Original article

Kosin Medical Journal 2023;38(3):193-200
pISSN: 2005-9531 • eISSN: 2586-7024
https://doi.org/10.7180/kmj.23.116

KMJ
KOSIN MEDICAL JOURNAL

The COVID-19 pandemic's impact on prostate cancer screening and diagnosis in Korea

Byeong Jin Kang, Kyung Hwan Kim, Hong Koo Ha

Department of Urology, Pusan National University Hospital, Busan, Korea

Background: The global coronavirus disease 2019 (COVID-19) pandemic, which started in early 2020, has had multiple impacts on cancer care. This study assessed how the COVID-19 pandemic influenced prostate cancer (PCa) screening and diagnosis in South Korea.

Methods: Patients who visited the outpatient clinic at a single institution for PCa evaluation were included in this study and divided into a pre-COVID-19 group and a COVID-19 pandemic group, based on the start of the COVID-19 pandemic and social distancing policies on March 1, 2020. The number of prostate-specific antigen (PSA) tests, patients with elevated PSA levels, and prostate biopsy results were analyzed.

Results: In total, 8,926 PSA tests were administered during the COVID-19 pandemic, compared to 15,654 before the pandemic (p<0.05). Of 2,132 patients with high PSA levels, 1,055 (49.5%) received prostate biopsies before the pandemic and 1,077 (50.5%) did so during the COVID-19 pandemic. The COVID-19 pandemic group had a higher detection rate of PCa, and increased rates of Gleason scores (GS) 7 and 9–10, while the rate of GS 6 decreased compared to the pre-COVID-19 group (p<0.05). The rate of clinically significant PCa (csPCa) was also higher during the pandemic (p<0.05). In both magnetic resonance imaging-guided and standard biopsies, the GS 6 rate decreased, and the csPCa rate increased during the COVID-19 pandemic (each, p<0.05).

Conclusions: During the COVID-19 pandemic, the detection rate of prostate biopsies and the rate of csPCa increased significantly. Thus, PCa was diagnosed at a more advanced state in Korea during the COVID-19 pandemic.

Keywords: COVID-19; Prostate-specific antigen; Prostatic neoplasms

Introduction

The number of diseases worldwide has increased dramatically after the coronavirus disease 2019 (COVID-19) appeared in the last month of 2019 in the Chinese province of Wuhan. Crowd control protocols have been implemented worldwide as a response to the outbreak [1]. In Korea, COVID-19 has spread nationwide since the first case occurred on January 20, 2020. On February 29, 2020, the Korean government announced its social distancing policy. Since then, it has continued for 2 years, with several phase changes [2]. The worldwide pandemic influenced cancer screening, diagnosis, and transfer [3,4]. That negatively affected both regular prostate-specific antigen (PSA) screening and the diagnosis of prostate cancer (PCa), as evidenced by research conducted in the United States. The absolute PCa screening shortfall in the U.S. population is 1.6 million [5-7]. Studies evaluating the pandemic of

Received: April 2, 2023; **Revised:** May 30, 2023; **Accepted:** June 5, 2023
Corresponding Author: Hong Koo Ha, MD, PhD
Department of Urology, Pusan National University Hospital, Pusan National University School of Medicine, 179 Gudeok-ro, Seo-gu, Busan 49241, Korea
Tel: +82-51-240-7344 Fax: +82-51-247-5443 E-mail: hongkooha@naver.com

COVID-19's effects on PCa detection, diagnosis, and therapy have been published in several nations [8-11]. Several studies conducted in Korea analyzed the influences of the pandemic situation on colorectal and breast cancer. Still, PCa research has not yet been published [1,12]. This study examined if the COVID-19 epidemic in Korea delayed PCa screening and detection, deteriorating clinical status at diagnosis.

Methods

Ethical statements: This study was approved by the Institutional Review Board of Pusan National University Hospital (IRB No. 2303-019-125) and was conducted in accordance with the recent Declaration of Helsinki. Informed consent was waived by the board.

1. Patients

We analyzed the number of PSA tests, cases diagnosed with elevated PSA, and patients with PCa at a single Korean institution during the study period. Additionally, we examined the pathology reports of prostate biopsies at our institution. The patients were divided into a pre-COVID-19 period (from March 2018 to February 2020) and a COVID-19 pandemic period (from March 2020 to February 2022). This division was chosen because the Korean government started its social distancing campaign on March 1, 2020 [2]. This study excluded patients who got a diagnosis of PCa.

