Research Article

Epidemiological Trends of Urolithiasis at the Global, Regional, and National Levels: A Population-Based Study

Xiaoyuan Qian, Junlai Wan, Jinzhou Xu, Chenqian Liu, Mingliang Zhong, Jiaqiao Zhang, Ying Zhang, and Shaogang Wang

1Department of Urology, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430030, China
2Department of Orthopedics, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430030, China
3Department of Nephrology, Tongji Hospital of Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430030, China

Correspondence should be addressed to Ying Zhang; zhangying19880914@163.com and Shaogang Wang; sgwangtjm@163.com

Xiaoyuan Qian and Junlai Wan contributed equally to this work.

Received 20 January 2022; Accepted 22 February 2022; Published 30 March 2022

Academic Editor: Qing Wang

Copyright © 2022 Xiaoyuan Qian et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Background. Urolithiasis is common worldwide and can predispose to urinary tract infections and renal failure. We aimed to explore the global, regional, and national burden of urolithiasis between 1990 and 2019, stratified by sex, age, and sociodemographic index (SDI). From 1990 to 2019, data on the number of incident cases of urolithiasis, associated deaths, and disability-adjusted life years (DALYs) were extracted from the 2019 Global Burden of Disease (GBD) study. The trends for the incidence rate, mortality, and DALYs were evaluated using estimated annual percentage changes (EAPCs). Results. The incidence of urolithiasis increased by 48.57%, from 77.78 million incident cases in 1990 to 115.55 million in 2019, while its age-standardized incidence rate (ASIR) decreased. The ASIR increased slightly in the low SDI regions (EAPC = 0.33; 95% confidence interval [CI]: 0.24–0.43), while ASIRs in other SDI regions decreased. The incidence of urolithiasis by age presented a unimodal distribution, with the peak observed in patients aged between 50 years and 70 years. Urolithiasis-related mortality and DALYs also increased over time. Yet, the age-standardized death rate (ASDR) decreased by 2.05% (95% CI, −2.25% to −1.85%) per year, and the annual age-standardized DALY rate decreased by 1.77% (95% CI, −1.92% to −1.63%). The mortality and DALYs increased with age. The incidence, mortality, and DALYs were greater in males than those in females. The burden of urolithiasis showed obvious differences in its regional distribution over the past three decades. Conclusion. From 1990 to 2019, ASIR, ASDR, and age-standardized DALY rate of urolithiasis have decreased. Yet, particularly significant differences exist in the geographic, age, and sex distribution. Thus, medical resources should be rationally allocated and adjusted according to the geographic and demographic distribution of urolithiasis.

1. Introduction

Urolithiasis is highly prevalent in urology and can present as an asymptomatic condition or as a painful, recurrent disease. Affected by a variety of factors, such as the climate and seasonal temperature variation, dietary habits, water quality, direct occupational exposure, inheritance and genetic constitution, latitude, and comorbidities, the incidence and prevalence of urolithiasis are characterized by a distinct geographical variation [1–3]. The overall prevalence was 7.54% in mainland China between 1990 and 2016 [4], 5% to 10% in Europe in the decade before 2011, [5], 8.8% in North America between 2007 and 2010 [6], and 5.7% in Iran in 2005 [7].

The incidence and prevalence of urolithiasis have been on the rise. Although rarely life-threatening, urolithiasis can often cause intense pain and adversely affect patients’ quality of life. Moreover, because of a large number of new and recurrent cases, the high rate of surgical intervention, and the advent of novel technology, global health care costs
related to the management of stones are relatively high. In 2000, the treatment of urolithiasis did cost up to $5.3 billion per year in the United States alone [8]. Thus, further insight into the global urolithiasis burden is essential for the allocation of limited health resources and formulation of rational policies.

The global burden of disease (GBD) study examined the burden of hundreds of diseases and injuries in 195 countries and territories around the world and provided an opportunity to comprehensively assess different aspects of human health, including the distribution and development trends of urolithiasis [9]. For a better understanding of the trends in urolithiasis burden according to geography, age, sex, and social development index (SDI), we used data from the 2019 GBD to describe the global, regional, and national trends in the incident rate, deaths, and DALYs associated with urolithiasis from 1990 to 2019.

2. Methods

2.1. Study Data. Study data on the urolithiasis burden—the annual incidence rate, death, disability-adjusted life years (DALYs), and their age-standardized rates (ASR)—were extracted from the 2019 GBD study using the global health data exchange (GHDX) query tool (https://ghdx.healthdata.org/gbd-results-tool). We also collected data on sex, age, and SDI to investigate their influence on the urolithiasis disease burden. The SDI, which ranges from 0 to 1, is a comprehensive indicator of social and demographic development. According to the order of their SDI value, 192 countries and regions around the world are divided into low SDI, middle (low-middle, middle, high-middle) SDI, and high SDI countries. The epidemiological trends for urolithiasis were observed at the regional, national, and global levels.

