

Review Article

Patterns of Presentation of Prostate Cancer among Patients at Port Sudan Oncology Center, Red Sea State, Sudan: A Retrospective Cross-Sectional Study (2022-2026)

Mohammed AT Jebreel*, and Hala MM Mahmoud[#]

Faculty of Medicine, Eastern Sudan University, Port Sudan, Sudan

[#]Author contributed equally to this article

***Corresponding author**

Mohammed AT Jebreel, and Hala MM. Mahmoud,
Faculty of Medicine, Eastern Sudan University, Port
Sudan, Sudan

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- Late Presentation
- Diagnostic Delay
- Prostate-Specific Antigen (PSA)
- Gleason Score
- Metastatic Disease
- Oncology
- Sudan

Abstract

Background: Prostate Cancer (PCa) is a leading cause of cancer-related mortality and a major public health challenge worldwide. With over 1.4 million new cases diagnosed annually, its incidence is notably increasing in low- and middle-income countries. The disease typically affects men older than 65 years and presents a broad spectrum of clinical manifestations, ranging from indolent, asymptomatic tumors to aggressive variants associated with rapid progression and distant metastasis.

Methods: A descriptive cross-sectional retrospective study was conducted to analyze the presentation patterns of PCa among patients in the Red Sea State, Sudan (2022–2026). Data were extracted from the medical records of 129 patients at the Port Sudan Oncology Center, which serves as the primary and sole oncology facility in this region.

Results: The cohort's mean age was 69.9 years, with 80.6% of patients aged ≥ 60 years. Lower Urinary Tract Symptoms (LUTS) were the most frequent presenting complaint (50%), followed by urinary retention (34.8%) and back pain (27.7%). The mean serum PSA level was exceptionally high at 194.95 ng/mL, with more than one-third of the cohort exceeding 100 ng/mL, strongly indicating advanced disease. Histopathologically, adenocarcinoma was the predominant type (99.2%), and 59.3% of patients had high-grade tumors (Gleason score 8–10). Strikingly, all patients with available staging data were diagnosed with Stage IV disease. A diagnostic delay was evident, as most patients experienced symptoms for 3–12 months prior to formal diagnosis.

Conclusion: PCa in the Red Sea State is predominantly diagnosed at an advanced stage, characterized by markedly elevated PSA levels and high-grade tumors. Delayed presentation remains a critical challenge, underscoring the urgent need for increased health awareness, early detection strategies, and effective screening programs to improve clinical outcomes.

INTRODUCTION

The prostate is a lobular tubuloalveolar exocrine gland that weighs 20-25 grams and secretes fluid rich in PSA and proteins that contribute to seminal fluid. It's situated beneath the pubs, ventral to the rectum, below the bladder, and surrounding the urethra. Because of this dangerous location, prostate cancer affects sexual, urinary, and bowel function [1]. This gland consists of three zones: firstly, peripheral zone that make up the bulk of the gland that is located anterior to the urethra and it's palpable during digital rectal examination DRE, secondly center zone that is located anterior to the peripheral zone, thirdly transition zone surrounding urethra [1]. The main growth-

related diseases that develop in the prostate are benign prostatic hyperplasia BPH and prostate cancer. 90% of prostate cancer originates from the peripheral zone, and 10% originates from the central zone and transition zone the origin of BPH [2]. Histologically, the prostate is composed of three cells: firstly, the luminal (secretory) cell is a columnar cell responsible for PSA production; secondly, the basal cell acts as a stem-like cell supporting the luminal cell; and thirdly, the neuroendocrine cell controls the growth of luminal and basal cells by secretion of signaling molecules such as serotonin, chromogranin A, and peptides [1]. Most prostate cancer is adenocarcinoma that develops from luminal cells (Figures 1,2).

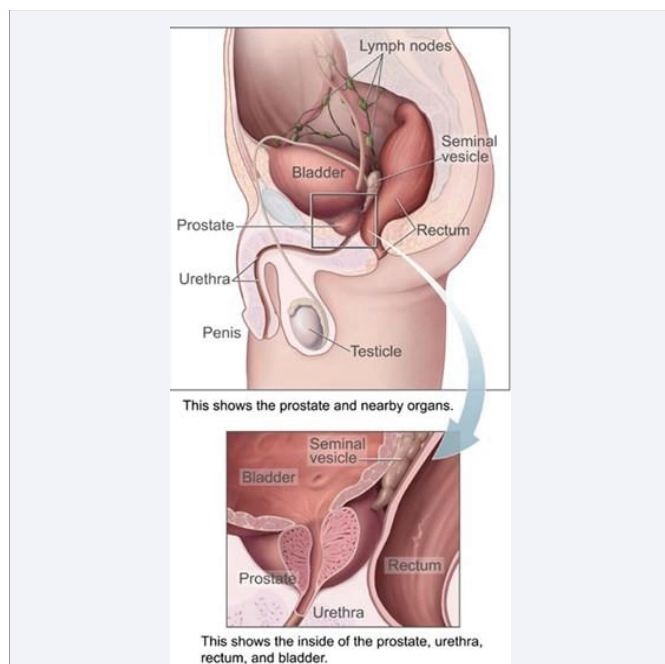


Figure 1 Anatomical location of prostate

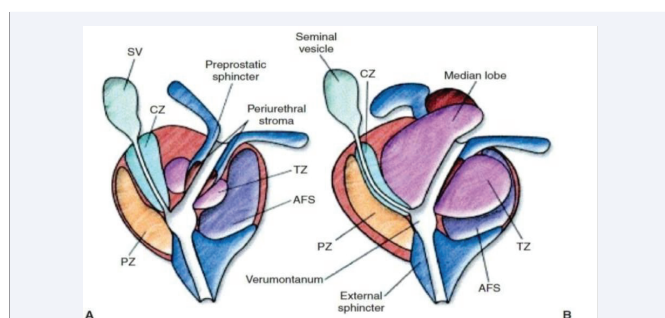


Figure 2 Zonal anatomy of the prostate. A: Young male with minimal transition zone hypertrophy. Note that the preprostatic sphincter and periejaculatory duct zone (central zone of McLean) are clearly defined. B: Older male with transition zone hypertrophy, which effaces the preprostatic sphincter and compresses the periejaculatory duct zone. SV, seminal vesicle; CZ, central zone; TZ, transition zone; AFS, anterior fibromuscular stroma; PZ, peripheral zone.

Prostate Cancer (PCa) is one of the most common malignancies in men worldwide and a major challenge of public health. It is the second most common cancer diagnosed and a leading cause of cancer-related death among men Worldwide, recent studies indicate that more than 1.4 million new cases of prostate cancer are diagnosed each year, with an increasing incidence in low- and middle-income countries [3,4].