2. Prostate biopsy procedure

The inclusion criteria regarding prostate biopsy consisted of a PSA over 4.0 ng/mL, a palpable hard nodule from digital rectal examination, or any lesion exhibiting a Prostate Imaging Reporting and Data System (PI-RADS) score of 3 or higher on magnetic resonance imaging (MRI) [13,14]. All prostate biopsies were performed transrectally using ultrasound-guidance (standard biopsy, 12 cores). Patients with pre-biopsy MRI underwent targeted biopsy using MRI-ultrasound fusion (two cores for each target lesion) plus standard biopsy (MRI-guided biopsy) [15]. We divided all patients into MRI-guided and standard biopsy groups and analyzed the differences in prostate biopsy results preceding and following the COVID-19 pandemic in each group. Patients were not strictly categorized into the MRI-guided and sstandard biopsy groups with specific indications. However, Patients with high cancer risk, such as atypical small acinar proliferation or extensive prostatic intraepithelial neoplasia on previous biopsy, were strongly recommended to undergo MRI. Additionally, MRIs were recommended for men with persistently elevated PSA following a negative biopsy. All patients with PI-RADS ≥3 on MRI underwent MRI-guided biopsy [16].

3. Assessment variables

The following clinical parameters consisted of the analysis: PSA level, age, diagnosis of elevated PSA, the detection rate of PCa, Gleason score (GS), and clinically significant PCa (csPCa; defined as GS of 7 or greater).

4. Statistical analysis

A *p*-value of lower than 0.05 was determined to be statistically significant. The statistical analyses were conducted utilizing IBM SPSS Statistics for Windows, version 22.0 (IBM Corp.).

Results

1. PCa screening number

Throughout the research duration, 24,580 PSA tests were performed, with 8,926 tests completed during the Korean pandemic of COVID-19. This was less than the 15,654 cases conducted prior to the emergence of the COVID-19 virus (63.7% vs. 36.3%). In addition, the number of outpatient visits for elevated PSA (n=1,756 [54.7%] vs. n=1,457 [45.3%], $p<0.05$) and PCa (n=3,084 [63.2%] vs. n=1,795 [36.8%], $p<0.05$) was significantly lower in the pandemic period. The patients' number who had return visits decreased significantly during the pandemic ($p<0.05$) (Table 1).

2. Prostate biopsy results in the pre-COVID-19 and COVID-19 pandemic periods

A total of 2,132 patients diagnosed with elevated PSA levels underwent prostate biopsy. One thousand fifty-five patients (49.5%) and 1,077 patients (50.5%) underwent prostate biopsy during pre-COVID-19 and the COVID-19 pandemic, respectively. The average age (68.1 years vs. 69.0 years) and median PSA (6.88 vs. 7.05) were higher during the pandemic, but the differences were insignificant. The COVID-19 pandemic group had a higher PCa detection rate (53.7% vs. 48.7%, $p<0.05$) (Table 2). The rates of GS 7 (4+3

Table 1. Number of prostate cancer-related cases before and during the COVID-19 pandemic

Variable	Pre-COVID-19	COVID-19 pandemic	Total	*p*-value
No. of PSA tests	15,654 (63.7)	8,926 (36.3)	24,580 (100)	
No. of patients with elevated PSA	1,756 (54.7)	1,457 (45.3)	3,213 (100)	<0.05
First visits	1,216 (69.2)	1,311 (90.0)	2,527 (78.6)	
Return visits	540 (30.8)	146 (10.0)	686 (21.4)	<0.05
No. of patients with prostate cancer	3,084 (63.2)	1,795 (36.8)	4,879 (100)	<0.05
First visits	1,080 (35.0)	1,066 (59.4)	2,146 (44.0)	
Return visits	2,004 (65.0)	729 (40.6)	2,733 (56.0)	<0.05

Values are presented as number (%).
COVID-19, coronavirus disease 2019; PSA, prostate-specific antigen.
p-values were calculated using the chi-square test for categorical variables.

