Original Article - Urological Oncology

Investig Clin Urol 2024;65:23-31.
https://doi.org/10.4111/icu.20230247
pISSN 2466-0493 • eISSN 2466-054X

INVESTIGATIVE AND CLINICAL UROLOGY
ICUROLOGY

Twenty-two-year incidence trend of urological cancers in the Republic of Korea: 1999–2020

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Purpose: Cancer is a disease with high social costs, and policymaking through accurate statistics is very important. This study presents the national cancer statistics on the incidence of urological cancers in the Republic of Korea over 22 years, from 1999 to 2020.

Materials and Methods: Through the Korean Statistical Information Service, data on the incidence of urological cancers by sex and age in each year was obtained. For each urological cancer, the number of cases, crude incidence rate (CIR), and age-standardized incidence rate (ASR) were calculated, and the statistical trends were confirmed by joinpoint regression analysis.

Results: Urological cancers, which have increased ASR over 22 years, are as follows: prostate cancer (average annual percent change [AAPC]=6.72%, p-trend<0.05), testicular cancer (AAPC=5.26%, p-trend<0.05), ureter cancer (AAPC=4.16%, p-trend<0.05), kidney cancer (AAPC=4.14%, p-trend<0.05), renal pelvis cancer (AAPC=3.86%, p-trend<0.05), and total urological cancer (AAPC=4.37%, p-trend<0.05). Urological cancers, which has decreased ASR over 22 years, are as follows: penile cancer (AAPC=-2.93%, p-trend<0.05) and bladder cancer (AAPC=-0.31%, p-trend<0.05).

Conclusions: It was confirmed that the ASR of all urological cancers increased for 22 years, except for bladder and penile cancer. With the aging of the population, the CIR increased for all urological cancers. This study will serve as basic data for future research and policy decisions.

Keywords: Epidemiology; Kidney neoplasms; Penile neoplasms; Prostatic neoplasms; Ureteral neoplasms

INTRODUCTION

In the Republic of Korea (ROK), the national causes of death statistics have been compiled since 1983, and since then, cancer has been the number one cause of death [1]. Due to the rapid aging of the population in the ROK, the number of cancer incidences has also been increasing rapidly [2]. Providing accurate statistics on cancer is very important. Therefore, the Headquarter of Korea Central Cancer Registry (KCCR) registers cancer-related data in accordance with the Cancer Control Act and publishes an annual report every year [3]. However, since the cancer statistics book mainly describes only the most common types of cancers, it is up to each researcher to analyze the statistical data of detailed cancers [4]. Among the new cancers that occurred in the ROK in 2020, urological cancers accounted for 12.0% (29,690/247,952) [3]. This study intends to provide statistics on the incidence of urological cancers over the past 22 years

Received: 24 July, 2023 • **Revised:** 23 October, 2023 • **Accepted:** 6 November, 2023 • **Published online:** 21 December, 2023
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based on open national statistical data. The results of this study will be used as basic data for future research and policy establishment about urological cancers.

MATERIALS AND METHODS

1. Data collection

Korean Statistical Information Service (KOSIS) is the national statistical database operated by Statistics Korea. As a gateway for Korea's official statistics, KOSIS offers a convenient one-stop service to a full range of major domestic statistics. Official statistics produced by over 120 statistical agencies covering more than 500 subject matters are available on KOSIS. Data is provided in an open form and can be easily accessed by anyone [5]. We obtained the data on urological cancers from 1999 to 2020 through the KOSIS. We obtained the following data: the number of incidences of each urological cancer by 5-year age groups and sex, and the population structure and midyear population for each year (July 1). The cancer data registered in KOSIS was created and managed by the KCCR, Ministry of Health and Welfare (MOHW).

2. Malignancy classification

The urological cancers were categorized according to the International Classification of Diseases for Oncology 3rd edition (ICD-O-3) [4]. For consistent comparison and convenience, these malignancies were converted to the International Classification of Diseases, 10th edition (ICD-10) [6]. The classification of urological malignancies according to ICD-10 were as follows: malignant neoplasm of penis (C60, penile cancer), malignant neoplasm of prostate (C61, prostate cancer), malignant neoplasm of testis (C62, testicular cancer), malignant neoplasm of other and unspecified male genital organs (C63), malignant neoplasm of kidney, except renal pelvis (C64, kidney cancer), malignant neoplasm of renal pelvis (C65, renal pelvis cancer), malignant neoplasm of ureter (C66, ureter cancer), malignant neoplasm of bladder (C67, bladder cancer), and malignant neoplasm of other and unspecified urinary organs (C68). In this study, unspecified male genital organs (C63) and malignant neoplasm of other and unspecified urinary organs (C68) were excluded from each cancer incidence analysis. In the overall incidence analysis of urological cancers, we included all C60 to C68. We analyzed penile, prostate, and testicular cancer only in the male population, and other cancers, including total urological cancer, were analyzed in the entire population.

