|---|---|---|---|---|
| | Cases (*n*), 1990 | Incidence (per 100000 population), 1990 | Cases (*n*), 2019 | Incidence (per 100000 population), 2019 | Cases change (%) | AAPC (1990–2019) |
| Global | 3,778,197 (2725896 to 5212905) | 1744.52 (1258.64 to 2406.98) | 8,357,953 (6126619 to 11303565) | 1768.50 (1296.36 to 2391.78) | 121.22 (112.76 to 134.27) | 0.02 (0 to 0.03) |
| SDI | | | | | | |
| High | 681,530 (504197 to 920603) | 1215.10 (898.93 to 1641.35) | 1,268,882 (948649 to 1685017) | 1171.84 (876.10 to 1556.15) | 86.18 (78.99 to 95.62) | -0.06 (-0.08 to -0.04) |
| High Middle | 1,213,322 (883015 to 1667473) | 2165.37 (1575.88 to 2975.87) | 2,312,690 (1693810 to 3116617) | 1988.75 (1456.56 to 2680.07) | 90.09 (82.11 to 100.03) | -0.37 (-0.42 to -0.33) |
| Middle | 1,137,500 (805246 to 1586572) | 2007.01 (1420.78 to 2799.35) | 2,862,907 (2089644 to 3866897) | 1996.04 (1456.91 to 2696.03) | 120.57 (110.13 to 137.25) | -0.04 (-0.08 to -0.01) |
| Low Middle | 586,884 (414340 to 823128) | 1722.36 (1215.99 to 2415.68) | 1,525,708 (1093984 to 2101140) | 1995.65 (1430.95 to 2748.33) | 158.37 (145.40 to178.45) | 0.55 (0.51 to 0.58) |
| Low | 156,936 (109448 to 221580) | 1154.92 (805.45 to 1630.66) | 383,679 (270342 to 534148) | 1374.44 (968.44 to 1913.47) | 126.75 (114.34 to 145.27) | 0.63 (0.57 to 0.68) |
| Region | | | | | | |
| Andean Latin America | 24,394 (17336 to 33727) | 2154.23 (1530.97 to 2978.44) | 75,870 (55172 to 103041) | 2376.09 (1727.87 to 3227.03) | 211.02 (185.98 to 245.39) | 0.46 (0.2 to 0.72) |
| Australasia | 22,394 (15775 to 30763) | 1639.18 (1154.67 to 2251.78) | 44,637 (31679 to 61948) | 1522.63 (1080.61 to 2113.12) | 99.33 (79.63 to 117.45) | 0.06 (0.03 to 0.08) |
| Caribbean | 28,130 (19904 to 38936) | 1842.40 (1303.62 to 2550.15) | 55,295 (38864 to 77190) | 1893.95 (1331.17 to 2643.89) | 96.57 (83.48 to 107.04) | 0.07 (-0.04 to 0.17) |
| Central Asia | 33,844 (24245 to 47069) | 1600.06 (1146.23 to 2225.29) | 60,990 (43731 to 84085) | 1734.59 (1243.72 to 2391.42) | 80.21 (71.26 to 90.21) | 0.14 (0.06 to 0.23) |
| Central Europe | 186,023 (137652 to 249815) | 2333.01 (1726.36 to 3133.06) | 253,277 (186790 to 337293) | 2074.57 (1529.98 to 2762.73) | 36.15 (29.55 to 43.69) | -0.3 (-0.34 to -0.26) |
| Central Latin America | 123,299 (91264 to 164216) | 2699.58 (1998.18 to 3595.44) | 348,742 (261068 to 462525) | 2696.10 (2018.30 to 3575.75) | 182.84 (173.65 to 193.56) | 0.02 (0.01 to 0.02) |
| Central Sub-Saharan Africa | 9144 (6202 to 13020) | 773.62 (524.71 to 1101.48) | 18,494 (12717 to 26219) | 763.59 (525.06 to 1082.53) | 102.25 (88.04 to 120.69) | -0.08 (-0.09 to -0.08) |
| East Asia | 1,050,241 (726430 to 1501536) | 2106.55 (1457.06 to 3011.74) | 2,520,663 (1832302 to 3455766) | 1989.56 (1446.24 to 2727.64) | 140.01 (119.44 to 167,12) | -0.2 (-0.29 to -0.11) |
| Eastern Europe | 447,346 (330567 to 602482) | 3774.91 (2789.48 to 5084.02) | 642,103 (469664 to 861663) | 3832.89 (2803.55 to 5143.50) | 43.54 (35.42 to 51.22) | 0.19 (0.1 to 0.27) |
| Eastern Sub-Saharan Africa | 33,657 (23125 to 48223) | 802.36 (551.29 to 1149.62) | 65,706 (45225 to 94424) | 793.46 (546.14 to 1140.27) | 95.22 (88.48 to 102.24) | 0 (-0.03 to 0.02) |
| High-income Asia Pacific | 94,450 (67401 to 129425) | 885.69 (632.04 to 1213.65) | 192,260 (136618 to 266520) | 779.34 (553.79 to1080.36) | 103.56 (90.25 to 115.52) | 0 (-0.07 to 0.07) |
| High-income North America | 186,537 (133081 to 253079) | 972.33 (693.68 to 1319.18) | 383,591 (294605 to 500532) | 1035.47 (795.26 to 1351.15) | 105.64 (84.82 to 135.34) | 0.08 (0.06 to 0.11) |
| North Africa and Middle East | 60,663 (40938 to 87384) | 611.14 (412.42 to 880.33) | 151,775 (103653 to 219315) | 619.15 (422.84 to 894.67) | 150.19 (140.83 to 160.09) | 0.11 (0.09 to 0.14) |