Table 2. Prostate biopsy outcomes before and during the COVID-19 pandemic

Variable	No. (%)			*p*-value
	Pre-COVID-19	COVID-19 pandemic	Total	
No. of patients	1,055 (49.5)	1,077 (50.5)	2,132 (100)	
Average age (yr)	68.1	69.0	68.5	0.89
PSA (ng/mL)				
Median	6.88	7.05	6.96	0.62
Interquartile range	4.86–12.20	4.76–12.45	4.81–12.30	
PCa detection				<0.05
PCa	514 (48.7)	578 (53.7)	1,092	
No tumor	541 (51.3)	499 (46.3)	1,040	
Gleason score (GS)				<0.05
3+3	130 (25.3)	65 (11.2)	195 (17.9)	<0.05
3+4	92 (17.9)	148 (25.6)	240 (22.0)	
4+3	96 (18.7)	150 (25.6)	246 (22.5)	
8	127 (24.7)	111 (19.2)	238 (21.8)	
9–10	69 (13.4)	104 (18.0)	173 (15.8)	<0.05
csPCa (GS≥7)				<0.05
Yes	384 (74.7)	513 (88.8)	897 (82.1)	
No	130 (25.3)	65 (11.2)	195 (17.9)	

COVID-2019, coronavirus disease 2019; PSA, prostate-specific antigen; PCa, prostate cancer; csPCa, clinically significant PCa.

and 3+4: 51.2% vs. 36.6%, $p<0.05$) and 9–10 increased (18.0% vs. 13.4%, $p<0.05$) in the period of the pandemic, while the rate of GS 6 decreased by contrast to the period of pre-COVID-19 (11.2% vs. 25.3%, $p<0.05$). The csPCa was more frequent in the period of the pandemic than in the period of pre-COVID-19 (88.8% vs. 74.7%, $p<0.05$) (Table 2, Fig. 1).

3. Results of MRI-guided biopsy and standard biopsy

Of the 2,132 patients who underwent biopsy, 921 (43.2%) and 1,211 (56.8%) underwent MRI-guided biopsy and standard biopsy, respectively. More MRI-guided biopsies were performed during the pandemic of COVID-19 than during the period of pre-COVID-19 (n=369 [40.1%] vs. n=552 [59.9%], $p<0.05$). We divided the patients into an MRI-guided biopsy group and a standard biopsy group and analyzed the biopsy results (Table 3). Of the 921 men who underwent MRI-guided biopsy, 552 (59.9%) underwent prostate biopsy during the COVID-19 pandemic, and the age and PSA levels were significantly higher in the group that underwent biopsy during this time ($p<0.05$). The PCa detection rate was also higher in the group that underwent MRI-guided biopsy during the pandemic ($p<0.05$). Comparing the GS results of

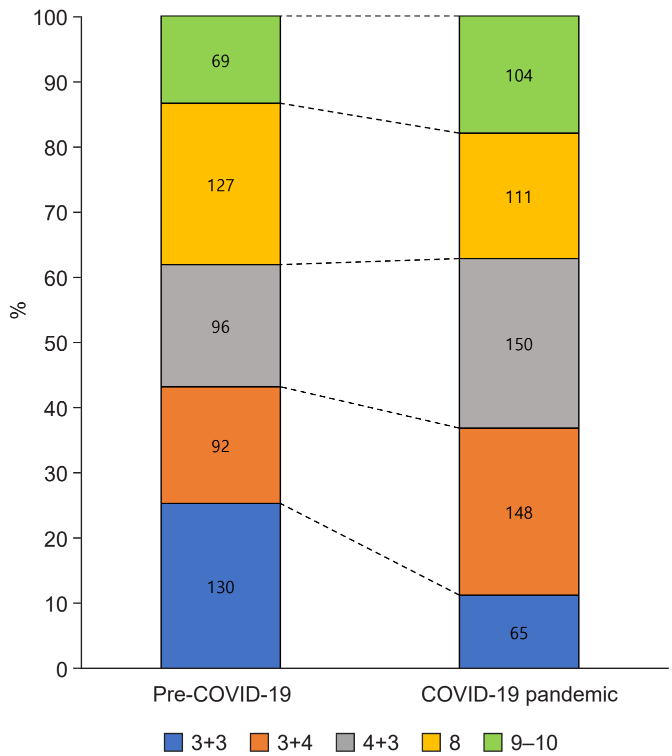

Fig. 1. Differences in the distribution of Gleason scores (GS) in prostate biopsies before and during the coronavirus disease 2019 (COVID-19) pandemic. Each GS is represented by a color, and the number inside the bar represents the number. The y-axis represents the proportion of each GS.