Prostate cancer incidence increases with age in men older than 65 years, The disease may present a broad spectrum of clinical manifestations, varying from indolent tumors that remain asymptomatic for years to aggressive variants associated with rapid progression and distant metastasis.

How does prostate cancer occur?

Prostate cancer doesn't happen suddenly but rather progresses through a phase starting from the following:

Phase 1: genetic and molecular alteration:

Gene mutation is the first step, and the next two are BRCA2 and PTEN, which are Tumor Suppressor Genes (TSGs).

Phase 2: hormonal effect:

Prostate growth is dependent mainly on testosterone and Dihydrotestosterone (DHT) when mutation of TSG occurs.

The prostate gland becomes more sensitive to this hormone, and this stimulates rapid, continuous, uncontrolled division of prostate cells.

Phase 3: prostatic intraepithelial neoplasia "pre-malignant":

In this step the cells are atypical and do not invade the basement membrane of the prostate cells.

Phase 4: loss of basal cells:

This occurs due to the rapid growth of luminal cells.

Phase 5: Invasion and metastasis:

In this step the tumor enlarges, and cancer cells invade the basement membrane and also invade nearby organs. After that, the tumor continues to progress and reach the distant organ, "metastasis," and the most common site of metastasis is bone, appearing as osteoblastic lesions [1].

Numerous risk factors have been found, such as advanced age, ethnicity, genetic susceptibility (such as BRCA1 and BRCA2 mutations), and family history [5].

African American men had a much higher incidence and death rate than the other populations, Prostate-Specific Antigen (PSA) testing and Digital Rectal Examination (DRE) are common screening modalities for early-stage prostate cancer, often found in asymptomatic patients. But, in symptomatic patients, hematuria, Lower Urinary Tract Symptoms (LUTS), or symptoms of metastasis are usually present, especially bone pain. When cancer is present, a pathologist assigns the tumor a Gleason score (higher numbers indicate a more dangerous tumor).

Doctors may use medical imaging to check for cancer that has spread beyond the prostate. Imaging data are used to assign a stage of 1 to 4 to a cancer, based on PSA

levels and the Gleason score. A higher degree indicates a more serious and advanced disease [3].

Most prostate tumors stay little and don't create any health issues. Active surveillance is used to manage them, keeping an eye on the tumor through routine testing to make sure it hasn't expanded. Radiation therapy can kill tumors that are more likely to be hazardous, or radical prostatectomy can remove them surgically. Hormone therapy, which lowers levels of the androgens (masculinizing sex hormones) required for prostate cells to survive, is used to treat patients whose cancer extends outside of the prostate.

Cancer cells may eventually become resistant to this therapy. Castration-resistant prostate cancer, the most advanced stage of the illness, is treated with ongoing hormone treatment in addition to the chemotherapy medication docetaxel. Certain tumors metastasize, or spread, to other parts of the body, especially the lymph nodes and bones. Tumors there cause excruciating bone pain. Paralysis or weakness of the legs, and ultimately death. The prognosis for prostate cancer is determined by the extent of the disease at diagnosis. 99% of men with low-risk cancers that are limited to the prostate survive for more than ten years after being diagnosed. With a five-year survival rate of 30–40%, tumors that have spread to distant body sites are the most fatal.

Globally, the widespread use of screening programs in high-income countries has led to earlier detection and improved outcomes [6]. In contrast, studies from Africa consistently demonstrate a different pattern of presentation. A systematic review reported that the incidence of prostate cancer in Africa is approximately 22 per 100,000 people [7]. Furthermore, evidence suggests that prostate cancer incidence in sub-Saharan Africa is increasing steadily.

Importantly, patients in African settings tend to present at more advanced stages of the disease. Lack of screening programs decreased awareness, and limited access to healthcare services are all significantly associated with late presentation. Prostate cancer data is extremely scarce in Sudan. Based on a study conducted in Central Sudan, about 54% of patients had lower urinary tract symptoms at the time they first presented, and many of them had Stage III or IV illness with noticeably high PSA levels [8].

The clinical manifestation of prostate cancer in Eastern Sudan, especially in Port Sudan, is not well documented. This study aims to address this gap.

Problem statement: Most of the studies are conducted

in central regions, with very little information available from Eastern Sudan, including Port Sudan. The lack of data hampers understanding of disease patterns and delays diagnosis in this region. Thus, the present study aimed to determine the clinical characteristics of prostate cancer among patients attending oncology centers in Port Sudan.

Justification

The study is important due to the scarcity of available data on the clinical characteristics of prostate cancer patients in Port Sudan. Prostate cancer in Sudan is also frequently associated with high mortality rates due to late presentation and diagnosis at advanced stages.

To enhance early detection, inform clinical practice, and aid future awareness and screening programs, knowledge of the clinical presentation of the disease in this region is critical.

METHODOLOGY

Study Design and Setting:

A descriptive cross-sectional retrospective study was employed to analyze the patterns of presentation of prostate cancer among patients in port Sudan, red sea state, Sudan. Data were collected from hospital records of patients diagnosed with prostate cancer over the study period. The total sample comprised 129 patients. The study setting encompassed the Port Sudan oncology center, which serves as the only primary center for oncology in this region.

Study Population

All patients diagnosed with prostate cancer from 2022 - 2026 over study period

Inclusion criteria:

-Histologically confirmed prostate cancer.

Exclusion criteria:

-Patients with other primary cancers.

- Females.

Data Collection

Data were collected from available medical records using lists including categorical variable (age, clinical symptoms, PSA level, Gleason score, staging, histological type, duration)

Data Analysis

Statistical Methods: Data were analyzed using

comprehensive descriptive and inferential statistical methods. Descriptive statistics included frequencies and percentages for categorical variables and means with standard deviations for continuous variables. For age, PSA, and Gleason score, approximate means and standard deviations were calculated using group midpoints, as only aggregate data were available. The following specific statistical tests were employed:

Chi-square goodness-of-fit test: Used to assess whether the distribution of categorical variables (age groups, PSA categories, Gleason score categories, and symptom duration categories) significantly deviated from a uniform distribution. This test determines whether certain categories are over-represented, indicating non-random clustering of patient characteristics.

One-sample t-test: Used to test whether the mean PSA level and mean Gleason score were significantly higher than clinically important thresholds (PSA > 4ng/mL; Gleason>6) therapy confirming the advanced nature of disease presentation at population level. **One-sample z-test for proportions:** To determine whether the proportion of high-grade tumors (Gleason score ≥ 8), PSA levels that are elevated (> 100 ng/mL), and Stage 4 presentation were significantly greater than reference proportions providing statistical evidence of advanced disease burden.