3. Statistical analysis

Based on the collected data from KOSIS, we described the number of incidence cases of each urological cancer by year. The average annual percent changes (AAPCs) were analyzed using a joinpoint regression model. The joinpoint regression program is a trend analysis software developed by the United States National Cancer Institute (NCI) [7]. This method describes changes in data trends by connecting several different line segments on a logarithmic scale at joinpoints. Tests of significance use a Monte Carlo permutation method. In addition, an AAPC for each line segment and the corresponding 95% confidence interval were estimated. The AAPC is tested to determine whether a difference exists from the null hypothesis of no change. In the final model, each joinpoint informs a statistically significant change in trends, and each of those trends is described by an AAPC [8]. The crude incidence rate (CIR) for each year and the age-standardized incidence rate (ASR) were calculated by defining the 2020 midyear population (the population count as of July 1, 2020) as the standard population (CIR=[The number of new patients/Midyear population]×1,000,000), (ASR=1,000,000×∑[Incidence rate by sex and age group×The number of population by sex and age group of standard population]/The number of standard population). The unit for each age group was 5 years. The CIRs and ASRs were rounded to four decimal places. Among the 2020 male data, one subject whose age was unknown was excluded from the ASR analysis.

RESULTS

1. Kidney cancer

The number of newly diagnosed kidney cancer increased by 319.0% from 1,419 in 1999 to 5,946 in 2020. The AAPC in incidence cases during this period was 7.46%, and the trend was statistically significant ($p<0.05$). The CIR per million population increased by 284.8% from 30.09 in 1999 to 115.80 in 2020. The AAPC in CIR during this period was 7.01%, and the trend was statistically significant ($p<0.05$). The ASR per million population increased by 117.5% from 53.25 in 1999 to 115.80 in 2020. The AAPC in ASR during this period was 4.14%, and the trend was statistically significant ($p<0.05$) (Supplementary Table 1, Fig. 1).

2. Renal pelvis cancer

The number of newly diagnosed renal pelvis cancer increased by 323.9% from 163 in 1999 to 691 in 2020. The AAPC in incidence cases during this period was 7.81%, and the trend was statistically significant ($p<0.05$). The CIR per

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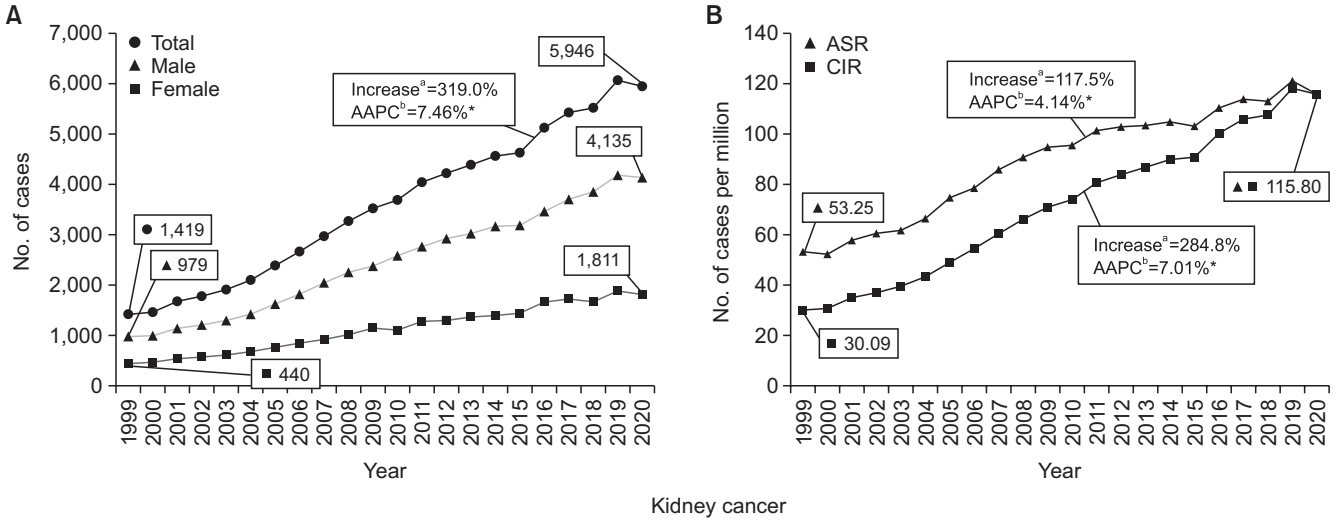

Fig. 1. Annual incidence of kidney cancer in the Republic of Korea. (A) Number of kidney cancer cases. (B) Crude and age-standardized incidence rate of kidney cancer per million using the 2020 Korean standard population. AAPC, average annual percent change; ASR, age-standardized incidence rate; CIR, crude incidence rate. [a]:Comparing 1999 and 2020. [b]:Average annual percent change by joinpoint regression analysis. *p<0.05.