the MRI-guided biopsy, the proportion of GS 6 decreased by 18.7% from 28.7% to 10.0% during the pandemic. The ratio of csPCa with a GS 7 or higher increased from 71.3% to 90.0% ($p<0.05$) (Table 3, Fig. 2).

We analyzed 1,211 patients with standard biopsies throughout the pre-COVID-19 and COVID-19 pandemic, and the two periods had no significant differences in age or PSA levels. The PCa detection rate did not exhibit a statistically significant difference (n=340 [49.6%] vs. n=268 [51.0%], $p=0.61$). However, GS6 rates declined significantly from 23.5% to 12.7%, while csPCa rates increased by 10.8% from 76.5% to 87.3% ($p<0.05$) (Table 3, Fig. 2).

Discussion

Our research indicates a significant reduction in outpatient visits for elevated PSA and PCa following the emergence of the Korean pandemic of COVID-19. As the pandemic progressed, social distancing policies reduced access to hospital care [2]. Patients may also have postponed cancer screening tests or biopsies during outpatient appointments or hospital visits due to anxiety about the risk of COVID-19 infection.

The 2020 Korean Cancer Registry Statistics showed results similar to our study's. The incidence ranking of PCa went up to third place from fourth; however, the incidence rate per 100,000 decreased from 34.5 to 32.7 [17]. This phenomenon is similar to those observed in other countries. The U.S. has an estimated deficit of 1.6 million PCa cases in the entire population. The pattern of decline and recovery in PCa screening varies according to geographic region and socioeconomic status. The Northeast region saw the fastest decline in screenings from March to May 2020, while the West recovered more slowly than the Midwest and southern regions [7].

According to Dutch research, the COVID-19 epidemic considerably reduced the incidence of PCa diagnosis and prostate biopsies. In contrast, the detection rate of biopsies showed a substantial increase in 2020. The researchers explained that patients were reluctant to visit their general practitioners for PSA testing during the lockdown, reduction of PSA testing among asymptomatic individuals. Urologists also conducted fewer biopsies and encouraged low-risk patients to postpone biopsies [9]. These results are consistent with our findings.

In contrast, researchers from Australia reported that PSA screening, prostate MRI, and prostate biopsy showed no significant differences in 2020 owing to the pandemic of COVID-19, except in Victoria. Compared to other nations, the pandemic had little influence, and the effectiveness of Australia's medical care system is credited to researchers. For example, while the COVID-19 outbreak, Australia had less restrictive social policies than other countries, resulting in a lower pandemic influence [10]. These findings indicate that, with some regional variations, PCa screenings and diagnoses reduced globally throughout the COVID-19 pandemic. Differences in basic health systems, government policies on infectious diseases, and sociocultural factors can explain disparities in how various nations have been affected by the COVID-19 pandemic.

The biopsy counts conducted before and after the pandemic did not significantly differ according to this study.

Table 3. MRI-guided and standard prostate biopsy outcomes before and during the COVID-19 pandemic