Spearman Rank Correlation: The conceptual basis for assessing the ordinal association between PSA levels and Gleason score and symptom duration and disease stage. However, the analyses were limited to descriptive interpretation of aggregate distributions as individual level paired data were unavailable. (Dawson-Saunders 1994)

All statistical analyses were performed in Python (version 3.12) using the SciPy (version 1.x), NumPy and statsmodels libraries. For all analyses, statistical significance was defined as a two-sided p-value <0.05. All estimates of proportions are presented with 95% confidence intervals.

Data Quality Assessment: An important assessment of data completeness was undertaken prior to analysis, as missing data are an important consideration in the interpretation of results. Extent of missing data across key variables is summarized below: A notable limitation is the high proportion of missing data for disease staging (65.9%) and duration of symptoms (45.7%).

The absence of staging data may reflect an incomplete diagnostic workup, with patients not subjected to full staging investigations due to resource constraints or loss

to follow-up. Poor documentation or the patient's inability to recall the onset of symptoms may explain the missing duration data. These gaps are taken care of explicitly in the respective sections. All percentages are reported with respect to the available sample size for the respective variable and not the total study population unless otherwise indicated.

Table: Missing Data Assessment

Variable	Available (n)	Missing (n)	Missing (%)
Age	129	0	0.0%
Clinical Symptoms	112	17	13.2%
Duration of Symptoms	70	59	45.7%
PSA Level	106	23	17.8%
Gleason Score	91	38	29.5%
Disease Staging	44	85	65.9%

Ethical Approval: The Eastern Sudan University for Medical Sciences and Technology's Ethics Committee granted informed ethical permission for this study. Additionally, the Red Sea Research Institute and the Port Sudan Oncology Center granted official clearance to carry out the study. Prior to data collection, all necessary administrative approvals were obtained, and the study was carried out in compliance with institutional ethical standards.

RESULT

Demographic Characteristics

A total of 129 patients who were identified with prostate cancer were examined to explore the age distribution of the group (cohort). Findings showed a significant presence of older individuals as the average age of those with prostate cancer was around 69.9 years. A notable 80.6% of individuals diagnosed with prostate cancer were aged 60 and above (indicating a trend in older patients) with the most substantial group being those over 70. Comparatively a mere 3.1% of prostate cancer cases were identified in patients under 50. Analysis of the statistics revealed a meaningful and varied distribution within these age categories. Findings reveal that older age groups comprise a larger portion of prostate cancer patients (indicating a demographic trend).

Observations show that prostate cancer rates rise sharply as individuals grow older. Consequently, results strengthen the clinical perspective that age is a crucial influencing factor in prostate cancer development (Table 1) (Figure 3).

Clinical Presentation

Analysis was conducted on clinical symptom data

Age Group (years)	Frequency (n)	Percentage (%)
< 50	4	3.1%
50 – 60	21	16.3%
61 – 70	44	34.1%
> 70	60	46.5%
Total	129	100.0%

Approximate Mean $\pm$ SD: 69.9 $\pm$ 10.46 years; Median group: 61–70 years; $\chi^2 = 56.829$, $p < 0.001$

Table 1 Demographic Characteristics of Prostate Cancer Patients (N = 129)

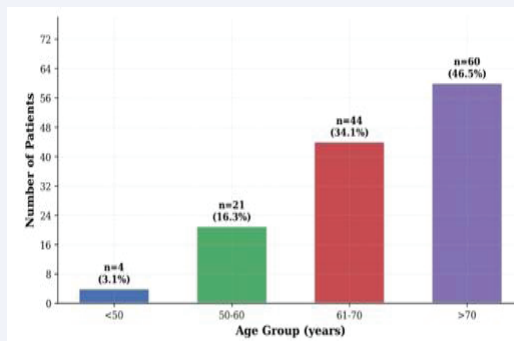


Figure 3 Age Distribution of Prostate Cancer Patients (N = 129)

from 112 patients accounting for 86.8% of the overall cohort while records for 17 patients were not accessible (i-e; they were missing). Among those with documented clinical symptom profiles Lower Urinary Tract Symptoms (LUTS) emerged as the most common issue appearing in 50% of instances. A high frequency of clinical symptoms aligns with the anatomical closeness of the prostate to both the urethra and bladder were tumor advancement results in notable mechanical blockage. Secondary clinical symptoms included urinary retention observed in 34.8% of the individuals (indicating a significant issue). Many patients showed advanced obstruction highlighting the need for urgent intervention. Back pain noted in 27.7% of the cohort is another important clinical symptom linked with possible skeletal metastasis. Reported clinical symptoms encompassed urinary frequency hematuria and diverse types of pelvic or suprapubic pain (i-e; discomfort in the lower abdomen). Multiple individuals often displayed several concurrent symptoms which lead to the overall report of clinical symptoms being higher than the actual number of patients. A significant occurrence of obstructive problems paired with bone pain reveals that many of those affected had locally advanced or metastatic diseases. Clinical symptom patterns indicate that most cases were not detected during early-stage screening instead of presenting at a later more advanced stage (Table 2) (Figure 4).

PSA Levels Distribution

Serum PSA levels were recorded for 106 individuals

Clinical Symptom	Frequency (n)	Percentage (%)
Lower urinary tract symptoms (LUTS)	56	50.0%
Urinary retention	39	34.8%
Back pain	31	27.7%
Frequency	21	18.8%
Hematuria	14	12.5%
Burning micturition	11	9.8%
Suprapubic pain	6	5.4%
Pelvic pain	6	5.4%
Hesitancy	6	5.4%
Incontinence	5	4.5%
Urgency	5	4.5%
Weak urinary stream	3	2.7%
Intermittency	2	1.8%
Polyuria	1	0.9%
Note	Multiple symptoms per patient possible	

Note: Symptom data unavailable for 17 patients (13.2%). Percentages calculated from n=112. Multiple symptoms per patient were documented; therefore, percentages do not sum to 100%.