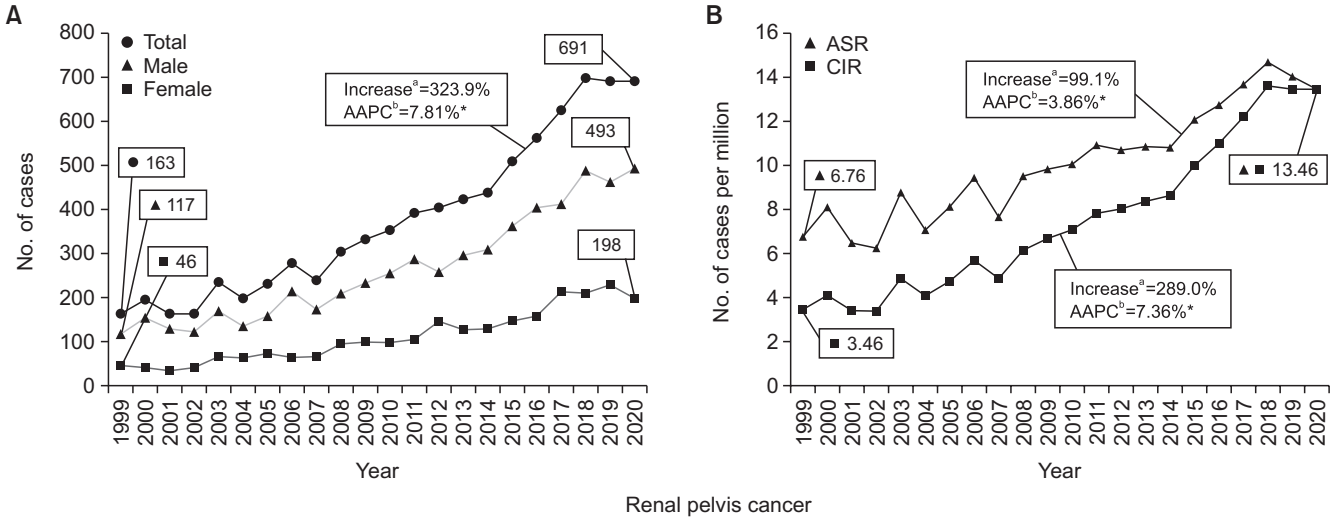

Fig. 2. Annual incidence of renal pelvis cancer in the Republic of Korea. (A) Number of renal pelvis cancer cases. (B) Crude and age-standardized incidence rate of renal pelvis cancer per million using the 2020 Korean standard population. AAPC, average annual percent change; ASR, age-standardized incidence rate; CIR, crude incidence rate. [a]:Comparing 1999 and 2020. [b]:Average annual percent change by joinpoint regression analysis. *p<0.05.

million population increased by 289.0% from 3.46 in 1999 to 13.46 in 2020. The AAPC in CIR during this period was 7.36%, and the trend was statistically significant (p<0.05). The ASR per million population increased by 99.1% from 6.76 in 1999 to 13.46 in 2020. The AAPC in ASR during this period was 3.86%, and the trend was statistically significant (p<0.05) (Supplementary Table 2, Fig. 2).

3. Ureter cancer

The number of newly diagnosed ureter cancer increased by 380.0% from 160 in 1999 to 768 in 2020. The AAPC in incidence cases during this period was 8.38%, and the trend was statistically significant (p<0.05). The CIR per million population increased by 341.3% from 3.39 in 1999 to 14.96 in 2020. The AAPC in CIR during this period was 7.92%, and the trend was statistically significant (p<0.05). The ASR per million population increased by 114.6% from 6.97 in 1999 to 14.96 in 2020. The AAPC in ASR during this period was 4.16%, and the trend was statistically significant (p<0.05) (Supplementary Table 3, Fig. 3).

4. Bladder cancer

The number of newly diagnosed bladder cancer increased by 116.5% from 2,195 in 1999 to 4,753 in 2020. A total