Variable	No. (%)			*p*-value
	Pre-COVID-19	COVID-19 pandemic	Total	
Biopsy protocol				<0.05
MRI-guided biopsy (target+standard)	369 (40.1)	552 (59.9)	921 (43.2)	
Standard biopsies	686 (56.6)	525 (43.4)	1,211 (56.8)	
Total biopsies	1,055 (49.5)	1,077 (50.5)	2,132 (100)	
MRI-guided biopsies				
No. of patients	369 (40.1)	552 (59.9)	921 (100)	
Average age (yr)	66.2	68.5	67.6	<0.05
Median PSA (ng/mL)	6.82	6.91	6.89	<0.05
PCa detection				<0.05
PCa	174 (47.2)	310 (56.2)	484 (52.6)	
No tumor	195 (52.8)	242 (43.8)	437 (47.4)	
Gleason score (GS)				<0.05
3+3	50 (28.7)	31 (10.0)	81 (16.7)	
3+4	29 (16.7)	81 (26.1)	110 (22.7)	
4+3	38 (21.8)	87 (28.1)	125 (25.8)	
8	42 (24.1)	57 (18.4)	99 (20.5)	
9–10	15 (8.7)	54 (17.4)	69 (14.3)	
csPCa (GS≥7)				<0.05
Yes	124 (71.3)	279 (90.0)	403 (83.3)	
No	50 (28.7)	31 (10.0)	81 (16.7)	
Standard biopsies				
No. of patients	686 (56.6)	525 (43.4)	1,211 (100)	
Average age (yr)	69.1	69.5	69.3	0.34
Median PSA (ng/mL)	6.83	7.03	7.02	0.38
PCa detection				0.61
PCa	340 (49.6)	268 (51.0)	608 (50.2)	
No tumor	346 (50.4)	257 (49.0)	603 (49.8)	
GS				<0.05
3+3	80 (23.5)	34 (12.7)	114 (18.8)	
3+4	63 (18.5)	67 (25.0)	130 (21.4)	
4+3	58 (17.1)	63 (23.5)	121 (19.9)	
8	85 (25.0)	54 (20.1)	139 (22.9)	
9–10	54 (15.9)	50 (18.7)	104 (17.0)	
csPCa (GS≥7)				<0.05
Yes	260 (76.5)	234 (87.3)	494 (81.2)	
No	80 (23.5)	34 (12.7)	114 (18.8)	

MRI, magnetic resonance imaging; COVID-2019, coronavirus disease 2019; PSA, prostate-specific antigen; PCa, prostate cancer; csPCa, clinically significant PCa.

However, during the pandemic, the detection rate of PCa from prostate biopsy increased significantly, and PCa was diagnosed with a higher GS. According to the European Association of Urology risk stratification classification, the rate of csPCa increased accordingly, and the proportion of the low-risk group decreased significantly [18]. Therefore, we confirmed that more advanced cancers were diagnosed during this period. This finding suggests that biopsies were performed later during the pandemic, and PCa patients were diagnosed at more advanced stage than pre-COVID-19.