Table 2 Clinical Presentation of Prostate Cancer Patients (n=112)

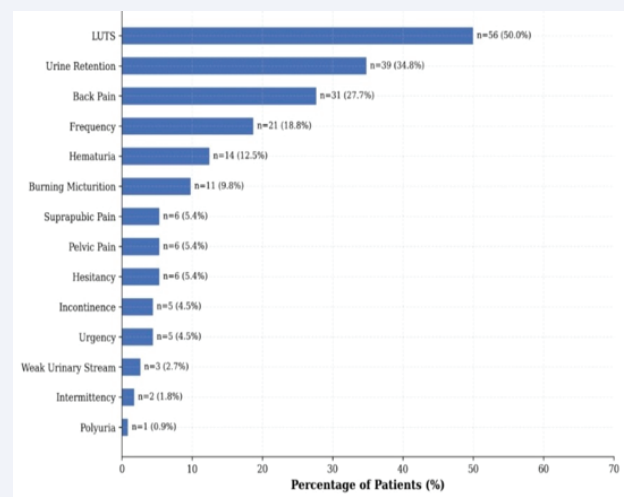


Figure 4 Clinical Presentation of Prostate Cancer (n = 112)

accounting for 82.2% of the study group (i-e; the majority of participants) whereas 17.8% of the files did not include PSA information. Analysis of the PSA levels showed a marked occurrence of notably high readings. The mean PSA value calculated was roughly 194. At 95 ng/mL this measurement is about 49 times more than the typical serum PSA limit of 4 ng/mL (which serves as a standard benchmark). A statistical assessment performed with a one-sample t-test indicated that the mean PSA level was considerably above the given reference threshold implying that the patient group displays significantly heightened tumor markers during the initial diagnosis. Among the observed PSA categories the most common was 100–500 ng/mL accounting for 40 patients (which indicates a significant concentration within this group). In contrast low PSA values below 10 ng/mL were noted in just 11 patients. Lower readings could indicate early-stage disease or tumors that produce minimal PSA. Notably 48

patients showed PSA levels above 100 ng/mL a range often linked to metastatic disease. Results from a chi-square test revealed that PSA levels did not follow a uniform distribution (i.e. there were significant variances). A z-test for proportions further indicated that the group of patients exhibiting PSA levels exceeding 100 ng/mL constituted a significant portion of over 30% of the sample. Findings indicate that many patients displayed PSA levels that are often associated with advanced metastatic cancer (Table 3) (Figure 5).

Gleason Score Distribution

Clinical examination of patient information shows that the Gleason score serves as an essential diagnostic measure (i.e. it significantly affects outcomes). Out of 129 patients assessed 91 had their Gleason score documented and 38 entries lacked histological details. Evaluation of the documented Gleason scores indicates a significant occurrence of high-grade disease in the group. A mean Gleason score of 7.88 indicates a notable departure from the boundary linked to low-grade cancers (i.e; malignancy). Distribution patterns of the Gleason score reveal that

scores of 8 and 7 dominate the dataset. Statistical analysis shows a significant prevalence of higher Gleason score categories within this group. Data analysis reveals that 13.2% of patients had low-grade disease (which indicates a less severe condition) 27.5% were diagnosed with intermediate-grade disease and a significant 59.3% had high-grade disease. High-grade tumors are prominent indicating that most cases align with types linked to more aggressive clinical characteristics. A significant clinical observation is the large number of patients exhibiting high scores (which indicates a concerning situation) as such cases often correlate with a greater likelihood of metastatic progression and a less favorable prognosis compared to those with lower-grade conditions. Assessing the Gleason score is crucial for grasping the biological characteristics of these tumors and directing suitable treatment approaches. Understanding the Gleason score aids in making informed medical decisions ensuring optimal care for affected individuals (Table 4) (Figure 6).

Disease Staging

Data on disease staging were accessible for merely 44 patients (a considerable shortfall in the dataset) as 85

PSA Level (ng/mL)	Frequency (n)	Percentage (%)
< 10	11	10.4%
10 – 30	11	10.4%
30 – 60	14	13.2%
60 – 100	22	20.8%
100 – 500	40	37.7%
> 500	8	7.5%
Total	106	100.0%

Approximate Mean $\pm$ SD: 194.95 $\pm$ 200.12 ng/mL; $\chi^2 = 40.377$, $p < 0.001$; One-sample t-test vs. 4 ng/mL: $t = 9.778$, $p < 0.001$; Proportion PSA > 100 ng/mL: 45.3% ($z = 3.161$, $p = 0.002$ vs. H_0 : $p = 0.30$)

Table 3 Distribution of PSA Levels among Prostate Cancer Patients (n=106)

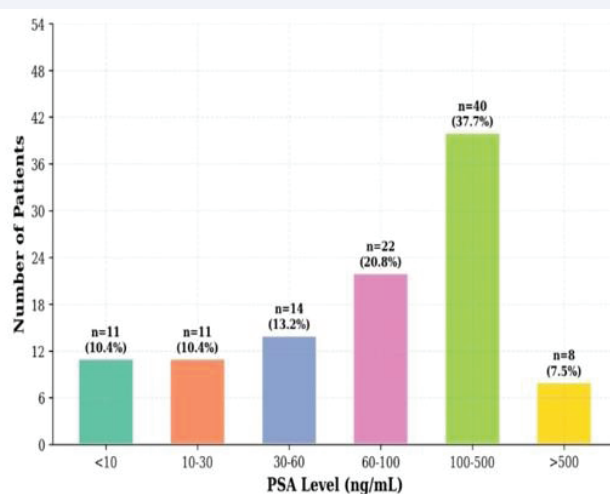


Figure 5 Distribution of PSA Levels (n = 106)

Gleason Score	Grade Group	Frequency (n)	Percentage (%)
6	Low (Group 1)	12	13.2%
7	Intermediate (Group 2–3)	25	27.5%
8	High (Group 4)	26	28.6%
9	High (Group 5)	18	19.8%
10	High (Group 5)	10	11.0%
Total	—	91	100.0%

Mean $\pm$ SD: 7.88 $\pm$ 1.19; $\chi^2 = 11.692$, $p = 0.020$; One-sample t-test vs. Gleason 6: $t = 14.934$, $p < 0.001$; High-grade proportion (GS $\geq$ 8): 59.3% ($z = 1.814$, $p = 0.070$ vs. H_0 : $p = 0.50$)

Table 4 Gleason Score Distribution among Prostate Cancer Patients (n=91)