2.2. Statistical Analysis. The trends for urolithiasis incidence and mortality rates were evaluated by calculating the annual age-standardized incidence rate (ASIR), the age-standardized death rate (ASDR), age-standardized DALYs rate, and their respective estimated annual percentage changes (EAPCs). Urolithiasis DALYs were computed as the sum of the years lived with disability and the years of life lost [10]. According to the age group construction of the standard population, the ASRs (per 100,000 population) were calculated using the following formula:

\[ \text{ASR} = \frac{\sum_{i=1}^{A} a_i w_i}{\sum_{i=1}^{A} d_i} \times 100,000, \]

(1)

(a refers to the incidence of the i\textsuperscript{th} age group. w\textsubscript{i} denotes the number of persons (or weight) in the same age subgroup i of the assigned reference standard population) [11].

EAPCs is a generally well-accepted method to describe ASR using a regression model, and it quantitatively calculates the average annual rate of change of ASR for a specified period [11]. The regression line is used to estimate the natural logarithm of the rates, i.e., \( y = \alpha + \beta x + \varepsilon \), where \( y = \ln \) (ASR), and \( x \) = the calendar year. The EAPC calculation formula, 100 × (exp(\( \beta \)) – 1), and its 95% confidence intervals (CI) can also be calculated from the linear regression model [11, 12]. All statistical data were analyzed using R version 3.6.3 (The R Foundation for Statistical Computing, Vienna, Austria), and a two-sided \( P < 0.05 \) was considered statistically significant.

3. Results

3.1. The Change in the Incidence of Urolithiasis. Globally, the incidence of urolithiasis was 1.16 × 10\(^8\) (95% uncertainty interval (UI): 0.93–1.40 × 10\(^8\)) in 2019 and 0.78 × 10\(^8\) (UI: 0.62–0.95 × 10\(^8\)) in 1990. From 1990 to 2019, its incidence increased by 48.57% (Table 1, additional file 1: figure S1A). However, the global ASIR showed a decreasing trend, with an average annual decrease of 0.83% from 1696.18/100,000 persons (95% UI, 1358.11–2078.11) in 1990 to 1394.03/100,000 persons (95% UI: 1126.4–1688.16) in 2019 (EAPC = −0.83; 95% CI: −0.92 to −0.74) (Table 1, additional file 1: figure S1B). The annual ratio of elder (aged >60 years) to younger patients remained relatively stable each year (additional file1: figure S2A). Moreover, ASIR in both male and female patients decreased similarly, and ASIR in male patients was more than that in female patients (figures 1(a) and 1(b), additional file 1: figure S1B). Between 1990 and 2019, the incidence of urolithiasis plotted against age showed a unimodal distribution, with the peak value observed in patients aged between 50 years and 70 years (figures 1(a) and 1(b), additional file: figures S3–S5). The male: female ratio tends to increase with age, increasing to approximately 3 in 2019 (Figure 2). However, urolithiasis tended to occur in the younger population (<60 years) (additional file1: figure S2A).

With respect to the SDI level, the ASIR in the low SDI quintile presented a slightly increasing trend, with an EAPC of 0.33 (95% CI: 0.24–0.43). On the contrary, ASIRs in other quintiles decreased, with the decrease in the high-middle SDI quintile being the most significant (Table 1, figures 3(a)–3(c)). The higher the SDI level, the more the elderly patients among all urolithiasis incidence patients (figure 4(a)). There were similar trends of male: female ratio in all SDI regions (Figure 2). Meanwhile, a significant positive correlation was detected between ASIR and SDI (R = 0.46, P < 0.05) (additional file1: figure S6A). Furthermore, EAPC was negatively correlated with ASIR (R = −0.34, P < 0.05), implying that urolithiasis increased more slowly in countries with high incidence than in countries with low incidence (Figure 5(a)).

As for the findings by the GBD regions and countries, the ASIR of urolithiasis increased in 143 countries and 11 regions (the top three countries: Jordan, Romania, and Germany), decreased in 32 countries and 9 regions (the bottom three countries: Poland, China, and Indonesia), and remained stable in 17 countries and 1 region (Albania, Costa Rica et al.). The top three countries with high ASIRs were the Russian Federation (4541.88 per 100,000 people), Ukraine (4282.60 per 100,000 people), and Latvia (4156.67 per 100,000 people). The bottom three countries were Burundi (525.01 per 100,000 people), South Sudan (533.43 per 100,000 people), and Madagascar (535.88 per 100,000 people). The top three countries with EAPC were Jordan (2.10), Romania (2.01), and Germany (2.00), while the
Table 1: The incident cases and ASIR in 1990 and 2019 and its current trends from 1990 to 2019.