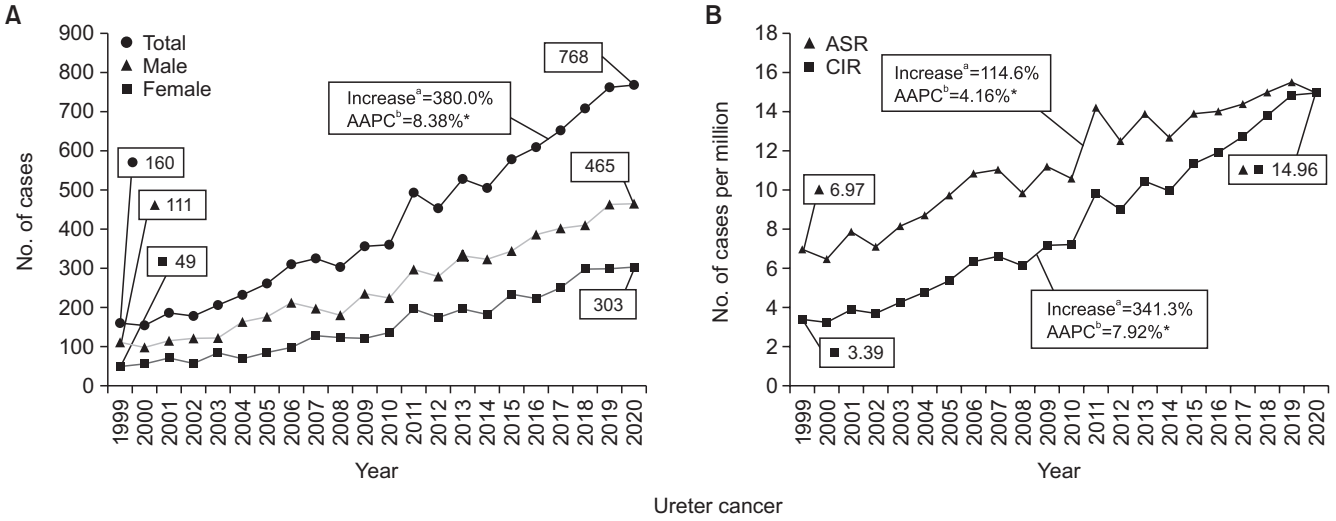

Fig. 3. Annual incidence of ureter cancer in the Republic of Korea. (A) Number of ureter cancer cases. (B) Crude and age-standardized incidence rate of ureter cancer per million using the 2020 Korean standard population. AAPC, average annual percent change; ASR, age-standardized incidence rate; CIR, crude incidence rate. [a]:Comparing 1999 and 2020. [b]:Average annual percent change by joinpoint regression analysis. *p<0.05.

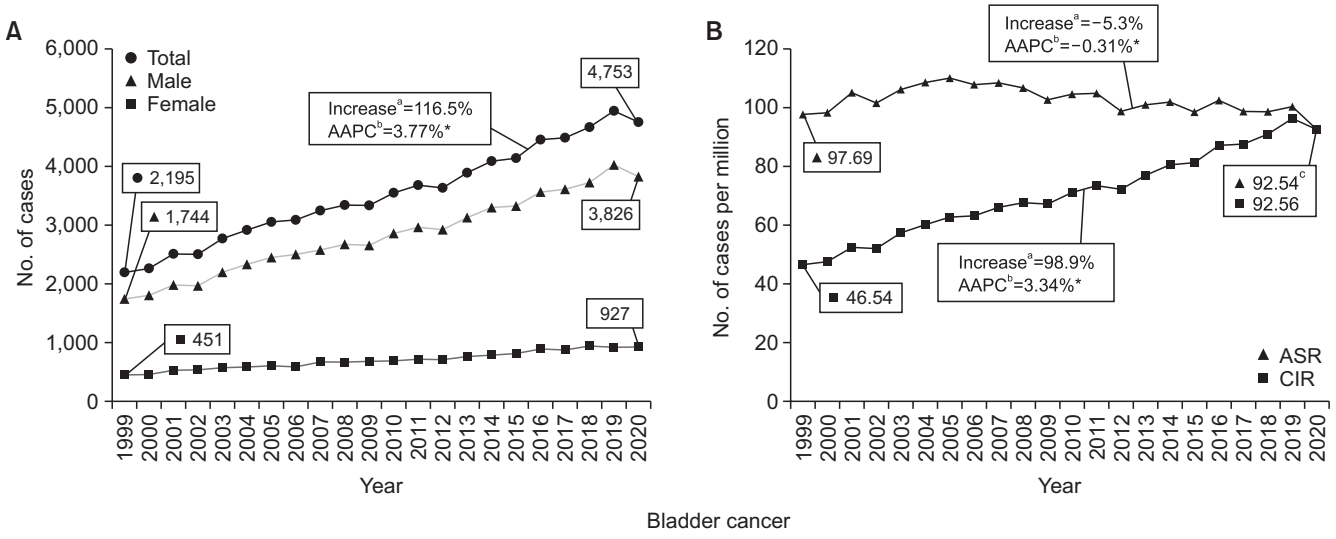

Fig. 4. Annual incidence of bladder cancer in the Republic of Korea. (A) Number of bladder cancer cases. (B) Crude and age-standardized incidence rate of bladder cancer per million using the 2020 Korean standard population. AAPC, average annual percent change; ASR, age-standardized incidence rate; CIR, crude incidence rate. [a]:Comparing 1999 and 2020. [b]:Average annual percent change by joinpoint regression analysis. [c]:Excluding 1 subject of unknown age from the ASR analysis. *p<0.05.

of 4,752 cases were analyzed except for one male with no age information in ASR calculation. The AAPC in incidence cases during this period was 3.77%, and the trend was statistically significant (p<0.05). The CIR per million population increased by 98.9% from 46.54 in 1999 to 92.56 in 2020. The AAPC in CIR during this period was 3.34%, and the trend was statistically significant (p<0.05). The ASR per million population increased by -5.3% from 97.69 in 1999 to 92.54 in 2020. The AAPC in ASR during this period was -0.31%, and the trend was statistically significant (p<0.05) (Supplementary Table 4, Fig. 4).

5. Penile cancer

The number of newly diagnosed penile cancer increased by 34.5% from 55 in 1999 to 74 in 2020. The AAPC in incidence cases during this period was 1.82%, and the trend was statistically significant (p<0.05). The CIR per million population increased by 24.6% from 2.32 in 1999 to 2.89 in 2020. The AAPC in CIR during this period was 1.42%, and the trend was statistically significant (p<0.05). The ASR per million population increased by -50.9% from 5.88 in 1999 to 2.89 in 2020. The AAPC in ASR during this period was -2.93%, and the trend was statistically significant (p<0.05) (Supplemen-