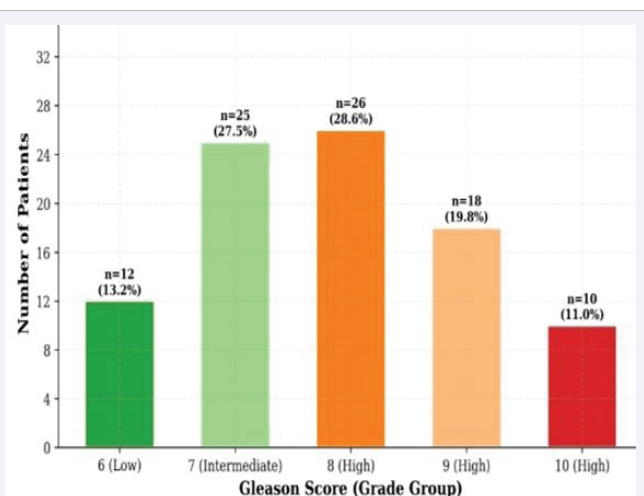


Figure 6 Gleason Score Distribution (n = 91)

records were missing this crucial information. All patients with available data were at Stage 4 indicating the existence of metastatic disease upon diagnosis. Given that every case presented uniformly at Stage 4 performing statistical tests to evaluate staging distribution proves impractical; yet this finding continues to hold substantial importance. Evidence suggests an advanced condition of prostate cancer during the initial clinical presentation. Several factors could explain the lack of early-stage or locally advanced staging in the current records (i.e. missing data). A possible reason for patients with early-stage disease going undiagnosed is the absence of formal screening initiatives. A significant percentage of 65.9% of patients had no staging information available; nonetheless clinical indicators imply that most of these individuals probably had advanced disease. Additionally, findings could be affected by selection bias as clinical staging tends to be prioritized for patients with evident metastatic disease leaving those with less severe symptoms often without comprehensive staging evaluations. The occurrence of Stage 4 disease illustrates significant hurdles in early detection (i.e. the need for timely identification). Utilizing staging information to define this group faces obstacles due to numerous missing records; however, the current staging trends clearly reveal the seriousness of the illness. Filling these gaps in staging is vital for enhancing future outcomes in oncology (Table 5).

Histological Type

Data regarding histological types were examined for all 129 individuals in the study group (which is essential for understanding the conditions being addressed). Adenocarcinoma represented the most common histological type affecting 128 individuals or 99.2% of the cohort. Alternatively, a single individual received a diagnosis of transitional cell carcinoma commonly referred to as urothelial carcinoma associated with the prostate. Histological types exhibit a distribution that corresponds with recognized global epidemiology. Adenocarcinoma's significant presence aligns well with worldwide diagnostic

trends. A solitary case of transitional cell carcinoma signifies an uncommon histological variant that develops from the prostatic urethral epithelium (i.e. it's a unique source). Since this histological variant originates in a way that differentiates it from glandular epithelium a unique clinical strategy is required. Addressing rare histological types even as adenocarcinoma dominates prostate pathology discussions proves crucial. What these distinctions between histological types portray allow clinicians to enhance treatment plans tailored to each specific variant. Understanding various histological types leads to more effective management strategies (Figure 7).

Duration of Symptoms

Studies focused on the time frame of symptoms leading to diagnosis reveal notable trends in how patients present clinically (duration of symptoms). Information about symptom duration was accessible for 70 patients but 59 records were lacking completions. In the documented cases 58.6% of patients had symptoms lasting between 3 to 12 months prior to receiving a formal diagnosis. Additionally, 25. A small proportion of patients (7%) experienced symptoms lasting longer than one year. Notably only 15.7% sought medical attention within three months of the symptoms starting. Analysis of the data reveals a varied pattern in symptom duration with the duration between 3 and 12 months appearing to be especially common. The average duration of symptoms is estimated to be around 9.3 months (a notable timeframe). Correlation exists between extended symptom duration high PSA levels and elevated Gleason scores indicating a clear case of diagnostic delay. A significant duration of symptoms implies that numerous patients experience an extensive phase of disease development prior to being assessed clinically. Frequent reports from patients about prolonged symptom

Disease Stage	Frequency (n)	Percentage (%)
Stage 1	0	0.0%
Stage 2	0	0.0%
Stage 3	0	0.0%
Stage 4	44	100.0%
Not documented	85	—
Total	129	—

Note: Staging data available for only 44/129 patients (34.1%). All staged patients presented with Stage 4 (metastatic) disease. The 85 unstaged patients are excluded from percentage calculations.

Table 5 Disease Staging at Presentation (n=44)

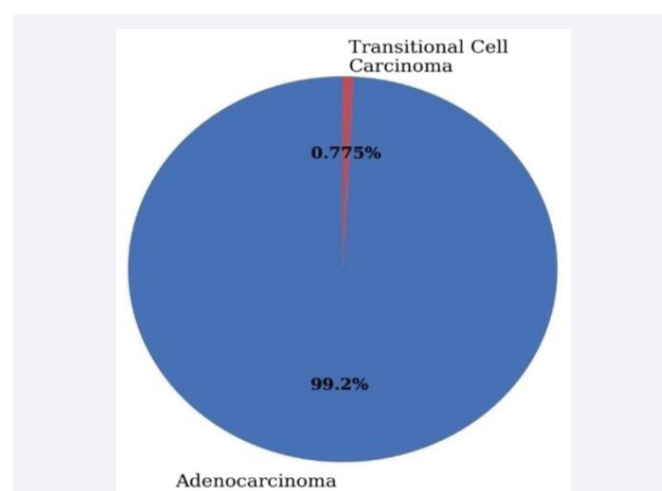


Figure 7 Histological Type Distribution (N = 129)

duration indicate that current diagnostic techniques may obstruct timely disease detection (i.e.; timely response). Statistical evaluations regarding patients experiencing symptoms for over a year have produced ambiguous findings. Nonetheless the overall evidence illustrates that extended symptom durations often happen prior to patients obtaining medical assistance. Comprehending and tackling the factors that contribute to this prolonged symptom duration is vital for improving clinical results for these patients (Table 6) (Figure 8).

Statistical Relationship Analysis:

Age and Disease Stage: Analyzing the connection between age and disease stage necessitates thorough examination (i.e.; assessment of factors). Although data specific to individuals was not accessible for detailed analysis summary data from 44 individuals points to a link. Research indicates that older age correlates positively with more severe disease stages. Notably a significant number of patients above the age of 60 along with every case classified as Stage 4 demonstrates that older individuals often show signs of metastatic disease. Populations engaged in screening initiatives typically show a reverse relationship between age and disease stage (i.e.; older individuals often have earlier disease). In contrast those without screening experience extended periods without detection leading to more severe disease stages as they age. Researchers recommend using a Chi-square test or

Fisher's exact test as suitable statistical approaches to investigate how age and disease stage relate. Given the limited availability of data points this study underscores the significance of exploring age and disease stage patterns to enhance patient outcomes. Assessing age and disease stages continues to be a vital goal for grasping clinical progression thoroughly.

PSA Levels and Gleason Score: Understanding how PSA levels relate to Gleason scores is essential for managing prostate cancer (i.e.; treatment decisions). Elevated PSA levels usually suggest higher Gleason scores reflecting a more aggressive cancer progression. Given the absence of individual-level data the overall distributions still provide significant indirect support for this connection. PSA and Gleason score distributions show marked right-skewness (meaning many patients have extreme values) as a notable number of individuals display PSA levels exceeding 100 ng/mL and Gleason scores of 8 or more. A concentration in these higher values indicates a positive relationship between PSA and Gleason scores. Findings from various studies support this revealing that high PSA levels typically relate to greater tumor grade volume and stage. In cases where researchers have access to individual-level data (which can enhance the analysis) employing a Spearman rank correlation analysis serves as the most suitable method for assessing the connection between PSA and Gleason scores. Given that these variables typically demonstrate non-linear trends this statistical technique effectively verifies the impact of PSA on the understanding of Gleason scores in clinical practice (Figure 9).