**Table 2** (continued)

| Location | Incidence | | | | | |
|---|---|---|---|---|---|---|
| | Cases (*n*), 1990 | Incidence (per 100000 population), 1990 | Cases (*n*), 2019 | Incidence (per 100000 population), 2019 | Cases change (%) | AAPC (1990–2019) |
| Oceania | 3910 (2678 to 5479) | 2330.47 (1596.26 to 3266.17) | 9283 (6420 to 13043) | 2436.47 (1685.05 to 3423.21) | 137.42 (122.68 to 152.16) | 0.21 (0.16 to 0.27) |
| South Asia | 576,052 (401111 to 808043) | 1758.57 (1224.51 to 2466.78) | 1,828,825 (1290217 to 2546103) | 2239.91 (1580.23 to 3118.42) | 217.48 (195.19 to 246.09) | 0.82 (0.73 to 0.91) |
| Southeast Asia | 340,643 (240391 to 473478) | 2551.67 (1800.71 to 3546.70) | 767,471 (549125 to 1066933) | 2389.05 (1709.36 to 3321.24) | 125.30 (115.93 to 136.71) | -0.44 (-0.47 to -0.41) |
| Southern Latin America | 21,248 (14606 to 30347) | 832.06 (571.97 to 1188.37) | 36,840 (25227 to 52536) | 800.89 (548.43 to 1142.12) | 73.38 (59.93 to 86.69) | 0.06 (0.03 to 0.08) |
| Southern Sub-Saharan Africa | 15,104 (10449 to 21609) | 1115.63 (771.81 to 1596.14) | 30,668 (21321 to 43422) | 1144.71 (795.84 to 1620.76) | 103.05 (95.91 to 110.99) | 0.07 (0.06 to 0.09) |
| Tropical Latin America | 65,221 (48443 to 86841) | 1321.03 (981.20 to 1758.94) | 162,698 (121002 to 214479) | 1235.32 (918.73 to 1628.47) | 149.46 (140.55 to 159.11) | -0.15 (-0.18 to -0.12) |
| Western Europe | 417,938 (309558 to 565862) | 1353.29 (1002.35 to 1832.27) | 636,802 (471976 to 855899) | 1266.54 (938.71 to 1702.30) | 52.37 (46.71 to 58.56) | -0.07 (-0.09 to -0.05) |
| Western Sub-Saharan Africa | 37,961 (26131 to 54285) | 754.28 (519.21 to 1078.63) | 71,963 (49666 to 103737) | 746.65 (515.30 to1076.31) | 89.57 (85.62 to 94.58) | 0.04 (0.02 to 0.06) |