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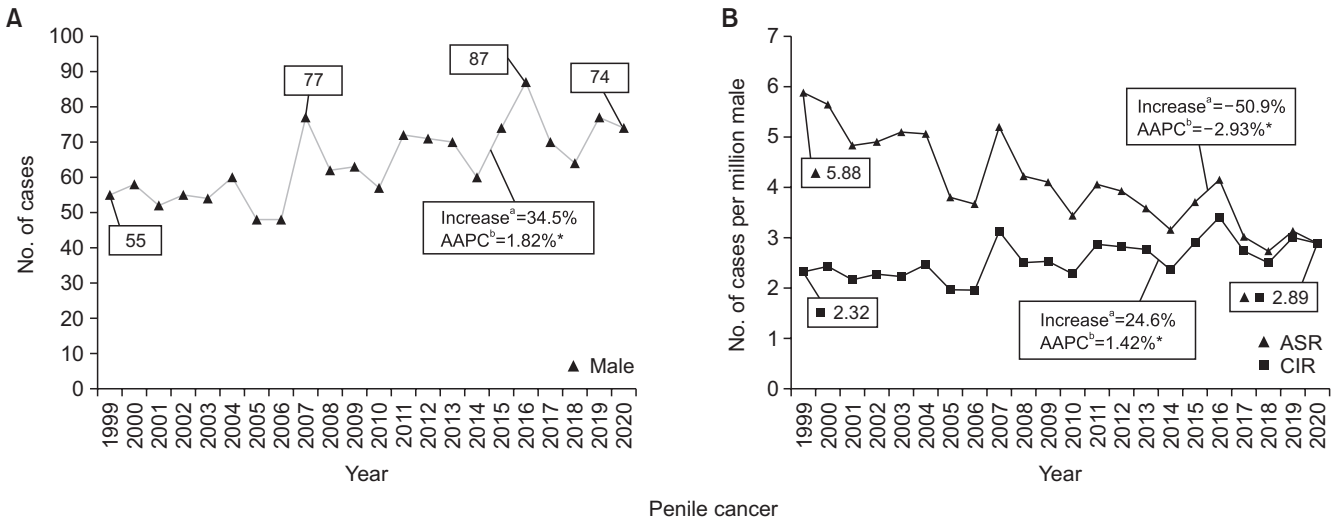

Fig. 5. Annual incidence of penile cancer in the Republic of Korea. (A) Number of penile cancer cases. (B) Crude and age-standardized incidence rate of penile cancer per million using the 2020 Korean male standard population. AAPC, average annual percent change; ASR, age-standardized incidence rate; CIR, crude incidence rate. [a]:Comparing 1999 and 2020. [b]:Average annual percent change by joinpoint regression analysis. *p<0.05.

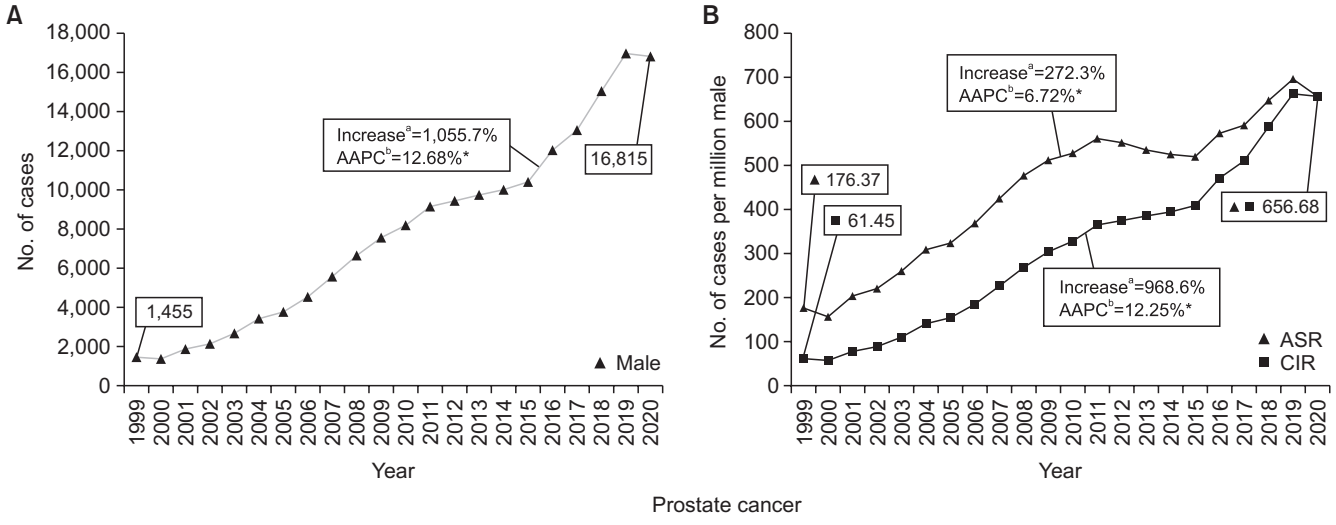

Fig. 6. Annual incidence of prostate cancer in the Republic of Korea. (A) Number of prostate cancer cases. (B) Crude and age-standardized incidence rate of prostate cancer per million using the 2020 Korean male standard population. AAPC, average annual percent change; ASR, age-standardized incidence rate; CIR, crude incidence rate. [a]:Comparing 1999 and 2020. [b]:Average annual percent change by joinpoint regression analysis. *p<0.05.

tary Table 5, Fig. 5).