It is interpreted that this trend is partly reflected in the

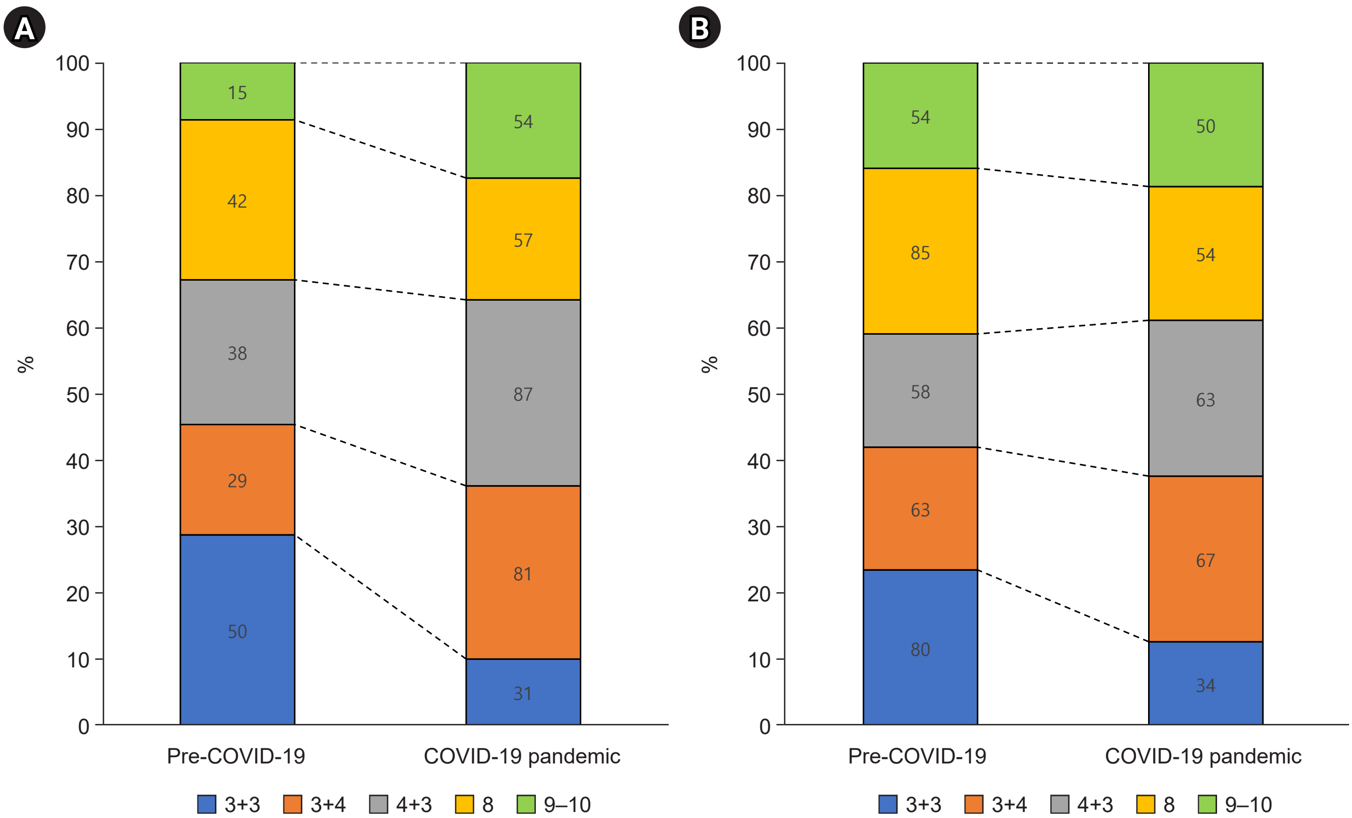

Fig. 2. Differences in the Gleason score (GS) distribution of magnetic resonance imaging (MRI)-guided and standard biopsies before and during the coronavirus disease 2019 (COVID-19) pandemic. Each GS is represented by a color, and the number inside the bar represents the number. The y-axis represents the proportion of each GS. (A) The MRI-guided biopsies comprised MRI-ultrasound fusion targeted target biopsies (two cores per target lesion) and standard biopsies. The group with these biopsies was compared before and during the COVID-19 pandemic. (B) The standard biopsy group was compared before and during the COVID-19 pandemic.

significant increase in age and PSA after the COVID-19 pandemic in the MRI-guided biopsy group. In the MRI-guided biopsy group, a higher proportion of patients were diagnosed with atypical small acinar proliferation and prostatic intraepithelial neoplasia after a biopsy was performed at the other institution and had a higher risk of cancer, but the diagnosis was delayed. These patients are typically older and have higher PSA than prostate biopsy naïve patients. It is inferred that the screening and biopsy of these patients have been delayed at a particularly high rate since the COVID-19 pandemic, which may explain the significant increase in age and PSA in the MRI-guided biopsy group.

While it is debatable whether the postponed detection and management of PCa due to the pandemic has impacted patient oncologic outcomes [19], several countries have published similar analyses. Nyk et al. [8] found that adverse pathological outcomes after robot-assisted radical prostatectomy were associated with the pandemic. They indicated that the pandemic in Poland had resulted in lockdowns or limitations, which had a negative impact and increased the chance of the disease worsening without prompt, effective treatment. They also explained that the pandemic might have made screening tools less available, leading to incorrect preoperative risk assessments [8]. The Netherlands study noted a 1.5% increase in patients with metastatic disease and a 2% drop in the proportion of low-risk groups during the wave of COVID-19 [9].

The diagnosis and management of PCa were influenced by social concerns and regulations in addition to the COVID-19 pandemic. One such example is the restrictions on PSA screening in the United States. In 2012, the U.S. Preventive Services Task Force advised avoiding PSA testing in light of grade D evidence, citing concerns that PCa may be overdiagnosed and overtreated [20]. A grade D recommendation means that the task force recommends against a particular screening or intervention, as the potential harm outweighs the potential benefits. After these policies were implemented, PSA screening declined, and PCa-specific mortality plateaued or increased [21]. Butler et al. [22] found that from 2012 to 2015, the occurrence of localized disease declined, whereas distant metastatic disease continued to increase. In Korea, PSA screening tests are not included in national cancer screening workups. The pandemic may have further increased the rate of advanced PCa at diagnosis, especially in Korean circumstances. We can explain that this effect is reflected in our results.