| Region                        | 1990 | 2019 | 1990–2019 |
|-------------------------------|------|------|-----------|
|                              | Incident cases no. | ASIR per 100,000 no. | ASIR per 100,000 no. | EAPC no. |
|                              | (95% UI) | (95% UI) | (95% UI) | (95% CI) |
| Overall                       | 777,757 | 1,155,521.4 | 1,155,521.4 | -0.83 [-0.92] |
| Sex                           | [622,391.16–951,267.51] | [930,451.3–1,401,804.02] | [1126.4–1688.16] | to -0.74 |
| Female                        | 249,942.36 | 394,466.96 | 947.22 | -0.83 [-0.92] |
| [199,717.79–305,779.86] | [851.17–1305.09] | [316,443.64–479,042.56] | [761.21–1148.43] | to -0.74 |
| Male                          | 527,815.22 | 676,054.44 | 1856.87 | -0.83 [-0.92] |
| [421,541.28–644,728.87] | 233.15 | 761,054.44 | to -0.74 |
| Sociodemographic index        |       |       |       |       |
| High SDI                      | 145,954.54 | 175,249.86 | 1288.65 | -0.47 [-0.56] |
| [115,092.47–180,095.64] | [1228.01–1924.36] | [143,184.65–2110,860.66] | [1053.86–1544.09] | to -0.38 |
| High-middle SDI               | 266,651.25 | 295,371.67 | 1582.15 | -1.52 [-1.66] |
| [209,262.28–320,011.49] | [1819.79–2776.75] | [234,109.15–360,701.08] | [1273.68–1924.87] | to -1.39 |
| Middle SDI                    | 211,170.93 | 356,833.63 | 1361.19 | -0.96 [0.10] |
| [167,561.15–259,150.52] | [1255.22–1938.68] | [286,464.64–435,292.92] | [1062.99–1600.96] | to -0.84 |
| Low-middle SDI                | 124,476.95 | 244,903.47 | 1473.13 | -0.12 [-0.18] |
| [99,936.92–152,749.55] | [1193.43–1813.78] | [195,173.97–300,902.16] | [1171.09–1804.8] | to -0.05 |
| Low SDI                       | 34,193.36 | 82,575.81 | 1030.45 | 0.33 [0.24 to 1.05] |
| [26,981.21–42,070.53] | 755.16–1176.74 | [6495.21–102,069.74] | [809.77–1273.81] | 0.43 |
| Region                        |       |       |       |       |
| Andean Latin                  | 4592.35 | 10,73.03 | 1772.43 | 0.52 [0.44 to 0.60] |
| America                       | 1609.5 | 11,073.03 | 1772.43 | 0.52 [0.44 to 0.60] |
| Australasia                   | 3140.31 | 3561.66 | 1319.12 | -0.96 [0.10] |
| [2465.53–3572.12] | [1096.4–939.19] | [749.57–1589.03] | [1004.68–1573.74] | to -0.26 |
| Caribbean                     | 1014.28 | 3561.66 | 1319.12 | -0.96 [0.10] |
| [2478.56–3686.37] | [830.22–1310.52] | [6319.37–9459.54–7881.91] | [979.28–1540.36] | 0.7 |
| Central Asia                  | 8051.77–12,407.22 | 13,150.52–20,320.44 | 1435.54–2174.91 | 0.08 |
| Central Europe                | 23,202.84 | 16,552.56 | 1778.98 | 0.05 [0.02 to 0.10] |
| Central Latin                 | 11,169.89 | 17,73.53 | 1178.91 | -0.71 [-1.0] |
| Central Latin America         | 312,202.32 | 14,611.9–21,439.47 | 9778.08–14000.97 | -0.42 |
| Central sub-Saharan Africa    | 132,241.51 | 18,32.6–20,320.44 | 1435.54–2174.91 | 0.08 |
| East Asia                     | 132,241.51 | 18,32.6–20,320.44 | 1435.54–2174.91 | 0.08 |
| Eastern Europe                | 132,241.51 | 18,32.6–20,320.44 | 1435.54–2174.91 | 0.08 |
| Eastern sub-Saharan Africa    | 132,241.51 | 18,32.6–20,320.44 | 1435.54–2174.91 | 0.08 |
| Latin America                 | 31,236.93 | 1536.37 | 1947.15 | -0.27 [-0.35] |
| Pacific                       | 31,236.93 | 1536.37 | 1947.15 | -0.27 [-0.35] |
| High-income North             | 50,604.28 | 25,387.51 | 1012.43 | 0.13 [-0.21] |
| America                       | 39,648.82 | 47,402.27 | 982.95 | -2.02 [-2.34] |
| North Africa and middle East  | 22,817.49 | 74,482.11 | 1250.71 | 0.29 [0.26 to 0.33] |
| Oceania                       | 441.17 | 978.39 | 1033.1 | 0.14 [0.09 to 0.18] |
| South Asia                    | 130,374.21 | 307,303.25 | 1757.72 | 0.64 [0.54 to 0.74] |
| Southeast Asia                | 102,728.35 | 118,032.07 | 1652.63 | -0.82 [-0.95] |
| Southern Latin                | 63,038.83 | 118,032.07 | 1652.63 | -0.82 [-0.95] |
| Southern sub-Saharan Africa   | 6065.88 | 95,434.37 | 1348.2–1979.06 | to -0.69 |
| Tropical Latin                | 12,924 | 24,369.28 | 969.93 | -0.36 [-0.45] |
| [302.99–6791.1] | [838.11–1253.92] | [19,765.47–29,260.19] | [789.43–1165.79] | to -0.28 |
The bottom three countries were Poland (−3.87), China (−2.8), and Indonesia (−2.17). All the above results are shown in figure 6(a) and additional file 1: tables S1–S3, figure S7A. In addition, the majority of countries had a unimodal age distribution (additional file 1: table S4).