6. Prostate cancer

The number of newly diagnosed prostate cancer increased by 1,055.7% from 1,455 in 1999 to 16,815 in 2020. The AAPC in incidence cases during this period was 12.68%, and the trend was statistically significant (p<0.05). The CIR per million population increased by 968.6% from 61.45 in 1999 to 656.68 in 2020. The AAPC in CIR during this period was 12.25%, and the trend was statistically significant (p<0.05). The ASR per million population increased by 272.3% from 176.37 in 1999 to 656.68 in 2020. The AAPC in ASR during this period was 6.72%, and the trend was statistically significant (p<0.05) (Supplementary Table 6, Fig. 6).

7. Testicular cancer

The number of newly diagnosed testicular cancer increased by 179.8% from 129 in 1999 to 361 in 2020. The AAPC in incidence cases during this period was 4.95%, and the trend was statistically significant (p<0.05). The CIR per million population increased by 158.7% from 5.45 in 1999 to 14.10 in 2020. The AAPC in CIR during this period was 4.55%, and the trend was statistically significant (p<0.05). The ASR per million population increased by 201.3% from 4.68 in 1999 to

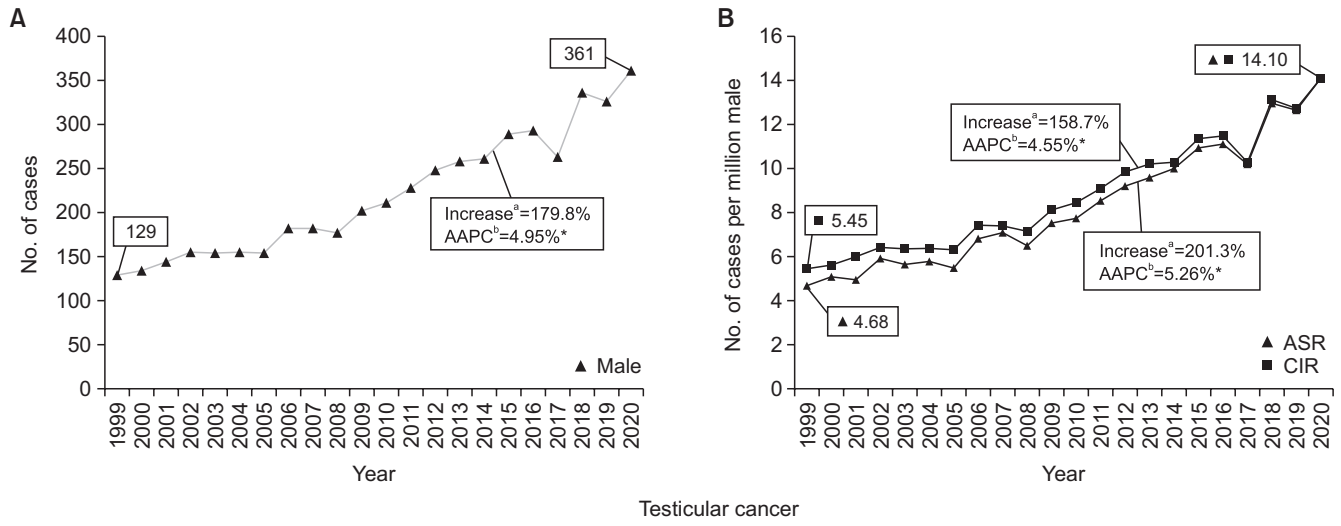

Fig. 7. Annual incidence of testicular cancer in the Republic of Korea. (A) Number of testicular cancer cases. (B) Crude and age-standardized incidence rate of testicular cancer per million using the 2020 Korean male standard population. AAPC, average annual percent change; ASR, age-standardized incidence rate; CIR, crude incidence rate. [a]:Comparing 1999 and 2020. [b]:Average annual percent change by joinpoint regression analysis. *p<0.05.