The 2020 cancer statistics report for Korea states that the relative survival rate for PCa patients from 2016 to 2020 reached 102.6% in localized PCa and 99.9% in locally advanced PCa but decreased significantly to 45.9% in distant metastatic PCa [17]. Hence, it is probable that a more significant number of individuals got diagnoses at more aggravated states linked with the COVID-19 pandemic, thereby carrying the potential to exert a substantial adverse influence on oncological outcomes, including cancer-specific survival in PCa. Long-term follow-up is needed to determine how government policies and sociological responses to pandemic have affected the oncological outcomes.

Various constraints limited the present research. The present study was conducted retrospectively at a single institution. Thus, the possibility of bias in selection could not be entirely eradicated. The results of this study from a single tertiary referral center are limited in understanding the screening and diagnostic patterns of patients with PCa in Korea. Therefore, further multicenter studies or studies using a Common Data Model for the screening and diagnosing PCa in the course of the Korean pandemic. Second, this study analyzed the COVID-19 pandemic's influence using only outpatient visits, screening tests, and biopsy results related to PCa. Additional information on the results of imaging screening tests, such as MRI, bone scans, and post-prostatectomy pathologic reports, would provide a more accurate PCa patients' clinical presentation. Third, this study did not examine the long-term outcomes of PCa patients. In the future, it will be necessary to establish a multicenter database to evaluate recurrence-free or cancer-specific survival after treating patients diagnosed at that time.

In conclusion, during the COVID-19 pandemic, outpatient visits and screenings for PCa decreased. Simultaneously, the diagnostic rate of PCa with biopsies increased during this period, and patients with PCa tended to be diagnosed at a more aggravated state. Additional research is required to examine the ongoing influence of the COVID-19 pandemic on the oncological outcomes of PCa in Korea.

Article information

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

Funding

This work was supported by clinical research grant from Pusan National University Hospital in 2023.

Author contributions

Conceptualization: BJK, HKH. Data curation: BJK. Formal analysis: BJK. Funding acquisition: BJK. Investigation: BJK. Methodology: BJK, HKH. Project administration: KHK. Resources: BJK. Software: BJK. Supervision: HKH. Validation: KHK. Visualization: BJK, KHK. Writing - original draft: BJK. Writing - review & editing: BJK, KHK. Approval of final manuscript: all authors.

ORCID

Byeong Jin Kang, https://orcid.org/0000-0003-4498-5895
Kyung Hwan Kim, https://orcid.org/0000-0001-7162-6527
Hong Koo Ha, https://orcid.org/0000-0002-8240-7765

References

1. Lim JH, Lee WY, Yun SH, Kim HC, Cho YB, Huh JW, et al. Has the COVID-19 pandemic caused upshifting in colorectal cancer stage? Ann Coloproctol 2021;37:253–8.
2. Ko HJ, Cho YJ, Kim KK, Kang JH, Kim YS, Haam JH, et al. COVID-19 and related social distancing measures induce significant metabolic complications without prominent weight gain in Korean adults. Front Med (Lausanne) 2022;9:951793.
3. London JW, Fazio-Eynullayeva E, Palchuk MB, Sankey P, McNair C. Effects of the COVID-19 pandemic on cancer-related patient encounters. JCO Clin Cancer Inform 2020;4:657–65.
4. Kaufman HW, Chen Z, Niles J, Fesko Y. Changes in the number