Note. Data in parentheses are 95% uncertainty intervals for cases and incidence, and 95% CIs for AAPCs. SDI: sociodemographic index, UI: uncertainty interval. AAPC: average annual percentage change

were highest in China. Several epidemiological studies based on the Chinese population have addressed this issue. Xiong et al. reported that 12.01% of middle-aged and older Chinese people were considered to have BPH according to national longitudinal data from 2015 [32]. Furthermore, using a complex sampling design, Wang et al. reported that the weighted total prevalence of BPH in males aged 45 years and older was 13.1% [33]. However, the aforementioned studies also pinpointed that older people with comorbidities were inclined to have a higher prevalence [32, 33]. In summary, because older people are linked to multiple chronic diseases, the number of BPH patients is increasing, especially in emerging aging countries, such as China.

The prevalence of BPH has been altered due to lifestyle changes, population growth, aging, and medical activities [34–37]. In our analysis, we observed that population growth contributed to the largest share of the prevalence of BPH, followed by population aging. Therefore, we should maintain our concerns about populous countries and regions. For example, we observed that China, India, and United States of America ranked in the top three countries in prevalent cases. Moreover, East Asia, South Asia, and Western Europe contributed to the greatest number of prevalent cases. These results may be related to the allocation of healthcare resources, exposure to risk factors, and public health awareness. Over the past few decades, most Asian countries have focused their disease prevention and control efforts on fatal diseases, resulting in insufficient healthcare resources allocated to nonfatal diseases such as BPH [38]. Consequently, the burden of BPH has continued to increase. Furthermore, existing studies have shown that obesity, hypertension, metabolic syndrome, dietary habits, smoking and alcohol consumption, and lack of physical activity are associated with the progression of BPH [39–41]. These risk factors remain inadequately controlled in countries such as China and India [42–44]. Additionally, with economic development and improved education levels, public health awareness has increased [45], leading to more patients being diagnosed and treated at early stages of the disease. This has indirectly contributed to the increase in prevalence, incidence, and DALYs. Moreover, treatment modalities also influence the trends in the BPH burden. Currently, there is no standardized treatment method for BPH patients [46]. Common treatments include medication and surgery, with medication being the preferred choice for most patients in countries like China and India [47, 48]. However, contrary to our study, other studies have shown that the prostate volumes of men in Japan, China, and India are significantly smaller than those of men in Australia or the United States [49] and that the incidence of BPH in Asian men is lower than that in Caucasian men [50]. This discrepancy may be due to variations in the

methodologies and populations studied in different studies, leading to different outcomes.

Notably, rapidly increasing cases have been reported in Andean Latin America, South Asia, and Central Latin America. A previous study revealed that the disease burden of LUTS will be greatest in Asia, South America and Africa in the coming decades [31]. Nevertheless, our findings provide a warning against the increasing prevalence of BPH in burgeoning countries. The economic burden attributed to BPH has been highlighted in the 21st century. In 2000, the U.S. recorded approximately 8 million clinic visits for benign prostatic hyperplasia, incurring a direct treatment expenditure of US$1.1 billion, excluding outpatient medication costs [31, 51]. In the global male population aged > 65 years, the estimated economic burden of BPH is $73.8 billion annually [52, 53]. According to our analysis, the prevalence in Western European peaked in 2019, with 42171.49 per 100,000, along with increased medical expenditures. Hence, our findings are highly relevant for the enhancement of health service infrastructure, capacity development of human resources, and prediction of economic burdens. Furthermore, our study results indicate that the burden of BPH has increased most significantly in high-middle SDI regions, which is consistent with previous findings [54, 55]. This is primarily due to changes in dietary patterns and lifestyles as SDI levels rise, increasing men's exposure to BPH risk factors, along with the extended life expectancy of men.