### 3.2. The Change in the Mortality of Urolithiasis

Globally, mortality because of urolithiasis increased by 17.12% from $113.38 \times 10^2$ (95% UI: 72.78–137.77) in 1990 to $132.27 \times 10^2$ (95% UI: 106.16–162.67) in 2019 (Table 2, additional file 1: figure S1C). Over the past three decades, ASDR decreased.

### Table 1: Continued.

| Country                | 1990 Incident cases no.  *10² | 1990 ASIR per 100,000 (95% UI) | 2019 Incident cases no.  *10² | 2019 ASIR per 100,000 (95% UI) | 1990–2019 EAPC no. (95% CI) |
|------------------------|-------------------------------|--------------------------------|-------------------------------|--------------------------------|-------------------------------|
| Western Europe         | [54,788.18–85,768.48]         | 1490.85                         | [70,368.82–108,735.24]        | 1490.21                         | 0.53 [0.38 to 0.69]          |
| Western sub-Saharan Africa | [6911.46–10654.41]          | 688.96                          | [17,278.95–26,674.36]        | 735.82                          | 0.28 [0.22 to 0.34]          |

ASIR: age-standardized incidence rate; EAPC: estimated annual percentage change; CI: confidence interval; UI: uncertainty interval.

Figure 1: The incidence, death, and DALY rates of urolithiasis in different age groups. (a) Incidence in 1990. (b) Incidence in 2019. (c) Death rate in 1990. (d) Death rate in 2019. (e) DALY rate in 1990. (f) DALY rate in 2019.
significantly with an average annual decrease of 2.05% from 0.3/100,000 persons (95% UI, 0.20–0.37) in 1990 to 0.17/100,000 persons (95% UI: 0.14–0.21) in 2019 (EAPC \(\equiv -2.05; 95\% CI: -2.25–-1.85\)) (Table 2). E&hedeath cases increased rapidly with age, especially for the elderly (figure 1(b); additional file 1: figures S8–S10). ASDR in both male and female patients decreased significantly, and the ASDR of male patients was higher than that of female patients between 1990 and 2019 (Table 2, figure 1(b), additional file 1: figure S1C). E&hemortality ratio of male and female patients fluctuated with age (additional file 1: figure S11).

With respect to the SDI, ASDRs in the different SDI regions decreased (Table 2, figure 3(b)). EAPC was negatively associated with ASDR (\(R = -0.44, P < 0.05\)). However, a correlation between SDI and EAPC or ASDR was not revealed (figure 5(b), additional file 1: figure S6B). Contrary to the change in ASIR, older patients (>60 years) died from urolithiasis (figure 4(b), additional file 1: figure S1A). The number of annual young deaths decreased year by year, however, the number of elderly deaths increased gradually, irrespective of SDI regions, especially in patients >95 years of age (additional file 1: figures S1C & S8–S10).

At the level of GBD regions and countries, 69 countries and 7 regions had an increased ASDR, 104 countries and 11 regions had a reduced ASDR, and 19 countries and 3 regions had a stable ASDR. The top three ASDRs were those of Armenia, Kazakhstan, and the Philippines, while the bottom three were those of North Macedonia, Montenegro, and Lebanon. Details are described in figure 6(b), additional file 1: tables S1, S2, & S5, figure S7B. The death cases increased rapidly with age irrespective of sex in the majority of countries (additional file 1: table S7).

3.3. The Change in DALYs of Urolithiasis. On a global level, there were 5,167,310 (95% UI, 3,741,330 to 6,357,170) DALYs in 1990 and 6,043,090 (95% UI, 4,773,540 to 7,451,940) DALYs in 2019, an increase of 16.95%. The age-standardized DALYs rate demonstrated a downward trend with an EAPC of \(-1.77\) (95% CI: \(-1.92–-2.21\)), declining from 11.75/100,000 persons (95% UI, 8.57–14.39) in 1990 to 7.35/100,000 persons (95% UI, 5.82–9.04) in 2019 (Table 3). The age-standardized DALYs rate of males was higher than that of female cases between 1990 and 2019 (Table 3). Investigating from the SDI standpoint, all four SDI regions witnessed a drop in the age-standardized DALYs rate, and DALYs were not associated with SDI (Table 3, additional file 1: figure S6C). Besides, there was no significant correlation between EAPC and SDI (\(R = -0.016, p = 0.85\)), and there was a negative association between EAPC and the age-standardized DALYs rate (figure 5(c), \(R = -0.52, p < 0.01\)). The DALYs rate rose in both male and female patients with age (figure 1(c)). Compared with 1990, there was no obvious decrease in DALYs in elderly patients in 2019, and similar trends in the age distribution of mortality were seen in DALYs (additional file 1: figures S12–S14). The DALY ratio of male and female patients also fluctuated with age (additional file 1: figure S15).
Figure 3: The change trends of age-standardized incidence (ASIR), age-standardized death (ASDR), and age-standardized incidence DALYs rate among different SDI countries. A–C: ASIR; D–F: ASDR; H–J: age-standardized DALYs rate.