of US patients with newly identified cancer before and during the coronavirus disease 2019 (COVID-19) pandemic. JAMA Netw Open 2020;3:e2017267.
5. Lee KM, Bryant AK, Alba P, Anglin T, Robison B, Rose BS, et al. Impact of COVID-19 on the incidence of localized and metastatic prostate cancer among White and Black Veterans. Cancer Med 2023;12:3727–30.
6. Englum BR, Prasad NK, Lake RE, Mayorga-Carlin M, Turner DJ, Siddiqui T, et al. Impact of the COVID-19 pandemic on diagnosis of new cancers: a national multicenter study of the Veterans Affairs Healthcare System. Cancer 2022;128:1048–56.
7. Chen RC, Haynes K, Du S, Barron J, Katz AJ. Association of cancer screening deficit in the United States with the COVID-19 pandemic. JAMA Oncol 2021;7:878–84.
8. Nyk L, Kamecki H, Zagozdzon B, Tokarczyk A, Baranek P, Mielczarek L, et al. The impact of the ongoing COVID-19 epidemic on the increasing risk of adverse pathology in prostate cancer patients undergoing radical prostatectomy. Curr Oncol 2022;29:2768–75.
9. Deukeren DV, Heesterman BL, Roelofs L, Kiemeney LA, Witjes JA, Smilde TJ, et al. Impact of the COVID-19 outbreak on prostate cancer care in the Netherlands. Cancer Treat Res Commun 2022;31:100553.
10. Jain A, Macneil J, Kim L, Patel MI. The effect of COVID-19 on prostate cancer testing in Australia. BMC Urol 2022;22:88.
11. Fallara G, Sandin F, Styrke J, Carlsson S, Lissbrant IF, Ahlgren J, et al. Prostate cancer diagnosis, staging, and treatment in Sweden during the first phase of the COVID-19 pandemic. Scand J Urol 2021;55:184–91.
12. Kang YJ, Baek JM, Kim YS, Jeon YW, Yoo TK, Rhu J, et al. Impact of the COVID-19 pandemic on the diagnosis and surgery of breast cancer: a multi-institutional study. J Breast Cancer 2021;24:491–503.
13. Huang GL, Kang CH, Lee WC, Chiang PH. Comparisons of cancer detection rate and complications between transrectal and transperineal prostate biopsy approaches: a single center preliminary study. BMC Urol 2019;19:101.
14. Kortenbach KC, Logager V, Thomsen HS, Boesen L. Comparison of PSA density and lesion volume strategies for selecting men with equivocal PI-RADS 3 lesions on bpMRI for biopsies. Abdom Radiol (NY) 2023;48:688–93.
15. Yarlagadda VK, Lai WS, Gordetsky JB, Porter KK, Nix JW, Thomas JV, et al. MRI/US fusion-guided prostate biopsy allows for equivalent cancer detection with significantly fewer needle cores in biopsy-naive men. Diagn Interv Radiol 2018;24:115–20.
16. Wiener S, Haddock P, Cusano J, Staff I, McLaughlin T, Wagner J. Incidence of clinically significant prostate cancer after a diagnosis of atypical small acinar proliferation, high-grade prostatic intraepithelial neoplasia, or benign tissue. Urology 2017;110:161–5.
17. National Cancer Center (NCC). Annual report of cancer statistics in Korea in 2020 [Internet]. NCC; c2020 [cited 2023 Jun 18]. https://ncc.re.kr/cancerStatsView.ncc?bbsnum=638&searchKey=total&searchValue=&pageNum=1
18. Mottet N, van den Bergh RC, Briers E, Van den Broeck T, Cumberbatch MG, De Santis M, et al. EAU-EANM-ESTRO-ESUR-SIOG Guidelines on Prostate Cancer-2020 Update. Part 1: Screening, Diagnosis, and Local Treatment with Curative Intent. Eur Urol 2021;79:243–62.
19. Diamand R, Ploussard G, Roumiguie M, Oderda M, Benamran D, Fiard G, et al. Timing and delay of radical prostatectomy do not lead to adverse oncologic outcomes: results from a large European cohort at the times of COVID-19 pandemic. World J Urol 2021;39:1789–96.
20. Moyer VA; U.S. Preventive Services Task Force. Screening for prostate cancer: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med 2012;157:120–34.
21. Burgess L, Aldrighetti CM, Ghosh A, Niemierko A, Chino F, Huynh MJ, et al. Association of the USPSTF grade D recommendation against prostate-specific antigen screening with prostate cancer-specific mortality. JAMA Netw Open 2022;5:e2211869.
22. Butler SS, Muralidhar V, Zhao SG, Sanford NN, Franco I, Fullerton ZH, et al. Prostate cancer incidence across stage, NCCN risk groups, and age before and after USPSTF Grade D recommendations against prostate-specific antigen screening in 2012. Cancer 2020;126:717–24.