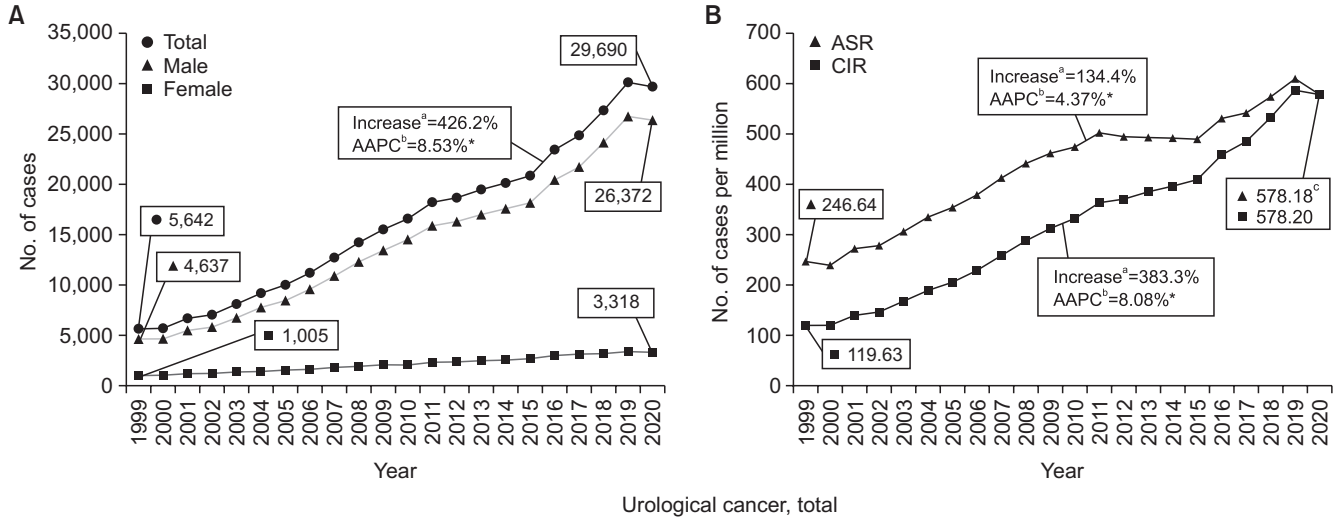

Fig. 8. Annual incidence of total urological cancers in the Republic of Korea. (A) Number of total urological cancer cases. (B) Crude and age-standardized incidence rate of total urological cancer per million using the 2020 Korean male standard population. AAPC, average annual percent change; ASR, age-standardized incidence rate; CIR, crude incidence rate. [a]:Comparing 1999 and 2020. [b]:Average annual percent change by joinpoint regression analysis. [c]:Excluding 1 subject of unknown age from the ASR analysis. *p<0.05.

14.10 in 2020. The AAPC in ASR during this period was 5.26%, and the trend was statistically significant (p<0.05) (Supplementary Table 7, Fig. 7).

8. Total urological cancer

The number of newly diagnosed total urological cancer increased by 426.2% from 5,642 in 1999 to 29,690 in 2020. The AAPC in incidence cases during this period was 8.53%, and the trend was statistically significant (p<0.05). The CIR per million population increased by 383.3% from 119.63 in 1999 to 578.20 in 2020. The AAPC in CIR during this period was 8.08%, and the trend was statistically significant (p<0.05). The ASR per million population increased by 134.4% from 246.64 in 1999 to 578.18 in 2020. The AAPC in ASR during this period was 4.37%, and the trend was statistically significant (p<0.05) (Supplementary Table 8, Fig. 8).

DISCUSSION

The Annual Report of Cancer Statistics, published annually by KCCR, mainly provides information on frequent cancers. Therefore, it is up to each researcher to analyze the

https://doi.org/10.4111/icu.20230247

data on specific minor cancers. The incidence of urological cancers is relatively low, so a specific analysis was conducted in this study. With the aging of the Korean population, the number of urological cancers showed an increasing trend. The AAPC of the incidence of prostate cancer was 12.68%, showing the highest upward trend among urological cancers between 1999 and 2020. All urological cancer CIRs showed a tendency to increase. The CIR of prostate cancer showed the highest increase. Compared to 1999, it increased by 1,055.7% in 2020. In ASR, except for penile and bladder cancer, it showed an increasing trend. The AAPC of ASR of penile cancer showed a decreasing trend of -2.93%. The AAPC of ASR of bladder cancer showed a decreasing trend of -0.31%. The order of increase in ASR over 22 years is as follows: prostate cancer (AAPC=6.72%), testicular cancer (AAPC=5.26%), ureter cancer (AAPC=4.16%), kidney cancer (AAPC=4.14%), renal pelvis cancer (AAPC=3.86%), bladder cancer (AAPC=-0.31%), and penile cancer (AAPC=-2.93%). Several previous studies on urological cancers in the ROK have shown similar results as obtained in this study. In the analysis of other previous studies from 1999 to 2011, the AAPC of prostate cancer and kidney cancer showed an increasing trend, while that of bladder cancer showed a decreasing trend [9]. In the analysis from 1999 to 2012, the incidence of most urological cancers increased (AAPC=6.39%), except for penile (AAPC=2.01%) and bladder (AAPC=-0.40%) cancers [10]. According to the previous studies and this study, it was confirmed that the ASR of all urological cancers increased except for bladder and penile cancer in the ROK for 22 years.

In the ROK in 2020, urological cancers ranked in the top 10 for cancer incidence in the total population of males and females are prostate and kidney cancer. In prostate cancer, 16,815 new cases occurred, accounting for 6.8% of the 247,952 cases of total cancer occurrence, ranking 6th in the cancer incidence ranking. In kidney cancer, 5,946 new cases occurred, accounting for 2.4% of all cancer incidences, ranking 10th in cancer incidence. In the male population, prostate cancer occurred in 16,815, accounting for 12.9% of the 130,618 total cases of male cancer incidences. In the male population, 4,135 new cases of kidney cancer occurred, accounting for 3.2% of males' cancer incidences. In addition, bladder cancer was newly diagnosed in 3,826 cases, accounting for 2.9% of all males' cancer incidences. The incidence of prostate, kidney, and bladder cancers in males was 3rd, 8th, and 10th, respectively. There were no urological cancers in the top 10 for incidence in the females population [3]. In 2021, the number of deaths from prostate cancer in Korean males was 2,360, ranking 7th. There were 1,159 males deaths from bladder cancer, which was outside the top 10 for cancer deaths. There were 375 deaths from bladder cancer in females, outside the top 10 for females cancer deaths [1]. In the ROK, urological cancers were found to be relatively more important cancers in males than in females.