Symptom Duration and Cancer Stage: Understanding clinical outcomes heavily relies on the relationship between symptom duration and disease stage (i.e.; key factors). Insightful analysis of these aspects reveals their connection as valuable diagnostic metrics. In this study results indicate that prolonged periods of symptoms are typically associated with later stages of disease. This relationship emphasizes the importance of symptom duration in evaluating disease progression. Prolonged

Duration of Symptoms	Frequency (n)	Percentage (%)
< 3 months	11	15.7%
3 – 12 months	41	58.6%
> 1 year	18	25.7%
Total	70	100.0%

Approximate Mean $\pm$ SD: 9.26 $\pm$ 5.56 months; $\chi^2 = 21.114$, $p < 0.001$; Data unavailable for 59 patients (45.7%)

Table 6 Duration of Symptoms before diagnosis

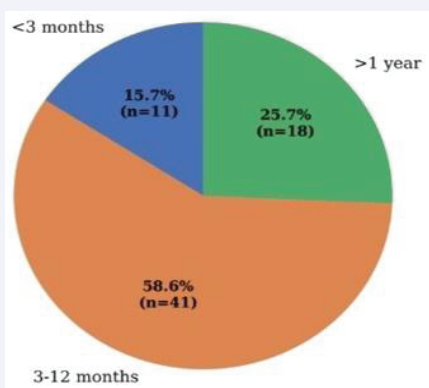


Figure 8 Duration of Symptoms before Diagnosis (n = 70)

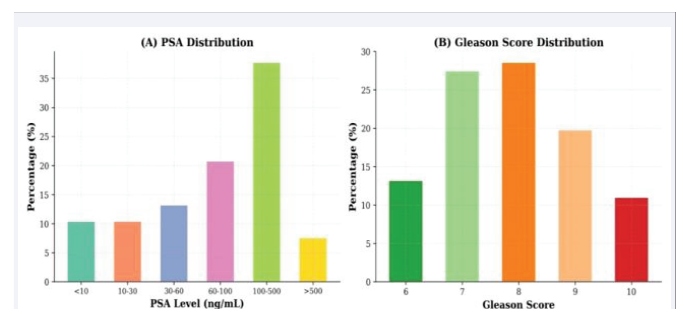


Figure 9 PSA Levels and Gleason Score Patterns Indicating Advanced Disease

symptom duration before patients seek medical attention highlights the risks tied to delays in diagnosis (i.e. seeking timely care). Extended periods of symptoms lead to a higher chance of identifying advanced disease stages. A considerable amount of absent information related to both the length of symptoms and the stage of the disease hinders the ability to draw clear conclusions (i.e.; definite insights). Future studies must focus on thorough data gathering to effectively assess the link between symptom length and disease stage. Employing suitable statistical techniques might provide insights into the relationship between symptom duration and severity of disease stage.

Clinical Symptoms and Disease Severity: Examining clinical symptoms offers vital understanding regarding disease severity (i.e.; the degree of illness). A notable occurrence of signs pointing to severe disease is clear as clinical symptoms including back pain urinary retention and hematuria indicate notable advancement. Observations of these clinical symptoms correlate with advanced staging and high-grade pathology commonly found in these instances. Fifty percent of patients experience lower urinary tract symptoms (which indicates a significant concern). Although benign conditions can cause these symptoms their notable frequency in this group implies a likely mix of both benign and malignant blockages. What raises alarm is the detection of skeletal-related symptoms, particularly back pain since bone metastases signify Stage 4 illness and result in considerable morbidity. Statistical techniques may enhance the understanding of these findings (i.e.; offering deeper insights). Researchers could analyze the connection between clinical signs and disease severity indicators including Gleason scores or PSA categories.

DISCUSSION

A statistical examination focuses on patterns of prostate cancer presentation in Sudan's Red Sea State (i.e.; a quantitative study). Results reveal that advanced prostate cancer is commonly detected at the time of diagnosis. Elevated PSA levels, high Gleason scores and signs of metastasis are often seen in patients. Additionally, every case assessed is classified as Stage 4 prostate cancer reflecting notable difficulties within the healthcare system for early identification. Diagnostic lags imply that the existing framework lacks the necessary resources to recognize prostate cancer while it remains treatable. An urgent requirement for enhanced screening is underscored by the analysis of prostate cancer (which holds significant implications for patient outcomes). Late-stage prostate cancer results in fewer treatment alternatives making it essential to tackle these deficiencies in order to manage prostate cancer effectively.

Advanced Age at Presentation

Average age within this group is nearly 69.9 years (which parallels global prostate cancer trends) since occurrences of prostate cancer usually rise during people's 70s and 80s. Notably within Sudan where the typical life expectancy for men is around 65 years this older diagnosis age calls for thorough investigation. What many men may face is an earlier onset of prostate cancer that goes unnoticed until symptoms appear. A small percentage of patients diagnosed with prostate cancer before reaching 50 may indicate the genuinely low frequency of early-onset prostate cancer (i.e.; those under 50). Conversely the limited number could reveal potential overlooked diagnoses in younger males due to a lack of clinical awareness and inadequate screening methods for prostate cancer. Studies performed in Nigeria demonstrate similar average ages when individuals pursue treatment while observations from East Africa highlight an ongoing regional pattern of late diagnosis. Consequently, the tendency for older ages at diagnosis in the Red Sea State corresponds with wider regional trends concerning prostate cancer.

Markedly Elevated PSA Levels

Mean PSA levels in this group (averaging 195 ng/mL) surpass international norms significantly. In areas where PSA-based screening happens regularly median PSA levels at the time of diagnosis usually vary from 5 to 10 ng/mL aiding in the prompt identification of organ-confined disease. Notably a percentage of 45.3% of patients display a PSA level surpassing 100 ng/mL which is a significant sign of advanced disease (i.e.; progression). Elevated levels of PSA at this point are closely tied to metastatic disease with studies revealing that 80–90% of those having a PSA over 100 ng/mL show radiological signs of bone metastases. Patients exhibiting a PSA level over 500 ng/mL (indicating a very severe tumor burden) constitute 7.5% of the total often demonstrating extensive bone involvement and an unfavorable outcome. In contrast clinical data shows that average PSA values upon diagnosis in North Africa lie between 40 and 80 ng/mL highlighting the likelihood of significant diagnostic delays in that region.