Some limitations of this work should be acknowledged. First, the estimation and description of the GBD database should be meticulous because the results depend on the quality of the data source and the robustness of the methodology. Second, the temporal analysis of BPH in the GBD was divided into distinct age, sex, year, and geographic location groups; however, the differences in race and ethnicity merit further study. For example, we found heterogeneous rates across Eastern countries and Western countries that represented diverse populations. Third, this study relies on the GBD 2019 database; however, the estimates for different countries and regions worldwide may lack accuracy due to variations in healthcare infrastructure, data collection methods, and reporting practices. The quality of GBD data can differ significantly across countries, with lower-income countries often having less comprehensive health data systems. This can lead to underreporting or misclassification of BPH cases, particularly in countries such as China, India, and the Russian Federation, where large-scale epidemiological surveys are lacking. These factors can affect the reliability of our estimates. Fourth, according to the designed GBD framework, each death was assigned to a unique underlying cause of death. The mortality associated with BPH was attributed to diverse complications and was excluded from the BPH estimates. Finally, owing to data limitations, this study did not explore the impact of socioeconomic factors and healthcare accessibility on the economic burden of BPH across different countries and regions. Variations in socioeconomic status and access to healthcare can significantly influence the diagnosis, treatment, and management of BPH, affecting reported prevalence and incidence rates. Future research should examine how these factors contribute to differences in the burden of BPH across various settings to provide a more comprehensive understanding of its impact on healthcare resources.

## Conclusions

Preventing BPH threatens global male health, especially in people aged 60 years and older, leading to significant disease burdens and economic expenditures. Our findings show that the increasing prevalent cases of BPH impacts individuals aged 60 years and over and that population growth is an underlying determinant. In the future, several populous countries, such as China, India, and United States of America, will experience a greater disease burden of BPH among older people aged 60 years and over. Effective health decisions are imperative for the prevention and treatment of BPH. For example, enhancing the allocation of relevant healthcare resources, strengthening health education campaigns, promoting knowledge about the prevention of urinary system diseases, and advocating for healthy diets and lifestyles can help rapidly reduce the global burden of BPH.