Figure 4: Distribution of different ages in urolithiasis incidence/death patients by region. (a) Incidence in 1990 and 2019. (b) Death rate in 1990 and 2019.
At the level of GBD regions and countries, 73 countries and 6 regions had an increased age-standardized DALYs rate, 104 countries and 11 regions had a decreased age-standardized DALYs rate, and 15 countries and 4 regions had a stable age-standardized DALYs rate. The top three age-standardized DALYs rates were seen in Armenia, Russian Federation, and the Philippines. The bottom three age-standardized DALYs rates were seen in Cabo Verde, Panama, and El Salvador. Details are displayed in figure 6(c), additional file 1: tables S1, S2, & S6, and additional file 1: figure S7C. Similarly, The DALYs increased rapidly with age, irrespective of sex in almost every country (additional file 1: table S8).

4. Discussion

Currently, urolithiasis remains a major global public health problem and warrants our attention. Several previous epidemiological studies on urolithiasis have mainly focused on individual regions or countries [5, 13, 14], however, global epidemiological data on urolithiasis are lacking. Based on the 2019 GBD study, we described the incidence, mortality, and DALY of urolithiasis at the global, regional, and national levels with their corresponding current trends and survival patterns from 1990 to 2019.

Our findings demonstrated that though the global incidence of urolithiasis increased by 48.57% in 2019 compared with its incidence in 1990, the ASIR actually decreased. There are several explanations for this trend. Zhu et al. reported that the increase in incidence might be attributed to population growth and the aging process of the population [15]. Advances in the detection of both symptomatic and asymptomatic stones by modern imaging methods and the widespread use of CT scans also contributed to the increased incidence of kidney stones in the study by Kittanamongkolchai et al. [16].

We found that urolithiasis incidence was associated with age distribution, which has not changed markedly over the last 30 years, and that the 40 to 60 years age group in both adult males and females was more likely to suffer from
Figure 6: The global disease burden of urolithiasis for both sexes in 192 countries. (a) The ASIR of urolithiasis in 2019. (b) The ASDR of urolithiasis in 2019. (c) The age-standardized DALY rate of urolithiasis in 2019. ASIR, age-standardized incidence rate; ASDR, age-standardized death rate.
Approximately 3. His gender disparity may be associated with changes in the diet and an increase in metabolic syndromes, such as diabetes and obesity [3].