High-Grade Gleason Scores

A significant finding is represented by the prevalence of high-grade Gleason scores particularly those rated at 8 or higher (i.e. indicating severe cancer aggressiveness). High-grade Gleason scores are categorized as aggressive adenocarcinoma which leads to quick disease advancement and lower survival probabilities. Often patients facing these Gleason scores encounter a bleak prognosis without timely treatment. High-grade Gleason scores therefore

necessitate urgent attention to improve patient outcomes. Clinical data indicates that a significant portion of the cohort shows high-grade Gleason scores (which implies that numerous individuals receive diagnoses after considerable progression of the disease). In comparison, populations undergoing screening in different areas frequently display a greater prevalence of lower-grade tumors. Differences in Gleason score distribution underscore the influence of early detection programs on patient outcomes. Highlights from this data emphasize the importance of understanding Gleason scores in various contexts. High-grade Gleason scores represent a biologically aggressive type of cancer resulting in a limited timeframe for effective treatment (i.e.; curative options). What these Gleason scores reveal is their importance as a crucial marker of the total disease impact on the population.

Universal Stage 4 Presentation

A key result from this research shows that all (i.e.; 100%) of the 44 patients for whom staging data was accessible were diagnosed at Stage 4. While a significant number of unstaged patients may create possible selection bias, no instances of early-stage presentation have been seen in current literature. Comparatively in various resource-limited environments early-stage disease usually makes up 5–15% of cases whereas Stage 3 disease generally represents 15–25%. Several reasons might explain the uniform Stage 4 presentation within this cohort (i.e. multiple influences at play). Early detection is often insufficient, leading to the identification of only advanced symptomatic cases. Staging may also be influenced by selection bias particularly if it is predominantly conducted for patients exhibiting apparent metastatic disease. Patients exhibiting early symptoms might avoid seeking medical help or could be wrongly diagnosed with benign prostatic hyperplasia. Despite various factors the significant occurrence of Stage 4 presentation reveals a crucial lack of care (which requires attention). Urgent implementation of strong screening and early detection initiatives becomes evident in light of this Stage 4 presentation trend. Focusing on the patterns related to Stage 4 presentation is crucial for enhancing outcomes as the current rate of Stage 4 presentation indicates that current diagnostic approaches fall short. Optimizing how Stage 4 presentation is handled is essential for upcoming public health efforts.

Clinical Presentation and Diagnostic Delay

Analysis of the symptom profile in this group suggests the presence of advanced prostate cancer instead of early-stage screening-detected illness (especially given the severe nature). Notably symptoms related to the lower

urinary tract and issues like urinary retention point toward considerable prostatic enlargement and obstruction while back pain typically indicates potential metastatic bone disease. These symptoms signify a severe advancement in the situation. Symptom duration prior to diagnosis typically lasts around 9.3 months (highlighting a major holdup that may hasten disease advancement). In the Red Sea State various obstacles lead to this diagnostic delay. Restricted access to medical services cultural obstacles and minimal public knowledge about prostate cancer hinder prompt treatment. Financial hardships along with a lack of PSA testing and biopsy resources worsen the situation. Prostate cancer remains a critical issue in addressing these delays effectively. Prolonged symptom duration coupled with advanced staging and high-grade pathology highlights a notable case of systematic diagnostic failure (i.e.; challenges in diagnosis). Enhancing outcomes requires addressing these concerns as the persistent diagnostic delay represents a significant barrier to quality patient care.

Indicators of Diagnostic Delay

A notable finding in the dataset reveals that a major reason for the advanced stage of prostate cancer in the Red Sea State is attributed to significant diagnostic delays (i.e.; slow identification). Key statistics illustrate the severity of this concern. Mean PSA levels are around 195 ng/mL indicating nearly 49 times the normal limit which implies that tumors tend to grow unchecked prior to an official diagnosis. Furthermore, the high-grade Gleason score prevalence of 59.3% classified as ≥ 8 reflects how often the illness develops into more aggressive forms. Additionally, the findings indicate that every patient presents at Stage 4 (i.e.; they are all affected by metastatic disease) during their first assessment. A mean duration of symptoms lasting 9.3 months represents a significant timeframe of illness before seeking medical advice. Moreover, obstructive and metastatic indicators largely characterize the symptom profile showing less emphasis on early incidental discoveries. Indicators point to the fact that the regional healthcare system primarily detects prostate cancer at advanced symptomatic and frequently untreatable stages (not encouraging). A failure in early detection is more evident than any shortcomings in treatment options. An alarming number of late-stage cases highlights the critical need for enhanced screening measures. Addressing this diagnostic delay matters significantly for improving patient outcomes.

Comparison with International Data

Research on prostate cancer within the Red Sea

State reflects patterns found throughout sub-Saharan Africa though it constitutes an exceptionally problematic diagnostic situation (i.e. one of the worst). Regional investigations reveal substantial difficulties related to prostate cancer; for example, findings from Nigeria Ghana Kenya and Egypt demonstrate elevated mean PSA levels and common diagnoses at advanced stages [5-12]. In contrast the group examined in the Red Sea State displays even more alarming prostate cancer markers indicating significant delays in diagnosis. Outcomes for prostate cancer show a striking difference when compared between the United States and Europe (which have distinct healthcare systems). Populations that undergo screening in those areas generally exhibit notably reduced PSA levels for prostate cancer and a lower frequency of advanced cases. A gap highlights a significant disparity in managing prostate cancer across regions with ample resources versus those with limited means. Prostate cancer data clearly signifies that the introduction of effective early detection initiatives is vital to alleviate the worldwide burden of this disease [6-19].

CONCLUSION

An examination of 129 patients from Red Sea State Sudan reveals a notable trend of advanced prostate cancer during diagnosis (indicating serious health concerns). Data shows that prostate cancer typically emerges at a later stage highlighted by an average age of 69.9 years alongside a significant average PSA level of 195 ng/mL. Additionally, the average Gleason score of 7.88 suggests that most instances involve high-grade prostate cancer confirming its severity. The pattern of advanced prostate cancer is evident as various metrics consistently reflect a concerning situation. Understanding these statistics can help frame future research and treatment strategies. All patients included in this cohort exhibited Stage 4 disease (indicating a significant progression of prostate cancer at diagnosis). A mean symptom duration of 9.3 months is noted with individuals often experiencing urinary obstructions and pain in the bones.