The previous analysis results for urological cancer incidence are as follows. A systematic review of the incidence of upper tract urothelial carcinoma (UTUC) highlights that UTUC increases with age and is higher in Asian countries [11]. Based on data from the International Agency for Research on Cancer (IARC) and the World Health Organization (WHO), the incidence of bladder cancer seems to reflect the smoking rate [12]. In the ROK, the smoking rate is declining every year from 35.1% in 1998 to 19.3% in 2021 [13]. The ASR decrease in bladder cancer confirmed in this study seems to be due to the decrease in smoking rate in the ROK. In the case of renal cell carcinoma (RCC), the incidence pattern varies worldwide. Smoking, obesity, and hypertension are known to be associated with RCC [14]. The incidence of testicular cancer in the West has increased. Several theories have been suggested for this, from chemicals to fetal exposure, increased levels of estrogen, and a rise in maternal body weight. It is known that environmental endocrine disruptors and perfluorinated compounds are associated with the development of testicular and kidney cancer. A meta-analysis suggested that perfluorooctanoic acid might affect the incidence of kidney and testicular cancer. Increased rates of kidney and testicular cancers may be associated with increased worldwide use of these chemicals [15-18]. Cancer incidence patterns vary regionally and socioeconomically, and there are also significant differences between developing and developed countries. In a study that analyzed the incidence of urological cancers in the United Kingdom over 14 years from 2001 to 2013, the increase in prostate cancer, kidney cancer, and urinary tract cancer and the decrease in bladder cancer were consistent with the results of this study was conducted in the ROK [19]. According to the Global Burden of Disease database, bladder and prostate cancer showed a decreasing trend worldwide, but kidney cancer showed an increasing trend. Kidney, bladder, and prostate cancers remain major global public health challenges, but with distinct trends for different disease entities across different regions and socioeconomic status [20]. Further research is needed on the cause of the increase in urological cancers.

The strength of this study is that the descriptive study was conducted based on accurate national statistics. The Cancer Registration Statistics Program is a government-led project conducted in the ROK to track cancer patients' diseases and collect statistical information. This project is implemented to collect data necessary for the effective

treatment and prevention of cancer patients and to analyze cancer prevalence and trends for policy establishment and research. The Cancer Registration Statistics Program centers on the National Cancer Center, and cancer patient information is collected nationwide from hospitals and medical institutions. Along with the KCCR, 11 population-based Regional Cancer Registry collect, analyze, and manage cancer-related data in accordance with the Cancer Control Act [21,22]. This project provides important data for treating and preventing cancer patients and helps the government, medical institutions, and researchers establish cancer-related policies and make decisions [3]. Data is provided through the KOSIS and KCCR, and more use by related researchers is required.

The limitations of this study are as follows. The first limitation of this study is that D-coded neoplasms were not included. The scope of cancer defined by epidemiologists and urologists may be different. Epidemiologists define only C-coded neoplasms as cancer, but urologists usually clinically define D-coded neoplasms, such as carcinoma *in situ* and neoplasms of uncertain of unknown behavior, as cancer as well [19]. In this study, only C-coded neoplasms were included in accordance with the Cancer Control Act, so D-coded neoplasms must be considered when comparing the results of other studies. Second, the increase in urological cancer incidence seen in this study may be due to an increase in detection rather than an actual increase in cancer (detection or surveillance bias). Over the past few decades, a health check-up culture has developed in the ROK, along with the development of medicine [23,24]. There is a possibility of overdiagnosis due to the ROK's health check-up culture, so this should be considered when compared with other countries. Lastly, there have been significant changes in the diagnosis, staging, and treatment of urinary cancer over the past 22 years, but these were not taken into consideration in this study [25]. Detailed studies on stage, survival rate, cancer burden, causes, and prevention should be conducted in future research.

CONCLUSIONS

The ROK entered the aged society (when the proportion of the population aged ≥65 years comprises 14% of the total population) in 2017, and the aging of the population will proceed more rapidly in the future. As a result, the social burden of cancer will increase rapidly. In this study, it was confirmed that most urological cancers increased in the ROK. Prevention and preparation for the increase in urological cancers are necessary. Further research is needed on policies to prepare for this burden and the cause of the increase in cancer incidence.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

FUNDING

None.

ACKNOWLEDGMENTS

The authors thank all Gwangju Jeonnam Regional Cancer Center members at Chonnam National University Hwasun Hospital. The authors also thank the Regional Cancer Registries in the ROK and the KCCR. We thank the researchers for their efforts in collecting and managing data in each region.

AUTHORS' CONTRIBUTIONS

Research conception and design: Won-Ju Park and Seunghyeon Cho. Data acquisition: Seunghyeon Cho. Statistical analysis: Won-Ju Park. Data analysis and interpretation: Won-Ju Park. Drafting of the manuscript: Seunghyeon Cho. Critical revision of the manuscript: Won-Ju Park and Seunghyeon Cho. Administrative, technical, or material support: Seunghyeon Cho. Supervision: Won-Ju Park. Approval of the final manuscript: all authors.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.4111/icu.20230247.

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