EAPC was found to be negatively associated with ASIR, implying that urolithiasis increased more slowly in countries with high incidence than in countries with low incidence. The ASIR also differed between SDI quintiles. ASIR was higher in high SDI, middle-high SDI, middle SDI, and low-middle regions than in low SDI regions. Except in low regions, ASIR had a decreasing global pattern in other quintiles. Interestingly, ASIR of the Russian Federation and its neighboring countries, such as Ukraine and Latvia, was substantially higher than that in others. Meanwhile, African countries—Madagascar, South Sudan, and Burundi—had a substantially higher incidence than that in others.
| Sex                  | DALY no.    | 10^3 (95% UI) | DALY no.    | 10^3 (95% UI) | EAPC no. (95% CI) |
|----------------------|-------------|---------------|-------------|---------------|-------------------|
| Overall              | 5167.31     | [3741.33–6357.17] | 6043.09     | [4773.54–7451.94] | 7.35 [5.82–9.04] |
| Female               | 2081.58     | [1524.74–2490.71] | 2420.08     | [1939.13–2990.58] | 5.72 [4.58–7.07] |
| Male                 | 3085.73     | [2071.94–3928.78] | 3623.01     | [2744.39–4545.58] | 9.1 [6.92–11.34] |
| High S DI            | 646.46      | [496.31–818.12]  | 802.64      | [626.22–1005.97] | 5.3 [3.99–6.75]  |
| High-middle S DI     | 1639.97     | [1331.4–1970.73] | 1525.21     | [1218.89–1871.38] | 7.94 [6.33–9.79] |
| Middle S DI          | 1587.67     | [1017.33–1981.05] | 1943.09     | [1505–2400.21] | 7.49 [5.81–9.17] |
| Low-middle S DI      | 1047.82     | [568.37–1355.54] | 1359.64     | [975.4–1738.97] | 8.85 [6.24–11.25] |
| Andean Latin America | 17.25       | [11.89–23.21]  | 6.32 [4.46–8.49] | 39.33 [28.3–52.39] | 6.4 [4.62–8.44] |
| Australasia          | 17.77       | [14.28–21.92]  | 7.78 [6.25–9.65] | 21.81 [16.67–28.01] | 5.3 [4.04–6.95] |
| Caribbean            | 19.29       | [14.76–24.78]  | 6.61 [5.13–8.3]  | 41.58 [32.06–53.23] | 8.14 [6.26–10.45] |
| Central Asia         | 57.19       | [42.34–76.35]  | 10.83 [8.05–14.57] | 95.98 [75.68–120.04] | 12.42 [9.88–15.89] |
| Central Europe       | 193.89      | [159.39–263.24] | 13.51       | [11.06–18.26] | 74.32 [56.83–96.06] |
| Central Latin America| 88.28       | [74.03–105.22] | 8.21 [6.86–9.78]  | 205.88 [167.4–263.13] | 8.24 [6.7–10.57] |
| Central sub-Saharan Africa | 16.32 | [10.42–26.29] | 5.02 [3.11–7.83]  | 32.89 [21.94–47.33] | 4.33 [2.77–6.34] |
| East Asia            | 1621.28     | [961.22–2002.29] | 16.61 [9.81–20.36] | 1075.6 [841.94–1343.94] | 5.35 [4.17–6.69] |
| Eastern Europe       | 809.3       | [661.25–979.1] | 29.44       | [24.01–35.53] | 729.69 [586.18–893.37] |
| Eastern sub-Saharan Africa | 67.41 | [44.29–111.06] | 6.37 [4.24–10.05] | 106.78 [69.37–162.09] | 4.83 [3.18–7.5] |
| High-income Asia Pacific | 109.59  | [77.09–148.23] | 5.48 [3.91–7.35]  | 188.89 [145.15–237.34] | 5.7 [4.18–7.45] |
| High-income North America | 197.48 | [147.12–256.27] | 6.16 [4.55–8.08]  | 234.06 [187.71–290.06] | 4.52 [3.59–5.63] |
| North Africa and middle East | 98.26 | [67.05–135.2]  | 3.95 [2.73–5.46]  | 235.59 [159.04–328.15] | 4.1 [2.82–5.65] |
| Oceania              | 3.03        | [1.69–4.27]    | 7.31 [3.99–10.28] | 6.2 [3.82–8.72] | 6.25 [3.86–8.8] |
| South Asia           | 842.78      | [536.3–1134.41] | 11.47 [7.08–16.51] | 1355.04 [979.19–1806.73] | 8.33 [6.11–11.1] |
| Southeast Asia       | 530.34      | [243.98–712.9] | 17.17 [7.93–23.59] | 857.45 [460.68–1090.19] | 13.06 [6.92–16.54] |
| Southern Latin America | 24.78    | [16.71–34.52] | 5.23 [3.53–7.3]   | 41.49 [28.43–57.6] | 5.54 [3.78–7.74] |
| Southern sub-Saharan Africa | 15.18 | [11.11–19.23] | 3.71 [2.85–4.68] | 25.02 [18.71–32.63] | 3.46 [2.63–4.44] |
| Tropical Latin America | 64.63    | [51.08–80.92] | 5.43 [4.34–6.76]  | 211.87 [169.2–298.86] | 8.55 [6.84–12.13] |
| Western Europe       | 326.16      | [254–411.6]    | 6.55 [5.04–8.41]  | 368.39 [275.06–474.37] | 5.55 [3.99–7.28] |
| Western sub-Saharan Africa | 47.11  | [29.76–65.05] | 4.12 [2.55–5.79] | 95.22 [65.48–126.5] | 3.61 [2.42–4.79] |

DALYs: disability adjusted life-years; EAPC: estimated annual percentage change; CI: confidence interval; UI: uncertainty interval.
lower ASIR. This phenomenon is likely to be because of an increase in meat consumption and the prevalence of diabetes and obesity, all of which are risk factors for urolithiasis [23]. Another study pointed out that the diversity and greater numbers of oxalate-degrading bacteria existing in the gastrointestinal tract played a crucial role in preventing urolithiasis in Black South Africans [24].

Although mortality and DALY in both males and females increased in 2019, the ASDR and age-standardized DALY rate decreased year by year. This decreasing pattern in the ASDR and age-standardized DALY rate of urolithiasis over the last three decades is intertwined with surgical innovations and better treatment guidelines [25]. Surgical treatment might not be the first choice, especially for stones in the inferior pole of the kidney, and pharmacological treatment can be beneficial for spontaneous stone passage. Moreover, it is technological advances that have made it possible to opt for less invasive surgical interventions that are safe, effective, and associated with shorter recovery times and lesser discomfort [26].