Thus, the study highlights undeniable evidence of a delay in diagnosis. Prostate cancer is often not discovered until reaching these late stages, which limits the possibility of curative treatment options. Indicators clearly point to a pressing requirement for better screening methods aimed at identifying prostate cancer prior to its progression to an incurable stage (i.e; advanced issues). Enhanced screening for prostate cancer must take precedence to ensure early detection and treatment.

Analysis of statistical data including chi-square

goodness-of-fit tests, one-sample t-tests and proportional z-tests reveals significant variances from expected population trends (i.e.; deviations). Current systems for detecting prostate cancer are not functioning as they should. Increasing PSA levels, high-grade Gleason scores and the prevalence of metastatic cases highlight a critical healthcare concern requiring immediate attention. A thorough reevaluation of prostate cancer detection systems is essential to secure improved results for patients facing this substantial health challenge. Missing information about staging and symptom duration restricts how broadly these findings can be applied (i-e; generalize). Available data however continuously illustrates an advanced presentation of prostate cancer. Lacking such data would not significantly change these conclusions.

A critical foundation for enhancing methods of prostate cancer detection and management strategies is established by this study (i.e.; vital groundwork). Improving prostate cancer detection and management within the Red Sea State is crucial. Moreover advancements in prostate cancer detection and management throughout comparable resource-challenged regions in sub-Saharan Africa can lead to marked improvements in clinical results. Prostate cancer detection and prostate cancer management are key to better health outcomes in such areas.

RECOMMENDATIONS

Clinical and Healthcare Recommendations

To ensure early detection targeted PSA screening initiatives for men aged 50–75 in the Red Sea State is crucial (i.e. vital for health outcomes). Limited resources necessitate a practical strategy that includes opportunistic PSA testing during standard check-ups and community outreach efforts. Individuals with a family history or particular urinary symptoms warrant special attention. Enhancing the infrastructure for PSA testing is important to tackle notable diagnostic deficiencies. Missing data is currently widespread, especially concerning Gleason scores and staging (which hampers effective treatment planning). Stakeholders must emphasize enhancing biopsy facilities and histopathological services. Added these PSA testing gaps achieve is improved accuracy in disease characterization. Standardized staging protocols play a vital role in managing clinical situations (i.e.; patient treatment). A significant number of patients lack staging data which obstructs both research efforts and the quality of patient care. Mandatory implementation of protocols using CT MRI and bone scintigraphy is essential. Reliable staging data is crucial for closing gaps in the diagnostic process.

Establishing these protocols will enhance research and improve patient outcomes significantly. Enhancing clinical documentation is essential for the systematic recording of all pertinent variables (such as patient's condition and treatment history). Utilizing standardized tools for data gathering can minimize gaps in information related to symptom duration PSA levels and staging. Comprehensive documentation will promote improved clinical care and elevate the quality of research by guaranteeing that thorough data is accessible for analysis.

Developing comprehensive treatment pathways holds significant importance in managing advanced prostate cancer (a complex condition). Many patients may not have a curable form of this disease, making it essential to establish well-defined protocols that include androgen deprivation therapy alongside palliative care. Optimizing patient quality of life is achievable through these organized pathways. Prioritization of PSA testing thorough staging and enhanced documentation enables the medical system to efficiently tackle the challenges posed by prostate cancer.

Research Recommendations

Prioritizing future research involves focusing on prospective studies that utilize individual-level data (i-e; data from specific participants). Using an organized method to gather paired data allows researchers to conduct formal statistical analyses evaluating the relationships among different variables. Such prospective studies provide more robust evidence essential for improving clinical decision-making. Investigating obstacles to the early recognition of symptoms is essential (i-e; identifying the issues individuals face). Utilizing both qualitative and quantitative research methods aids in pinpointing the distinct cultural economic and systemic obstacles that hinder men in the Red Sea State from obtaining prompt medical care. Recognizing these barriers plays an important role in crafting public health initiatives.

Public health responses must address and not overlook the identified barriers for greater effectiveness. Creating a cancer registry based on the population is encouraged by the Red Sea State (providing valuable insights). A registry would support continuous monitoring of prostate cancer yielding extensive information about incidence diagnostic phases and treatment trends. Furthermore, a cancer registry allows for the ongoing evaluation of early detection initiatives ensuring that healthcare approaches maintain their effectiveness over time.

Experts ought to perform a cost-effectiveness analysis (which helps in the efficient use of resources) to enhance

the distribution of resources. Limitations present an opportunity to evaluate various screening strategies which can lead to recognizing sustainable healthcare models. A comprehensive analysis of cost-effectiveness might show that risk-stratified screening or single-visit testing could be the best option for the region. By undertaking thorough prospective studies tackling known obstacles maintaining a cancer registry and executing cost-effectiveness analysis the healthcare system can greatly boost prostate cancer outcomes.

LIMITATIONS

Acknowledgment of certain limitations is essential when analyzing the findings of this study (i-e; constraints exist). A retrospective design hinders the ability to determine causal relationships and is exposed to biases inherent in medical record keeping. Limitations concerning both study design and record quality significantly impact on the reliability of the results presented. Challenges arise in the study because a notable amount of data is missing (for instance information on staging).

Significant deficiencies exist in aspects such as symptom duration Gleason scores and PSA levels which ultimately leads to a decrease in the effective sample size. Missing data could lead to selection biases, especially if healthcare providers tend to record cases of more severe illness preferentially. As a result, the elevated rates of metastatic presentation might not accurately reflect the true prevalence of these conditions.

Third analysis depends on collective data instead of observations at the individual level (i.e.; personal insights). Grouped data limits the ability to perform exact statistical tests to investigate relationships among variables. Means and standard deviations that are calculated serve merely as approximations based on midpoints. Estimates might not faithfully reflect the actual parameters of the population. For PSA levels this presents specific concerns as the distribution is notably unbalanced and using midpoints brings considerable doubt into the outcomes of this research.

Limitations exist in the study due to its narrow range of facilities (i-e; restricted sample size). Findings related to prostate cancer patterns may not truly reflect the wider population. Staging data is missing leaving the actual spread of the disease unclear. Additionally, without survival data evaluating the prognostic significance is not possible.

Constraints suggest that the research presents an inadequate examination of the prostate cancer burden

(in terms of completeness). Yet consistent findings of advanced presentation highlight a considerable challenge posed by prostate cancer. Limitations may narrow the analysis but essential insights into the prostate cancer landscape remain evident. Future studies must fill these gaps to enhance comprehension of the prostate cancer effects in this regional population.

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Ethics Approval and Consent to Participate

Ethical approval was obtained from the Ethics Committee of the Red Sea State Ministry of Health. This study was conducted in strict accordance with the guidelines of the Declaration of Helsinki. Due to the retrospective design of the study and the use of anonymized medical records, the requirement for informed consent was formally waived by the Ethics Committee.

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