**Table 3** DALYs of benign prostatic hyperplasia between 1990 and 2019 at the global and regional level

| Location | DALYs | | | | | |
|---|---|---|---|---|---|---|
| | Cases (*n*), 1990 | DALYs (per 100000 population), 1990 | Cases (*n*), 2019 | DALYs (per 100000 population), 2019 | Cases change (%) | AAPC (1990–2019) |
| Global | 713,921 (422473 to 1087192) | 329.64 (195.07 to 501.99) | 1,561,886 (928180 to 2351441) | 330.49 (196.40 to 497.55) | 118.78 (109.61 to 128.96) | 0.01 (0 to 0.03) |
| SDI | | | | | | |
| High | 141,540 (85363 to 209875) | 252.35 (152.20 to 374.19) | 267,878 (163681 to 392477) | 247.39 (151.16 to 362.46) | 89.26 (81.06 to 98.79) | -0.07 (-0.08 to -0.05) |
| High Middle | 231,564 (137661 to 350738) | 413.26 (245.68 to 625.95) | 433,299 (259837 to 654955) | 372.61 (223.44 to 563.22) | 87.12 (78.41 to 96.55) | -0.36 (-0.41 to -0.32) |
| Middle | 201,996 (116439 to 312082) | 356.40 (205.44 to 550.64) | 502,355 (295820 to 761702) | 350.25 (206 to 531) | 148.70 (135.83 to 165.65) | -0.05 (-0.08 to -0.01) |
| Low Middle | 108,966 (63398 to 168723) | 319.79 (186.06 to 495.16) | 285,202 (167171 to 436613) | 373.05 (218.66 to 571.10) | 161.73 (145.29 to 179.17) | 0.54 (0.51 to 0.56) |
| Low | 29,445 (16993 to 46509) | 216.69 (125.06 to 342.27) | 72,338 (41955 to 111020) | 259.13 (150.29 to 397.70) | 145.67 (131.00 to 162.20 ) | 0.63 (0.59 to 0.67) |
| Region | | | | | | |
| Andean Latin America | 4994 (2879 to 7828) | 440.98 (254.22 to 691.34) | 16,065 (9606 to 24289) | 503.11 (300.82 to 760.67) | 221.70 (196.78 to 255.32) | 0.45 (0.19 to 0.71) |
| Australasia | 3836 (2224 to 5934) | 280.80 (162.81 to 434.39) | 8347 (4875 to 12945) | 284.74 (166.28 to 441.55) | 117.60 (100.19 to 137.19) | 0.05 (0.02 to 0.08) |
| Caribbean | 5809 (3379 to 9076) | 380.49 (221.28 to 594.45) | 11,259 (6544 to 17557) | 385.64 (224.13 to 601.36) | 93.81 (85.36 to 103.31) | 0.05 (-0.06 to 0.16) |
| Central Asia | 6332 (3646 to 9898) | 299.34 (172.35 to 467.97) | 10,906 (6342 to 16814) | 310.19 (180.38 to 478.20) | 72.26 (64.66 to 81,17) | 0.14 (0.06 to 0.23) |
| Central Europe | 35,757 (21554 to 52946) | 448.44 (270.32 to 664.02) | 50,174 (30860 to 73820) | 410.97 (252.77 to 604.65) | 40.32 (32.93 to 8.35) | -0.29 (-0.34 to -0.25) |
| Central Latin America | 25,908 (15749 to 38829) | 567.24 (344.82 to 850.14) | 73,721 (44672 to 108566) | 569.93 (345.36 to 839.32) | 184.55 (176.99 to 193.99) | 0.02 (0 to 0.03) |
| Central Sub-Saharan Africa | 1636 (936 to 2647) | 138.40 (79.21 to 223.94) | 3282 (1864 to 5231) | 135.49 (76.97 to 215.98) | 100.61 (85.64 to 117.03) | -0.07 (-0.1 to -0.04) |
| East Asia | 161,307 (91571 to 256432) | 323.55 (183.67 to 514.35) | 385,384 (224489 to 594785) | 304.18 (177.19 to 469.47) | 138.91 (117.98 to 163.86) | -0.21 (-0.29 to -0.12) |
| Eastern Europe | 92,942 (55397 to 140190) | 784.29 (467.47 to 1182.99) | 139,351 (81661 to 210641) | 831.82 (487.46 to 1257.37) | 49.93 (43.03 to 57.29) | 0.21 (0.11 to 0.31) |
| Eastern Sub-Saharan Africa | 6221 (3508 to 9873) | 148.31 (83.64 to 235.36) | 12,293 (6888 to 19279) | 148.45 (83.18 to 232.82) | 97.60 (91.87 to 104.41) | 0.01 (-0.01 to 0.03) |
| High-income Asia Pacific | 18,355 (10561 to 28475) | 172.12 (99.03 to 267.02) | 42,646 (25108 to 66177) | 172.87 (101.78 to 268.25) | 132.34 (118.37 to 148.02) | 0.02 (-0.04 to 0.08) |
| High-income North America | 39,897 (23990 to 58971 ) | 207.96 (125.05 to 307.39) | 78,059 (49269 to 113424) | 210.72 (133.00 to 306.18) | 95.65 (76.74 to 121.55) | 0.05 (0.03 to 0.08) |
| North Africa and Middle East | 12,079 (6871 to 19244) | 121.69 (69.22 to 193.88) | 30,612 (17705 to 48371) | 124.88 (72.22 to 197.32) | 153.43 (144.55 to 163.50) | 0.1 (0.07 to 0.12) |