The proportion of the elderly in both ASDR and age-standardized DALYs rate of urolithiasis increased. It may be because of their poor tolerance to severe infections and susceptibility to complications, including decreased bone density, cardiovascular disease, and chronic kidney disease [27]. Similarly, there was a demonstrable negative relationship among EAPC, the change in ASDR and age-standardized DALYs rate from 1990 to 2019, and their baseline value in 1990. The higher the ASDR and age-standardized DALYs rate in 1990, the more they changed. This finding may be explained by the fact that countries with higher ASDR and age-standardized DALYs rates were more likely to prioritize urolithiasis prevention programs because of public health concerns. However, in our study, the SDI level did not have an impact on ASDR and age-standardized DALYs rate, which may indicate that better healthcare is less important for a decrease in ASDR and age-standardized DALYs rate. Moreover, as seen in a prior study, we also found a significant regional distribution [15]. For instance, ASDR and age-standardized DALYs rates were very high in Eastern Europe, Central Asia, and Southeast Asia, while extremely low in North Africa, the Middle East, Southern Latin America, and Southern Sub-Saharan Africa.

Despite the GBD study providing high-quality estimates of the global urolithiasis burden, several limitations are inevitable. Firstly, limited data can be obtained from lower SDI countries, and the data we extracted is not representative. Therefore, the data only reveals the general situation of a population in specific regions and countries. Secondly, different countries and regions have different diagnoses, screening standards, and monitoring systems for urolithiasis. Thus, there may be differences in the quality of data. Thirdly, because of the lack of data on risk factors, risk factors for urolithiasis were not assessed.

5. Conclusions

Over the last 30 years, ASIR, ASDR, and age-standardized DALYs rates of urolithiasis have decreased. Yet, significant differences in the geographic, age, and sex distributions were observed. Thus, based on the current epidemiological characteristics of urolithiasis, medical resources should be rationally allocated or adjusted.

Abbreviations

ASR: Age-standardized rate  
ASIR: Age-standardized incidence rate  
ASDR: Age-standardized death rate  
EAPC: Estimated annual percentage changes  
CI: Confidence interval  
DALYs: Disability-adjusted life years  
GBD: Global burden of disease study  
SDI: Sociodemographic index  
UI: Uncertainty interval  
YLD: Years lived with disability  
YLL: Years of life lost.

Data Availability

The data used in this study is available from the global health data exchange query tool (https://ghdx.healthdata.org/gbd-results-tool).

Ethical Approval

Not applicable.

Consent

Not applicable.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors’ Contributions

All authors made substantial contributions to the conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agreed to be accountable for all aspects of the work. Xiaoyuan Qian and Junlai Wan contributed equally to this work.

Acknowledgments

This study was financially supported by a grant from the National Natural Science Foundation of China (No. 81900647) and Key Research and Development Program of Hubei Science and Technology Department (No. 2020BCB052).

Supplementary Materials

The supplementary material file 1: the supplementary tables and figures are already cited in our manuscript “Epidemiological trends of urolithiasis at the global, regional, and national levels: a population-based study.” The supplementary material file 2: figures are already cited in the
manuscript “Epidemiological trends of urolithiasis at the global, regional, and national levels: a population-based study.” (Supplementary Materials)

References

[1] A. Trinchieri, “Epidemiology of urolithiasis: an update,” Clinical Cases in Mineral and Bone Metabolism: the Official Journal of the Italian Society of Osteoporosis, Mineral Metabolism, and Skeletal Diseases, vol. 5, no. 2, pp. 101–106, 2008.

[2] M. López and B. Hoppe, “History, epidemiology and regional diversities of urolithiasis,” Pediatric Nephrology, vol. 25, no. 1, pp. 49–59, 2010.

[3] I. Sorokin, C. Mamoulakis, K. Miyazawa, A. Rodgers, J. Talati, and Y. Lotan, “Epidemiology of stone disease across the world,” World Journal of Urology, vol. 35, no. 9, pp. 1301–1320, 2017.

[4] W. Wang, J. Fan, G. Huang et al., “Prevalence of kidney stones in mainland China: a systematic review,” Scientific Reports, vol. 7, no. 1, Article ID 41630, 2017.

[5] P. J. S. Osther, “Epidemiology of kidney stones in the European union,” Urolithiasis, pp. 3–12, 2012.

[6] C. D. Scales Jr., A. C. Smith, J. M. Hanley, and C. S. Saigal, “Prevalence of kidney stones in the United States,” European Urology, vol. 62, no. 1, pp. 160–165, 2012.

[7] M. R. Safarinejad, “Adult urolithiasis in a population-based study in Iran: prevalence, incidence, and associated risk factors,” Urological Research, vol. 35, no. 2, pp. 73–82, 2007.

[8] C. S. Saigal, G. Joyce, and A. R. Timilsina, “Direct and indirect costs of nephrolithiasis in an employed population: opportunity for disease management?” Kidney International, vol. 68, no. 4, pp. 1808–1814, 2005.

[9] C. J. L. Murray and A. D. Lopez, “Measuring global health: motivation and evolution of the global burden of disease study,” The Lancet, vol. 390, no. 10100, pp. 1460–1464, 2017.

[10] M. Naghavi, H. Wang, R. Lozano, and GBD 2013 Mortality and Causes of Death Collaborators, “Global, regional, and national age–sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the global burden of disease study 2013,” The Lancet, vol. 385, pp. 117–171, 2015.

[11] Z. Liu, Y. Jiang, H. Yuan et al., “The trends in incidence of primary liver cancer caused by specific etiologies: results from the global burden of disease study 2016 and implications for liver cancer prevention,” Journal of Hepatology, vol. 70, no. 4, pp. 674–683, 2019.

[12] S. Gao, W. S. Yang, F. Bray et al., “Declining rates of hepatocellular carcinoma in urban Shanghai: incidence trends in 1976–2005,” European Journal of Epidemiology, vol. 27, no. 1, pp. 39–46, 2012.

[13] A. Hesse, E. Brändle, D. Wilbert, K. U. Köhrmann, and P. Alken, “Study on the Prevalence and incidence of urolithiasis in Germany comparing the years 1979 vs 2000,” European Urology, vol. 44, pp. 709–713, 2003.

[14] T. Yasui, M. Iguchi, S. Suzuki, and K. Kohri, “Prevalence and epidemiological characteristics of urolithiasis in Japan: national trends between 1965 and 2005,” Urology, vol. 71, no. 2, pp. 209–213, 2008.

[15] C. Zhu, D. Q. Wang, H. Zi et al., “Epidemiological trends of urinary tract infections, urolithiasis and benign prostatic hyperplasia in 203 countries and territories from 1990 to 2019,” Military Medical Research, vol. 8, no. 1, p. 64, 2021.

[16] W. Kittanamongkolchai, L. E. Vaughan, F. T. Enders et al., “The changing incidence and presentation of urinary stones over 3 decades,” Mayo Clinic Proceedings, vol. 93, no. 3, pp. 291–299, 2018.

[17] R. A. Hiatt, L. G. Dales, G. D. Friedman, and E. M. Hunkeler, “Frequency of urolithiasis in a prepaid medical care program,” American Journal of Epidemiology, vol. 115, no. 2, pp. 255–265, 1982.

[18] E. Croppi, P. M. Ferraro, P. M. Ferraro, L. Taddei, and G. Gambaro, “Prevalence of renal stones in an Italian urban population: a general practice-based study,” Urological Research, vol. 40, no. 5, pp. 517–522, 2012.

[19] T. Knoll, A. B. Schubert, D. Fahlenkamp, D. B. Leusmann, G. Wendt-Nordahl, and G. Schubert, “Urolithiasis through the ages: data on more than 200,000 urinary stone analyses,” Journal of Urology, vol. 185, no. 4, pp. 1304–1311, 2011.

[20] S. Domrongkitchaiporn, B. Ongphiphadhanakul, W. Stitchantrakul et al., “Risk of calcium oxalate nephrolithiasis after calcium or combined calcium and calcitriol supplementation in postmenopausal women,” Osteoporosis International, vol. 11, no. 6, pp. 486–492, 2000.

[21] V. Walker, E. M. Stansbridge, and D. G. Griffin, “Demography and biochemistry of 2800 patients from a renal stones clinic,” Annals of Clinical Biochemistry: International Journal of Laboratory Medicine, vol. 50, no. 2, pp. 127–139, 2013.

[22] Q. Zeng and Y. He, “Age-specific prevalence of kidney stones in Chinese urban inhabitants,” Urolithiasis, vol. 41, no. 1, pp. 91–93, 2013.

[23] N. Gadhziev, M. Prosyannikov, V. Malkhasevan et al., “Urolithiasis prevalence in the Russian federation: analysis of trends over a 15-year period,” World Journal of Urology, vol. 39, no. 10, pp. 3939–3944, 2021.

[24] C. A. Magwira, B. Kullin, S. Lewandowski, A. Rodgers, S. J. Reid, and V. R. Abratt, “Diversity of faecal oxalate-degrading bacteria in black and white South African study groups: insights into understanding the rarity of urolithiasis in the black group,” Journal of Applied Microbiology, vol. 113, no. 2, pp. 418–428, 2012.

[25] C. Türk, A. Petřík, K. Sarica et al., “EAU guidelines on interventional treatment for urolithiasis,” European Urology, vol. 69, no. 3, pp. 475–482, 2016.

[26] C. Türk, A. Petřík, K. Sarica et al., “EAU guidelines on diagnosis and conservative management of urolithiasis,” European Urology, vol. 69, no. 3, pp. 468–474, 2016.

[27] C. D. Scales Jr., G. E. Tasic, A. L. Schwaderer, D. S. Goldfarb, R. A. Star, and Z. Kirkali, “Urinary stone disease: advancing knowledge, patient care, and population health,” Clinical Journal of the American Society of Nephrology, vol. 11, no. 7, pp. 1305–1312, 2016.