**Table 3** (continued)

| Location | DALYs | | | | | |
|---|---|---|---|---|---|---|
| | Cases (*n*), 1990 | DALYs (per 100000 population), 1990 | Cases (*n*), 2019 | DALYs (per 100000 population), 2019 | Cases change (%) | AAPC (1990–2019) |
| Oceania | 632 (360 to 984) | 376.65 (214.40 to 586.50) | 1522 (870 to 2386) | 399.50 (228.40 to 626.21) | 140.89 (127.18 to 153.51) | 0.2 (0.15 to 0.25) |
| South Asia | 110,164 (64203 to 173689) | 336.31 (196.00 to 530.24) | 347,132 (201816 to 537446) | 425.16 (247.18 to 658.25) | 215.10 (186.52 to 244.34) | 0.8 (0.73 to 0.86) |
| Southeast Asia | 67,186 (39532 to 103705) | 503.27 (296.13 to 776.83) | 142,313 (8353 to 217339) | 443.00 (260.02 to 676.55) | 111.82 (103.21 to 122.81) | -0.44 (-0.46 to -0.41) |
| Southern Latin America | 4079 (2279 to 6456) | 159.72 (89.25 to 252.83) | 7421 (4205 to 11589) | 161.32 (91.41 to 251.94) | 81.93 (68.14 to 97.63) | 0.04 (0.02 to 0.06) |
| Southern Sub-Saharan Africa | 2991 (1721 to 4758) | 220.95 (127.09 to 351.45) | 6025 (3479 to 9467) | 224.90 (129.87 to 353.37) | 101.42 (94.55 to 108.20) | 0.06 (0.04 to 0.08) |
| Tropical Latin America | 11,933 (7303 to 17739) | 241.70 (147.91 to 359.30) | 30,681 (18758 to 45905) | 232.95 (142.42 to 348.54) | 157.11 (148.73 to 166.49) | -0.12 (-0.15 to -0.09) |
| Western Europe | 94,740 (57582 to 140447) | 306.77 (186.45 to 454.77) | 150,885 (91456 to 222107) | 300.10 (181.90 to 441.75) | 59.26 (53.79 to 64.96) | -0.07 (-0.09 to -0.06) |
| Western Sub-Saharan Africa | 7125 (4031 to 11277) | 141.57 (80.09 to 224.07) | 13,806 (7794 to 21645) | 143.24 (80.86 to 224.58) | 93.77 (89.57 to 98.54) | 0.05 (0.03 to 0.06) |

Note. Data in parentheses are 95% uncertainty intervals for DALYs, and 95% CIs for AAPCs. DALYs: disability-adjusted life-years. UI: uncertainty interval. AAPC: average annual percentage change

**Abbreviations**

| | |
|---|---|
| AAPCs | Average annual percentage changes |
| BPH | Benign prostatic hyperplasia |
| DALYs | Disability-adjusted life-years |
| GBD | Global Burden of Diseases |
| GHDx | Global Health Data Exchange |
| ICD | International Classification of Diseases |
| IPSS | International Prostatism Symptom Score |
| LUTS | Lower urinary tract symptoms |
| MR-BRT | Meta-regression-Bayesian, regularized, trimmed |
| N-QoL | Nocturia-specific Quality of Life |
| SDI | Sociodemographic index |
| UI | Uncertainty interval |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12894-024-01582-w.

Supplementary Material 1

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**Author contributions**

ZY. Y and ZZ. C designed the study. ZY. Y and ZZ. C organized the data, JH. W, YF. X, JY. L and LJ. X finished the statistical analyses. ZY. Y and ZZ. C drafted the initial manuscript. All authors have read and approved the final version of the manuscript, and agreed with the order of presentation of the authors.

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**Data availability**

To download the source data and analytic code used in these analyses, please visit the Global Health Data Exchange GBD 2019 website.

## Declarations

**Ethics approval and consent to participate**

Not applicable.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare no competing interests.

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